Waterbrook Lifestyle Resort
C/- Marchese Partners Engineering

Geotechnical and Acid Sulfate Soils Assessment: Proposed Seniors Living Development, Cabbage Tree Road, Bayview, NSW

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All enquiries regarding this project are to be directed to the Project Manager.

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1 Development and Investigation Scope

The proposed development details and investigation scope are summarised in Table 1.

Table 1: Summary of proposed development and investigation scope.

Item	Details
Property address	Lot 1 in DP 662920, Cabbage Tree Road, Bayview, NSW
Site area	North western portion of the lot ('the site'), approximately 6.35 ha (based on SIX Maps)
LGA	Northern Beaches Council
Proposed development	Demolition of part of Bayview Golf Course and construction of six new 4 and 5 storey senior living apartment building with basement car parking requiring bulk excavations of up to approximately 13.6 metres below ground level (mBGL) (RL 5.20 mAHD) and new site entry / exit access road.
Assessment purpose	To assist structural design of the proposed development
Previous assessment	A previous preliminary geotechnical and acid sulfate soils assessment was conducted by Martens and Associates (MA) in June 2014 to support a development application (DA) for the proposed seniors living development at the site (referenced P1404179JR03V01, dated June 2014 (MA, 2014)). This report supersedes MA, 2014 with the inclusion of the additional assessment results.
Investigation scope of work	o Twenty three boreholes (refer borehole logs in Attachment B) including: o Ten boreholes (BH101 to BH110) up to 6.2 mBGL conducted on 20 May 2014 o Thirteen boreholes (BH301 to BH309 and BH311 to BH314) up to 15.0 mBGL conducted on 20 and 21 September 2017 o Collection of soil and rock samples for laboratory testings and future reference o Installation of three groundwater monitoring wells including MW02, MW03 and MW05 in BH302, BH303 and BH305, respectively (refer well logs in Attachment B). o Twenty-nine Dynamic Cone Penetrometer (DCP) tests (refer Attachment C) including: o Ten (DCP101 to DCP110) up to 6.2 mBGL conducted on 20 May 2014 o Six (DCP201 to DCP206) up to 1.65 mBGL conducted on 4 June 2014 o Thirteen (DCP301 to DCP309 and DCP311 to DCP314) up to 2.6 mBGL conducted on 20 and 21 September 2017 Investigation locations are shown in Figure 2, Attachment A.
Laboratory testing	Testings carried out by National Association of Testing Authorities (NATA) accredited laboratories included: o Point load strength index testing on eight rock core samples, Atterberg Limits testing on two soil samples and CBR testing on two bulk soil samples by Resource Laboratories. o sPOCAS analysis on twenty nine soil and weathered rock samples and exposure classification on ten soil samples by Envirolab services.

2 Findings

2.1 Site Details and Conditions

General site details are summarised in Table 2.

Table 2: Summary of site details based on desktop review and site investigations.

Item	Comment
Topography	Within moderately undulating terrain; on a spur extending SE from a NE-SW ridge. Site is blanketing the crest of the spur down to a valley to the SW and floodplains to the S.
Typical slopes, aspect, elevation	Slopes at 10 – 15 % to the south and 5 – 10 % to the south west. Near southern and south site boundaries land slopes at > 35 % down to site boundaries and Cabbage Tree Road. Some scarps observed in these areas are evidence of previous slope movement. Site elevations vary from 4 mAHD in the south west to 38 mAHD in the north east
Existing Development	Bayview Golf Course (BGC operational)
Vegetation	Grass, predominately mature trees and bushes. The lean of some trees show evidence of slope movement.
Easements	None based on review of survey and site investigation
Drainage	The site generally drains towards the south eastern corner to a pit which discharges to a culvert under Cabbage Tree Road. The outlet of the culvert is piped and discharges south of the BGC maintenance shed to an unnamed creek that connects to golf course dams in the south. The western portion of the site drains towards an unnamed creek crossing the west and south western part of the BGC, eventually draining 50 m south to reservoirs on the BGC and Cahill Creek. Cahill Creek drains into Pittwater (1 km east).
Geology	Narrabeen Group Newport and Garie Formations comprising interbedded laminite, shale and quartz to lithic quartz sandstone (Sydney 1:100,000 Geological Series Sheet 9130).
Soil Landscape	The Sydney 1:100,000 Soil Landscape Map 9130 (Soil Conservation Service of N.S.W) indicates the majority of the site as being part of the Erina erosional landscape, consisting of undulating to rolling rises and low hills. Soils are moderately deep to deep (100 - >200cm). The eastern corner of the site is mapped as being part of the Deep Creek fluvial landscape, consisting of level to gently undulating alluvial floodplains draining the Hawkesbury Sandstone local relief.

2.2 Ground Conditions

Investigation revealed the following key subsurface units likely underlie the site:

Unit A: Assumed uncontrolled fill comprising clay / silt / sandy silt / silty clay / silty sand / clayey sand / gravelly sand / sand with varying consistencies / densities encountered in some portions of the site, particularly southern portion, up to approximately 5.0

mBGL. Fill, encountered in some boreholes, has likely been placed for landscaping and / or levelling purposes.

Unit B: Topsoil comprising generally stiff to very stiff silt / sandy silt and medium dense silty sand up to approximately 0.7 mBGL.

Unit C: Alluvial soil comprising firm to stiff sandy clay / clay encountered in south eastern portion of the site (i.e. in BH101 and BH314) up to approximately 5.8 mBGL.

Unit D: Residual clay / sandy clay / silty clay / sandy silt with consistencies varying between firm and hard and generally dense silty sand / clayey sand encountered up to approximately 5.2 mBGL.

Unit E: Weathered sandstone and claystone / siltstone from depths of between 0.6 mBGL (BH305) and 5.8 mBGL (BH101), generally from extremely low to low strength with some medium strength bands, up to 15 mBGL (Class V). In BH303 rock strength increased to medium strength from approximately 10 mBGL up to investigation termination depth of 13.4 mBGL (Class IV / III).

Numerous defects and discontinuities, including sheared zones, were observed within cored rock profile. This shearing is considered to be evidence of historical large-scale landsliding, considered to be relict and largely inactive. Evidence of more recent shallow movements, such as leaning trees and hummocky ground was observed within south western and southern portions of the site.

2.3 Groundwater

A review of the NSW Department of Primary Industries Water (DPIW) real time groundwater bore database revealed that there are two bores located within 500 m of the site with available groundwater data (Figure 1). Standing water level data from the database is shown in Table 3.

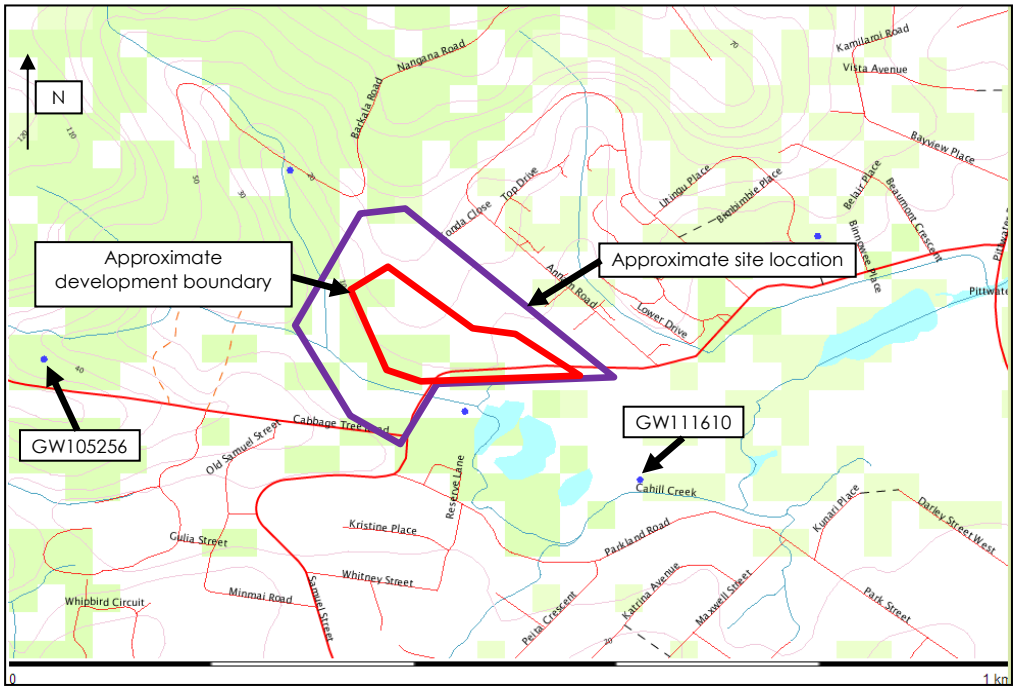


Figure 1: DPIW real time groundwater bore database search within 0.5 km of the site

Table 3: DPIW real time groundwater details for two bores in the vicinity of the site.

Bore #	Approx. Distance From Site	Approximate Elevation (mAHD) [1]	Standing Water Level (mBGL)	Approx. Groundwater Level (mAHD)
GW111610	South east, 180 m	3	1.2	1.8
GW105256	West, 285 m	62	18.0	44.0

Notes:

1. From Google Earth.

Groundwater inflow was encountered only during drilling of BH101 at 5.0 mBGL (RL 0.8 mAHD). This borehole is located on the lower slopes of the site (near Cabbage Tree Road) underlain by alluvial sediments (silty clay) to about 0.0 mAHD. Groundwater inflow was not encountered during drilling of other boreholes, which were drilled into the residual soil unit (except for BH314), up to 8.5 mBGL or observed below this depth due to the introduction of drilling fluids during rock coring.

Groundwater wells (MW02, MW03 and MW05) were installed to depths of 12.0 m, 13.4 m and 15.0 m with slotted screen lengths of 6.0 m, 10.4 m and 9 m, respectively. Summary of groundwater level readings within monitoring wells, undertaken on September and October 2017, are provided in table 4.

Table 4: Summary of groundwater levels at MW02, MW03 and MW05 (September and October 2017).

Date	Groundwater Level (mBGL)		
	MW02	MW03	MW05
21.09.17 (following installation) [1]	10.44	10.7	8.11
20.10.17	11.86	12.62	13.69

Notes:

[1] Readings are likely to have been influenced by inflow of drilling fluids introduced during rock coring.

We note that monitoring and recorded levels are within a dry period (i.e. no substantial rain in the last 3 months) and therefore these levels are considered not to be representative of the average or peak groundwater levels. Actual levels are likely to be 1 – 2 m greater than what was recorded on 21.10.17. To get a better understanding and more accurate assessment of groundwater levels / impacts through the site, groundwater level monitoring would need to be extended to cover 2 - 3 substantial at a minimum (i.e. greater than 10 mm of rain within 24 / 48 hrs).

Based on DPIW search results and field investigations we expect deep excavations, particularly in lower portions of the site, will intercept the permanent groundwater table. Groundwater level data loggers have been installed in monitoring wells and results of further monitoring will be provided in a letter after completion of readings to assess permanent water levels, where encountered.

3 Geotechnical Assessment

3.1 Laboratory Testing

3.1.1 Atterberg Limits Testing

Table 5 presents a summary of test results. A laboratory test certificate is provided in Attachment G.

Table 5: Summary of laboratory test results.

BH	Depth (mBGL)	Soil Type	Atterberg Limits (%)				Plasticity Classification
			LL[1]	PL[1]	PI[1]	LS[1]	
BH302	0.8	Silty CLAY	29	22	7	4.5	Low
BH304	1.0	Sandy CLAY	44	17	27	8.5	Medium

Notes:

[1] LL = Liquid limit, PL= Plastic limit, PI=Plasticity index, LS = Linear shrinkage

Laboratory test results indicate that the fine portion of the tested soil samples are generally of low and medium plasticity with a non-critical degree of reactivity to soil moisture content fluctuations.

3.1.2 Rock Coring and Laboratory Test Results

Laboratory test results are summarised in Table 6. A laboratory test certificate is provided in Attachment G. Rock core photos are provided in Figures 5 to 7, Attachment A.

Test results and observations during rock coring confirm that the rock at the development area is typically of extremely low and low strength sandstone / claystone / siltstone with some medium strength bands up to 15 mBGL, except for BH303 at which rock is of medium strength from approximately 10 mBGL up to investigation termination depth of 13.4 mBGL. It should be considered that testing was carried out on relatively intact core samples. Engineering properties of the rock mass will be impacted by the presence of the numerous defects and discontinuities including weathered, sheared and fractured zones observed in the rock profile. Some of these are considered to be associated with the previous large-scale landslide, which would further reduce rock strength. Rock strength properties and design parameters provided in the following sections have been estimated, considering the presence of highly sheared / fractured rock as well as laboratory test results. Supplementary investigations, including rock coring, may need to be carried out in the

south and southern portions of the site to better understand the extent and condition of sheared / fractured rock across the site.

Table 6: Point load strength index testing results.

Borehole	Sample Depth (mBGL)	Point Load Strength Index $I_{s(50)}$ (MPa)		UCS [1] (MPa)	Rock Strength [2]
		Diametral	Axial		
BH302	4.0	0.095	0.120	1.9-2.4	Very low to low
	8.6	0.190	0.530	3.8-10.6	Low
	10.67	0.045	0.049	0.9-1.0	Very low
BH303	2.62	0.034	0.016	0.3-0.7	Extremely to very low
	7.8	0.130	0.098	2.0-2.6	Very low to low
	13.12	0.440	0.510	8.8-10.2	Medium
BH305	4.65	0.047	0.045	0.9-1.0	Extremely to very low
	14.15	0.076	0.068	1.4-1.5	Very low

Notes:

1. Unconfined Compressive Strength of intact material, assuming UCS = 20 x $I_{s(50)}$.
2. Strength classification based on AS1726 (2017).

3.2 Preliminary Soil and Rock Strength Properties

Preliminary material properties have been estimated from field test results in conjunction with borehole derived soil / rock profile data and laboratory test results as well as engineering assumptions. They are summarised in Table 7.

Table 7: Preliminary estimates of soil and rock strength properties.

Unit [1]	$Y_{in\text{-}situ}$ [2] (kN/m³)	Cu [3] (kPa)	Φ' [4] (deg)	E' [5] (MPa)	UCS [6] (MPa)
Assumed uncontrolled FILL / TOPSOIL: (varying consistencies / densities)	16	NA [8]	NA [8]	NA [8]	NA [8]
ALLUVIAL / RESIDUAL: CLAY / sandy CLAY / silty CLAY (firm to stiff)	17	30	NA [8]	5	NA [8]
RESIDUAL: CLAY / sandy CLAY / silty CLAY (very stiff to hard)	18	100	NA [8]	20	NA [8]
WEATHERED ROCK: SANDSTONE / SILTSTONE / CLAYSTONE (Class V) [7]	22	NA [8]	24	50	0.3-10.6
WEATHERED ROCK: SANDSTONE / SILTSTONE / CLAYSTONE (Class IV / III) [7]	23	NA [8]	32	500	8.8-10.20

Notes:

1. Refer to borehole logs in Attachment B for material description details at test locations.
2. Inferred average in-situ unit weight, based on visual assessment only (± 2 kN/m³).
3. Undrained shear strength (± 5 kPa), considering normally consolidate clay.
4. Internal friction angle (± 2 °) assuming drained conditions; may be dependent on rock defect conditions e.g. a reduction of 5-10 ° may need to be considered in sheared zones.
5. Effective elastic modulus (±10 %).
6. Assumed average range of unconfined compressive strength of intact material.
7. P.J.N Pells et al (1998) Foundations on Sandstone and Shale in the Sydney Region.
8. Not applicable.

3.3 Risk Assessment of Proposed Development Works

Some portions of the site including north western, western and southern most portions are mapped on the Northern Beaches Council landslip risk map as 'Geotechnical Landslip Hazard H1' (refer Figure 3 in Attachment A).

Current site topography and observed defects and discontinuities encountered in the rock profile indicate that the site has likely been impacted by historical large-scale landslides and subsequent smaller movements of resultant steepened slopes. Evidence of recent slope movement was observed. We expect historical large scale landslide to be relict and largely inactive.

A geotechnical hazard risk assessment for the proposed works has been completed in accordance with the qualitative risk matrices provided in Section 7 of the Australian Geomechanics Society's *Landslide Risk Management Guidelines* (AGS, 2007). It is considered that four potential forms of geotechnical hazard are possible at the site (translational slide, rotational slide, soil creep and lateral spread). Of these, shallow and deep slides are most likely to impact the proposed development. A

summary of these hazards is presented in Table 8. The assessment is based on implementation of treatment measures, shown as a minimum. Risk evaluation calculations are provided as Attachment F.

Table 8: Summary of slope instability risk assessment, based on AGS (2007).

Description	Treatment Measures	Likelihood[1]	Risk to Life		Risk to Property	
			Established Probability[2]	Risk	Consequence	Risk
Shallow slide (Fill and residual soils)	Maintain vegetation of undeveloped areas. Provide subsurface drainage where possible. Limit surface water ponding at crest of embankments/top of slopes. Ensure appropriate foundations and footings design.	Rare[1]	7.77×10^{-7}	Acceptable	Low	Low
Deep slide (rock)	Good hill slope engineering practice. Do not over-steepen natural grades. Provide adequate surface and sub-surface drainage. Footings to be taken to sandstone bedrock. Do not place fill over topsoil or alluvial silt.	Unlikely[1]	9.42×10^{-7}	Acceptable	Low	Low

Notes:

[1] Based on 'treated' site conditions.

[2] Annual probability of loss of life of an individual.

Inferred geological cross sections are presented in Attachment D. A SLIDE model has been undertaken to assess the stability risk of the fill material along the southern parts of the site to the proposed development.

3.3.1 Preliminary Slide Model Analysis

3.3.1.1 Modelling Methodology and Assumptions

A slope stability analysis was undertaken using the *SLIDE 6.0* modelling software for the fill embankment located along the southern boundary and adjacent to Cabbage Tree Road. The cross section modelled was considered the worst case scenario (having slopes of approximately 50 degrees) along the existing embankment (Attachment E, Figures 10 and 11). SLIDE modelling was carried out to assess the impact of indicative stresses imposed by the proposed facilities and basement car park buildings adjacent to the embankment. This allows for the assessment of

Factor of Safety (FOS) against sliding for existing ground conditions and under loading (i.e. proposed development) conditions. We provide the following comments:

- Additional penetration tests were conducted in the vicinity of the existing embankment (Attachment C) to identify depth to rock downslope of the embankment.
- Existing ground levels were taken from existing survey data by Bee & Lethbridge Pty Ltd (dated April 2014, drawing number 18990).
- Two modelling scenarios were assessed based on the proposed development: Embankment with loading assuming a design load of 150 kPa; and without loading.
- The existing soil overburden comprises fill overlying a layer of residual clay overlying weathered rock.

3.3.1.2 Material Properties

A summary of strength properties used in the model is provided in Table 9. Soil strength parameters were estimated based on penetration test data. We have assumed that the fill generally consists of cohesive materials.

Table 9: Estimated strength properties of soil and rock used in *SLIDE 6.0* model.

Materials	Y_{dry} [1]	C_u (kPa) [2]	ϕ' (deg) [3]
Soil Overburden: Fill/Clay	15	15	-
Weathered rock	23	-	32

Notes:

[1] *In-situ* dry unit weight (±2).

[2] Assumed undrained cohesion (±5) assuming unconsolidated clays.

[3] Effective friction angle (±2) assuming drained conditions.

3.3.1.3 Results

A design minimum factor of safety (FOS) of 1.0 was adopted. The minimum FOS for global slip failure for the analysed scenarios are summarised in Table 10. Slide modelling results are provided in Attachment E, Figures 12 and 13.

Table 10: Minimum FOS for global slip failure from *SLIDE 6.0* modelling.

Loading Conditions	FOS
Existing embankment without any additional external stresses	1.5
Existing embankment assuming typical strip footing loading of 150kPa	0.70

3.3.1.4 Summary and Recommendations

Based on the slide modelling results we provide the following comments:

- The existing fill embankment has been modelled resulting in a FOS of 1.5.
- The stresses imposed at the southern section of the development area (assuming a typical design load of 150kPa) are likely to impact the underlying soil and weathered rock profile resulting in a FOS of 0.70.
- We recommend all footings for new structures along the fill embankment are taken through the soil profile and founded in sound bedrock.
- Slope vegetation should be retained, where possible.
- Appropriate surface and subsurface drainage should be provided to limit saturation of the soil profile.

3.3.2 Conclusion

Based on risk calculations and SLIDE modelling the proposed development is considered to constitute an acceptable risk to life and a low risk to property resulting from geotechnical hazards and is considered acceptable provided risks are mitigated by good hill slope engineering practices and the recommendations of this report are implemented. A description of good hill slope engineering practices is provided as Attachment H.

3.4 Foundation Exposure Classification

Sulphate and pH test results for exposure classification are summarised in Table 11, and the laboratory test certificate is provided in Attachment G.

Table 11: Exposure classification test results.

Sample ID[1]	Material	pH	Sulphate (SO_4) (mg/kg)	Chloride (Cl) (mg/kg)	Exposure Classification		
					AS 2159 [2]	AS 2159 [3]	AS 3600 [4]
6099/BH302/0.3	Sandy Clayey SILT	6.9	21	< 10	Non-aggressive	Non-aggressive	A1
6099/BH302/0.9	Sandy Clayey SILT	7.3	45	10	Non-aggressive	Non-aggressive	A1
6099/BH303/0.2	SILT	7.0	10	23	Non-aggressive	Non-aggressive	A1
6099/BH303/0.5	Silty CLAY	5.6	23	27	Non-aggressive / Mild	Non-aggressive	A1
6099/BH304/0.2	Sandy SILT	5.6	10	20	Non-aggressive / Mild	Non-aggressive	A1
6099/BH304/0.5	SILT	5.7	< 10	5.7	Non-aggressive / Mild	Non-aggressive	A1
6099/BH305/0.3	Silty SAND	5.2	< 10	5.2	Mild	Non-aggressive	A2
6099/BH309/0.4	Silty CLAY	5.0	20	5.0	Mild	Non-aggressive	A2
6099/BH312/0.2	Silty SAND	6.6	10	6.6	Non-aggressive	Non-aggressive	A1
6099/BH312/1.4	CLAY	7.0	20	7.0	Non-aggressive	Non-aggressive	A1

Notes:

1. Project#/Borehole#/Depth (mBGL).
2. Exposure classification for concrete piles in soil based on Table 6.4.2(C) of AS 2159 (2009).
3. Exposure classification for steel piles in soil based on Table 6.5.2(C) of AS 2159 (2009).
4. Exposure classification for buried reinforced concrete based on Tables 4.8.1 and 4.8.2 of AS 3600 (2009).

In accordance with AS2159 (2009), exposure classifications of ''Mild'' and "Non-aggressive" should be adopted for preliminary design of buried concrete and steel piles, respectively. In accordance with AS3600 (2009), an exposure classification of 'A2' should be adopted for shallow concrete footings.

4 Geotechnical Recommendations

4.1 Recommendations

Geotechnical recommendations for site development are provided below in Table 12. Further general geotechnical recommendations are provided in Attachment I.

Table 12: Geotechnical recommendations

Geotechnical Issue	Recommendations
Excavations and Vibrations	The following excavation techniques may be adapted: o Soils should be readily excavated using conventional earthmoving equipment. o Extremely low to low strength rock should generally be readily excavated with a 'toothed' bucket or a ripping tyne (or similar) although progress may be slow in low strength rock containing medium strength bands. o Rock breaker of ripping tyne attachments may be required for excavation of medium strength sandstone, if encountered. All excavation work should be completed with reference to the most recent version of Code of Practice 'Excavation Work', by Safe Work Australia. Excavation method statements will need to be prepared by the excavation contractor prior to the issue of CC. Consideration should be given to the use of rock sawing techniques, if medium strong rock is encountered, prior to the use of hydraulic hammer equipment to reduce noise and vibrations.
Batter Slopes / Shoring Methods	<u>Soils</u> Any temporary or permanent excavations into soil exceeding 0.75 m depth should be supported by suitably designed and installed retaining or shoring structures or, alternatively, using batter slopes of 1V:2H for temporary slopes (unsupported for less than 1 month) and 1V:3H for permanent long term unsupported slopes. It is recommended that unsupported soil excavations deeper than 1.0 m should be assessed by a geotechnical engineer for slope instability risk. <u>Rock</u> Temporary and permanent excavations for extremely low to low strength rock may be battered at 1V:2H. This batter may be increased to 1V:1H, subject to inspection and approval by a geotechnical engineer on site during excavation (i.e. likely every 1 m depth). Due to numerous shear zones and weak seams within this rock, additional stabilisation measurements, such as shotcrete, may be required. Medium strength rock can be battered at 4V:1H or steeper, provided there are no adversely oriented joints or defects in the rock. It is recommended that all excavated rock faces be inspected by a geotechnical engineer to determine whether any additional support, such as rock bolts or shotcrete, is required. Where there is insufficient room for temporary batters, excavations will need to be supported by temporary shoring or permanent retaining walls such as a soldier pile/infill panel wall system. <u>Heavy Machinery</u> Use of heavy machinery should be avoided, where possible, within 2 m of any open soil excavation to prevent excessive vibrations and undue settlement.

Geotechnical Issue	Recommendations
Rock support	Steeply dipping joints and sheared zones, observed within the rock core, may have an adverse effect on rock face stability and construction safety. Geotechnical mapping of the excavation should be conducted in 1.5 m height increments to identify such features and allow early mitigation of risks of rock movement, such as by installation of rock anchors or bolts. The presence of weakly cemented (extremely weathered) seams and sheared zones within the rock may adversely affect the stability of the cut faces and may require shotcreting and rock bolting. Rock support should be specified in terms of performance requirements and installed / placed by contractors experienced in ground anchor technology and on advisement by an experienced geotechnical engineer. Rock support should not extend beyond property boundaries unless approval has been granted by relevant property owners or stakeholders. The actual amount of stabilisation which will be required cannot be quantified at this stage and can only be determined at the time of construction. Martens and Associates can complete the necessary mapping and provide advice for possible remediation measures, where required.
Sub-grade Preparation	We recommend that any stripping of soil or sub-grades be undertaken at the on-set of excavation and suitably stockpiled for on-site re-use (where possible) or off-site disposal to a suitable location in accordance with NSW DECC (2009) *Waste Classification Guidelines.* For soil sub-grade areas where fill is to be placed to raise site levels and where on-grade slabs are to be constructed, preparation of sub-grade should consist of: o Compact the sub-grade with a minimum 12 tonne deadweight smooth drum vibratory roller to achieve a minimum density index (ID) of 65 % or a minimum density of 98 % Standard Maximum Dry Density (SMDD) for cohesionless soil (within +/- 2% of optimum moisture content (OMC)). o Proof rolling should be closely monitored by the project geotechnical engineer to detect soft or unstable areas which should be removed and replaced with engineered fill or alternatively stabilised or bridged. Density tests should be carried out at a frequency of one test per layer per 500m^2 or three (3) tests per visit, whichever requires the higher number of tests, to confirm the specifications provided in this report have been achieved. At least Level 2 testing of earthworks should be carried out in accordance with AS3798 (2007). Any areas of insufficient compaction will require reworking. Engineered fill is to be free from organic materials, other contaminants and deleterious substances and have a maximum particle size of 40 mm. We consider that the excavated clayey soil and weathered sandstone will be suitable as engineered fill. It should be placed in layers of a maximum 100 mm loose thickness and compacted to at least 98 % SMDD and within +/- 2% of OMC, which can be reduced to 95 % SMDD in landscaped areas. Further testing will be required to confirm this. All site earthworks should be undertaken in accordance with AS3798 (2007) and Aus-Spec 213 (2004).
Footings and Foundations	Footings of the proposed buildings should be founded in rock below zones affected by slope movement, i.e. sheared rock, using shallow footings or piers, depending on foundation level. They should be designed by a suitably qualified and experienced structural or geotechnical engineer. Estimated soil and rock strength parameters are provided in Section 4.2. All footings should be poured after excavation with minimal delay. All excavated bases should be free from all loose or softened materials prior to pouring. If water ponds in the base of the excavations, they should be pumped dry and then re-excavated to remove all loose and softened materials. If a

Geotechnical Issue	Recommendations
	delay in pouring is anticipated, a concrete blinding layer of at least 50 mm thickness is to be placed to protect the base of the footing excavation. All footing excavations should be inspected by a geotechnical engineer to confirm the required founding strata has been reached.
Groundwater	It is considered that the proposed excavations, particularly in lower portions of the site, will likely intercept the groundwater table. This should be confirmed based on groundwater monitoring data. Some seepage of surface water infiltration during and after rainfall events may also be encountered at the transition between residual soil and rock. We expect that sump and pump methods will be appropriate for removal of surface water and groundwater inflows, during and post construction, subject to final assessment of hydrogeological data. Basements associated with buildings in lower portions of the site may need to be designed as a tanked structure with inclusion of appropriate water proofing, depending on assessment results. All site discharges should be passed through a filter material prior to release to the Council stormwater system or approved alternative. Groundwater ingress should be monitored during excavation by a geotechnical engineer. Appropriate surface and sub-surface drainage should be provided upslope of the development to divert overland flows and groundwater away from excavation, and limit ponding of water in excavations and near footings.
Basement Car Park Retaining Walls	Basement retaining wall design should take appropriate surcharge and hydrostatic load into account and be designed adopting the preliminary geotechnical parameters provided in Sections 3.2 and 4.2. Potential impacts associated with previous slope movement should also be considered. Retaining structures may comprise soldier piles and shotcrete in fill panels, restrained with the aid of temporary soil anchors or bracing. Alternatively, cantilevered or anchored reinforced concrete contiguous pile walls may be adopted to support the excavation faces. Anchors should be proof tested to at least 1.3 times the working load under the supervision of a geotechnical engineer independent of the contractor. Pre-stressed anchors should be "locked off" at not greater than 85 % of the design working load. Backfill materials between the basement retaining wall and the rock face should comprise a high strength, durable, single sized washed aggregate, such as 'blue metal' gravel. Fill should be placed in a maximum of 200 mm horizontal layers and compacted using a hand held compactor. Care should be taken to ensure excessive compaction stresses are not transferred to retaining walls. Backfill areas to be geotextile wrapped with base drainage system. We recommend a drainage system be installed behind all retaining walls to dissipate pore pressures from water that may collect behind the retaining walls. Further consideration may need to be given to drainage below any basement slabs. Final drainage design is to be developed at construction phase of the project, following detailed structural design and additional pump testing to confirm likely groundwater inflow rates.
Trafficability and Construction Assess	Trafficability across exposed soil/sub-grade materials and weathered rock is expected to be adequate in dry weather for most construction plant such as conventional rubber tyre plant, four-wheel drive plant and track mounted plant. During wet weather, trafficability of all heavy machinery on exposed soil/sub-grade materials may be reduced. Provision for site grading, temporary open drains or toe/crest drains is suggested to collect any overland flow, prevent water ponding and hence minimise potential for any further soil/sub-grade softening or erosion, and to help improve trafficability. The use of dumped aggregate for temporary construction roads may be necessary to allow works during and immediately following wet weather.

Geotechnical Issue	Recommendations
Overland Flows	There exists a potential for stormwater flows to enter excavated areas during construction. All surface runoff should be diverted away from excavation areas during construction works. All site discharges should be passed through a filter material prior to release. Diverted flows should be directed (where possible) to a suitable stormwater system so as to prevent water accumulating in areas surrounding retaining structures, footings or the crest of embankments.
Soil Erosion Control	Removal of soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in the Council stormwater system and on neighbouring lands. All spoil on site should be properly controlled by erosion control measures to prevent transportation of sediments off-site. Appropriate soil erosion control methods in accordance with Landcom (2004) shall be required.

4.2 Preliminary Design Parameters

Preliminary design parameters for footings are presented in Table 13. These have been estimated from field test results in conjunction with borehole derived soil / rock profile data. The design parameters assume the base of excavation is free of water prior to placement of concrete and approved following inspection by an experienced geotechnical engineer.

Table 13: Preliminary geotechnical parameters for soil and rock encountered in boreholes.

Layer	Shallow Footings	Bored Piers				
	AEB [1&4] (kPa)	AEB [2&4] (kPa)	ASF [3&4] (kPa)	K_a [5]	K_p [5]	K_0 [5]
Assumed uncontrolled FILL / TOPSOIL: (varying consistencies / densities)	NA [6]	NA [6]	NA [6]	0.40	2.50	0.55
ALLUVIAL / RESIDUAL: CLAY / sandy CLAY / silty CLAY (firm to stiff)	NA [6]	NA [6]	NA [6]	0.40	2.50	0.55
RESIDUAL: CLAY / sandy CLAY / silty CLAY (very stiff to hard)	200	NA [6]	15	0.36	2.77	0.53
WEATHERED ROCK: SANDSTONE / SILTSTONE / CLAYSTONE (Class V)	450	700	100	0.33	3.00	0.50
WEATHERED ROCK: SANDSTONE / SILTSTONE / CLAYSTONE (Class IV / III)	750	1500	300	NA [6]	NA [6]	NA [6]

Notes:

[1] Allowable end bearing pressure (kPa) for shallow footings embedded at least 0.3 m and piles embedded at least 1 m or 1 pile diameter, whichever is greater, into the design material type.

[2] Assuming bored, cast in-situ concrete pile.

[3] Allowable skin friction (kPa) for bored pile in compression, assuming intimate contact between pile and foundation material. For up lift resistance, we recommend reducing ASF by 50% and checking against 'piston' and 'cone' pull-out mechanisms in accordance with AS2159 (2009).

[4] AEB and ASF are given with estimated factors of safety of 3 and 2 respectively, generally adopted in geotechnical practice to limit settlement to an acceptable level for conventional building structures.

[5] k_a = Coefficient of active earth pressure; k_p = Coefficient of passive earth pressure; k_0 = Coefficient of earth pressure at rest.

[6] Not applicable, or not recommended either due to depth or potential internal settlement of materials.

4.3 Site Classification

The site is classified as a class 'P' site in accordance with AS 2870 (2011), due to slope movement risk and variable ground conditions across the site. Subject to the inclusion of appropriate slope risk mitigation measures and on-site assessment of foundation conditions and confirmation by a geotechnical engineer at construction stage, a reclassification of 'H1' may be considered for design of shallow footings.

5 Acid Sulfate Soils (ASS) Assessment

5.1 Overview

The objectives of this ASS assessment include determining the presence of actual or potential ASS risks via geomorphic observations and laboratory testing of soils, and where required, provide an ASS management plan for the proposed development.

5.2 Desktop Review

5.2.1 ASS Risk Map Classification

The Pittwater Councils Acid Sulphate Soils Map categorises the site as Class 5 land, except for the south eastern corner, which is categorised as Class 2 land. Site location relating to ASS risk is presented in Figure 4, Attachment A.

5.2.2 Geomorphic Setting

The likelihood of ASS occurrence at a site is a function of various geomorphic parameters, in particular those listed in Table 14 (ASSMAC, 1998). Each is an indicator that ASS are likely to be present onsite.

Table 14: Geomorphic features indicative of acid sulfate soils.

Geomorphic Characteristic	Present on Site?	
	Class 5 land	Class 2 land
Holocene sediments	No	Yes
Soil horizons less than 5 mAHD	No	Yes
Marine / estuarine sediments or tidal lakes	No	Yes
Coastal wetland; backwater swamps; waterlogged or scaled areas; swales or coastal sand dunes	No	Unknown [2]
Dominant vegetation is mangroves, reeds, rushes and other swamp or marine tolerant species	No	Unknown [2]
Geologies containing sulfide bearing material / coal deposits or former marine shales/sediments	Possible [1]	Yes
Deep older (Pleistocene) estuarine sediments	No	Unlikely

Notes:

[1] Possible for fill materials.

[2] May have been present prior to previous development.

Some of the geomorphic features listed are either present or may formerly have been present within predominately the southern part of the site and possibly in filled areas of the site. The geomorphic setting of this area indicates that actual or potential ASS are likely to be present and laboratory testing of soils is required.

5.3 Laboratory Testing

5.3.1 Soil Sampling

Twenty-nine soil and weathered rock samples were collected from boreholes (Table 15) and submitted for sPOCAS analysis.

Table 15: Summary of samples analysed by laboratory for sPOCAS.

BH	Approximate Surface Elevation (mAHD)	Material	Sample Depth (mBGL)	Approximate Sample Elevation (mAHD)
BH101	6.0	Sandy CLAY	0.5	5.5
		CLAY	1.0	5.0
		CLAY	2.5	3.5
		Silty CLAY	3.5	2.5
		Silty CLAY	4.5	1.5
BH102	9.0	Sandy CLAY	1.0	8.0
		Weathered SANDSTONE	2.0	7.0
BH103	20.0	Weathered SANDSTONE	1.5	18.5
		Weathered SANDSTONE	2.0	18.0
BH104	26.0	CLAY	0.5	25.5
BH105	23.0	CLAY	1.0	24.0
BH106	22.0	Silty SAND	0.5	21.5
		Weathered SANDSTONE	1.5	20.5
BH107	11.0	CLAY	1.0	10.0
		Silty SAND	1.5	9.5
		Silty SAND	3.5	7.5
BH108	14.0	Weathered SANDSTONE	2.0	12.0

BH	Approximate Surface Elevation (mAHD)	Material	Sample Depth (mBGL)	Approximate Sample Elevation (mAHD)
BH109	14.0	Silty SAND	0.5	13.5
BH110	13.0	CLAY	1.0	12.0
		Weathered SANDSTONE	1.5	11.5
		Weathered SANDSTONE	3.0	10.0
BH302	19.7	Sandy Clayey SILT	0.3	19.4
		Sandy Clayey SILT	0.9	18.8
BH306	7.0	Sandy CLAY	0.3	6.7
		CLAY	1.4	5.6
		Silty CLAY	2.7	4.3
BH312	17.2	CLAY	1.4	15.8
BH313	7.0	Silty SAND	0.2	6.8
		Clayey SAND	0.5	6.5

5.3.2 Laboratory Test Results

Laboratory test results are summarised in Table 16 with the complete laboratory report provided in Attachment G.

Table 16: ASS (sPOCAS) testing results.

BH	Sample Depth (mBGL)	Grain Size	pH_{KCL} [1]	pH_{OX} [2]	TPA [3]	TSA [4]	S_{POS} [5]
BH101	0.5	F	6.3	6.3	5	5	0.01
	1.0	F	**7.4**	**5.1**	5	5	0.01
	2.5	F	4.1	3.9	**70**	16	0.01
	3.5	F	5.1	4.9	**92**	**51**	**0.05**
	4.5	F	4.7	4.3	**85**	**44**	**0.03**
BH102	1.0	F	4.5	4.4	20	5	0.01
	2.0	C	**3.9**	3.7	**57**	9	0.01
BH103	1.5	C	5.9	5.3	5	5	0.01

BH	Sample Depth (mBGL)	Grain Size	pH_{KCL} [1]	pH_{OX} [2]	TPA [3]	TSA [4]	S_{POS} [5]
	2.0	C	4.2	4.6	17	5	0.01
BH104	0.5	F	**3.8**	3.5	**150**	**56**	0.01
BH105	1.0	F	4.1	3.7	**90**	11	0.01
BH106	0.5	M	4.6	3.9	5	5	0.01
	1.5	C	4.2	4.3	**26**	5	0.01
BH107	1.0	F	4.2	4.3	**32**	5	0.01
	1.5	M	6.0	6.0	5	5	0.01
	3.5	M	5.1	4.5	5	5	0.01
BH108	2.0	C	**5.0**	**3.3**	5	5	0.02
BH109	0.5	M	**5.0**	**3.3**	5	5	0.02
BH110	1.0	F	4.2	4.2	**45**	5	0.01
	1.5	C	4.5	4.4	**35**	5	0.01
	3.0	C	**3.9**	3.9	**60**	5	0.01
BH302	0.3	F	**8.2**	**6.7**	< 5	< 5	0.03
	0.9	F	7.2	6.4	< 5	< 5	0.04
BH306	0.3	F	8.7	7.8	< 5	< 5	0.02
	1.4	F	4.2	3.8	**55**	9	0.01
	2.7	F	6.3	5.3	< 5	< 5	0.01
BH312	1.4	F	7.7	7.3	< 5	< 5	0.01
BH313	0.2	M	5.2	4.9	< 5	< 5	0.01
	0.5	M	4.5	4.2	**30**	< 5	< 0.01
Guideline Limit (action criteria) [6]	**Fine Grained (F) (> 40 % clay)** / **Medium Grained (M) (5-40 % clay)** / **Coarse Grained (C) (< 5 % clay)**				**18**	**18**	**0.03**

Notes:

1. pH (actual acidity).
2. pH after oxidation with peroxide (potential acidity).
3. Titratable Peroxide Acidity (Moles H+/tonne).
4. Titratable Sulfidic Acidity (Moles H+/tonne).

5. Oxidisable sulphur (%).
6. ASSMAC (1998) p.27, for 1-1,000 tonnes disturbed soil. Bolded values in table indicate exceedance of ASSMAC action criteria considering expected > 1000 tonnes soil disturbance.

5.3.3 ASS Classification

Based on the pH_{KCL} and post peroxide oxidation pH_{OX} criteria derived from the ASSMAC (1998) guidelines:

- Soils with a pH_{KCL} of $\leq$ 4.0 are classified as actual ASS.
- Soils with pH_{KCL} - pH_{ox} > 1 are classified as potential ASS.
- Soils with pH_{ox} < 3.5 are classified as potential ASS.

On the basis of these criteria we conclude the following:

- Three samples including two weathered rock samples (BH102 depth 2.0 m and BH110 depth 3.0 m) and one residual clay sample (BH104, depth 0.5 m) are classified as actual ASS.
- Four samples including one weathered rock sample (BH108 depth 2.0 m) and three soil samples (BH101 depth 1.0 m (fill), BH109 depth 0.5 m (topsoil) and BH302 depth 0.3 m (residual)) are classified as potential ASS.
- The remaining tested samples are neither actual nor potential ASS.

5.3.4 Action Criteria

According to Table 4.4 of ASSMAC (1998), a detailed management plan is required if the soil exhibits one of the following criteria (for >1,000 tonnes disturbed soil):

- Oxidisable sulphur (SPOS) is ≥ 0.03%; or
- TPA or TSA is ≥18 mol H^+/tonne.

On the basis of these action criteria we conclude that thirteen samples including three fill samples, one alluvial sample, five residual soil samples and four weathered rock samples (i.e. BH101 depths 2.5 m and 3.5 m (fill) and 4.5 m (alluvial), BH102 depth 2.0 m (weathered sandstone), BH104 depth 0.5 m (residual), BH105 depth 1.0 m (residual), BH106 depth 1.5 m (weathered sandstone), BH107 depth 1.0 m (fill), BH110 depths 1.0 m (residual),1.5 m and 3 m (weathered sandstone), BH306 depth 1.4 m (residual) and BH313 depth 0.5 m (residual)) exceed the criteria based on TPA, TSA and S_{pos}.

5.3.5 Conclusion

- AAS criteria exceedance within the proposed apartment building area was found in some sandstone bedrock samples and overlying clay samples. The origin of this acidity is therefore likely to be related to geology rather than from ASS. We conclude that preparation of a management plan is not essential for construction works (based on the current development proposal) of the proposed buildings as they are predominantly located within the residual soil landscape.
- AAS action criteria exceedance within the south eastern portion (proposed new entry / exit road) was found in one alluvial soil sample. We conclude that preparation of a management plan is required for any construction works, including the proposed new entry / exit road, within the south eastern portion of the site.

6 Preliminary Pavement Thickness Design

6.1 Overview

A preliminary pavement thickness design was undertaken for the proposed new entry / exit to the site. The design adopted a traffic loading of Equivalent Standard Axles (ESA) in accordance with Northern Beaches's Civil Engineering requirements, AUS-SPEC Specifications and Austroads (2012) *Guide to Pavement Technology Part 2 Pavement Structural Design*. A CBR value, adopted for the preliminary design, was estimated using limited lab and field test results.

6.2 Design Parameters

An ESA value of $3x10^5$ was adopted for design of the proposed new entry / exit to the site.

Two bulk soil samples were collected for CBR testing (Figure 2, Attachment A). A laboratory test certificate is provided in Attachment G. Given the limited laboratory test results, DCP-CBR correlations were carried out using Austroads (2012). Considering the variation in DCP 'N' counts, resulting from variable soil consistency, the potential variation in soil moisture conditions as well as the likely variable cut and fill requirements across the site, we have adopted a CBR value of 4 % for preliminary design purposes.

Subgrade improvement / replacement will likely be required where material of inferior quality is uncovered during excavation (i.e. CBR < 4 %). Alternatively, lower CBR values may be applicable and pavement material thickness may need to be revised. If material of superior quality is uncovered during excavation, higher CBR values may be applicable and pavement material thickness may be revised, subject to verification during construction by a geotechnical engineer and further on-site / laboratory testing.

6.3 Pavement Thickness

Table 17 presents recommended pavement types and material thicknesses for the proposed road.

Table 17: Preliminary pavement material thickness design for CBR 4 %.

Road Type	Total Thickness (mm)	Layer	Thickness (mm)	Materials
Access Street	440	Wearing Course	50	Primer + 10 mm one coat flush seal + 40 mm Asphalt Concrete (AC10) [1]
		Base	150 [1]	DGB20
		Sub-base	240 [1]	CSS40 or DGS40

Notes:

[1] Based on Austroads (2012) guideline.

6.4 Earthworks

6.4.1 Subgrade Preparation

The subgrade is to be trimmed and compacted, following the removal of topsoil and other unsuitable materials such as root containing soils or uncontrolled fill, with density testing of the upper 300 mm layer at a rate of 1 test per 50 m of road length. Minimum relative density of subgrade shall be 100 % Maximum Dry Density (MDD) at a standard compactive effort within 2 % of optimum moisture content (OMC). Prior to placement of pavement material, the subgrade shall be proof rolled and approved by a geotechnical engineer. If soft spots are encountered, they can be treated by one of the following methods subject to final design:

- Removal and replacement with approved fill under geotechnical engineer's direction.
- *In-situ* stabilisation with cement / lime or similar binding agent to a depth of at least 300 mm below finished level. Use of this method and extent will depend on the condition of material to be stabilised.

6.4.2 Subsoil Drainage

Surface and sub-soil drainage is to be provided in accordance with Council requirements and relevant standards. Typically, subsurface drains are installed on the upslope side, as a minimum, of all internal roads and generally extend at least 600 mm below pavement level.

6.4.3 Placement and Testing of Pavement Material

Pavement materials shall be placed in layers (when compacted) not thicker than 200 mm or less than 100 mm. Pavement materials shall be compacted to the following condition:

- Sub-base - Minimum 98 % MDD at modified compactive effort (±2% OMC).
- Base - Minimum 98% MDD at modified compactive effort (±2% OMC).

Compaction testing shall be undertaken by a NATA accredited laboratory in accordance with procedures as outlined in AS1289, and at a rate of no less than 1 per 50 linear metres, or per 250 m^2, whichever is the greater, with a minimum of 2 tests in any one length. Each pavement layer shall be proof rolled under Geotechnical Engineers' supervision. Subsequent pavement layers shall not be placed prior to approval of underlying layer by the Geotechnical Engineer.

6.4.4 Fill Placement

Should filling be required to raise subgrade levels, the use of site-won excavated residual soils may be considered, subject to implementing stringent moisture conditioning and compaction controls, or mixing with lime to assist placement of medium to high plasticity clay, and testing. Alternatively, suitable granular fill, approved for use by a Geotechnical Engineer may be adopted. All earthworks specification is to be prepared by the supervising engineer and be implemented by the contractor.

6.4.5 Other Considerations

Transitioning of existing and new pavement sections needs to be included in detailed design. The transition zone is to be keyed and adequately offset from wheel paths.

7 Further Assessments and Monitoring / Inspections

7.1 Further Works

We recommend the following additional geotechnical assessments are carried out to develop the final design:

1. Detailed design of any shoring / retaining/ foundation structures.

2. Supplementary investigations, including rock coring, particularly in the southern and south western portions of the site, to better understand the potential risks associated with sheared / fractured rock across the site.

3. Installation of inclinometers upslope of proposed excavations for the proposed development to measure ground movements and identify deflections in the support structures to manage risks associated with potential ground movements.

4. Review of the final design and construction staging plan by a senior geotechnical engineer to confirm adequate consideration of the geotechnical risks and adoption of the recommendations provided in this report.

7.2 Construction Monitoring and Inspections

We recommend the following is inspected and monitored during construction phase of the project (Table 18).

Table 18: Recommended inspection / monitoring requirements during site works.

Scope of Works	Frequency/Duration	Who to Complete
Inspect excavation retention (shoring, retaining wall, anchor, rock bolt) installations and monitor associated performance to assess need for additional support requirements.	Daily / As required [2]	Builder / MA [1]
Monitor groundwater seepage from excavation faces, if encountered, to assess stability of exposed materials and need for additional drainage requirements.	When encountered	Builder / MA [1]
Monitor excavation-induced ground settlement and lateral deflection of retained materials along south western and southern site boundaries, with the aid of inclinometers.	Daily at on-set of excavation and as agreed thereafter	MA [1]
Monitor and analyse ground movements and retaining wall deflections using inclinometers	As required	MA [1]
Inspect exposed material at foundation / subgrade level to verify suitability as foundation / lateral support /	Prior to reinforcement set-up and concrete	MA [1]

Scope of Works	Frequency/Duration	Who to Complete
subgrade.	placement	
Monitor sedimentation downslope of excavated areas.	During and after rainfall events	Builder
Monitor sediment and erosion control structures to assess adequacy and for removal of built up spoil.	After rainfall events	Builder

Notes:

[1] MA = Martens and Associates engineer

[2] MA inspection frequency to be determined based on initial inspection findings in line with construction program.

8 References

Australian Geomechanics Society (2007) *Practice Note Guidelines For Landslide Risk Management 2007,* Journal and News of the Australian Geomechanics Society Volume 42 No 1 March 2007.

Australian Standard 1289.6.3.2 (1997) *Determination of the penetration resistance of a soil - 9kg dynamic cone penetrometer test.*

Australian Standard 1726 (2017) *Geotechnical site investigations.*

Australian Standards 2159 (2009) *Piling-Design and Installation.*

Australian Standard 2870 (2011) *Residential slabs and footings.*

Australian Standard 3798 (2007) *Guidelines on earthworks for commercial and residential developments.*

Bertuzzi, R. and Pells, P. J. N. (2002) *Geotechnical parameters of Sydney sandstone and shale,* Australian Geomechanics, Vol. 37, No 5, pp 41-54.

Bee and Lethbridge Surveying Plan (2014), Drawing No. 18990, dated April 2014 (Bee and Lethbridge, 2014).

Department of Land and Water Conservation (DLWC, 2002), *Site Investigations for Urban Salinity.*

Herbert C. (1983) *Sydney 1:100 000 Geological Sheet 9130*, 1st edition, Geological Survey of New South Wales, Sydney.

Marchese Partners International Pty Ltd (2018) Job No. 14023, Drawing Nos. DA1.02, DA1.04, DA2.01 to DA07, DA2.21 to DA2.43, DA3.01 to DA3.08 and DA4.01 to DA4.04, dated June 2017, Drawing Nos. LEC2.01 to LEC2.06, LEC3.01, LEC3.03 to LEC3.05 and LEC5.23 dated August 2018 (Marchese Partners, 2018).

Northern Beaches Council (2015) *Development Control Plan, Amendment 19.*

NSW *Department of Primary Industries Water* (DPIW) real time groundwater bore database.

Pittwater Local Environmental Plan (2014) *Geotechnical Hazard Map – Sheet GTH_011.*

Safe Work Australia (2015) *Code of Practice 'Excavation Work'*.

Soil Conservation Service of NSW (1983), *Sydney Australia 1:100,000 Soil Landscape Series Sheet 9130*.

9 Attachment A – Figures

martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	HN	**GEOTECHNICAL TESTING PLAN AND CROSS SECTION LOCATIONS** **Proposed Seniors Living Development, Cabbage Tree Road, Bayview, NSW** (Source: Nearmap, 2017)	Drawing: **FIGURE 2**
Approved:	RE		
Date:	16.11.2017		
Scale:	NA		Job No: P1706099JR02V03

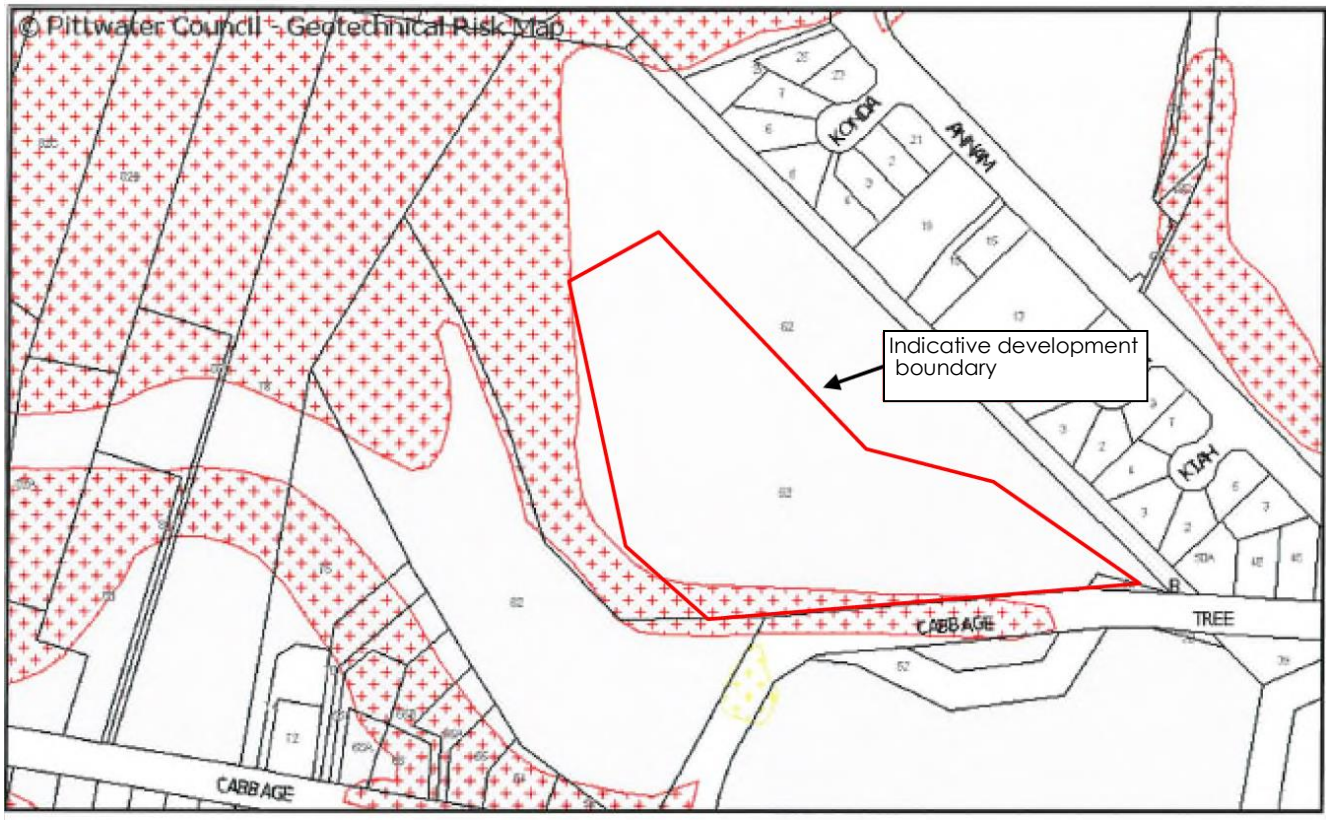
Pittwater Local Environmental Plan 2014

Geotechnical Hazard Map - Sheet GTH_011

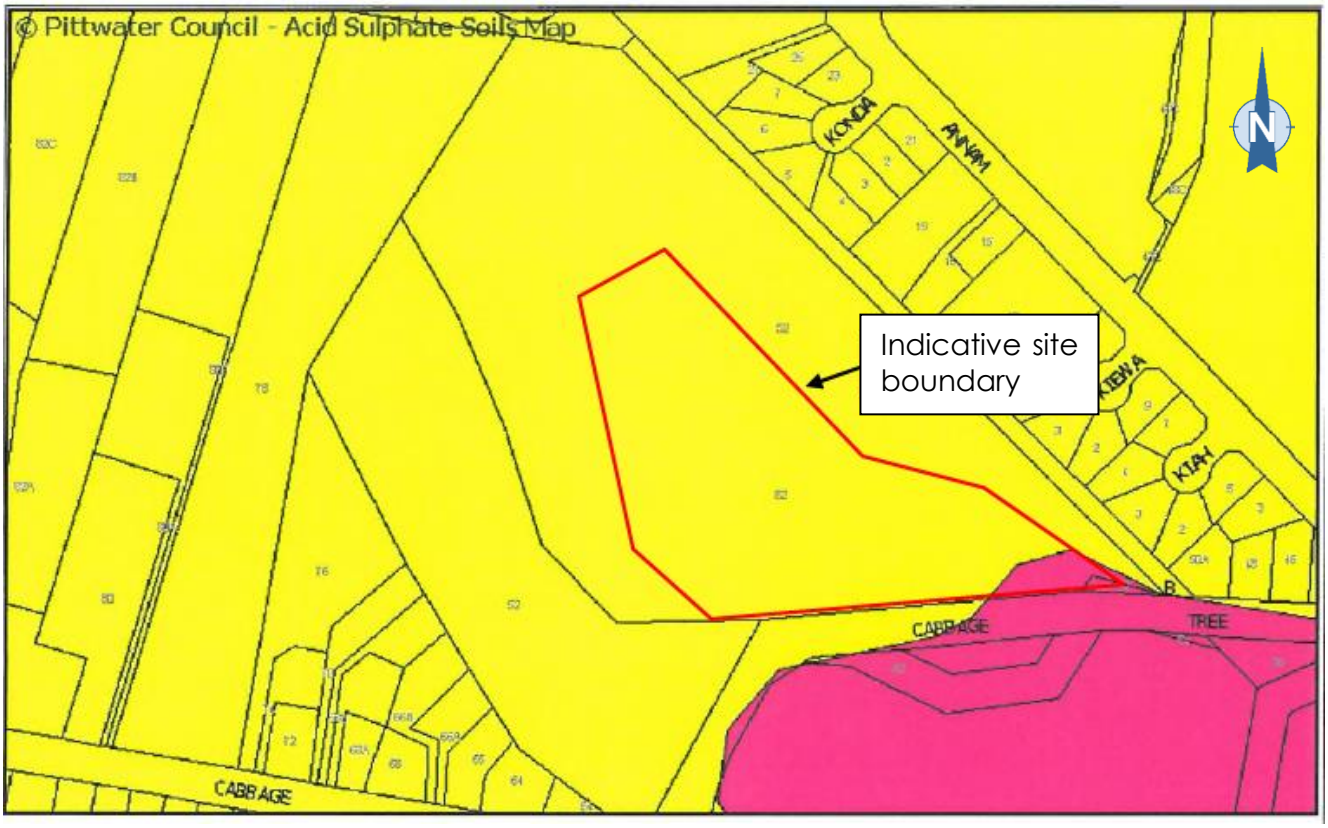
Geotechnical Hazard

Geotechnical Hazard H1

Geotechnical Hazard H2



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	HN	**Pittwater LEP, 2014 Geotechnical Hazard Map, showing site location relative to risk classes** (Source: Pittwater LEP, 2014)	**FIGURE 3**
Approved:	RE		
Date:	09.10.2017		
Scale:	Not to Scale		File No: P1706099JR02V03



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	HN	**Pittwater Council – Acid Sulphate Soils Map**	**FIGURE 4**
Approved:	RE		
Date:	09.10.2017		
Scale:	Not to Scale		File No: P1706099JR02V03

MARTENS & ASSOCIATES P/L

PROJECT: P1706099

BOREHOLE: BH302 DEPTH: 2.8 m – 12 m DATE: 20/09/2017

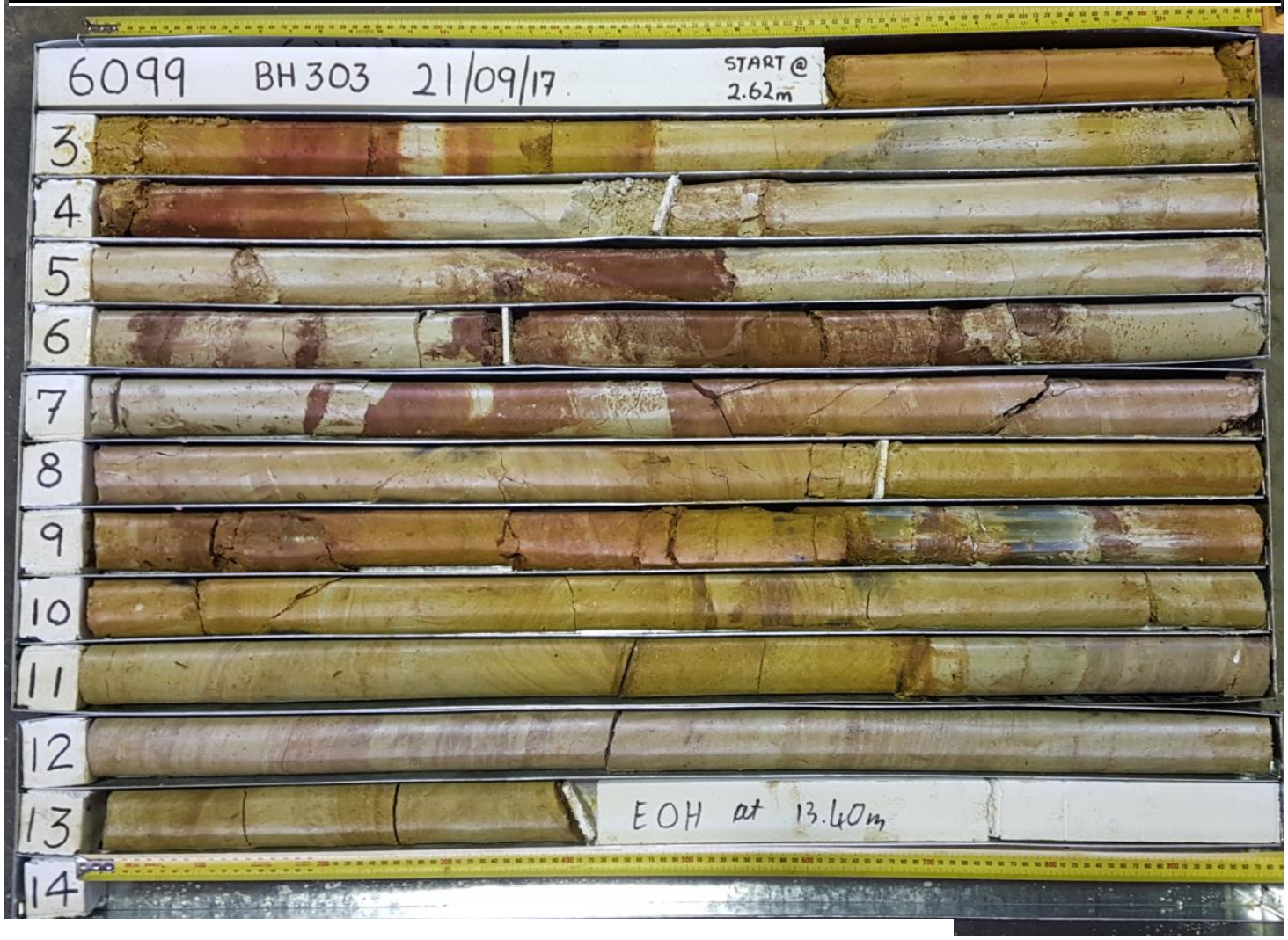
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	HN	**PHOTO OF ROCK CORE – BH302** **Proposed Seniors Living Development, Cabbage Tree Road, Bayview, NSW**	Drawing: **FIGURE 5**
Approved:	RE		
Date:	27.08.2018		
Scale:	NA		File No: P1706099JR02V03

martens

MARTENS & ASSOCIATES P/L

PROJECT: P1706099

BOREHOLE: BH303 DEPTH: 2.62 m – 13.4 m DATE: 20/09/2017

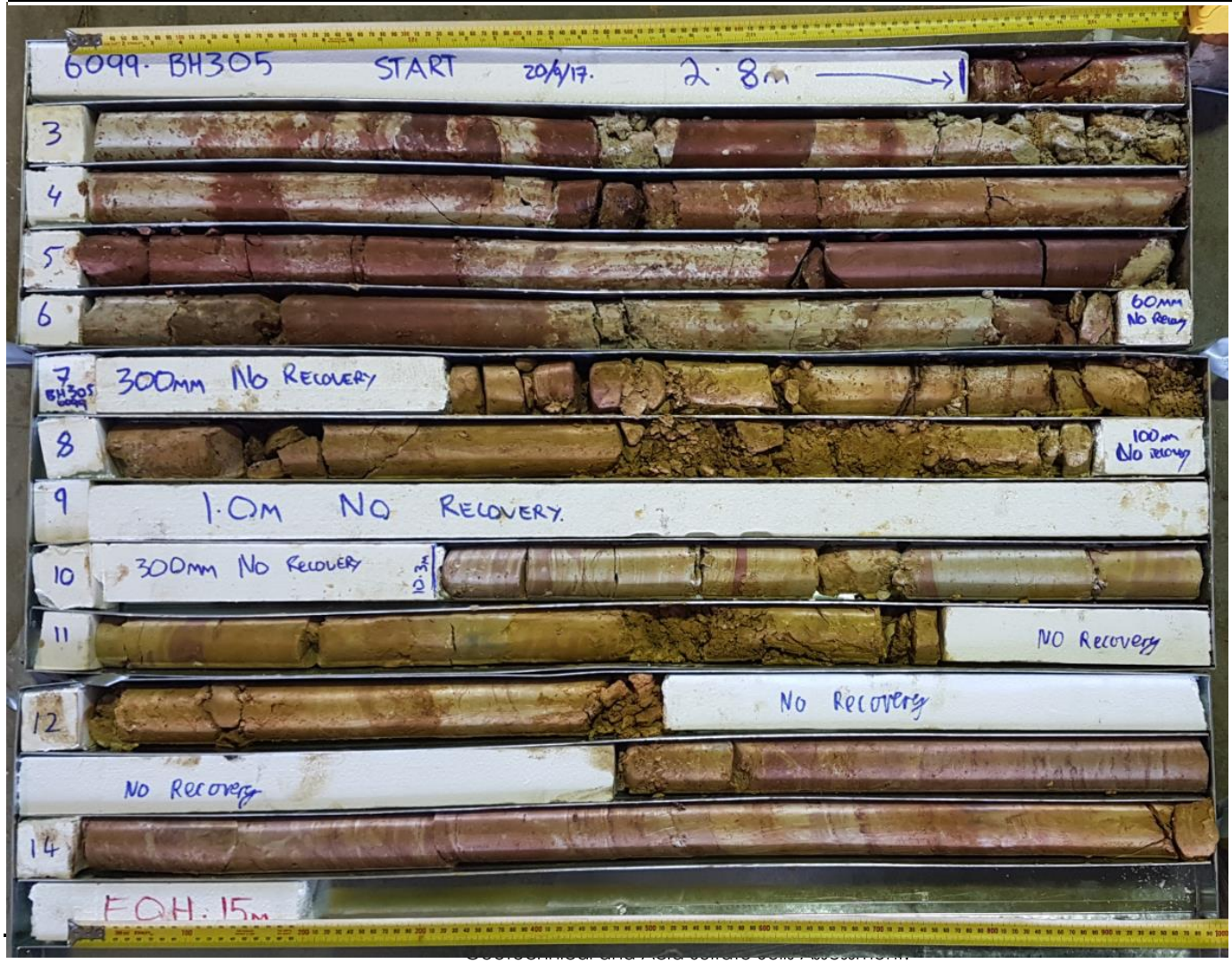


Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	HN	**PHOTO OF ROCK CORE – BH303** **Proposed Seniors Living Development, Cabbage Tree Road, Bayview, NSW**	Drawing: **FIGURE 6**
Approved:	RE		
Date:	27.08.2018		
Scale:	NA		File No: P1706099JR02V03

MARTENS & ASSOCIATES P/L

PROJECT: P1706099

BOREHOLE: BH305 DEPTH: 2.8 m – 15.0 m DATE: 20/09/2017



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	HN	**PHOTO OF ROCK CORE – BH305** **Proposed Seniors Living Development, Cabbage Tree Road, Bayview, NSW**	Drawing: **FIGURE 7**
Approved:	RE		
Date:	27.08.2018		
Scale:	NA		File No: P1706099JR02V03

10 Attachment B – Borehole and Monitoring Well Logs

CLIENT	**Planix Projects**	**COMMENCED**	20.05.14	**COMPLETED**	20.05.14	**REF**	**BH101**
PROJECT	**Geotechnical/Acid Sulphate Soils Assessment**	**LOGGED**	AB	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cabbage Tree Road, Bayview, NSW**	**GEOLOGY**	Hawkesbury Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1404179
EQUIPMENT	Hydraulic Auger	**EASTING**	-	**RL SURFACE**	6mAHD		
EXCAVATION DIMENSIONS	Ø100mm X 6.2m depth	**NORTHING**	-	**ASPECT**	South East	**SLOPE**	10-15%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
V	Nil	N	M	0.1		× × ×	OL	Organic SILT - Low plasticity, dark brown, organics, with sand.					- FILL	
V	Nil	N	M	0.5			CL	Sandy CLAY - Light brown/brown, low to medium plasticity, non homogenous.			A	0.5	- FILL 4179/101/ 0.5	
V	Nil	N	M	1.0			CI	CLAY - Medium plasticity, brown with light brown, red/orange mottles.			A	1.0	- FILL 4179/101/ 1.0	1.0
											A	1.5	4179/101/ 1.5	
				2.0							A	2.0	4179/101/ 2.0	2.0
				2.3										
V	Nil	N	M	3.0			CL	CLAY - Medium plasticity, brown/orange, yellow, trace gravels (2-30mm, 5%).			A	2.5	- FILL 4179/101/ 2.5	3.0
				3.2										
V	Nil	N 5.0 Y	M W	4.0			CH	Silty CLAY - High plasticity, black, dark brown, minor organics.	F-St		A	3.5	4179/101/ 3.5	
											A	4.0	4179/101/ 4.0	4.0
				5.0							A	4.5	4179/101/ 4.5	5.0
				5.8							A	5.5	4179/101/ 5.5	
V	Nil	Y	W	6.0				SANDSTONE - Inferred extremely low strength, red/brown, fine to medium grained, extremely weathered.			A	6.0	4179/101/ 6.0	6.0
				6.2									- V Bit refusal at 6.2m.	
								V-bit refusal on inferred very low strength sandstone at 6.2m.						
				7.0										7.0
				8.0										8.0
				9.0										9.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	Planix Projects	**COMMENCED**	20.05.14	**COMPLETED**	20.05.14	**REF**	**BH102**
PROJECT	Geotechnical/Acid Sulphate Soils Assessment	**LOGGED**	AB	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cabbage Tree Road, Bayview, NSW	**GEOLOGY**	Hawkesbury Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1404179
EQUIPMENT	Hydraulic Auger	**EASTING**	-	**RL SURFACE**	9mAHD		
EXCAVATION DIMENSIONS	Ø100mm X 2.5m depth	**NORTHING**	-	**ASPECT**	South East	**SLOPE**	10-15%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
V	Nil	N	M	0.3			SC	Clayey SAND - Fine to medium grained, brown/dark brown.		L			- TOPSOIL	
V	Nil	N	M	0.8			Cl	CLAY - Medium plasticity, with sand, dark brown.	F		A	0.5	4179/102/ 0.5 - RESIDUAL	
V	Nil	N	M	1.0 1.6			SC	Sandy CLAY - Low plasticity, dark grey.	F-St		A A	1.0 1.5	4179/102/ 1.0 - RESIDUAL 4179/102/ 1.5	1.0
V	Nil	N	M	2.0				SANDSTONE - Inferred extremely low strength, red/brown, extremely weathered.			A	2.0	4179/102/ 2.0 - V Bit refusal at 2.0m.	2.0
TC	Nil	N	M	2.5				SANDSTONE - Inferred, very low strength, grey/white, extremely to highly weathered.						
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Borehole terminated at 2.5m on inferred very low strength sandstone.						3.0 4.0 5.0 6.0 7.0 8.0 9.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**Planix Projects**	**COMMENCED**	20.05.14	**COMPLETED**	20.05.14	**REF**	**BH103**
PROJECT	**Geotechnical/Acid Sulphate Soils Assessment**	**LOGGED**	AB	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cabbage Tree Road, Bayview, NSW**	**GEOLOGY**	Hawkesbury Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1404179
EQUIPMENT	Hydraulic Auger	**EASTING**	-	**RL SURFACE**	20mAHD		
EXCAVATION DIMENSIONS	Ø100mm X 2.5m depth	**NORTHING**	-	**ASPECT**	South East	**SLOPE**	10-15%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.4			SM	Silty SAND - Fine to medium grained, dark brown.		L			- TOPSOIL
V	Nil	N	M	0.8			CL	CLAY - Low to medium plasticity, light brown/orange, with sand.	F-St		A	0.5	4179/103/ 0.5 - RESIDUAL
V	Nil	N	M	1.0 1.8				SANDSTONE - Inferred extremely low strength, red/brown, extremely weathered.			A A	1.0 1.5	4179/103/ 1.0 4179/103/ 1.5 - V Bit refusal at 1.8m.
TC	Nil	N	M	2.0 2.5				SANDSTONE - Inferred very low strength, grey/white, extremely to highly weathered.					
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Borehole terminated at 2.5m on inferred very low strength sandstone.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	Planix Projects	**COMMENCED**	20.05.14	**COMPLETED**	20.05.14	**REF**	**BH104**
PROJECT	Geotechnical/Acid Sulphate Soils Assessment	**LOGGED**	AB	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cabbage Tree Road, Bayview, NSW	**GEOLOGY**	Hawkesbury Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1404179
EQUIPMENT	Hydraulic Auger	**EASTING**	-	**RL SURFACE**	26mAHD		
EXCAVATION DIMENSIONS	Ø100mm X 2.4m depth	**NORTHING**	-	**ASPECT**	South East	**SLOPE**	10-15%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.4			SM	Silty SAND - Fine to medium grained, dark brown.		L			- TOPSOIL
V	Nil	N	M	1.0 1.1			CL	CLAY - Low to medium plasticity, light brown/orange, with sand. Grading to dark brown.	F-St		A A	0.5 1.0	4179/104/ 0.5 - RESIDUAL 4179/104/ 1.0 1.0
V	Nil	N	D	2.0 2.4				SANDSTONE - Inferred extremely low strength, red/brown, extremely weathered.			A	1.5	4179/104/ 1.5 2.0 - V Bit refusal at 2.4m.
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Borehole terminated at 2.4m on inferred very low strength sandstone.					3.0 4.0 5.0 6.0 7.0 8.0 9.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Planix Projects**	**COMMENCED**	20.05.14	**COMPLETED**	20.05.14	**REF**	**BH105**
PROJECT	**Geotechnical/Acid Sulphate Soils Assessment**	**LOGGED**	AB	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cabbage Tree Road, Bayview, NSW**	**GEOLOGY**	Hawkesbury Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1404179
EQUIPMENT	Hydraulic Auger	**EASTING**	-	**RL SURFACE**	23mAHD		
EXCAVATION DIMENSIONS	Ø100mm X 2.5m depth	**NORTHING**	-	**ASPECT**	South East	**SLOPE**	10-15%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	D	0.2			SM	Silty SAND - Fine to medium grained, dark brown.		L			- TOPSOIL
V	Nil	N	M	1.0			CL	CLAY - Low to medium plasticity, light brown/orange, with sand.	F-St		A	0.5	- RESIDUAL 4179/105/ 0.5
				1.5							A	1.0	4179/105/ 1.0 1.0
TC	Nil	N	M	2.0				SANDSTONE - Inferred extremely low strength, red/brown, extremely weathered.			A	1.5	4179/105/ 1.5 - V Bit refusal at 1.5m. 2.0
				2.5				Borehole terminated at 2.5m on inferred very low strength sandstone.					
				3.0									3.0
				4.0									4.0
				5.0									5.0
				6.0									6.0
				7.0									7.0
				8.0									8.0
				9.0									9.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Planix Projects**	**COMMENCED**	20.05.14	**COMPLETED**	20.05.14	**REF**	**BH106**
PROJECT	**Geotechnical/Acid Sulphate Soils Assessment**	**LOGGED**	AB	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cabbage Tree Road, Bayview, NSW**	**GEOLOGY**	Hawkesbury Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1404179
EQUIPMENT	Hydraulic Auger	**EASTING**	-	**RL SURFACE**	22mAHD		
EXCAVATION DIMENSIONS	Ø100mm X 2.5m depth	**NORTHING**	-	**ASPECT**	South East	**SLOPE**	10-15%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.6			SM	Silty SAND - Fine to medium grained, dark brown.		L	A	0.5	4179/106/ 0.5 - TOPSOIL
V	Nil	N	M	0.9			CL	CLAY - Low to medium plasticity, light brown/orange, with sand.			A	0.75	4179/106/ 0.75 - RESIDUAL
V	Nil	N	D	1.0 1.1				SANDSTONE - Inferred extremely low strength, red/brown, extremely weathered.			A	1.0	4179/106/ 1.0 - V Bit refusal at 1.1m. 1.0
TC	Nil	N	D	2.0 2.5				SANDSTONE - Inferred very low strength, grey/white, extremely to highly weathered.			A A	1.5 2.0	4179/106/ 1.5 4179/106/ 2.0 2.0
				3.0				Borehole terminated at 2.5m on inferred very low strength sandstone.					3.0
				4.0									4.0
				5.0									5.0
				6.0									6.0
				7.0									7.0
				8.0									8.0
				9.0									9.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**Planix Projects**	**COMMENCED**	20.05.14	**COMPLETED**	20.05.14	**REF**	**BH107**
PROJECT	**Geotechnical/Acid Sulphate Soils Assessment**	**LOGGED**	AB	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cabbage Tree Road, Bayview, NSW**	**GEOLOGY**	Hawkesbury Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1404179
EQUIPMENT	Hydraulic Auger	**EASTING**	-	**RL SURFACE**	11mAHD		
EXCAVATION DIMENSIONS	Ø100mm X 5.5m depth	**NORTHING**	-	**ASPECT**	South East	**SLOPE**	5-10%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	D	0.4			SP	SAND - Medium to coarse grained, dark brown,uniform.		L			- TOPSOIL
V	Nil	N	D	1.0 1.5			CL	CLAY - Low to medium plasticity, red/orange/brown.	F-St		A A A	0.5 1.0 1.5	4179/107/ 0.5 - FILL 4179/107/ 1.0 1.0 4179/107/ 1.5
V	Nil	N	D	2.0 3.0 4.0 5.0			SM	Silty SAND - Fine to medium grained, dark brown.			A A A A	2.0 3.5 4.5 5.0	- FILL 4179/107/ 2.0 2.0 4179/107/ 3.5 3.0 4.0 4179/107/ 4.5 4179/107/ 5.0 5.0
V	Nil	N	D	5.2			CL	CLAY - Low to medium plasticity, light brown/orange, with sand.	St				
V	Nil	N	D	5.5				SANDSTONE - Inferred extremely low strength, red/brown, extremely weathered.					
				6.0 7.0 8.0 9.0				Refusal at 5.5m on inferred extremely low strength sandstone.					6.0 7.0 8.0 9.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	Planix Projects	**COMMENCED**	20.05.14	**COMPLETED**	20.05.14	**REF**	**BH108**
PROJECT	Geotechnical/Acid Sulphate Soils Assessment	**LOGGED**	AB	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cabbage Tree Road, Bayview, NSW	**GEOLOGY**	Hawkesbury Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1404179
EQUIPMENT	Hydraulic Auger	**EASTING**	-	**RL SURFACE**	14mAHD		
EXCAVATION DIMENSIONS	Ø100mm X 5.5m depth	**NORTHING**	-	**ASPECT**	South East	**SLOPE**	5-10%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	D	0.4			SM	Silty SAND - Fine to medium grained, dark brown.					- TOPSOIL
V	Nil	N	D	0.6			CL	CLAY - Low to medium plasticity, light brown/orange, with sand.	F-St		A	0.5	4179/108/ 0.5 - FILL
V	Nil	N	D	0.9				SANDSTONE - Inferred extremely low strength, red/brown, extremely weathered.			A	0.75	4179/108/ 0.75 - FILL - V Bit refusal at 0.9m.
TC	Nil	N	D	1.0 2.0 3.0 4.0 4.3				SANDSTONE - Inferred very low strength, grey/white, extremely to highly weathered.			A A A A	1.5 2.0 2.5 3.5	4179/108/ 1.5 4179/108/ 2.0 4179/108/ 2.5 4179/108/ 3.5
TC	Nil	N	D	5.0 5.5			L	SANDSTONE - Inferred low strength, red/brown, fine to medium grained, highly to medium weathered.			A	4.5	4179/108/ 4.5
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on inferred low strength sandstone.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**Planix Projects**	**COMMENCED**	20.05.14	**COMPLETED**	20.05.14	**REF**	**BH109**
PROJECT	**Geotechnical/Acid Sulphate Soils Assessment**	**LOGGED**	AB	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cabbage Tree Road, Bayview, NSW**	**GEOLOGY**	Hawkesbury Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1404179
EQUIPMENT	Hydraulic Auger	**EASTING**	-	**RL SURFACE**	14mAHD		
EXCAVATION DIMENSIONS	Ø100mm X 2.5m depth	**NORTHING**	-	**ASPECT**	South East	**SLOPE**	10-15%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	M	0.6			SM	Silty SAND - Fine to medium grained, dark brown.			A	0.5	- TOPSOIL 4179/109/ 0.5
V	Nil	N	M	1.0 1.1			CL	CLAY - Low to medium plasticity, light brown/orange, with sand.			A	1.0	4179/109/ 1.0 1.0
V	Nil	N	M	1.5				SANDSTONE - Inferred extremely low strength, red/brown, extremely weathered.			A	1.5	4179/109/ 1.5
TC	Nil	N	D	2.0 2.5				SANDSTONE - Inferred very low strength, grey/white, extremely to highly weathered.			A	2.5	4179/109/ 2.5 2.0
				3.0				Borehole terminated at 2.5m on inferred very low strength sandstone.					3.0
				4.0									4.0
				5.0									5.0
				6.0									6.0
				7.0									7.0
				8.0									8.0
				9.0									9.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	Planix Projects	**COMMENCED**	20.05.14	**COMPLETED**	20.05.14	**REF**	**BH110**
PROJECT	Geotechnical/Acid Sulphate Soils Assessment	**LOGGED**	AB	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cabbage Tree Road, Bayview, NSW	**GEOLOGY**	Hawkesbury Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1404179
EQUIPMENT	Hydraulic Auger	**EASTING**	-	**RL SURFACE**	13mAHD		
EXCAVATION DIMENSIONS	Ø100mm X 5.5m depth	**NORTHING**	-	**ASPECT**	South East	**SLOPE**	15-20%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
V	Nil	N	D	0.15			GS	Gravelly SAND - Medium grained, beige/white, with silt.					- TOPSOIL
V	Nil	N	D	0.6			SP	Silty SAND - Dark brown, fine to medium grained.			A	0.5	- FILL 4179/110/ 0.5
V	Nil	N	M	1.0 1.1			CL	CLAY - Low to medium plasticity, light brown/orange, with sand.	F-St		A	1.0	- RESIDUAL 4179/110/ 1.0
V	Nil	N	D	1.6				SANDSTONE - Inferred extremely low strength, red/brown, extremely weathered, grading to light brown, red at 1.4m.			A	1.5	4179/110/ 1.5 - V Bit refusal at 1.6m.
TC	Nil	N	D	2.0 3.0 4.0 5.0 5.5				SANDSTONE - Inferred very low strength, grey/white, extremely to highly weathered.			A	3.0	4179/110/ 3.0
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on Inferred low strength sandstone.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH301**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 1 OF 1
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	15 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 3.00 m depth	NORTHING		ASPECT	East	SLOPE 5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L-M	Not Encountered	0	15.00	6099/BH301/0.2/S/1 D 0.20 m			ML	TOPSOIL: Sandy SILT, low liquid limit, dark brown.		St - VSt	TOPSOIL
				0.70								
				14.30				CL	Sandy CLAY, low plasticity, pale orange/brown.			RESIDUAL SOIL
			1	*1.10*	6099/BH301/0.9/S/1 D 0.90 m							
				13.90				CL	Silty CLAY, low plasticity, pale yellow, with sand.		VSt and H	
				1.60						D		
AD/T	M		2	13.40					SANDSTONE, medium grained, pale yellow, trace claystone bands, inferred extremely low and very low strength, distinctly weathered.			WEATHERED ROCK 1.60: V-bit refusal.
				2.50	6099/BH301/2.4/R/1 D 2.40 m							
				12.50					Pale pink/white.			
			3	*3.00*					Hole Terminated at 3.00 m			
			4									
			5									
			6									
			7									
			8									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH302**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	AM	CHECKED	RE	Sheet 1 OF 3
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	19.7 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 12.00 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	L			***0.15***				ML	TOPSOIL: SILT, low liquid limit, brown, with fine grained sand.	D		TOPSOIL
				19.55	P6099/302/0.1/S/1 D 0.10 m			CL	Silty CLAY, low plasticity, dark brown and red, with subangular sandstone gravels (<7mm).		F and St	RESIDUAL SOIL
AD/V					P6099/302/0.3/S/1 D 0.30 m							
	L-M									M		
					P6099/302/0.8/S/1 D 0.80 m						VSt	
			1		P6099/302/0.9/S/1 D 0.90 m							
				1.20								
				18.50					SANDSTONE, fine grained, light grey/red/brown/orange, with bands of claystone/siltstone, inferred extremely low and very low strength, distinctly weathered.			WEATHERED ROCK 1.20: V-bit refusal.
AD/T	M	Not Observed	2									
				2.80								
			3						Continued as Cored Borehole			
			4									
			5									
			6									
			7									
			8									

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH302**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	AM	CHECKED	RE	Sheet 2 OF 3
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	19.7 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 12.00 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	*DEPTH* RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
				1							
				2							
					2.80		Continuation from non-cored borehole				
NMLC	Not Observed		100 (100)	3	16.90		SANDSTONE, fine grained, bedding 0-10°, light grey and red-brown with some yellow-brown, with bands of claystone/siltstone (<300mm).	HW		2.80-2.85: DB	
			96 (100)	4						3.30: HB 3.52: HB 3.75-3.80: HB	
			96 (100)	5						4.12: JT, 3°, CN, UN, Sm 4.33: contact, 30° 4.37: HB 4.40: JT, 0°, Pl, Closed. 4.43-4.53: DB 3 4.66: JT, 5°, Pl, Closed 4.70: HB 4.82: JT, 5°, CN, Pl, RF 4.86: JT, 10°, CN, Pl, RF 4.87: JT, 40 - 45°, UN, Closed. 5.03: JT, 5°, SN, UN, RF 5.10: HB	
			91 (100)		***5.80***					5.55: BP, 2°, CN, Pl, RF 5.65: HB	
		100		6	13.90		SANDSTONE, fine grained, bedding 5-10°, yellow-brown and red-brown with some pale grey and grey, with bands of claystone/siltstone (<300mm).			5.65: JT, 45°, SN, Pl, RF 5.73: HB 5.80: JT, 5°, CN, Pl, RF 6.04: JT, 5°, SN, Pl, RF 6.11: contact, 20° 6.15: HB 6.20: HB 6.40: BP, 5°, SN, Pl, Ro 6.50: JT, 10°, SN, UN, Ro 6.68-6.90: SZ, 18 - 80°, Closed, ferruginised.	
			100 (100)	7						6.92: JT, 2°, CN, Pl, RF 7.05: HB 7.15: JT, 5°, CN, UN, RF	
			100 (100)	8						7.50: DB 7.50-7.60: Clay band. 7.55: DB 7.60: HB 7.70: HB 7.80-7.90: Clay band. 7.85-8.00: JT 8.10: HB 8.30: HB	
			84 (100)							8.62: BP, 5°, CN, UN, RF 8.70: BP, 5°, CT, UN, RF 8.70: JT, 60°, CT, Pl, RF	

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH302**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	AM	CHECKED	RE	Sheet 3 OF 3
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	19.7 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 12.00 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	*DEPTH* RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
NMLC	Not Observed	100	100 (100)	10			SANDSTONE, fine grained, bedding 5-10°, yellow-brown and red-brown with some pale grey and grey, with bands of claystone/siltstone (<300mm).	HW		8.78: JT, 2°, CT, UN, RF 8.80: contact, 65° 9.23: HB 9.60: HB 9.72: JT, 70°, SN, UN, RF 9.95: HB 10.05: HB	
			87 (100)	11						10.42: JT, 45°, SN, UN, RF 10.42-10.55: Possible SZ 10.44: HB 10.50: DB 10.52-10.53: JT, 20° 10.60: DB 10.73: BP, 2°, CN, PI, RF 11.25: HB 11.50: HB	
			100 (100)	12	*11.70* 8.00 *12.00* 7.70		SANDSTONE, fine grained, bedding ±10°, grey and red-brown, with bands of claystone/siltstone (<300mm). Hole Terminated at 12.00 m (Target depth reached)			11.70: BP, 5°, CN, PI, RF	
				13							
				14							
				15							
				16							
				17							

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF MW02**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	AM	CHECKED	RE	Sheet 1 OF 2
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	19.7 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 12.00 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
	L			*0.15* 19.55	P6099/302/0.1/S/1 D 0.10 m			ML	TOPSOIL: SILT, low liquid limit, brown, with fine grained sand.	D		MW02
AD/V	L-M				P6099/302/0.3/S/1 D 0.30 m			CL	Silty CLAY, low plasticity, dark brown and red, with subangular sandstone gravels (<7mm).	M	F and St	
			1		P6099/302/0.8/S/1 D 0.80 m						VSt	
				1.20 18.50	P6099/302/0.9/S/1 D 0.90 m				SANDSTONE, fine grained, light grey/red/brown/orange, with bands of claystone/siltstone, inferred extremely low and very low strength, distinctly weathered.			Bentonite
AD/T	M		2									
				2.80 16.90					SANDSTONE, fine grained, bedding 0-10°, light grey and red-brown with some yellow-brown, with bands of claystone/siltstone (<300mm).			
			3									
			4									Casing
			5									
				5.80 13.90								
NMLC	L-M		6						SANDSTONE, fine grained, bedding 5-10°, yellow-brown and red-brown with some pale grey and grey, with bands of claystone/siltstone (<300mm).			
			7									Sand
			8									Screen

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort	COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF MW02**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment	LOGGED	AM	CHECKED	RE	Sheet 2 OF 2
SITE	Bayview Golf Course, Bayview, NSW	GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	19.7 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 12.00 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
NMLC	L-M	21/09/17	10						SANDSTONE, fine grained, bedding 5-10°, yellow-brown and red-brown with some pale grey and grey, with bands of claystone/siltstone (<300mm).			MW02
			11	*11.70*								
				8.00					SANDSTONE, fine grained, bedding ±10°, grey and red-brown, with bands of claystone/siltstone (<300mm).			
			12	*12.00*					Hole Terminated at 12.00 m (Target depth reached)			
			13									
			14									
			15									
			16									
			17									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	21/09/2017	COMPLETED	21/09/2017	**REF BH303**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 1 OF 3
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	24.5 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 13.40 m depth	NORTHING		ASPECT	SE	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
				24.50								
AD/V	L-M	Not Observed		*0.30* 24.20	P6099/303/0.2/S/1 D 0.20 m			ML	TOPSOIL: SILT, low liquid limit, pale brown.			TOPSOIL
				0.70 23.80	P6099/303/0.5/S/1 D 0.50 m			CL	Silty CLAY, low plasticity, brown.	D	St - VSt	RESIDUAL SOIL
AD/T	M		1		P6099/303/0.8/R/1 D 0.80 m				SANDSTONE, medium to coarse grained, pale orange/yellow/brown, inferred extremely low and very low strength, with medium strength ironstone bands, distinctly weathered.			WEATHERED ROCK 0.70: V-bit refusal.
	H		2	*2.62*	P6099/303/1.5/R/1 D 1.50 m							
									Continued as Cored Borehole			
			3									
			4									
			5									
			6									
			7									
			8									

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	21/09/2017	COMPLETED	21/09/2017	**REF BH303**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 2 OF 3
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	24.5 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 13.40 m depth	NORTHING		ASPECT	SE	SLOPE 2-5%

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
				1							
				2	*2.62*		Continuation from non-cored borehole				
NMLC	Not Observed	100	100 (100)	3	21.88		SANDSTONE, fine grained, bedding 0-5°, yellow-brown with some pale grey-brown and red-brown, with claystone and siltstone bands (<700mm).	HW		2.81: HB 2.98: HB 3.05: HB 3.23: HB 3.30: JT, 30°, CN, UN, RF 3.30: HB 3.48: HB 3.58: JT, 5°, CN, UN, RF 3.66: contact	
			80 (100)	4	*4.40*					3.99: JT, 5°, CN, UN, RF 4.05: HB 4.22: HB	
			87 (100)	5	20.10		Pale grey and dark red-brown.			4.37: JT, 70°, Closed. 4.40-4.57: SZ 4.50-4.60: SZ	
			72 (100)	6						5.15: JT, 15°, SN, Pl, RF 5.18: HB 5.30-5.55: SZ	
			75 (100)	7						5.68: JT, 10°, CN, UN, RF 5.77: JT, 15°, CN, UN, RF 5.81: JT, 5°, SN, UN, RF 6.08: HB 6.12: HB 6.18: HB 6.28: DB 6.31-6.85: SZ	
			86 (100)	8	*7.50* 17.00		SANDSTONE, fine grained, bedding 5-10°, red-brown and yellow-brown, with claystone and siltstone bands (<700mm).			7.03: HB 7.04: HB 7.20: HB 7.20-8.80: SZ	
			65 (100)								

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	21/09/2017	COMPLETED	21/09/2017	**REF BH303**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 3 OF 3
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	24.5 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 13.40 m depth	NORTHING		ASPECT	SE	SLOPE 2-5%

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	*DEPTH* RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
NMLC	Not Observed	100	72 (100)	10			SANDSTONE, fine grained, bedding 5-10°, red-brown and yellow-brown, with claystone and siltstone bands (<700mm).	HW		9.06: JT, 2°, CT, UN, S 9.10-9.20: DS 9.34: BP, 3°, CN, UN, RF 9.45: JT, 10°, CN, UN, RF 9.50: JT, 5°, CN, UN, RF 9.50: JT, 80°, SN, UN, RF 9.60-9.90: SZ	
			91 (100)	11				MW		10.10: BP, 5°, CN, Pl, RF 10.13: JT, 45°, SN, UN, S 10.40: HB 10.50: HB 10.60: JT, 20°, CN, UN, S 10.65: HB 10.68: HB 10.90: JT, 2°, CN, UN, RF 11.03: HB	
			97 (100)	12	*11.70* 12.80		SANDSTONE, fine grained, pale grey and pale red-brown with yellow-brown, with claystone and siltstone bands (<700mm).			11.45-11.55: BP Set 2, 5°, SN, Pl, RF 11.66: JT, 15°, CT, UN, RF 11.96: BP, 10°, CN, Pl, RF 12.15-12.40: BP Set 2, 5°, CN, Pl, RF	
			100 (100)	13						13.12-13.23: BP Set 2, 2°, CN, Pl, RF	
			100 (100)		*13.40* 11.10		Hole Terminated at 13.40 m (Target depth reached)				
	Not Observed			14							
				15							
				16							
				17							

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	21/09/2017	COMPLETED	21/09/2017	**REF MW03**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 1 OF 2
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	24.5 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 13.40 m depth	NORTHING		ASPECT	SE	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level
				24.50								MW03
AD/V	L-M			*0.30* 24.20	P6099/303/0.2/S/1 D 0.20 m			ML	TOPSOIL: SILT, low liquid limit, pale brown.			
					P6099/303/0.5/S/1 D 0.50 m			CL	Silty CLAY, low plasticity, brown.	D	St - VSt	
				0.70 23.80								
AD/T	M		1		P6099/303/0.8/R/1 D 0.80 m				SANDSTONE, medium to coarse grained, pale orange/yellow/brown, inferred extremely low and very low strength, with medium strength ironstone bands, distinctly weathered.			Bentonite
	H		2		P6099/303/1.5/R/1 D 1.50 m							
				2.62 21.88								
NMLC			3						SANDSTONE, fine grained, bedding 0-5°, yellow-brown with some pale grey-brown and red-brown, with claystone and siltstone bands (<700mm).			Casing
			4	*4.40* 20.10					Pale grey and dark red-brown.			
			5									
			6									
			7	*7.50* 17.00					SANDSTONE, fine grained, bedding 5-10°, red-brown and yellow-brown, with claystone and siltstone bands (<700mm).			
			8									Sand

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	21/09/2017	COMPLETED	21/09/2017	**REF MW03**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 2 OF 2
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	24.5 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 13.40 m depth	NORTHING		ASPECT	SE	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID MW03 Static Water Level
NMLC		21/09/17	10						SANDSTONE, fine grained, bedding 5-10°, red-brown and yellow-brown, with claystone and siltstone bands (<700mm).			Screen
			11	11.70								
				12.80					SANDSTONE, fine grained, pale grey and pale red-brown with yellow-brown, with claystone and siltstone bands (<700mm).			
			12									
			13	13.40					Hole Terminated at 13.40 m (Target depth reached)			
			14									
			15									
			16									
			17									

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH304**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 1 OF 1
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	16.5 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 8.50 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
				16.50								
AD/V				*0.30* 16.20	P6099/304/0.2/S/1 D 0.20 m			ML	FILL: Sandy SILT, low liquid limit, dark brown, with organic material.		St - VSt	FILL
	L			*0.60* 15.90	P6099/304/0.5/S/1 D 0.50 m			ML	TOPSOIL: SILT, low liquid limit, dark red/dark brown, trace subangular sandstone gravels.			TOPSOIL
			1	*1.10* 15.40	P6099/304/1.0/S/1 D 1.00 m			SC	Clayey SAND, dark orange/brown, trace iron staining.	D	D	RESIDUAL SOIL
	M				P6099/304/1.5/R/1 D 1.50 m				SANDSTONE, fine to medium grained, red/grey/white, inferred extremely low to very low strength, distinctly weathered.			WEATHERED ROCK 1.10: V-bit refusal.
			2		P6099/304/1.9/R/1 D 1.90 m							
			3	*3.00* 13.50					With claystone/siltstone bands.			
AD/T	L-M	Not Encountered	4									
			5									
			6									
			7									
			8									
				8.50					Hole Terminated at 8.50 m			

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	21/09/2017	COMPLETED	21/09/2017	**REF BH305**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	AM	CHECKED	RE	Sheet 1 OF 3
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	19.9 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 15.00 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L	Not Observed		19.90 ***0.20***	P6099/305/0.1/S/1 D 0.10 m			ML	TOPSOIL: SILT, low liquid limit, brown, trace of fine grained sand, with subangular sandstone gravels.		St	TOPSOIL
				19.70	P6099/305/0.3/S/1 D 0.30 m			SM	TOPSOIL: Silty SAND, fine grained, brown/orange/red, with clay and trace of subangular sandstone gravels.		D	
	L-M			***0.60***								
AD/T	M		1 2	19.30 ***2.80***	P6099/305/0.7/R/1 D 0.70 m				SANDSTONE, fine grained, orange/red/grey, with claystone and siltstone bands, inferred extremely low and very low strength, distinctly weathered.	D		WEATHERED ROCK 0.60: V-bit refusal.
			3 4 5 6 7 8						Continued as Cored Borehole			

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	21/09/2017	COMPLETED	21/09/2017	**REF BH305**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	AM	CHECKED	RE	Sheet 2 OF 3
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	19.9 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 15.00 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	*DEPTH* RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
				1							
				2							
					2.80		Continuation from non-cored borehole				
NMLC	Not Observed	100	0 (100)	3	17.10		SANDSTONE, fine grained, red/brown/light grey, bedding 0-10°, with claystone and siltstone bands (<400mm).	HW		2.80-10.30: SZ	
		100	71 (71)	4							
		100	83 (100)	5							
		100	57 (100)	6							
		94	94 (94)	7							
					6.94						
					12.96		NO CORE				
					7.30						
		70	0 (60)	8	12.60		CLAYSTONE and SILTSTONE, bedding 5-10°, red/light grey/yellow-brown.				
		90	10 (40)								
					8.90						
					11.00						

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort	COMMENCED	21/09/2017	COMPLETED	21/09/2017	**REF BH305**	
PROJECT	Geotechnical and Acid Sulfate Soils Assessment	LOGGED	AM	CHECKED	RE	Sheet 3 OF 3	
SITE	Bayview Golf Course, Bayview, NSW	GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	19.9 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 15.00 m depth	NORTHING		ASPECT	South	SLOPE	2-5%

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
NMLC	Not Observed	0	0 (0)	10			NO CORE	HW			
		70	60 (70)		*10.30* 9.60		CLAYSTONE and SILTSTONE, light red/light grey/yellow-brown.			10.38-10.54: BP Set 4, 2°, CN, UN, RF	
		80	45 (50)	11	*11.80* 8.10		NO CORE			10.65: DB 10.74: DB 10.90: BP, 5°, CN, UN, RF 11.04: BP, 3°, CN, UN, RF 11.20-13.60: SZ	
		55	50 (50)	12	*12.00* 7.90		CLAYSTONE and SILTSTONE, red with light grey and yellow-brown.				
					12.50 7.40		NO CORE				
	Not Observed	50	46 (46)	13	*13.45* 6.45		CLAYSTONE and SILTSTONE, red with light grey and yellow-brown.				
		100	90 (100)	14						14.10: JT, 20°, CN, UN, RF 14.30: BP, 5°, CN, UN, RF 14.52: HB	
				15	*15.00* 4.90		Hole Terminated at 15.00 m (Target depth reached)			14.90: JT, 70°, CN, UN, RF 14.93: JT, 20°, CN, UN, RF 14.96: JT, 5°, CN, UN, RF	
				16							
				17							

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	21/09/2017	COMPLETED	21/09/2017	**REF MW05**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	AM	CHECKED	RE	Sheet 1 OF 2
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	19.9 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 15.00 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID / Static Water Level
AD/V	L			19.90 *0.20* 19.70	P6099/305/0.1/S/1 D 0.10 m P6099/305/0.3/S/1 D 0.30 m			ML SM	TOPSOIL: SILT, low liquid limit, brown, trace of fine grained sand, with subangular sandstone gravels. TOPSOIL: Silty SAND, fine grained, brown/orange/red, with clay and trace of subangular sandstone gravels.		St D	MW05
	L-M			*0.60* 19.30	P6099/305/0.7/R/1 D 0.70 m				SANDSTONE, fine grained, orange/red/grey, with claystone and siltstone bands, inferred extremely low and very low strength, distinctly weathered.			
AD/T	M		1							D		Bentonite
			2	*2.80* 17.10					SANDSTONE, fine grained, red/brown/light grey, bedding 0-10°, with claystone and siltstone bands (<400mm).			
			3									
			4									
			5									Casing
			6									
NMLC			7	*6.94* 12.96					NO CORE			
				7.30 12.60					CLAYSTONE and SILTSTONE, bedding 5-10°, red/light grey/yellow-brown.			
		21/09/17	8									
				8.90 11.00								

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	21/09/2017	COMPLETED	21/09/2017	**REF MW05**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	AM	CHECKED	RE	Sheet 2 OF 2
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	19.9 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 15.00 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID MW05 Static Water Level
NMLC			10	10.30 / 9.60					NO CORE			Sand
			11						CLAYSTONE and SILTSTONE, light red/light grey/yellow-brown.			Screen
				11.80 / 8.10					NO CORE			
			12	12.00 / 7.90					CLAYSTONE and SILTSTONE, red with light grey and yellow-brown.			
				12.50 / 7.40					NO CORE			
			13									
				13.45 / 6.45					CLAYSTONE and SILTSTONE, red with light grey and yellow-brown.			
			14									
			15	15.00					Hole Terminated at 15.00 m (Target depth reached)			
			16									
			17									

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort	COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH306**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment	LOGGED	MV	CHECKED	RE	Sheet 1 OF 1
SITE	Bayview Golf Course, Bayview, NSW	GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	7 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 2.80 m depth	NORTHING		ASPECT	Northeast	SLOPE 5-10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L	Not Encountered		6.95 *0.25* 6.75	6099/BH306/0.2/S/1 D 0.20 m 6099/BH306/0.3/S/1 D 0.30 m 6099/BH306/0.3-0.6/CBR CBR 0.30 m			SM CI CH	FILL: Silty SAND, fine to medium grained, brown. FILL: Sandy CLAY, medium plasticity, orange/brown. CLAY, high plasticity, pale brown/white.		MD St and VSt	FILL RESIDUAL SOIL
			1	*1.00* *1.10* 5.90	6099/BH306/1.0/S/1 D 1.00 m			CH	Mottled red/grey. CLAY, high plasticity, pale brown/grey.	M	St - VSt	
	L-M				6099/BH306/1.5/S/1 D 1.50 m							
			2	*2.00* 5.00	6099/BH306/2.2/S/1 D 2.20 m			CL-CI	Silty CLAY, low to medium plasticity, red/brown, trace subangular gravels.		H	
				2.80	P6099/BH306/2.7/S/1 D 2.70 m				Hole Terminated at 2.80 m			
			3									
			4									
			5									
			6									
			7									
			8									

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH307**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 1 OF 1
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	8.8 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 1.10 m depth	NORTHING		ASPECT	South	SLOPE 5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
				8.80				SM	TOPSOIL: Silty SAND, brown, fine grained.		MD	TOPSOIL
				0.20								
AD/V	M	Not Encountered		8.60	6099/BH307/0.25/S/1 D 0.25 m			SC	Clayey SAND, medium grained, pale yellow/grey.	D	D - VD	RESIDUAL SOIL
	H		1	*1.10*								
									Hole Terminated at 1.10 m			1.10: V-bit refusal on inferred very low strength sandstone.
			2									
			3									
			4									
			5									
			6									
			7									
			8									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH308**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 1 OF 1
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	11.9 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 2.50 m depth	NORTHING		ASPECT	Southeast	SLOPE 5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered	0	11.90	6099/BH308/0.2/S/1 D 0.20 m			SM	FILL: Silty SAND, fine grained, brown, sub angular gravels.		D	FILL
	H			*0.75*								
AD/T	VH		1	11.15				SC	FILL: Clayey SAND, fine to medium grained, red/brown, with sandstone gravels.			0.75: V-bit refusal on inferred sandstone boulder within soil profile.
				1.20								
	H			10.70					SANDSTONE, medium to coarse grained, orange/brown, white, inferred extremely low and very low strength, with medium strength bands, distinctly weathered.	D		WEATHERED ROCK
	M		2	*2.50*								
									Hole Terminated at 2.50 m			
			3									
			4									
			5									
			6									
			7									
			8									

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH309**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	DO	CHECKED	RE	Sheet 1 OF 1
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		Hand Auger	EASTING		RL SURFACE	15.1 m	DATUM AHD
EXCAVATION DIMENSIONS		⌀75 mm x 0.50 m depth	NORTHING		ASPECT	South	SLOPE 2-5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	L-M	Not Encountered		15.10	P6099/309/0.1/S/1 D 0.10 m			ML	TOPSOIL: SILT, low liquid limit, brown, with fine gravels.	D	St - VSt	TOPSOIL
				0.35	P6099/309/0.3/S/1 D 0.30 m							
	H			*0.50*	P6099/309/0.4/S/1 D 0.40 m			CL	Silty CLAY, low plasticity, brown/red, with sandstone gravels.			RESIDUAL SOIL
									Hole Terminated at 0.50 m			0.50: Hand auger refusal on sandstone bands within soil profile.

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH311**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	DO	CHECKED	RE	Sheet 1 OF 1
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		Hand Auger	EASTING		RL SURFACE	11.1 m	DATUM AHD
EXCAVATION DIMENSIONS		⌀75 mm x 0.80 m depth	NORTHING		ASPECT	South	SLOPE 10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	M-H	Not Encountered		11.10	P6099/311/0.1/D/1 D 0.10 m			ML	FILL: SILT, low liquid limit, brown, with organic materials, trace of fine grained sand.	D - M	VSt - H	FILL
				0.40 10.70	P6099/311/0.3/S/1 D 0.30 m			ML	TOPSOIL: SILT, low liquid limit, brown, trace of clay, with fine to medium gravels.			TOPSOIL
				0.65 *0.80*	P6099/311/0.5/S/1 D 0.50 m			CL	CLAY, low plasticity, brown/red, with fine to medium grained gravels, trace of fine grained sand.			RESIDUAL SOIL
			1						Hole Terminated at 0.80 m			0.80: Hand auger refusal due high resistance.
			2									
			3									
			4									
			5									
			6									
			7									
			8									

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH312**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 1 OF 1
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	17.2 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 3.70 m depth	NORTHING		ASPECT	South	SLOPE 5-10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		17.20				SM	FILL: Silty SAND, dark brown, fine grained, trace shells and clay.	D	MD	FILL
				0.30 16.90	6099/BH312/0.2/S/1 D 0.20 m			CI	FILL: Silty CLAY, medium plasticity, dark brown, trace red staining.			
	L		1		6099/BH312/0.8/S/1 D 0.80 m						St	
				1.20 16.00				CI	CLAY, medium plasticity, pale orange/brown.			RESIDUAL SOIL
				1.65 15.55	6099/BH312/1.4/S/1 D 1.40 m			SC	Clayey SAND, fine to medium grained, pale red/brown.	M		
	M		2								D - VD	
			3	*3.00* 14.20	6099/BH312/3.0/S/1 D 3.00 m				with clay bands.			
				3.70					Hole Terminated at 3.70 m			
			4									
			5									
			6									
			7									
			8									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Waterbrook Lifestyle Resort	COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH313**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment	LOGGED	MV	CHECKED	RE	Sheet 1 OF 1
SITE	Bayview Golf Course, Bayview, NSW	GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	7 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.50 m depth	NORTHING		ASPECT	Southeast	SLOPE 9%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T		Not Encountered		7.00				SM	TOPSOIL: Silty SAND, fine grained, brown.		MD	TOPSOIL
				0.30	6099/BH313/0.2/S/1 D 0.20 m							
				6.70	6099/BH313/0.5/S/1 D 0.50 m			SC	Clayey SAND, fine to medium grained, orange/brown, with subangular sandstone gravels.		D and VD	RESIDUAL SOIL
	M		1	*1.10*								
	H			5.90					SANDSTONE, fine to medium grained, red/brown, inferred extremely low and very low strength, with medium strength bands, distinctly weathered.	D		WEATHERED ROCK
			2									
			3									
			4	*4.50*								
									Hole Terminated at 4.50 m			
			5									
			6									
			7									
			8									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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CLIENT	Waterbrook Lifestyle Resort		COMMENCED	20/09/2017	COMPLETED	20/09/2017	**REF BH314**
PROJECT	Geotechnical and Acid Sulfate Soils Assessment		LOGGED	MV	CHECKED	RE	Sheet 1 OF 1
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Narrabeen Group	VEGETATION	Grass	PROJECT NO. P1706099
EQUIPMENT		4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	3.2 m	DATUM AHD
EXCAVATION DIMENSIONS		Ø100 mm x 2.50 m depth	NORTHING		ASPECT	East	SLOPE <2%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	H	Not Encountered		3.20				SM	FILL: Silty SAND, fine grained, brown, trace fine to medium subangular igneous gravel, trace clay.			FILL
					6099/BH314/0.2/S/1 D 0.20 m							
				0.40								
				2.80	6099/BH314/0.3-0.6/CBR CBR 0.30 m			SP	FILL: SAND, brown, fine grained, trace subangular gravels.	D	D	
				0.60								
				2.60	6099/BH314/0.5/S/1 D 0.50 m			SP	FILL: SAND, fine grained, dark brown, with clay, trace fine to medium subangular gravels.			
					6099/BH314/0.8/S/1 D 0.80 m							
			1	*1.00*				SC	FILL: Clayey SAND, fine grained, dark brown.		MD	
	L			2.20								
				1.50								
				1.70				CI	Sandy CLAY, medium plasticity, dark brown.	M	St	ALLUVIUM
			2		6099/BH314/2.0/S/1 D 2.00 m							
				2.30								
				0.90				CH	CLAY high plasticity, pale grey/red, with sand.			
				2.50	6099/BH314/2.4/S/1 D 2.40 m							
									Hole Terminated at 2.50 m			
			3									
			4									
			5									
			6									
			7									
			8									

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Engineering Log - BOREHOLE

11 Attachment C – DCP ‘N’ Counts

Dynamic Cone Penetrometer Test Log Summary

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Site	Cabbage Tree Road, Bayview, NSW		
Client	PLANIX Projects		
Logged by	GMT/AB	Date Logged	20/05/2014
Checked by	GT	Date Checked	
Comments			

TEST DATA

Depth Interval (m)	DCP 101	DCP 102	DCP 103	DCP 104	DCP 105	DCP 106	DCP 107	DCP 108	DCP 109	DCP 110
0.15	3	6	4	3	3	4	2	6	3	3
0.30	4	6	6	6	5	8	4	7	4	4
0.45	4	5	7	6	6	4	3	40+	5	12
0.60	2	7	6	8	7	40+	2	Bounce @	4	13
0.75	4	11	9	9	6	Bounce @	2	0.50 m	5	8
0.90	4	5	40+	10	6	0.65 m	6		9	13
1.05	8	10	Terminated @	15	10		8		15	9
1.20	10	13	0.95 m	10	22		8		32	10
1.35	5	13		10	40+		9		35	14
1.50	9	15		11	Bounce @		10		40+	40+
1.65	18	13		13	1.45 m		10		Terminated @	Bounce @
1.80	13	12		12			13		1.65 m	1.55 m
1.95	11	13		13			10			
2.10	12	16		14			17			
2.25	19	20		30			16			
2.40	17	27		40+			10			
2.55	12	31		Terminated @			25			
2.70	14	40+		2.45 m			16			
2.85	13	Terminated @					9			
3.00	21	2.80 m					12			
3.15	17						9			
3.30	14						18			
3.45	15						15			
3.60	14						12			
3.75	15						20			
3.90	16						17			
4.05	16						18			
4.20	17						17			
4.35	15						29			
4.50	13						21			
4.65	14						21			
4.80	19						22			
4.95	19						27			
5.10	23						30			
5.25	23						28			
5.40	21						40+			
5.55	20						Bounce @			
5.70	17						5.50 m			
5.85	20									
6.00	23									
6.15	36									
	40+									
	Terminated @									
	6.20 m									

Dynamic Cone Penetrometer Test Log Summary

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Site	Cabbage Tree Road, Bayview, NSW		
Client	PLANIX Projects		
Logged by	GMT/AB	Date Logged	4.6.14
Checked by	GT	Date Checked	24.6.14
Comments			

TEST DATA

Depth Interval (m)	DCP 201	DCP 202	DCP 203	DCP 204	DCP 205	DCP 206
0.15	5	1	7	10	3	7
0.30	9	9	7	40	9	40
0.45	6	21	20		14	
0.60	5	20	20	Terminated	20	Terminated
0.75	15	18	40	@	14	@
0.90	15	20		0.3m	14	0.3m
1.05	22	5	Terminated		15	
1.20	30	40	@		18	
1.35	13		0.7m		40	
1.50	18	Terminated				
1.65	40	@			Terminated	
		1.15m			@	
	Terminated				1.2m	
	@					
	1.65m					

Dynamic Cone Penetrometer Test Log Summary

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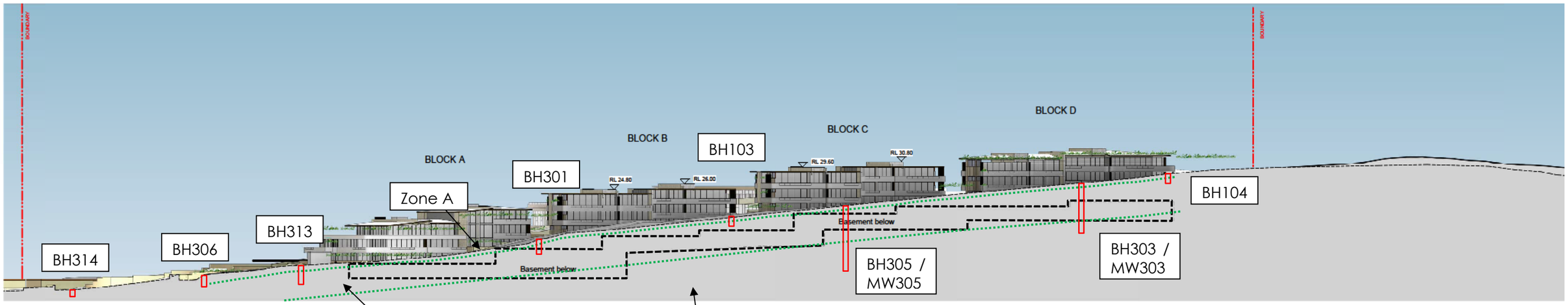
Site	Proposed Seniors Living Development, Cabbage Tree Road, Bayview, NSW	DCP Group Reference	P1706099JS01V01
Client	Waterbrook Lifestyle Resort C/- Marchesa Partners Engineering	Log Date	20-21.09.2017
Logged by	AM/MV/DOS		
Checked by	RE		
Comments	DCPs started with 50 mm tip in ground.		

TEST DATA

Depth Interval (m)	DCP301	DCP302	DCP303	DCP304	DCP305	DCP306	DCP307	DCP308	DCP309	DCP311	DCP312	DCP313	DCP314	
0.15	9	6	8	8	11	5	8	14	8	10	6	9	14	
0.30	10	8	21	9	13	16	16	19	8	22	5	20	28	
0.45	22	3	19	19	14	10	30	17	12	19	5	Bounced @ 0.35 m	17	
0.60	18	2	17 / 100 mm	15	21	15	20	16	10	20	5		30	
0.75	24	19	Bounced @ 0.6 m	21	4 / 50 mm	6	Bounced @ 0.65 m	17	10	17	6		25	
0.90	22	8		21	Bounced @ 0.7 m	4		23	18	14	9		29	
1.05	16	10		17		9		25	30	16	7		18	
1.20	Bounced @ 1.10 m	14		16		8		20	Terminated @ 1.10 m due to high 'N' counts	30	7		15	
1.35		14 / 70 mm		20		7		22		Terminated @ 1.25 m due to high 'N' counts	10		10	
1.50		Bounced @ 1.32 m		22		7		Bounced @ 1.40 m			5		5	
1.65				10 / 50 mm		7					6		4	
1.80				Bounced @ 1.6 m		8					10		10	
1.95						19					15		3	
2.10						29					18		4	
2.25						16					23		4	
2.40						18					15		6	
2.55						Terminated @ 2.45 m					Bounced @ 2.45 m		10	
2.70													Terminated @ 2.60 m	
2.85														
3.00														
3.15														

12 Attachment D – Geological Site Sections

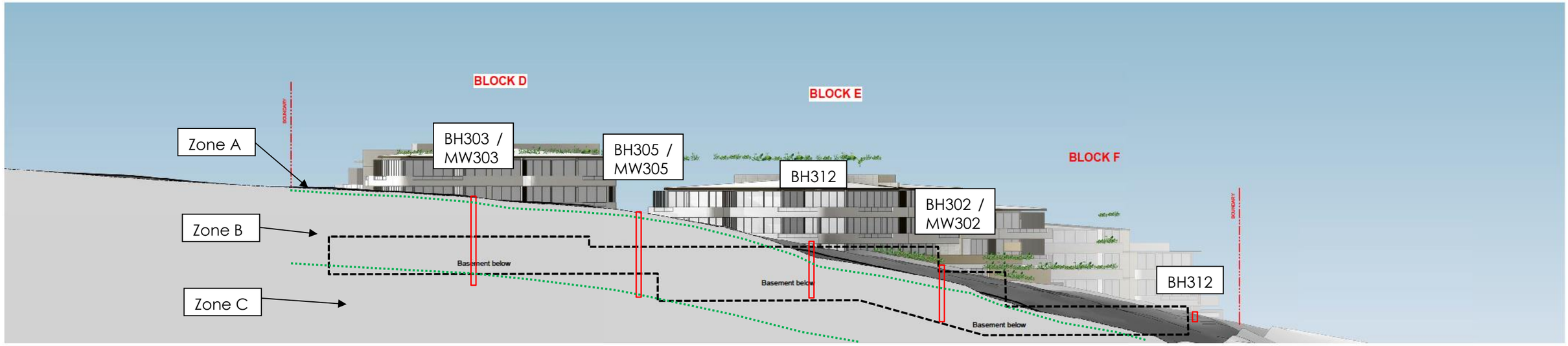


NORTH ELEVATION
1 : 500

Key

Zone A:	Fill / Topsoil / Alluvial clay in south eastern corner / Residual soils	▯	Approximate borehole location
Zone B:	Extremely low to low strength sandstone / siltstone / claystone (class V)	⋯	Approximate zone boundary
Zone C:	Medium strength sandstone / siltstone / claystone (class IV / III)	／	Approximate location of proposed basement

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	HN	**INFERRED GENERALISED CROSS SECTION A-A' (REFER FIGURE 2 FOR LOCATION)** **Proposed Seniors Living Development, Cabbage Tree Road, Bayview, NSW** (Source: Marchese Partners, 2018)	Drawing: **FIGURE 8**
Approved:	RE		
Date:	27.08.2018		File No: P1706099JR02V03
Scale:	NA		



WEST ELEVATION
1 : 250

Key

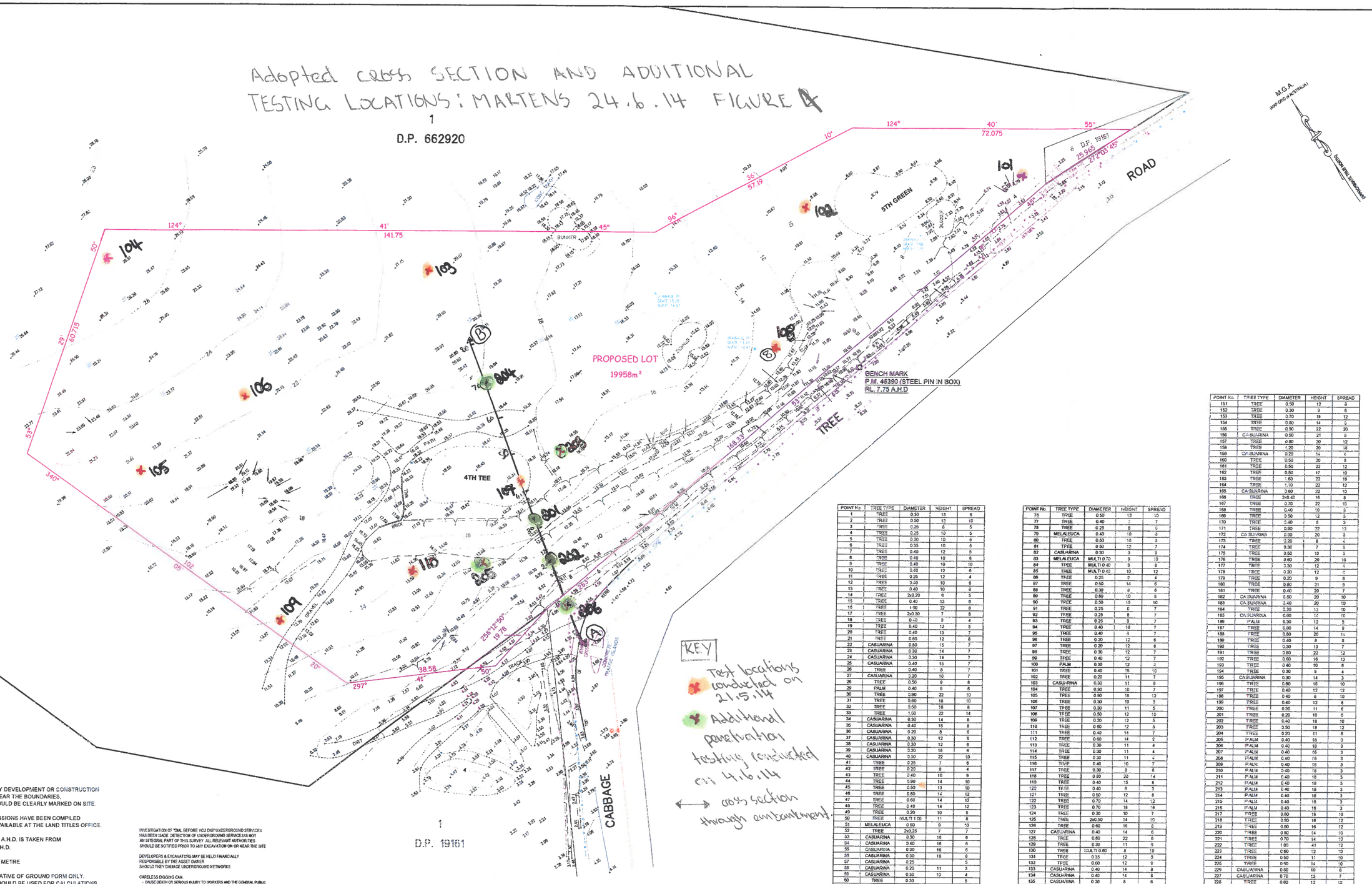
Zone A:	Fill / Topsoil / Alluvial clay in south eastern corner / Residual soils		Approximate borehole location
Zone B:	Extremely low to low strength sandstone / siltstone / claystone (class V)		Approximate zone boundary
Zone C:	Medium strength sandstone / siltstone / claystone (class IV / III)		Approximate location of proposed basement

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	HN	**INFERRED GENERALISED CROSS SECTION B-B' (REFER FIGURE 2 FOR LOCATION)** **Proposed Seniors Living Development, Cabbage Tree Road, Bayview, NSW** (Source: Marchese Partners, 2018)	Drawing: **FIGURE 9**
Approved:	RE		
Date:	27.08.2018		
Scale:	NA		File No: P1706099JR02V03

13 Attachment E – Preliminary Landslide Modelling Results

Adopted cross SECTION AND ADDITIONAL
TESTING LOCATIONS: MARTENS 24.6.14 FIGURE 4

1
D.P. 662920



KEY

- Test locations conducted on 21.5.14
- Additional penetration testing conducted on 4.6.14
- ⟷ cross section through embankment

POINT No.	TREE TYPE	DIAMETER	HEIGHT	SPREAD
151	TREE	0.50	12	8
152	TREE	0.30	8	6
153	TREE	0.70	18	12
154	TREE	0.80	14	9
155	TREE	0.90	22	20
156	CASUARINA	0.50	21	8
157	TREE	0.80	30	12
158	TREE	1.20	20	16
159	CASUARINA	0.20	14	4
160	TREE	0.50	20	3
161	TREE	0.50	22	12
162	TREE	0.50	17	10
163	TREE	1.60	22	16
164	TREE	1.10	22	12
165	CASUARINA	0.60	22	10
166	TREE	2x0.40	16	8
167	TREE	0.70	22	10
168	TREE	0.40	10	5
169	TREE	0.50	12	5
170	TREE	0.40	8	3
171	TREE	0.80	22	12
172	CASUARINA	0.50	20	3
173	TREE	0.20	8	4
174	TREE	0.30	7	5
175	TREE	0.50	10	5
176	TREE	0.60	20	10
177	TREE	0.30	12	4
178	TREE	0.30	12	4
179	TREE	0.20	9	6
180	TREE	0.80	21	9
181	TREE	0.40	20	7
182	CASUARINA	0.50	20	10
183	CASUARINA	0.40	20	10
184	TREE	0.30	12	10
185	CASUARINA	0.90	18	10
186	PALM	0.30	12	5
187	TREE	0.80	14	9
188	TREE	0.80	20	14
189	TREE	0.40	8	6
190	TREE	0.30	10	7
191	TREE	0.80	22	12
192	TREE	0.60	16	10
193	TREE	0.40	10	8
194	TREE	0.30	8	4
195	CASUARINA	0.30	14	3
196	TREE	0.60	16	10
197	TREE	0.40	12	12
198	TREE	0.40	8	10
199	TREE	0.40	12	8
200	TREE	0.30	11	6
201	TREE	0.20	10	6
202	TREE	0.40	18	10
203	TREE	0.50	18	12
204	TREE	0.20	11	6
205	PALM	0.40	18	3
206	PALM	0.40	18	3
207	PALM	0.40	18	3
208	PALM	0.40	18	3
209	PALM	0.40	18	3
210	PALM	0.40	18	3
211	PALM	0.40	18	3
212	PALM	0.40	18	3
213	PALM	0.40	18	3
214	PALM	0.40	18	3
215	PALM	0.40	18	3
216	PALM	0.40	18	3
217	TREE	0.80	18	10
218	TREE	0.80	18	12
219	TREE	0.80	18	12
220	TREE	0.80	14	10
221	TREE	0.70	14	10
222	TREE	1.00	41	12
223	TREE	0.60	12	10
224	TREE	0.50	11	10
225	TREE	0.50	14	10
226	CASUARINA	0.60	10	8
227	CASUARINA	0.70	13	7
228	TREE	0.60	12	10
229	TREE	0.60	12	10
230	TREE	0.50	14	12
231	TREE	0.50	11	5
232	TREE	0.40	11	6
233	TREE	0.70	11	8
234	CASUARINA	0.40	10	4
235	TREE	0.60	14	9
236	TREE	0.50	10	11
237	TREE	0.50	18	15
238	CASUARINA	0.40	10	6
239	TREE	0.50	10	8
240	TREE	0.30	14	5
241	TREE	0.60	14	9
242	TREE	0.60	12	10
243	TREE	0.60	12	10

POINT No	TREE TYPE	DIAMETER	HEIGHT	SPREAD
1	TREE	0.30	15	8
2	TREE	0.50	12	10
3	TREE	0.25	8	5
4	TREE	0.25	10	5
5	TREE	0.30	10	6
6	TREE	0.35	10	5
7	TREE	0.40	12	8
8	TREE	0.40	10	6
9	TREE	0.40	10	10
10	TREE	0.50	12	6
11	TREE	0.25	12	4
12	TREE	0.40	10	6
13	TREE	0.40	10	8
14	TREE	2x0.20	6	5
15	TREE	0.40	13	6
16	TREE	1.00	22	8
17	TREE	2x0.30	7	5
18	TREE	0.30	8	4
19	TREE	0.40	12	5
20	TREE	0.40	15	7
21	TREE	0.60	12	8
22	CASUARINA	0.50	15	7
23	CASUARINA	0.30	14	7
24	CASUARINA	0.30	14	7
25	CASUARINA	0.40	15	7
26	TREE	0.40	8	7
27	CASUARINA	0.20	10	7
28	TREE	0.50	9	8
29	PALM	0.40	6	6
30	TREE	0.90	22	10
31	TREE	0.60	18	10
32	TREE	0.50	16	8
33	TREE	1.00	22	14
34	CASUARINA	0.30	14	8
35	CASUARINA	0.40	16	8
36	CASUARINA	0.20	8	6
37	CASUARINA	0.30	12	5
38	CASUARINA	0.30	12	6
39	CASUARINA	0.30	16	6
40	CASUARINA	0.50	22	10
41	TREE	0.25	7	6
42	TREE	0.20	8	4
43	TREE	0.40	10	9
44	TREE	0.90	14	10
45	TREE	0.50	13	10
46	TREE	0.60	14	12
47	TREE	0.60	14	12
48	TREE	0.40	14	12
49	TREE	0.20	10	5
50	TREE	MULTI 1.00	11	8
51	MELALEUCA	0.60	9	10
52	TREE	2x0.25	7	7
53	CASUARINA	0.30	16	6
54	CASUARINA	0.40	16	6
55	CASUARINA	0.30	16	6
56	CASUARINA	0.30	18	6
57	CASUARINA	0.25		5
58	CASUARINA	0.20	11	3
59	CASUARINA	0.30	10	4
60	TREE	0.30		5
61	TREE	0.30	14	7
62	TREE	0.60	14	10
63	TREE	0.40	13	7
64	TREE	MULTI 0.40	8	5
65	TREE	MULTI 0.40	8	7
66	TREE	2x0.30	12	5
67	TREE	2x0.20	13	5
68	TREE	0.50	10	7
69	TREE	0.60	15	9
70	TREE	0.40	12	8
71	TREE	0.50	7	7
72	TREE	0.40	8	9
73	TREE	0.50	12	10
74	TREE	MULTI 0.40	8	6
75	TREE	MULTI 0.40	8	6

POINT No	TREE TYPE	DIAMETER	HEIGHT	SPREAD
76	TREE	0.50	12	10
77	TREE	0.40	[illegible]	7
78	TREE	0.25	8	6
79	MELALEUCA	0.40	10	8
80	TREE	0.50	16	3
81	TREE	0.50	12	7
82	CASUARINA	0.30	3	9
83	MELALEUCA	MULTI 0.70	9	10
84	TREE	MULTI 0.40	9	8
85	TREE	MULTI 0.40	10	12
86	TREE	0.25	8	4
87	TREE	0.50	14	6
88	TREE	0.30	9	6
89	TREE	0.60	10	6
90	TREE	0.50	15	10
91	TREE	0.25	8	7
92	TREE	0.25	8	7
93	TREE	0.25	8	7
94	TREE	0.40	18	7
95	TREE	0.40	8	7
96	TREE	0.20	12	6
97	TREE	0.20	12	6
98	TREE	0.30	12	7
99	TREE	0.40	12	7
100	PALM	0.30	12	3
101	TREE	0.40	15	10
102	TREE	0.20	11	7
103	CASUARINA	0.30	11	6
104	TREE	0.30	10	7
105	TREE	0.90	18	12
106	TREE	0.30	10	3
107	TREE	0.30	11	5
108	TREE	0.50	12	10
109	TREE	0.20	12	5
110	TREE	0.60	12	8
111	TREE	0.40	14	7
112	TREE	0.60	14	8
113	TREE	0.30	11	4
114	TREE	0.30	11	4
115	TREE	0.30	11	4
116	TREE	0.40	10	7
117	TREE	0.30	8	5
118	TREE	0.80	20	14
119	TREE	0.40	15	6
120	TREE	0.40	8	3
121	TREE	0.50	12	8
122	TREE	0.70	14	12
123	TREE	0.70	18	18
124	TREE	0.30	10	7
125	TREE	2x0.50	14	10
126	TREE	0.60	16	8
127	CASUARINA	0.40	14	6
128	TREE	0.60	22	8
129	TREE	0.30	11	5
130	TREE	MULTI 0.60	8	10
131	TREE	0.35	12	9
132	TREE	0.60	12	9
133	CASUARINA	0.40	14	8
134	CASUARINA	0.40	14	8
135	CASUARINA	0.30	8	6
136	CASUARINA	0.40	14	10
137	CASUARINA	0.20	9	5
138	CASUARINA	0.30	14	6
139	CASUARINA	0.20	6	5
140	CASUARINA	0.40	13	10
141	CASUARINA	0.50	13	11
142	TREE	0.60	18	11
143	CASUARINA	0.25	5	6
144	TREE	0.40	10	4
145	TREE	0.70	18	12
146	TREE	0.60	17	11
147	TREE	0.40	13	8
148	TREE	0.60	14	12
149	TREE	0.40	12	9
150	CASUARINA	0.60	18	10

NOTES:

1) CAUTION: SHOULD ANY DEVELOPMENT OR CONSTRUCTION BE PLANNED ON OR NEAR THE BOUNDARIES, THE BOUNDARIES SHOULD BE CLEARLY MARKED ON SITE.

2) ALL AREAS AND DIMENSIONS HAVE BEEN COMPILED FROM PLANS MADE AVAILABLE AT THE LAND TITLES OFFICE.

3) ORIGIN OF LEVELS ON A.H.D. IS TAKEN FROM P.M. 46390 RL 7.75 A.H.D.

4) CONTOUR INTERVAL 1 METRE

5) CONTOURS ARE INDICATIVE OF GROUND FORM ONLY. ONLY SPOT LEVELS SHOULD BE USED FOR CALCULATIONS OF QUANTITIES WITH CAUTION

6) TREE SPREADS ARE DIAGRAMMATIC ONLY AND ARE NOT SYMMETRICAL.

7) UNDERGROUND (NON VISIBLE) SERVICE LINES HAVE BEEN SHOWN FROM "DIAL BEFORE YOU DIG" SERVICE AUTHORITY RECORDS & ARE DIAGRAMMATIC ONLY IN REGARD TO THEIR POSITION & WIDTH UNLESS STATED OTHERWISE.

8) SPOT LEVELS ARE ACCURATE.

9) BEARINGS SHOWN ARE ON M.G.A.-(MAP GRID of AUSTRALIA.)

INVESTIGATION OF "DIAL BEFORE YOU DIG" UNDERGROUND SERVICES HAS BEEN MADE. DETECTION OF UNDERGROUND SERVICES IS NOT AN INTEGRAL PART OF THIS SURVEY. ALL RELEVANT AUTHORITIES SHOULD BE NOTIFIED PRIOR TO ANY EXCAVATION OR WORK IN THE SITE

DEVELOPERS & EXCAVATORS MAY BE HELD FINANCIALLY RESPONSIBLE BY THE ASSET OWNER SHOULD THEY DAMAGE UNDERGROUND NETWORKS

CARELESS DIGGING CAN:
- CAUSE DEATH OR SERIOUS INJURY TO WORKERS AND THE GENERAL PUBLIC
- INCONVENIENCE USERS OF ELECTRICITY, GAS, WATER AND COMMUNICATIONS
- LEAD TO CRIMINAL PROSECUTION AND DAUNTING CLAIMS
- CAUSE EXPENSIVE FINANCIAL LOSSES TO BUSINESS
- CUT OFF EMERGENCY SERVICES
- DELAY PROJECT COMPLETION TIMES (WHILE THE DAMAGE IS REPAIRED)

MINIMISE YOUR RISK AND DIAL BEFORE YOU DIG
TEL 1100

www.dialbeforeyoudig.com.au
DIAL 1100 BEFORE YOU DIG

0 4 8 12 16 20 40 METRES
SCALE 1:400

LEGEND
TOP OF BANK
BOTTOM OF BANK

PLAN SHOWING BOUNDARIES, RELATIVE HEIGHTS & PHYSICAL FEATURES OVER PART OF LOT 1 IN D.P. 662920 & PART OF LOT 1 IN D.P. 19161 KNOWN AS BAYVIEW GOLF CLUB, BAYVIEW.

L.G.A.: PITTWATER

Bee & Lethbridge
Quality Surveying & Development Solutions
Bee & Lethbridge Pty Ltd
Suite 2, 14 Stanley Street,
PO Box. 330, Forestville, NSW 2087
Phone: 9451 0757 Fax: 9975 3535
Email: survey@beeleth.com.au
ABN: 13 003 194 447
www.beeleth.com.au

CLIENT	PLANIX PROJECTS		REF No 18990
PROPERTY	BAYVIEW GOLF CLUB, BAYVIEW		
DATUM A.H.D.	SCALE 1:400 @ B1	DATE APRIL 2014	SHEET No 1 of 1
SURVEYED B.W.	DRAWN R.M.	DWG No 18990	REV No 00

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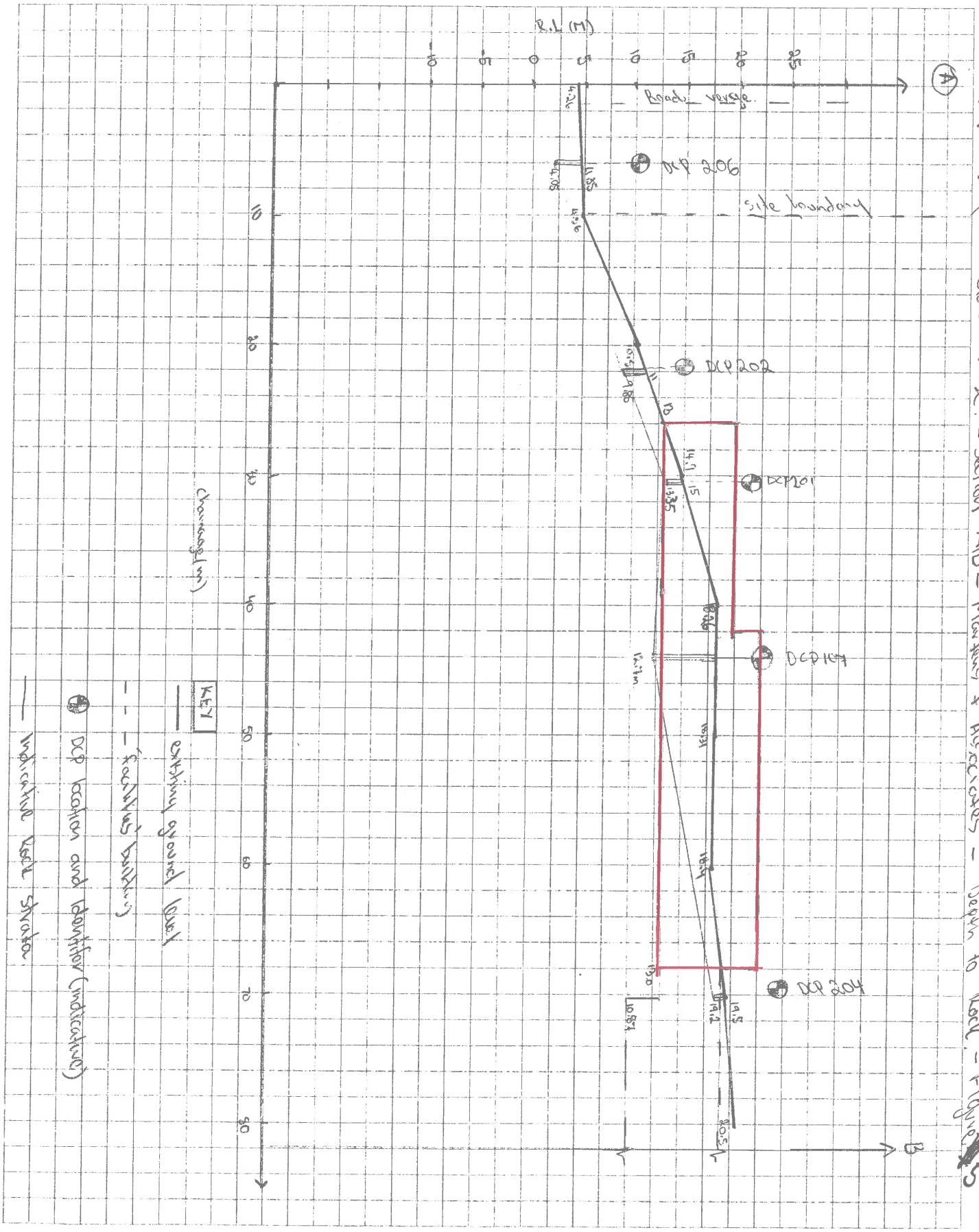
System P5, Form 3 Issued 6/5/06

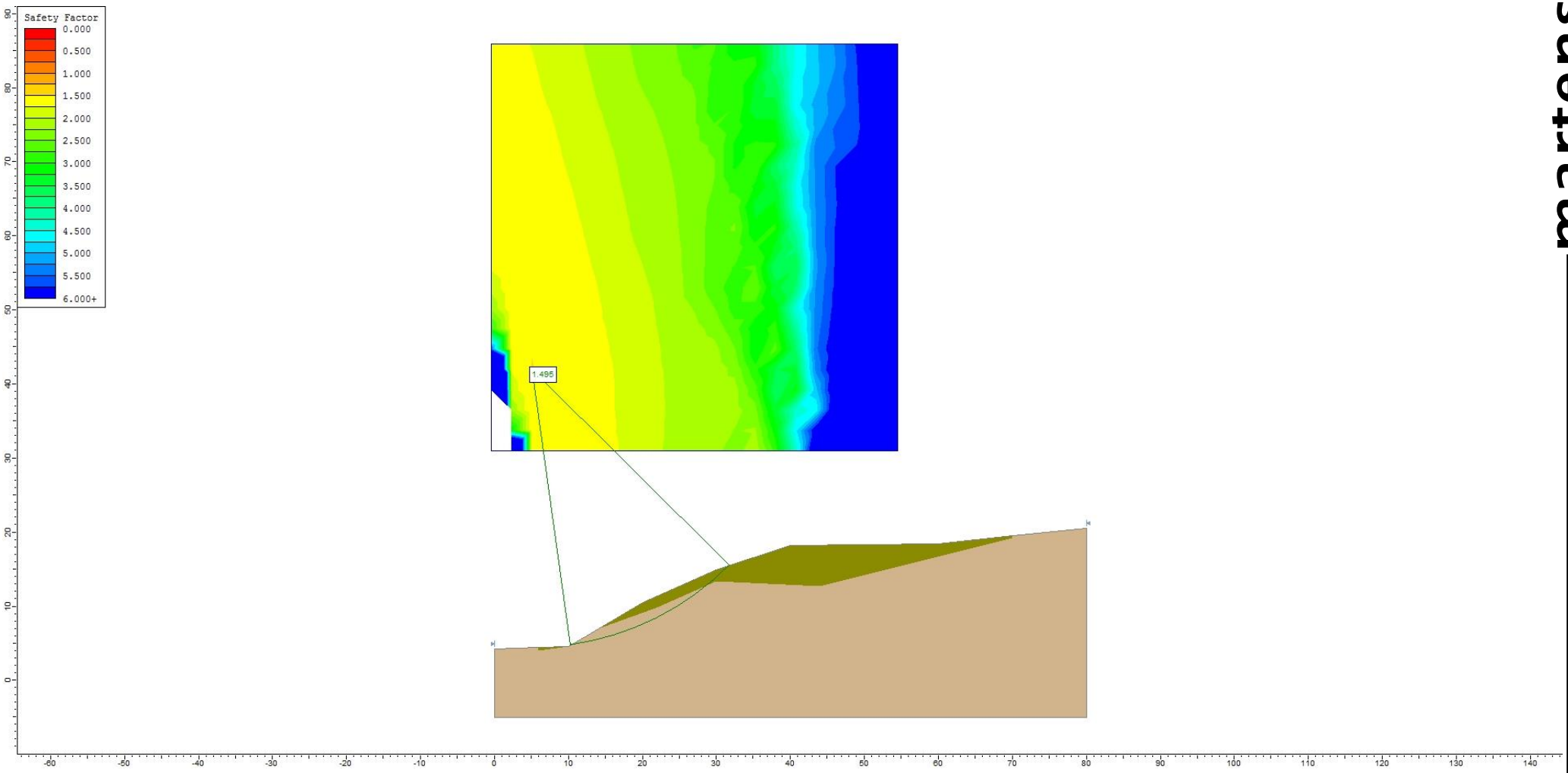
CALCULATION SHEET

REFERENCE NO. 41749

Project Slide modelling	Page No.	Date 18.6.14
MA Officer Adam	MA Officer Signature	

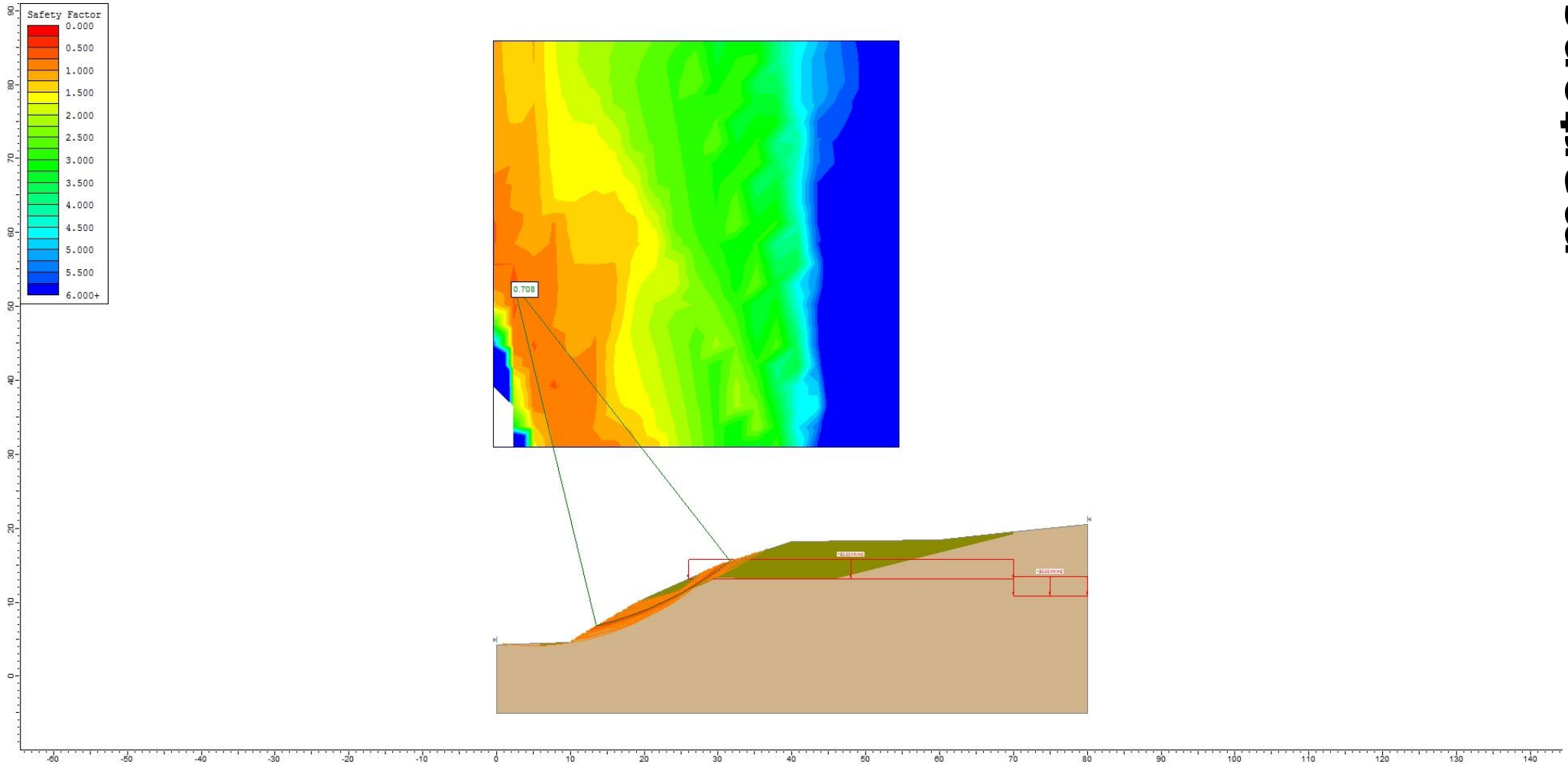


P:\41749 - Bowland Golf Course - Section A/B - Mawhinney & Associates - Designs to Rock - Figure 5



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	AB	**Slide Modeling v6:** **Bayview Golf Course, Bayview, NSW** **Existing Embankment Without Loading**	Drawing No: Figure 12
Approved:	GT		
Date:	24.6.14		
Scale:	NA		Job No: P1706099

martens



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	AB	**Slide Modeling v6:** **Bayview Golf Course, Bayview, NSW** **Existing Embankment With 150kPa Loading**	Drawing No: Figure 13
Approved:	GT		
Date:	24.6.14		
Scale:	NA		Job No: P1706099

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14 Attachment F – Geotechnical Risk Calculations

Landslide Hazard Evaluation - Risk to Life Assessment

Method based on Walker *et al.* in AGS Vol 42 No. 1 March 2007

Method ST-24 Revised 20.02.08

6/37 Leighton Place, Hornsby, NSW 2007, Ph: (02) 9476 9999 Fax: (02) 9476 8767, mail@martens.com.au, www.martens.com.au

PROJECT DETAILS

Project	Geotechnical Assessment			Ref. No.	P1404179
Author	GMT	Reviewed	GT	Created	23.05.14

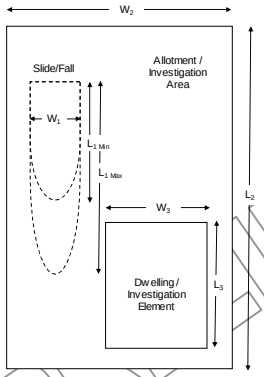
STEP 1 : ENTER SITE AND DESIGN DATA

Hazard Type	**Soil Creep**

$P_{(H)}$	Annual probability of landslide	**0.00001**

INDICATIVE VALUE	RECURRENCE INTERVAL	DESCRIPTION	DESCRIPTOR	LEVEL
10^{-1}	10 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	100 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	1000 years	The event could occur under tadverse conditions over the design life.	POSSIBLE	C
10^{-4}	10,000 years	The enent might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	100,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	1,000,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

$P_{(S:H)}$	Probability of spatial impact impacting building location taking into account travel distance and travel direction	**0.96**



FACTOR	DESCRIPTION	UNITS	VALUE
W_1	Likely slide/fall width	m	**180**
W_2	Width of allotment / investigation area	m	**180**
W_3	Width of dwelling / investigation element	m	**60**
L_{1Min}	Minimum run-out length	m	**1**
L_{1Max}	Maximum run-out length	m	**200**
L_2	Length of allotment / investigation area	m	**270**
L_3	Length of dwelling / investigation element	m	**50**
$L_{P:Min}$	Probability of runout being 0 - 1 m long	(0 - 1)	**0.05**
L_{PMax}	Probability of runout being 0 - 200 m long	(0 - 1)	0.95
W_F	Likelihood of across slope strike on risk element	(0 - 1)	**1.00**
$L_{F:Min}$	Likelihood of downslope strike on risk element for minimum run-out distance	(0 - 1)	0.19
$L_{F:Max}$	Likelihood of downslope strike on risk element for maximum run-out distance	(0 - 1)	1.00
$L_{F:Design}$	Likelihood of downslope strike (integrated) on risk element run-out distance	(0 - 1)	**0.96**

$P_{(T:S)}$	Temporal spatial probability given the spatial impact	**0.81**

FACTOR	DESCRIPTION	UNITS	VALUE
T_1	Percentage of time person(s) are on-site	m	90%
T_2	Percentage of dwelling / element that person(s) occupy	m	90%

$V_{(V:D)}$	Vulnerability of the individual (ie. probability of loss of life given the impact)	**0.10**

CASE	DESCRIPTION	RANGE IN DATA	RECOMMENDED VALUE	COMMENTS
Person in open space	If struck by a rockfall	0.1 - 0.7	0.50	May be injured but unlikely to cause death
	If buried by debris	0.8 - 1.0	1.00	Death by asphyxia almost certain
	If not buried	0.1 - 0.5	0.10	High chance of survival
Person in a vehicle	If vehicle is buried / crushed	0.9 - 1.0	1.00	Death is almost certain
	If the vehicle is damaged only	0.0 - 0.3	0.30	High chance of survival
Persons in building	If the building collapses	0.9 - 1.0	1.00	Dealth is almost certain
	If the building is inundated with debris and the person is buried	0.8 - 1.0	1.00	Death is highly likely
	If the debris strikes the building only	0.0 - 0.1	0.05	Very high chance of survival

STEP 2 : RISK EVALUATION

$V_{(D:T)}$	Risk (annual probability of loss of life of an individual)	**7.77E-07**
Risk Assessment	**Acceptable risk for loss of life for the person(s). Risk level suitable for new developments.**	

Landslide Hazard Evaluation - Risk to Life Assessment

Method based on Walker *et al.* in AGS Vol 42 No. 1 March 2007

Method ST-24 Revised 20.02.08

6/37 Leighton Place, Hornsby, NSW 2007, Ph: (02) 9476 9999 Fax: (02) 9476 8767, mail@martens.com.au, www.martens.com.au

PROJECT DETAILS

Project	Geotechnical Assessment			Ref. No.	P1404179
Author	GMT	Reviewed	GT	Created	23.05.14

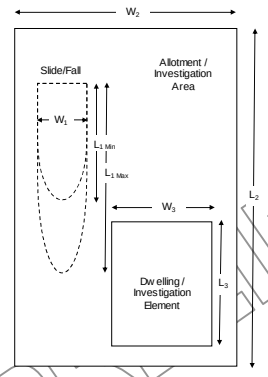
STEP 1 : ENTER SITE AND DESIGN DATA

Hazard Type	**Slide Failure**

$P_{(H)}$	Annual probability of landslide	**0.0001**

INDICATIVE VALUE	RECURRENCE INTERVAL	DESCRIPTION	DESCRIPTOR	LEVEL
10^{-1}	10 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	100 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	1000 years	The event could occur under tadverse conditions over the design life.	POSSIBLE	C
10^{-4}	10,000 years	The enent might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	100,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	1,000,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

$P_{(S:H)}$	Probablity of spatial impact impacting building location taking into account travel distance and travel direction	**0.31**



FACTOR	DESCRIPTION	UNITS	VALUE
W_1	Likely slide/fall width	m	**10**
W_2	Width of allotment / investigation area	m	**214**
W_3	Width of dwelling / investigation element	m	**60**
L_{1Min}	Minimum run-out length	m	**1**
L_{1Max}	Maximum run-out length	m	**200**
L_2	Length of allotment / investigation area	m	**270**
L_3	Length of dwelling / investigation element	m	**50**
L_{PMin}	Probability of runout being 0 - 1 m long	(0 - 1)	**0.05**
L_{PMax}	Probability of runout being 0 - 200 m long	(0 - 1)	0.95
W_F	Likelihood of across slope strike on risk element	(0 - 1)	**0.33**
$L_{F Min}$	Likelihood of downslope strike on risk element for minimum run-out distance	(0 - 1)	0.19
$L_{F Max}$	Likelihood of downslope strike on risk element for maximum run-out distance	(0 - 1)	1.00
$L_{F Design}$	Likelihood of downslope strike (integrated) on risk element run-out distance	(0 - 1)	**0.96**

$P_{(T:S)}$	Temporal spatial probability given the spatial impact	**0.30**

FACTOR	DESCRIPTION	UNITS	VALUE
T_1	Percentage of time person(s) are on-site	(0-1)	60%
T_2	Percentage of dwelling / element that person(s) occupy	(0-1)	50%

$V_{(V:D)}$	Vulnerability of the individual (ie. probability of loss of life given the impact)	**0.10**

CASE	DESCRIPTION	RANGE IN DATA	RECOMMENDED VALUE	COMMENTS
Person in open space	If struck by a rockfall	0.1 - 0.7	0.50	May be injured but unlikely to cause death
	If buried by debris	0.8 - 1.0	1.00	Death by asphyxia almost certain
	If not buried	0.1 - 0.5	0.10	High chance of survival
Person in a vehicle	If vehicle is buried / crushed	0.9 - 1.0	1.00	Death is almost certain
	If the vehicle is damaged only	0.0 - 0.3	0.30	High chance of survival
Persons in building	If the building collapses	0.9 - 1.0	1.00	Death is almost certain
	If the building is inundated with debris and the person is buried	0.8 - 1.0	1.00	Death is highly likely
	If the debris strikes the building only	0.0 - 0.1	0.05	Very high chance of survival

STEP 2 : RISK EVALUATION

$V_{(D:T)}$	Risk (annual probability of loss of life of an individual)	**9.42E-07**
Risk Assessment		**Acceptable risk for loss of life for the person(s). Risk level suitable for new developments.**

15 Attachment G – Laboratory Test Certificates

Envirolab Services Pty Ltd
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CERTIFICATE OF ANALYSIS 110182

Client:

Martens & Associates Pty Ltd
6/37 Leighton Place
Hornsby
NSW 2077

Attention: Adam Budji

Sample log in details:

Your Reference:	**P1404179 - Bayview Golf Club**
No. of samples:	21 soils
Date samples received / completed instructions received	21/05/14 / 21/05/14

Analysis Details:

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

Report Details:

Date results requested by: / Issue Date:	29/05/14 / 29/05/14
Date of Preliminary Report:	not issued

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Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

sPOCAS Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ---------- ----------	110182-1 4179/101 0.5 20/05/2014 soil	110182-2 4179/101 1.0 20/05/2014 soil	110182-3 4179/101 2.5 20/05/2014 soil	110182-4 4179/101 3.5 20/05/2014 soil	110182-5 4179/101 4.5 20/05/2014 soil
Date prepared	-	23/05/2014	23/05/2014	23/05/2014	23/05/2014	23/05/2014
Date analysed	-	23/05/2014	23/05/2014	23/05/2014	23/05/2014	23/05/2014
pH $_{kcl}$	pH units	6.3	7.4	4.1	5.1	4.7
TAA pH 6.5	moles H^+/t	<5	<5	54	41	41
s-TAA pH 6.5	%w/w S	<0.01	<0.01	0.09	0.07	0.07
pH $_{Ox}$	pH units	6.3	5.1	3.9	4.9	4.3
TPA pH 6.5	moles H^+/t	<5	<5	70	92	85
s-TPA pH 6.5	%w/w S	<0.01	<0.01	0.11	0.15	0.14
TSA pH 6.5	moles H^+/t	<5	<5	16	51	44
s-TSA pH 6.5	%w/w S	<0.01	<0.01	0.03	0.08	0.07
ANC_E	% $CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
a-ANC_E	moles H^+/t	<5	<5	<5	<5	<5
s-ANC_E	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
S_{KCl}	%w/w S	<0.005	<0.005	0.03	0.01	<0.005
S_P	%w/w	0.01	0.01	0.03	0.06	0.03
S_{POS}	%w/w	0.01	0.01	0.007	0.05	0.03
a-S_{POS}	moles H^+/t	6	7	<5	34	21
Ca_{KCl}	%w/w	0.15	0.23	0.1	0.15	0.09
Ca_P	%w/w	0.17	0.25	0.08	0.18	0.1
Ca_A	%w/w	0.020	0.015	<0.005	0.023	<0.005
Mg_{KCl}	%w/w	0.021	0.025	0.023	0.020	0.016
Mg_P	%w/w	0.023	0.030	0.023	0.026	0.017
Mg_A	%w/w	<0.005	0.005	<0.005	0.006	<0.005
S_{HCl}	%w/w S	[NT]	[NT]	0.028	[NT]	[NT]
S_{NAS}	%w/w S	[NT]	[NT]	<0.005	[NT]	[NT]
a-S_{NAS}	moles H^+/t	[NT]	[NT]	<5	[NT]	[NT]
s-S_{NAS}	%w/w S	[NT]	[NT]	<0.01	[NT]	[NT]
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	<10	<10	59	75	62
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	4.4	5.6	4.7
a-Net Acidity without ANCE	moles H^+/t	NA	NA	NA	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA	NA	NA	NA

sPOCAS Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ---------- ----------	110182-6 4179/102 1.0 20/05/2014 soil	110182-7 4179/102 2.0 20/05/2014 soil	110182-8 4179/103 1.5 20/05/2014 soil	110182-9 4179/103 2.0 20/05/2014 soil	110182-10 4179/104 0.5 20/05/2014 soil
Date prepared	-	23/05/2014	23/05/2014	23/05/2014	23/05/2014	23/05/2014
Date analysed	-	23/05/2014	23/05/2014	23/05/2014	23/05/2014	23/05/2014
pH $_{kcl}$	pH units	4.5	3.9	5.9	4.2	3.8
TAA pH 6.5	moles H^+/t	31	49	<5	21	99
s-TAA pH 6.5	%w/w S	0.05	0.08	<0.01	0.03	0.16
pH $_{Ox}$	pH units	4.4	3.7	5.3	4.6	3.5
TPA pH 6.5	moles H^+/t	20	57	<5	17	150
s-TPA pH 6.5	%w/w S	0.03	0.09	<0.01	0.03	0.25
TSA pH 6.5	moles H^+/t	<5	9	<5	<5	56
s-TSA pH 6.5	%w/w S	<0.01	0.01	<0.01	<0.01	0.09
ANC_E	% $CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
a-ANC_E	moles H^+/t	<5	<5	<5	<5	<5
s-ANC_E	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
S_{KCl}	%w/w S	0.006	0.01	<0.005	<0.005	0.005
S_P	%w/w	0.01	0.02	0.005	0.007	0.01
S_{POS}	%w/w	0.007	<0.005	0.005	0.006	0.009
a-S_{POS}	moles H^+/t	<5	<5	<5	<5	6
Ca_{KCl}	%w/w	0.06	0.008	0.08	0.01	0.01
Ca_P	%w/w	0.06	0.007	0.1	0.02	0.01
Ca_A	%w/w	<0.005	<0.005	0.016	0.009	<0.005
Mg_{KCl}	%w/w	0.015	0.007	0.007	0.006	0.014
Mg_P	%w/w	0.015	0.006	0.007	0.007	0.015
Mg_A	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
S_{HCl}	%w/w S	0.007	0.013	[NT]	<0.005	0.008
S_{NAS}	%w/w S	<0.005	<0.005	[NT]	<0.005	<0.005
a-S_{NAS}	moles H^+/t	<5	<5	[NT]	<5	<5
s-S_{NAS}	%w/w S	<0.01	<0.01	[NT]	<0.01	<0.01
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	36	51	<10	26	110
Liming rate	kg $CaCO_3$/t	2.7	3.8	<0.75	2.0	8.0
a-Net Acidity without ANCE	moles H^+/t	NA	NA	NA	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA	NA	NA	NA

sPOCAS						
Our Reference:	UNITS	110182-11	110182-12	110182-13	110182-14	110182-15
Your Reference	----------	4179/105	4179/106	4179/106	4179/107	4179/107
Depth	----------	1.0	0.5	1.5	1.0	1.5
Date Sampled		20/05/2014	20/05/2014	20/05/2014	20/05/2014	20/05/2014
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	23/05/2014	23/05/2014	23/05/2014	23/05/2014	23/05/2014
Date analysed	-	23/05/2014	23/05/2014	23/05/2014	23/05/2014	23/05/2014
pH $_{kcl}$	pH units	4.1	4.6	4.2	4.2	6.0
TAA pH 6.5	moles H^+/t	79	26	34	42	<5
s-TAA pH 6.5	%w/w S	0.13	0.04	0.05	0.07	<0.01
pH $_{Ox}$	pH units	3.7	3.9	4.3	4.3	6.0
TPA pH 6.5	moles H^+/t	90	<5	26	32	<5
s-TPA pH 6.5	%w/w S	0.14	<0.01	0.04	0.05	<0.01
TSA pH 6.5	moles H^+/t	11	<5	<5	<5	<5
s-TSA pH 6.5	%w/w S	0.02	<0.01	<0.01	<0.01	<0.01
ANC_E	%$CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
a-ANC_E	moles H^+/t	<5	<5	<5	<5	<5
s-ANC_E	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
S_{KCl}	%w/w S	<0.005	<0.005	0.01	0.01	<0.005
S_P	%w/w	0.009	0.01	0.01	0.02	0.01
S_{POS}	%w/w	0.006	0.01	<0.005	0.005	0.006
a-S_{POS}	moles H^+/t	<5	7	<5	<5	<5
Ca_{KCl}	%w/w	0.01	0.03	<0.005	0.06	0.1
Ca_P	%w/w	0.01	0.03	<0.005	0.06	0.10
Ca_A	%w/w	<0.005	<0.005	<0.005	<0.005	0.005
Mg_{KCl}	%w/w	0.011	0.007	0.006	0.022	0.018
Mg_P	%w/w	0.012	0.006	0.006	0.022	0.015
Mg_A	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
S_{HCl}	%w/w S	0.005	[NT]	0.014	0.015	[NT]
S_{NAS}	%w/w S	<0.005	[NT]	<0.005	<0.005	[NT]
a-S_{NAS}	moles H^+/t	<5	[NT]	<5	<5	[NT]
s-S_{NAS}	%w/w S	<0.01	[NT]	<0.01	<0.01	[NT]
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	83	33	37	46	<10
Liming rate	kg $CaCO_3$/t	6.3	2.5	2.8	3.5	<0.75
a-Net Acidity without ANCE	moles H^+/t	NA	NA	NA	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA	NA	NA	NA

sPOCAS Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ---------- ----------	110182-16 4179/107 3.5 20/05/2014 soil	110182-17 4179/108 2.0 20/05/2014 soil	110182-18 4179/109 0.5 20/05/2014 soil	110182-19 4179/110 1.0 20/05/2014 soil	110182-20 4179/110 1.5 20/05/2014 soil
Date prepared	-	23/05/2014	23/05/2014	23/05/2014	23/05/2014	23/05/2014
Date analysed	-	23/05/2014	23/05/2014	23/05/2014	23/05/2014	23/05/2014
pH $_{kcl}$	pH units	5.1	4.1	5.0	4.2	4.5
TAA pH 6.5	moles H^+/t	16	51	21	61	39
s-TAA pH 6.5	%w/w S	0.03	0.08	0.03	0.1	0.06
pH $_{Ox}$	pH units	4.5	4.4	3.3	4.2	4.4
TPA pH 6.5	moles H^+/t	<5	47	<5	45	35
s-TPA pH 6.5	%w/w S	<0.01	0.08	<0.01	0.07	0.06
TSA pH 6.5	moles H^+/t	<5	<5	<5	<5	<5
s-TSA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
ANC_E	%$CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
a-ANC_E	moles H^+/t	<5	<5	<5	<5	<5
s-ANC_E	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
S_{KCl}	%w/w S	0.01	<0.005	<0.005	0.005	0.01
S_P	%w/w	0.02	0.006	0.02	0.01	0.02
S_{POS}	%w/w	0.01	<0.005	0.02	0.007	0.007
a-S_{POS}	moles H^+/t	6	<5	11	<5	<5
Ca_{KCl}	%w/w	0.1	0.008	0.14	0.04	0.06
Ca_P	%w/w	0.12	0.008	0.14	0.06	0.06
Ca_A	%w/w	0.019	<0.005	0.006	0.022	<0.005
Mg_{KCl}	%w/w	0.012	0.007	0.016	0.014	0.009
Mg_P	%w/w	0.018	0.008	0.012	0.033	0.018
Mg_A	%w/w	0.005	<0.005	<0.005	0.019	0.008
S_{HCl}	%w/w S	[NT]	<0.005	[NT]	0.009	0.016
S_{NAS}	%w/w S	[NT]	<0.005	[NT]	<0.005	0.006
a-S_{NAS}	moles H^+/t	[NT]	<5	[NT]	<5	<5
s-S_{NAS}	%w/w S	[NT]	<0.01	[NT]	<0.01	<0.01
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	22	53	32	68	45
Liming rate	kg $CaCO_3$/t	1.7	4.0	2.4	5.1	3.4
a-Net Acidity without ANCE	moles H^+/t	NA	NA	NA	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA	NA	NA	NA

sPOCAS		
Our Reference:	UNITS	110182-21
Your Reference	----------	4179/110
Depth	----------	3.0
Date Sampled		20/05/2014
Type of sample		soil
Date prepared	-	23/05/2014
Date analysed	-	23/05/2014
pH kcl	pH units	3.9
TAA pH 6.5	moles H^+/t	61
s-TAA pH 6.5	%w/w S	0.1
pH Ox	pH units	3.9
TPA pH 6.5	moles H^+/t	60
s-TPA pH 6.5	%w/w S	0.1
TSA pH 6.5	moles H^+/t	<5
s-TSA pH 6.5	%w/w S	<0.01
ANC_E	% $CaCO_3$	<0.05
a-ANC_E	moles H^+/t	<5
s-ANC_E	%w/w S	<0.05
S_{KCl}	%w/w S	0.04
S_P	%w/w	0.05
S_{POS}	%w/w	0.01
a-S_{POS}	moles H^+/t	6
Ca_{KCl}	%w/w	<0.005
Ca_P	%w/w	<0.005
Ca_A	%w/w	<0.005
Mg_{KCl}	%w/w	0.012
Mg_P	%w/w	0.012
Mg_A	%w/w	<0.005
S_{HCl}	%w/w S	0.053
S_{NAS}	%w/w S	0.012
a-S_{NAS}	moles H^+/t	5
s-S_{NAS}	%w/w S	<0.01
Fineness Factor	-	1.5
a-Net Acidity	moles H^+/t	73
Liming rate	kg $CaCO_3$/t	5.5
a-Net Acidity without ANCE	moles H^+/t	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA

Method ID	Methodology Summary
Inorg-064	sPOCAS determined using titrimetric and ICP-AES techniques. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			23/05/214	110182-1	23/05/2014 || 23/05/2014	LCS-1	23/05/2014
Date analysed	-			23/05/2014	110182-1	23/05/2014 || 23/05/2014	LCS-1	23/05/2014
pH kcl	pH units		Inorg-064	[NT]	110182-1	6.3 || 6.3 || RPD: 0	LCS-1	91%
TAA pH 6.5	moles H^+/t	5	Inorg-064	<5	110182-1	<5 || <5	LCS-1	109%
s-TAA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	110182-1	<0.01 || <0.01	[NR]	[NR]
pH Ox	pH units		Inorg-064	[NT]	110182-1	6.3 || 6.5 || RPD: 3	LCS-1	112%
TPA pH 6.5	moles H^+/t	5	Inorg-064	<5	110182-1	<5 || <5	LCS-1	89%
s-TPA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	110182-1	<0.01 || <0.01	[NR]	[NR]
TSA pH 6.5	moles H^+/t	5	Inorg-064	<5	110182-1	<5 || <5	LCS-1	88%
s-TSA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	110182-1	<0.01 || <0.01	[NR]	[NR]
ANC_E	% $CaCO_3$	0.05	Inorg-064	<0.05	110182-1	<0.05 || <0.05	[NR]	[NR]
a-ANC_E	moles H^+/t	5	Inorg-064	<5	110182-1	<5 || <5	[NR]	[NR]
s-ANC_E	%w/w S	0.05	Inorg-064	<0.05	110182-1	<0.05 || <0.05	[NR]	[NR]
S_{KCl}	%w/w S	0.005	Inorg-064	<0.005	110182-1	<0.005 || <0.005	LCS-1	98%
S_P	%w/w	0.005	Inorg-064	<0.005	110182-1	0.01 || 0.01 || RPD: 0	LCS-1	89%
S_{POS}	%w/w	0.005	Inorg-064	<0.005	110182-1	0.01 || 0.01 || RPD: 0	LCS-1	86%
a-S_{POS}	moles H^+/t	5	Inorg-064	<5	110182-1	6 || 6 || RPD: 0	LCS-1	86%
Ca_{KCl}	%w/w	0.005	Inorg-064	<0.005	110182-1	0.15 || 0.15 || RPD: 0	LCS-1	100%
Ca_P	%w/w	0.005	Inorg-064	<0.005	110182-1	0.17 || 0.17 || RPD: 0	[NR]	[NR]
Ca_A	%w/w	0.005	Inorg-064	<0.005	110182-1	0.020 || 0.019 || RPD: 5	[NR]	[NR]
Mg_{KCl}	%w/w	0.005	Inorg-064	<0.005	110182-1	0.021 || 0.021 || RPD: 0	LCS-1	98%
Mg_P	%w/w	0.005	Inorg-064	<0.005	110182-1	0.023 || 0.023 || RPD: 0	[NR]	[NR]
Mg_A	%w/w	0.005	Inorg-064	<0.005	110182-1	<0.005 || <0.005	[NR]	[NR]
S_{HCl}	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NR]	[NR]
S_{NAS}	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NR]	[NR]
a-S_{NAS}	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NR]	[NR]
s-S_{NAS}	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NR]	[NR]
Fineness Factor	-	1.5	Inorg-064	<1.5	110182-1	1.5 || 1.5 || RPD: 0	[NR]	[NR]
a-Net Acidity	moles H^+/t	10	Inorg-064	<10	110182-1	<10 || <10	LCS-1	87%
Liming rate	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	110182-1	<0.75 || <0.75	LCS-1	87%

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
a-Net Acidity without ANCE	moles H^+/t	10	Inorg-064	<10	110182-1	NA || NA	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	110182-1	NA || NA	[NR]	[NR]

QUALITY CONTROL sPOCAS	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	110182-11	23/05/2014 || 23/05/2014	LCS-2	23/05/2014
Date analysed	-	110182-11	23/05/2014 || 23/05/2014	LCS-2	23/05/2014
pH $_{kcl}$	pH units	110182-11	4.1 || 4.1 || RPD: 0	LCS-2	93%
TAA pH 6.5	moles H^+/t	110182-11	79 || 79 || RPD: 0	LCS-2	125%
s-TAA pH 6.5	%w/w S	110182-11	0.13 || 0.13 || RPD: 0	[NR]	[NR]
pH $_{Ox}$	pH units	110182-11	3.7 || 3.8 || RPD: 3	LCS-2	112%
TPA pH 6.5	moles H^+/t	110182-11	90 || 95 || RPD: 5	LCS-2	87%
s-TPA pH 6.5	%w/w S	110182-11	0.14 || 0.15 || RPD: 7	[NR]	[NR]
TSA pH 6.5	moles H^+/t	110182-11	11 || 16 || RPD: 37	LCS-2	85%
s-TSA pH 6.5	%w/w S	110182-11	0.02 || 0.03 || RPD: 40	[NR]	[NR]
ANCE	% $CaCO_3$	110182-11	<0.05 || <0.05	[NR]	[NR]
a-ANCE	moles H^+/t	110182-11	<5 || <5	[NR]	[NR]
s-ANCE	%w/w S	110182-11	<0.05 || <0.05	[NR]	[NR]
S_{KCl}	%w/w S	110182-11	<0.005 || <0.005	LCS-2	105%
S_P	%w/w	110182-11	0.009 || 0.009 || RPD: 0	LCS-2	84%
S_{POS}	%w/w	110182-11	0.006 || 0.006 || RPD: 0	LCS-2	78%
a-S_{POS}	moles H^+/t	110182-11	<5 || <5	LCS-2	78%
Ca_{KCl}	%w/w	110182-11	0.01 || 0.01 || RPD: 0	LCS-2	103%
Ca_P	%w/w	110182-11	0.01 || 0.01 || RPD: 0	[NR]	[NR]
Ca_A	%w/w	110182-11	<0.005 || <0.005	[NR]	[NR]
Mg_{KCl}	%w/w	110182-11	0.011 || 0.010 || RPD: 10	LCS-2	98%
Mg_P	%w/w	110182-11	0.012 || 0.012 || RPD: 0	[NR]	[NR]
Mg_A	%w/w	110182-11	<0.005 || <0.005	[NR]	[NR]
S_{HCl}	%w/w S	110182-11	0.005 || 0.005 || RPD: 0	[NR]	[NR]
S_{NAS}	%w/w S	110182-11	<0.005 || <0.005	[NR]	[NR]
a-S_{NAS}	moles H^+/t	110182-11	<5 || <5	[NR]	[NR]
s-S_{NAS}	%w/w S	110182-11	<0.01 || <0.01	[NR]	[NR]
Fineness Factor	-	110182-11	1.5 || 1.5 || RPD: 0	[NR]	[NR]
a-Net Acidity	moles H^+/t	110182-11	83 || 83 || RPD: 0	LCS-2	80%

QUALITY CONTROL sPOCAS	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Liming rate	kg $CaCO_3$ /t	110182-11	6.3 || 6.2 || RPD: 2	LCS-2	79%
a-Net Acidity without ANCE	moles H^+/t	110182-11	NA || NA	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$ /t	110182-11	NA || NA	[NR]	[NR]

QUALITY CONTROL sPOCAS	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	110182-21	23/05/2014 || 23/05/2014
Date analysed	-	110182-21	23/05/2014 || 23/05/2014
pH $_{kcl}$	pH units	110182-21	3.9 || 4.1 || RPD: 5
TAA pH 6.5	moles H^+/t	110182-21	61 || 54 || RPD: 12
s-TAA pH 6.5	%w/w S	110182-21	0.1 || 0.09 || RPD: 11
pH $_{Ox}$	pH units	110182-21	3.9 || 3.8 || RPD: 3
TPA pH 6.5	moles H^+/t	110182-21	60 || 60 || RPD: 0
s-TPA pH 6.5	%w/w S	110182-21	0.1 || 0.1 || RPD: 0
TSA pH 6.5	moles H^+/t	110182-21	<5 || 6
s-TSA pH 6.5	%w/w S	110182-21	<0.01 || 0.01
ANC_E	% $CaCO_3$	110182-21	<0.05 || <0.05
a-ANC_E	moles H^+/t	110182-21	<5 || <5
s-ANC_E	%w/w S	110182-21	<0.05 || <0.05
S_{KCl}	%w/w S	110182-21	0.04 || 0.04 || RPD: 0
S_P	%w/w	110182-21	0.05 || 0.05 || RPD: 0
S_{POS}	%w/w	110182-21	0.01 || 0.01 || RPD: 0
a-S_{POS}	moles H^+/t	110182-21	6 || 7 || RPD: 15
Ca_{KCl}	%w/w	110182-21	<0.005 || <0.005
Ca_P	%w/w	110182-21	<0.005 || <0.005
Ca_A	%w/w	110182-21	<0.005 || <0.005
Mg_{KCl}	%w/w	110182-21	0.012 || 0.012 || RPD: 0
Mg_P	%w/w	110182-21	0.012 || 0.012 || RPD: 0
Mg_A	%w/w	110182-21	<0.005 || <0.005
S_{HCl}	%w/w S	110182-21	0.053 || 0.050 || RPD: 6
S_{NAS}	%w/w S	110182-21	0.012 || 0.011 || RPD: 9
a-S_{NAS}	moles H^+/t	110182-21	5 || 5 || RPD: 0
s-S_{NAS}	%w/w S	110182-21	<0.01 || <0.01
Fineness Factor	-	110182-21	1.5 || 1.5 || RPD: 0

QUALITY CONTROL sPOCAS	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
a-Net Acidity	moles H^+/t	110182-21	73 || 66 || RPD: 10
Liming rate	kg $CaCO_3$/t	110182-21	5.5 || 5.0 || RPD: 10
a-Net Acidity without ANCE	moles H^+/t	110182-21	NA || NA
Liming rate without ANCE	kg $CaCO_3$/t	110182-21	NA || NA

Report Comments:

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

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

Quality Control Definitions

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

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

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

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

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

Laboratory Acceptance Criteria

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

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

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

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

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CERTIFICATE OF ANALYSIS 176282-A

Client Details

Client	Martens & Associates Pty Ltd
Attention	Hamed Naghibi
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P1706099 - Contamination Investigation at Cabbage**
Number of Samples	Additional Testing on 15 Soils
Date samples received	22/09/2017
Date completed instructions received	25/09/2017

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	03/10/2017
Date of Issue	03/10/2017

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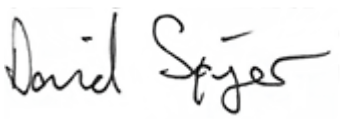
Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Nick Sarlamis, Inorganics Supervisor
Priya Samarawickrama, Senior Chemist

Authorised By



David Springer, General Manager

sPOCAS + %S w/w						
Our Reference		176282-A-23	176282-A-24	176282-A-32	176282-A-34	176282-A-35
Your Reference	UNITS	6099 / BH302	6099 / BH302	6099 / BH306	6099 / BH306	6099 / BH306
Depth		0.3	0.9	0.3	1.4	2.2
Date Sampled		21/09/2017	21/09/2017	21/09/2017	21/09/2017	21/09/2017
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	26/09/2017	26/09/2017	26/09/2017	26/09/2017	26/09/2017
Date analysed	-	26/09/2017	26/09/2017	26/09/2017	26/09/2017	26/09/2017
pH $_{kcl}$	pH units	8.2	7.2	8.7	4.2	6.3
TAA pH 6.5	moles H^+ /t	<5	<5	<5	46	<5
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01	0.07	<0.01
pH $_{Ox}$	pH units	6.7	6.4	7.8	3.8	5.3
TPA pH 6.5	moles H^+ /t	<5	<5	<5	55	<5
s-TPA pH 6.5	%w/w S	<0.01	<0.01	<0.01	0.09	<0.01
TSA pH 6.5	moles H^+ /t	<5	<5	<5	9	<5
s-TSA pH 6.5	%w/w S	<0.01	<0.01	<0.01	0.01	<0.01
ANC_E	% $CaCO_3$	0.38	<0.05	0.56	<0.05	<0.05
a-ANC_E	moles H^+ /t	75	<5	110	<5	<5
s-ANC_E	%w/w S	0.12	<0.05	0.18	<0.05	<0.05
S_{KCl}	%w/w S	<0.005	<0.005	0.006	0.02	<0.005
S_P	%w/w	0.04	0.04	0.02	0.03	0.01
S_{POS}	%w/w	0.03	0.04	0.02	0.01	0.01
a-S_{POS}	moles H^+ /t	21	22	11	7	6
Ca_{KCl}	%w/w	0.41	0.31	0.31	0.02	0.12
Ca_P	%w/w	0.28	0.20	0.51	0.02	0.13
Ca_A	%w/w	<0.005	<0.005	0.20	<0.005	0.012
Mg_{KCl}	%w/w	0.022	0.017	0.060	0.012	0.020
Mg_P	%w/w	0.027	0.020	0.086	0.013	0.016
Mg_A	%w/w	0.005	<0.005	0.020	<0.005	<0.005
S_{HCl}	%w/w S	<0.005	<0.005	<0.005	0.023	<0.005
S_{NAS}	%w/w S	<0.005	<0.005	<0.005	0.005	<0.005
a-S_{NAS}	moles H^+ /t	<5	<5	<5	<5	<5
s-S_{NAS}	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+ /t	<5	7	<5	56	10
s-Net Acidity	%w/w S	<0.01	0.01	<0.01	0.09	0.02
Liming rate	kg $CaCO_3$ /t	<0.75	<0.75	<0.75	4.2	0.76
s-Net Acidity without -ANCE	%w/w S	0.034	0.036	0.017	0.089	0.016
a-Net Acidity without ANCE	moles H^+ /t	21	22	11	56	10
Liming rate without ANCE	kg $CaCO_3$ /t	1.6	1.7	0.81	4.2	0.76

sPOCAS + %S w/w				
Our Reference		176282-A-46	176282-A-47	176282-A-48
Your Reference	UNITS	6099 / BH312	6099 / BH313	6099 / BH313
Depth		1.4	0.2	0.5
Date Sampled		21/09/2017	21/09/2017	21/09/2017
Type of sample		soil	soil	soil
Date prepared	-	26/09/2017	26/09/2017	26/09/2017
Date analysed	-	26/09/2017	26/09/2017	26/09/2017
pH $_{kcl}$	pH units	7.7	5.2	4.5
TAA pH 6.5	moles H^+ /t	<5	<5	26
s-TAA pH 6.5	%w/w S	<0.01	<0.01	0.04
pH $_{Ox}$	pH units	7.3	4.9	4.2
TPA pH 6.5	moles H^+ /t	<5	<5	30
s-TPA pH 6.5	%w/w S	<0.01	<0.01	0.05
TSA pH 6.5	moles H^+ /t	<5	<5	<5
s-TSA pH 6.5	%w/w S	<0.01	<0.01	<0.01
ANC_E	% $CaCO_3$	0.44	<0.05	<0.05
a-ANC_E	moles H^+ /t	88	<5	<5
s-ANC_E	%w/w S	0.14	<0.05	<0.05
S_{KCl}	%w/w S	<0.005	<0.005	<0.005
S_P	%w/w	0.01	0.006	0.005
S_{POS}	%w/w	0.009	0.006	<0.005
a-S_{POS}	moles H^+ /t	5	<5	<5
Ca_{KCl}	%w/w	0.34	0.06	0.06
Ca_P	%w/w	0.37	0.06	0.06
Ca_A	%w/w	0.040	<0.005	<0.005
Mg_{KCl}	%w/w	0.012	0.013	0.016
Mg_P	%w/w	0.018	0.012	0.016
Mg_A	%w/w	0.007	<0.005	<0.005
S_{HCl}	%w/w S	<0.005	<0.005	<0.005
S_{NAS}	%w/w S	<0.005	<0.005	<0.005
a-S_{NAS}	moles H^+ /t	<5	<5	<5
s-S_{NAS}	%w/w S	<0.01	<0.01	<0.01
Fineness Factor	-	1.5	1.5	1.5
a-Net Acidity	moles H^+ /t	<5	8	29
s-Net Acidity	%w/w S	<0.01	0.01	0.05
Liming rate	kg $CaCO_3$ /t	<0.75	<0.75	2.2
s-Net Acidity without -ANCE	%w/w S	<0.01	0.012	0.046
a-Net Acidity without ANCE	moles H^+ /t	5.4	7.6	29
Liming rate without ANCE	kg $CaCO_3$ /t	<0.75	<0.75	2.2

Misc Inorg - Soil						
Our Reference		176282-A-23	176282-A-24	176282-A-25	176282-A-26	176282-A-27
Your Reference	UNITS	6099 / BH302	6099 / BH302	6099 / BH303	6099 / BH303	6099 / BH304
Depth		0.3	0.9	0.2	0.5	0.2
Date Sampled		21/09/2017	21/09/2017	21/09/2017	21/09/2017	21/09/2017
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	27/09/2017	27/09/2017	27/09/2017	27/09/2017	27/09/2017
Date analysed	-	27/09/2017	27/09/2017	27/09/2017	27/09/2017	27/09/2017
pH 1:5 soil:water	pH Units	6.9	7.3	7.0	5.6	5.6
Chloride, Cl 1:5 soil:water	mg/kg	<10	10	23	27	20
Sulphate, SO4 1:5 soil:water	mg/kg	21	45	10	23	10

Misc Inorg - Soil						
Our Reference		176282-A-28	176282-A-30	176282-A-40	176282-A-44	176282-A-46
Your Reference	UNITS	6099 / BH304	6099 / BH305	6099 / BH309	6099 / BH312	6099 / BH312
Depth		0.5	0.3	0.4	0.2	1.4
Date Sampled		21/09/2017	21/09/2017	21/09/2017	21/09/2017	21/09/2017
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	27/09/2017	27/09/2017	27/09/2017	27/09/2017	27/09/2017
Date analysed	-	27/09/2017	27/09/2017	27/09/2017	27/09/2017	27/09/2017
pH 1:5 soil:water	pH Units	5.7	5.2	5.0	6.6	7.0
Chloride, Cl 1:5 soil:water	mg/kg	10	<10	<10	<10	10
Sulphate, SO4 1:5 soil:water	mg/kg	<10	<10	20	10	20

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-064	sPOCAS determined using titrimetric and ICP-AES techniques. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL: sPOCAS + %S w/w						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			26/09/2017	23	26/09/2017	26/09/2017		26/09/2017	[NT]
Date analysed	-			26/09/2017	23	26/09/2017	26/09/2017		26/09/2017	[NT]
pH $_{kcl}$	pH units		Inorg-064	[NT]	23	8.2	8.2	0	97	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-064	<5	23	<5	<5	0	115	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	23	<0.01	<0.01	0	[NT]	[NT]
pH $_{Ox}$	pH units		Inorg-064	[NT]	23	6.7	6.8	1	102	[NT]
TPA pH 6.5	moles H^+/t	5	Inorg-064	<5	23	<5	<5	0	101	[NT]
s-TPA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	23	<0.01	<0.01	0	[NT]	[NT]
TSA pH 6.5	moles H^+/t	5	Inorg-064	<5	23	<5	<5	0	[NT]	[NT]
s-TSA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	23	<0.01	<0.01	0	[NT]	[NT]
ANC_E	% $CaCO_3$	0.05	Inorg-064	<0.05	23	0.38	0.38	0	[NT]	[NT]
a-ANC_E	moles H^+/t	5	Inorg-064	<5	23	75	75	0	[NT]	[NT]
s-ANC_E	%w/w S	0.05	Inorg-064	<0.05	23	0.12	0.12	0	[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-064	<0.005	23	<0.005	<0.005	0	[NT]	[NT]
S_P	%w/w	0.005	Inorg-064	<0.005	23	0.04	0.04	0	[NT]	[NT]
S_{POS}	%w/w	0.005	Inorg-064	<0.005	23	0.03	0.03	0	[NT]	[NT]
a-S_{POS}	moles H^+/t	5	Inorg-064	<5	23	21	20	5	[NT]	[NT]
Ca_{KCl}	%w/w	0.005	Inorg-064	<0.005	23	0.41	0.38	8	[NT]	[NT]
Ca_P	%w/w	0.005	Inorg-064	<0.005	23	0.28	0.34	19	[NT]	[NT]
Ca_A	%w/w	0.005	Inorg-064	<0.005	23	<0.005	<0.005	0	[NT]	[NT]
Mg_{KCl}	%w/w	0.005	Inorg-064	<0.005	23	0.022	0.020	10	[NT]	[NT]
Mg_P	%w/w	0.005	Inorg-064	<0.005	23	0.027	0.026	4	[NT]	[NT]
Mg_A	%w/w	0.005	Inorg-064	<0.005	23	0.005	0.007	33	[NT]	[NT]
S_{HCl}	%w/w S	0.005	Inorg-064	<0.005	23	<0.005	<0.005	0	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-064	<0.005	23	<0.005	<0.005	0	[NT]	[NT]
a-S_{NAS}	moles H^+/t	5	Inorg-064	<5	23	<5	<5	0	[NT]	[NT]
s-S_{NAS}	%w/w S	0.01	Inorg-064	<0.01	23	<0.01	<0.01	0	[NT]	[NT]
Fineness Factor	-	1.5	Inorg-064	<1.5	23	1.5	1.5	0	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-064	<5	23	<5	<5	0	[NT]	[NT]
s-Net Acidity	%w/w S	0.01	Inorg-064	<0.01	23	<0.01	<0.01	0	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	23	<0.75	<0.75	0	[NT]	[NT]
s-Net Acidity without -ANCE	%w/w S	0.01	Inorg-064	<0.01	23	0.034	0.032	6	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-064	<5	23	21	20	5	[NT]	[NT]

QUALITY CONTROL: sPOCAS + %S w/w						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	23	1.6	1.5	6	[NT]	[NT]

QUALITY CONTROL: Misc Inorg - Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	176282-A-24
Date prepared	-			27/09/2017	23	27/09/2017	27/09/2017		27/09/2017	27/09/2017
Date analysed	-			27/09/2017	23	27/09/2017	27/09/2017		27/09/2017	27/09/2017
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	23	6.9	7.2	4	101	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	23	<10	<10	0	96	84
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	23	21	23	9	103	84

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

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

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

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

resource laboratories
AGGREGATE, ROCK, AND SOIL TESTING
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Sydney: 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
Ph: (02) 9674 7711 | Fax: (02) 9674 7755 | Email: info@resourcelab.com.au

Test Report

Customer: Martens & Associates Pty Ltd
Project: P1706099
Location: Seniors Living Development, Bayview Golf Course, Bayview, NSW

Job number: 17-0095
Report number: 1

Point Load Strength Index

Sampling method: Samples tested as received
Test method(s): AS 4133.4.1 Clause 3.2, 3.3

	Results				
Laboratory sample no.	12770	12771	12772	12773	12774
Customer sample no.	6099/BH302/ 4.0m/R/1	6099/BH302/ 8.6m/R/1	6099/BH302/ 10.67m/R/1	6099/BH303/ 2.62m/R/1	6099/BH303/ 7.8m/R/1
Sample depth	4.0m	8.6m	10.67m	2.62m	7.8m
Date sampled	20-21/09/2017	20-21/09/2017	20-21/09/2017	20-21/09/2017	20-21/09/2017
Date tested	05/10/2017	05/10/2017	05/10/2017	05/10/2017	05/10/2017
Lithological description	SANDSTONE	SANDSTONE	SANDSTONE	SANDSTONE	SANDSTONE
Diametral					
Moisture content condition	Moist	Moist	Moist	Moist	Moist
Nature of weakness planes	Laminated	Laminated	Laminated	Laminated	Laminated
Specimen size					
Length (mm)	121.5	105.0	125.6	131.0	177.0
Diameter (mm)	51.6	51.6	51.6	51.6	51.3
I_s (MPa)	**0.094**	**0.19**	**0.044**	**0.034**	**0.13**
$I_{s(50)}$ (MPa)	**0.095**	**0.19**	**0.045**	**0.034**	**0.13**
Failure mode	Parallel to Laminae	Parallel to Laminae	Parallel to Laminae	Parallel to Laminae	Parallel to Laminae
Axial					
Moisture content condition	Moist	Moist	Moist	Moist	Moist
Nature of weakness planes	Laminated	Laminated	Laminated	Laminated	Laminated
Specimen size					
Height (mm)	38.5	45.4	35.7	44.6	34.5
Diameter (mm)	51.6	51.6	51.6	51.6	51.3
I_s (MPa)	**0.12**	**0.51**	**0.049**	**0.015**	**0.10**
$I_{s(50)}$ (MPa)	**0.12**	**0.53**	**0.049**	**0.016**	**0.098**
Failure mode	Perpendicular to Laminae	Perpendicular to Laminae	Perpendicular to Laminae	Perpendicular to Laminae	Perpendicular to Laminae

Notes:

Approved Signatory: E. Maldonado **Date:** 05/10/2017

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Test Report

Customer: Martens & Associates Pty Ltd
Job number: 17-0095
Project: P1706099
Report number: 1
Location: Seniors Living Development, Bayview Golf Course, Bayview, NSW

Point Load Strength Index

Sampling method: Samples tested as received
Test method(s): AS 4133.4.1 Clause 3.2, 3.3

	Results				
Laboratory sample no.	12775	12776	12777		
Customer sample no.	6099/BH303/ 13.12m/R/1	6099/BH305/ 4.65m/R/1	6099/BH305/ 14.15m/R/1		
Sample depth	13.12m	4.65m	14.15m		
Date sampled	20-21/09/2017	20-21/09/2017	20-21/09/2017		
Date tested	05/10/2017	05/10/2017	05/10/2017		
Lithological description	SANDSTONE	CLAYSTONE	SILTSTONE		
Diametral					
Moisture content condition	Moist	Moist	Moist		
Nature of weakness planes	Laminated	n/a	Laminated		
Specimen size					
Length (mm)	123.9	148.0	186.5		
Diameter (mm)	51.4	51.0	50.8		
I_s (MPa)	**0.44**	**0.047**	**0.076**		
$I_{s(50)}$ (MPa)	**0.44**	**0.047**	**0.076**		
Failure mode	Parallel to Laminae	Through fabric of specimen	Parallel to Laminae		
Axial					
Moisture content condition	Moist	Moist	Moist		
Nature of weakness planes	Laminated	n/a	Laminated		
Specimen size					
Height (mm)	44.4	36.2	40.8		
Diameter (mm)	51.4	51.0	50.8		
I_s (MPa)	**0.49**	**0.046**	**0.067**		
$I_{s(50)}$ (MPa)	**0.51**	**0.045**	**0.068**		
Failure mode	Perpendicular to Laminae	Through fabric of specimen	Partial chip		

Notes:

Approved Signatory:  E. Maldonado
Date: 05/10/2017

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Test Report

Customer: Martens & Associates Pty Ltd
Project: P1706099
Location: Seniors Living Development, Bayview Golf Course, Bayview, NSW

Job number: 17-0095
Report number: 2
Page: 1 of 1

Soil Index Properties

Sampling method: Samples tested as received

Test method(s): AS 1289.1.1, 2.1.1, 3.1.2, 3.2.1, 3.3.1 .3.4.1

	Results				
Laboratory sample no.	12778	12779			
Customer sample no.	6099/BH302/ 0.8m/S/1	6099/BH304/ 1.0m/S/1			
Date sampled	20-21/09/2017	20-21/09/2017			
Material description	sandy CLAY, trace of gravel, dark grey mottled brown	sandy CLAY, trace of gravel, brown			
Liquid limit (%)	29	44			
Plastic limit (%)	22	17			
Plasticity index (%)	7	27			
Linear shrinkage (%)	4.5	8.5			
Cracking / Curling / Crumbling	Cracking	Cracking			
Sample history	Air dried	Air dried			
Preparation	Dry sieved	Dry sieved			

Approved Signatory:  E. Maldonado **Date:** 11/10/2017

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025.

NATA Accredited Laboratory Number: **17062**

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Test Report

Customer: Martens & Associates Pty Ltd
Job number: 17-0095
Project: P1706099
Report number: 3
Location: Seniors Living Development, Bayview Golf Course, Bayview, NSW

California Bearing Ratio

Sampling method: Samples tested as received
Test method(s): AS 1289.1.1, 2.1.1, 5.1.1, 6.1.1

	Results			
Laboratory sample no.	12780	12781		
Customer sample no.	6099/BH306/ 0.3-0.6m/CBR	6099/BH314/ 0.3-0.6m/CBR		
Date sampled	20-21/09/2017	20-21/09/2017		
Material description	CLAY, with sand, trace of gravel, mottled grey/ red/brown	SAND, with gravel, trace of silt and clay, brown		
Maximum dry density (t/m^3)	1.84	1.82		
Optimum moisture content (%)	15.6	15.5		
Field moisture content (%)	n/a	n/a		
Oversize retained on 19.0mm sieve (%)	6	2		
Minimum curing time (hours)	48	48		
Dry density before soak (t/m^3)	1.81	1.79		
Dry density after soak (t/m^3)	1.78	1.78		
Moisture content before soak (%)	15.1	15.1		
Moisture content after soak (%)	17.3	16.3		
Moisture content after test - top 30mm (%)	18.4	16.9		
Moisture content after test - remaining depth (%)	16.1	15.1		
Density ratio before soaking (%)	98.5	98.0		
Moisture ratio before soaking (%)	97.0	97.5		
Period of soaking (days)	4	4		
Compactive effort	Standard	Standard		
Mass of surcharge applied (kg)	4.5	4.5		
Swell after soaking (%)	1.5	0.0		
Penetration (mm)	5.0	5.0		
CBR Value (%)	**4.0**	**20**		

Notes: Specified LDR: 98 ±1%

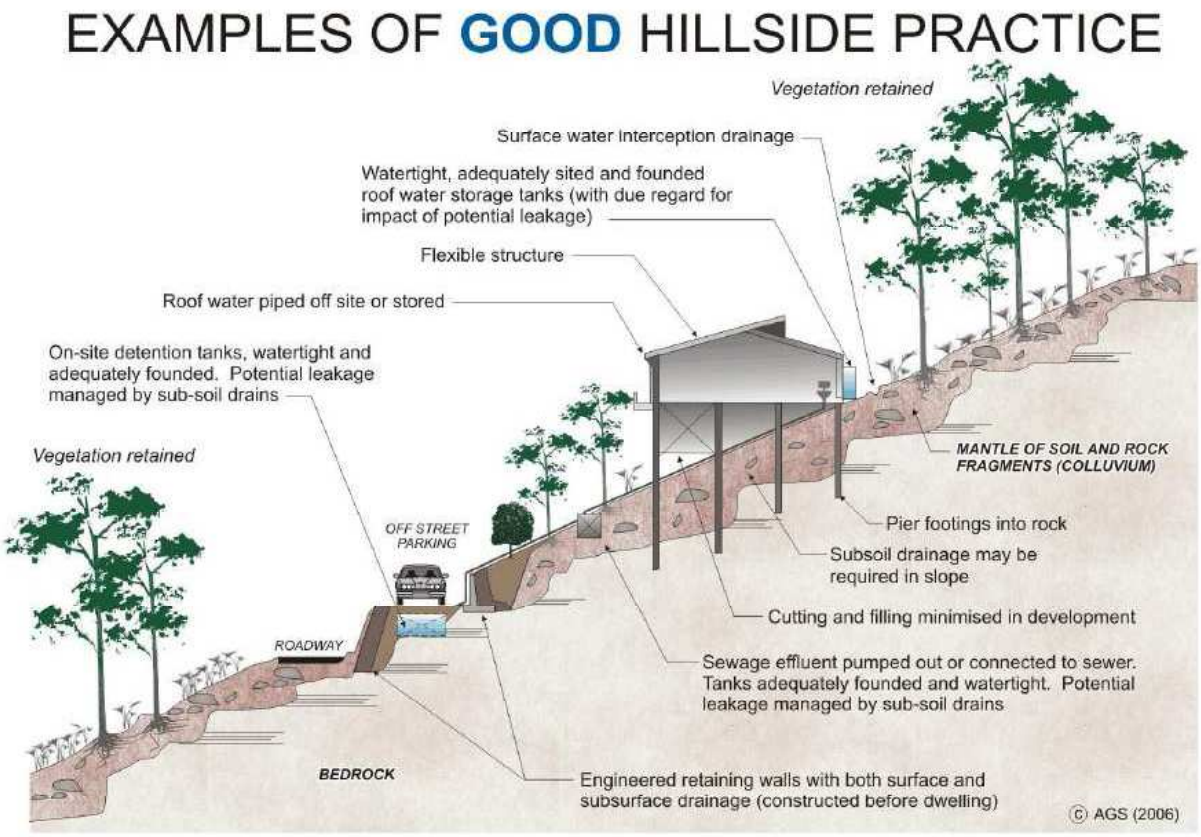
Method of establishing plasticity level - Visual / tactile

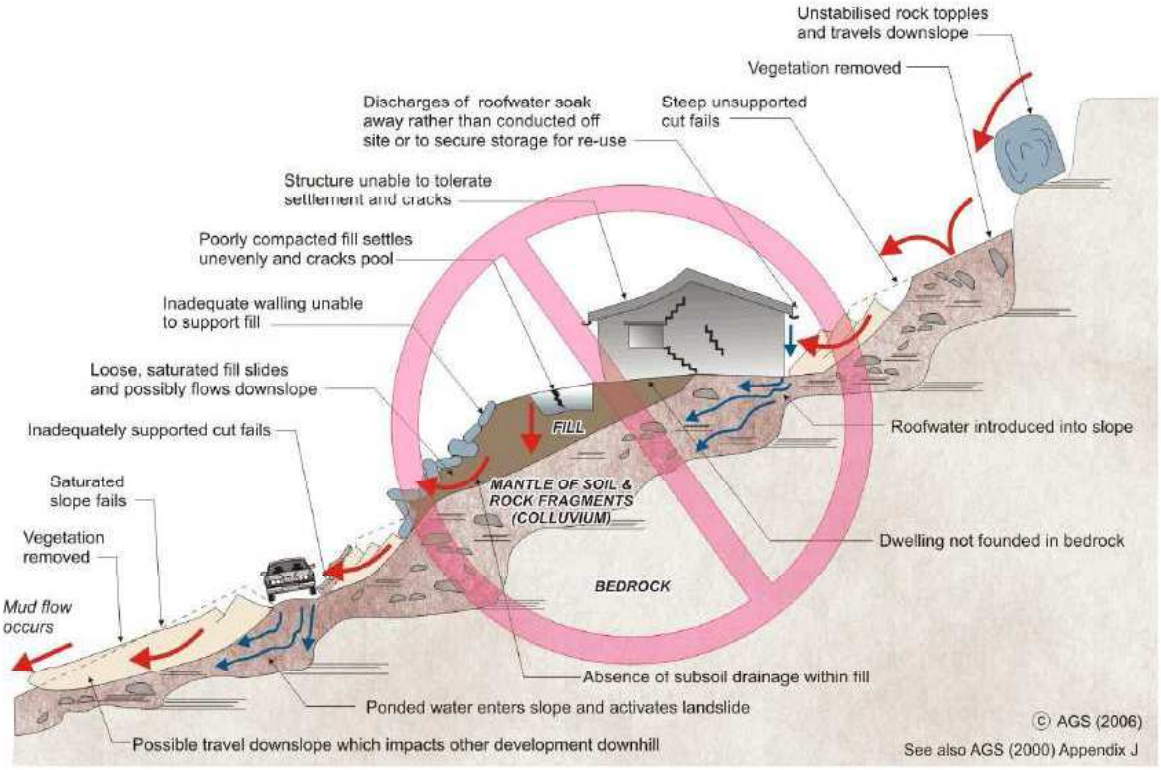
Approved Signatory:  E. Maldonado **Date:** 11/10/2017

16 Attachment H – Hillside Construction Guidelines (AGS, 2007)

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	


EXAMPLES OF GOOD HILLSIDE PRACTICE
Vegetation retained
Surface water interception drainage
Watertight, adequately sited and founded roof water storage tanks (with due regard for impact of potential leakage)
Flexible structure
Roof water piped off site or stored
On-site detention tanks, watertight and adequately founded. Potential leakage managed by sub-soil drains
Vegetation retained
MANTLE OF SOIL AND ROCK FRAGMENTS (COLLUVIUM)
OFF STREET PARKING
Pier footings into rock
Subsoil drainage may be required in slope
Cutting and filling minimised in development
ROADWAY
Sewage effluent pumped out or connected to sewer. Tanks adequately founded and watertight. Potential leakage managed by sub-soil drains
BEDROCK
Engineered retaining walls with both surface and subsurface drainage (constructed before dwelling)
© AGS (2006)


EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles unevenly and cracks pool
Inadequate walling unable to support fill
Loose, saturated fill slides and possibly flows downslope
Inadequately supported cut fails
FILL
Roofwater introduced into slope
Saturated slope fails
MANTLE OF SOIL & ROCK FRAGMENTS (COLLUVIUM)
Vegetation removed
Dwelling not founded in bedrock
BEDROCK
Mud flow occurs
Absence of subsoil drainage within fill
Ponded water enters slope and activates landslide
© AGS (2006)
Possible travel downslope which impacts other development downhill
See also AGS (2000) Appendix J

17 Attachment I – General Geotechnical Recommendations

Geotechnical Recommendations

Important Recommendations About Your Site (1 of 2)

These general geotechnical recommendations have been prepared by Martens to help you deliver a safe work site, to comply with your obligations, and to deliver your project. Not all are necessarily relevant to this report but are included as general reference. Any specific recommendations made in the report will override these recommendations.

Batter Slopes

Excavations in soil and extremely low to very low strength rock exceeding 0.75 m depth should be battered back at grades of no greater than 1 Vertical (V) : 2 Horizontal (H) for temporary slopes (unsupported for less than 1 month) and 1 V : 3 H for longer term unsupported slopes.

Vertical excavation may be carried out in medium or higher strength rock, where encountered, subject to inspection and confirmation by a geotechnical engineer. Long term and short term unsupported batters should be protected against erosion and rock weathering due to, for example, stormwater run-off.

Batter angles may need to be revised depending on the presence of bedding partings or adversely oriented joints in the exposed rock, and are subject to on-site inspection and confirmation by a geotechnical engineer. Unsupported excavations deeper than 1.0 m should be assessed by a geotechnical engineer for slope instability risk.

Any excavated rock faces should be inspected during construction by a geotechnical engineer to determine whether any additional support, such as rock bolts or shotcrete, is required.

Earthworks

Earthworks should be carried out following removal of any unsuitable materials and in accordance with AS3798 (2007). A qualified geotechnical engineer should inspect the condition of prepared surfaces to assess suitability as foundation for future fill placement or load application.

Earthworks inspections and compliance testing should be carried out in accordance with Sections 5 and 8 of AS3798 (2007), with testing to be carried out by a National Association of Testing Authorities (NATA) accredited testing laboratory.

Excavations

All excavation work should be completed with reference to the *Work Health and Safety (Excavation Work) Code of Practice (2015)*, by Safe Work Australia. Excavations into rock may be undertaken as follows:

1. Extremely low to low strength rock - conventional hydraulic earthmoving equipment.

2. Medium strength or stronger rock - hydraulic earthmoving equipment with rock hammer or ripping tyne attachment.

Exposed rock faces and loose boulders should be monitored to assess risk of block / boulder movement, particularly as a result of excavation vibrations.

Fill

Subject to any specific recommendations provided in this report, any fill imported to site is to comprise approved material with maximum particle size of two thirds the final layer thickness. Fill should be placed in horizontal layers of not more than 300 mm loose thickness, however, the layer thickness should be appropriate for the adopted compaction plant.

Foundations

All exposed foundations should be inspected by a geotechnical engineer prior to footing construction to confirm encountered conditions satisfy design assumptions and that the base of all excavations is free from loose or softened material and water. Water that has ponded in the base of excavations and any resultant softened material is to be removed prior to footing construction.

Footings should be constructed with minimal delay following excavation. If a delay in construction is anticipated, we recommend placing a concrete blinding layer of at least 50 mm thickness in shallow footings or mass concrete in piers / piles to protect exposed foundations.

A geotechnical engineer should confirm any design bearing capacity values, by further assessment during construction, as necessary.

Shoring - Anchors

Where there is a requirement for either soil or rock anchors, or soil nailing, and these structures penetrate past a property boundary, appropriate permission from the adjoining land owner must be obtained prior to the installation of these structures.

Shoring - Permanent

Permanent shoring techniques may be used as an alternative to temporary shoring. The design of such structures should be in accordance with the findings of this report and any further testing recommended by this report. Permanent shoring may include [but not be limited to] reinforced block work walls, contiguous and semi contiguous pile walls, secant pile walls and soldier pile walls with or without reinforced shotcrete infill panels. The choice of shoring system will depend on the type of structure, project budget and site specific geotechnical conditions.

Permanent shoring systems are to be engineer designed and backfilled with suitable granular

material and free-draining drainage material. Backfill should be placed in maximum 100 mm thick layers compacted using a hand operated compactor. Care should be taken to ensure excessive compaction stresses are not transferred to retaining walls.

Shoring design should consider any surcharge loading from sloping / raised ground behind shoring structures, live loads, new structures, construction equipment, backfill compaction and static water pressures. All shoring systems shall be provided with adequate foundation designs.

Suitable drainage measures, such as geotextile enclosed 100 mm agricultural pipes embedded in free-draining gravel, should be included to redirect water that may collect behind the shoring structure to a suitable discharge point.

Shoring - Temporary

In the absence of providing acceptable excavation batters, excavations should be supported by suitably designed and installed temporary shoring / retaining structures to limit lateral deflection of excavation faces and associated ground surface settlements.

Soil Erosion Control

Removal of any soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in any formal stormwater drainage system, on neighbouring land and in receiving waters. Where possible, this may be achieved by one or more of the following means:

1. Maintain vegetation where possible
2. Disturb minimal areas during excavation
3. Revegetate disturbed areas if possible

All spoil on site should be properly controlled by erosion control measures to prevent transportation of sediments off-site. Appropriate soil erosion control methods in accordance with Landcom (2004) shall be required.

Trafficability and Access

Consideration should be given to the impact of the proposed works and site subsurface conditions on trafficability within the site e.g. wet clay soils will lead to poor trafficability by tyred plant or vehicles.

Where site access is likely to be affected by any site works, construction staging should be organised such that any impacts on adequate access are minimised as best as possible.

Vibration Management

Where excavation is to be extended into medium or higher strength rock, care will be required when using a rock hammer to limit potential structural distress from excavation-induced vibrations where nearby structures may be affected by the works.

To limit vibrations, we recommend limiting rock hammer size and set frequency, and setting the hammer parallel to bedding planes and along defect planes, where possible, or as advised by a geotechnical engineer. We recommend limiting vibration peak particle velocities (PPV) caused by construction equipment or resulting from excavation at the site to 5 mm/s (AS 2187.2, 2006, Appendix J).

Waste – Spoil and Water

Soil to be disposed off-site should be classified in accordance with the relevant State Authority guidelines and requirements.

Any collected waste stormwater or groundwater should also be tested prior to discharge to ensure contaminant levels (where applicable) are appropriate for the nominated discharge location.

MA can complete the necessary classification and testing if required. Time allowance should be made for such testing in the construction program.

Water Management - Groundwater

If the proposed works are likely to intersect ephemeral or permanent groundwater levels, the management of any potential acid soil drainage should be considered. If groundwater tables are likely to be lowered, this should be further discussed with the relevant State Government Agency.

Water Management – Surface Water

All surface runoff should be diverted away from excavation areas during construction works and prevented from accumulating in areas surrounding any retaining structures, footings or the base of excavations.

Any collected surface water should be discharged into a suitable Council approved drainage system and not adversely impact downslope surface and subsurface conditions.

All site discharges should be passed through a filter material prior to release. Sump and pump methods will generally be suitable for collection and removal of accumulated surface water within any excavations.

Contingency Plan

In the event that proposed development works cause an adverse impact on geotechnical hazards, overall site stability or adjacent properties, the following actions are to be undertaken:

1. Works shall cease immediately.
2. The nature of the impact shall be documented and the reason(s) for the adverse impact investigated.
3. A qualified geotechnical engineer should be consulted to provide further advice in relation to the issue.

18 Attachment J – Notes About This Report

Information

Important Information About Your Report (1 of 2)

These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all are necessarily relevant to all reports but are included as general reference.

Engineering Reports - Limitations

The recommendations presented in this report are based on limited investigations and include specific issues to be addressed during various phases of the project. If the recommendations presented in this report are not implemented in full, the general recommendations may become inapplicable and Martens & Associates accept no responsibility whatsoever for the performance of the works undertaken.

Occasionally, sub-surface conditions between and below the completed boreholes or other tests may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact Martens & Associates.

Relative ground surface levels at borehole locations may not be accurate and should be verified by on-site survey.

Engineering Reports – Project Specific Criteria

Engineering reports are prepared by qualified personnel. They are based on information obtained, on current engineering standards of interpretation and analysis, and on the basis of your unique project specific requirements as understood by Martens. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the Client.

Where the report has been prepared for a specific design proposal (e.g. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (e.g. to a twenty storey building). Your report should not be relied upon, if there are changes to the project, without first asking Martens to assess how factors, which changed subsequent to the date of the report, affect the report's recommendations. Martens will not accept responsibility for problems that may occur due to design changes, if not consulted.

Engineering Reports – Recommendations

Your report is based on the assumption that site conditions, as may be revealed through selective point sampling, are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced. Therefore your site investigation report recommendations should only be regarded as preliminary.

Only Martens, who prepared the report, are 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 another party undertakes the implementation of the recommendations of this report, there is a risk that the report will be misinterpreted and Martens cannot be held responsible for such misinterpretation.

Engineering Reports – Use for Tendering Purposes

Where information obtained from investigations is provided for tendering purposes, Martens recommend that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document.

Martens would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Engineering Reports – Data

The report as a whole presents the findings of a site assessment and should not be copied in part or altered in any way.

Logs, figures, drawings *etc* are customarily included in a Martens report and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel), desktop studies and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Engineering Reports – Other Projects

To avoid misuse of the information contained in your report it is recommended that you confer with Martens before passing your report on to another party who may not be familiar with the background and purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Subsurface Conditions - General

Every care is taken with the report in relation to interpretation of subsurface conditions, discussion of geotechnical aspects, relevant standards and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions - the potential will depend partly on test point

(eg. excavation or borehole) spacing and sampling frequency, which are often limited by project imposed budgetary constraints.

- Changes in guidelines, standards and policy or interpretation of guidelines, standards and policy by statutory authorities.

- The actions of contractors responding to commercial pressures.

- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

  The actual interface between logged materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

If these conditions occur, Martens will be pleased to assist with investigation or providing advice to resolve the matter.

Subsurface Conditions - Changes

Natural processes and the activity of man create subsurface conditions. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Reports are based on conditions which existed at the time of the subsurface exploration / assessment.

Decisions should not be based on a report whose adequacy may have been affected by time. If an extended period of time has elapsed since the report was prepared, consult Martens to be advised how time may have impacted on the project.

Subsurface Conditions - Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those that were expected from the information contained in the report, Martens requests that it immediately be notified. Most problems are much more readily resolved at the time when conditions are exposed, rather than at some later stage well after the event.

Report Use by Other Design Professionals

To avoid potentially costly misinterpretations when other design professionals develop their plans based on a Martens report, retain Martens to work with other project professionals affected by the report. This may involve Martens explaining the report design implications and then reviewing plans and specifications produced to see how they have incorporated the report findings.

Subsurface Conditions – Geo-environmental Issues

Your report generally does not relate to any findings, conclusions, or recommendations about the potential for hazardous or contaminated materials existing at the site unless specifically required to do so as part of Martens' proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geo-environmental or site contamination assessments. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Martens for information relating to such matters.

Responsibility

Geo-environmental reporting relies on interpretation of factual information based on professional judgment and opinion and has an inherent level of uncertainty attached to it and is typically far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded.

To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Martens to other parties but are included to identify where Martens' responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Martens closely and do not hesitate to ask any questions you may have.

Site Inspections

Martens will always be pleased to provide engineering inspection services for aspects of work to which this report relates. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site. Martens is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction.

Soil Data

Explanation of Terms (1 of 3)

Definitions

In engineering terms, soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material does not exhibit any visible rock properties and can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

The methods of description and classification of soils and rocks used in this report are typically based on Australian Standard 1726 and the Unified Soil Classification System (USCS) – refer Soil Data Explanation of Terms (2 of 3). In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

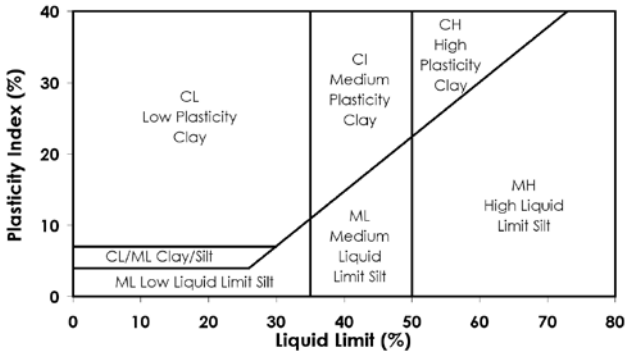
Particle Size

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy CLAY). Unless otherwise stated, particle size is described in accordance with the following table.

Division	Subdivision	Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2.36 to 6
SAND	Coarse	0.6 to 2.36
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
SILT		0.002 to 0.075
CLAY		< 0.002

Plasticity Properties

Plasticity properties of cohesive soils can be assessed in the field by tactile properties or by laboratory procedures.



Moisture Condition

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 damp and is 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.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

Term	C_u (kPa)	Approx. SPT "N"	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort. Sample extrudes between fingers when squeezed in fist.
Soft	12 - 25	2 – 4	A finger can be pushed into the soil to about 25mm depth. Easily moulded in fingers.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated. Can be moulded by strong pressure in the figures.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure. Difficult to cut with a knife. Thumbnail can readily indent.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail. Brittle. Tends to break into fragments.
Friable	-	-	Crumbles or powders when scraped by thumbnail.

Density of Granular Soils

Non-cohesive soils are classified on the basis of relative density, generally from standard penetration test (SPT) or Dutch cone penetrometer test (CPT) results as below:

Relative Density	%	SPT 'N' Value* (blows/300mm)	CPT Cone Value (q_c MPa)
Very loose	< 15	< 5	< 2
Loose	15 - 35	5 - 10	2 - 5
Medium dense	35 - 65	10 - 30	5 - 15
Dense	65 - 85	30 - 50	15 - 25
Very dense	> 85	> 50	> 25

* Values may be subject to corrections for overburden pressures and equipment type.

Minor Components

Minor components in soils may be present and readily detectable, but have little bearing on general geotechnical classification. Terms include:

Term	Assessment	Proportion of Minor component In:
Trace of	Presence just detectable by feel or eye. Soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5 % Fine grained soils: < 15 %
With some	Presence easily detectable by feel or eye. Soil properties little different to general properties of primary component.	Coarse grained soils: 5 – 12 % Fine grained soils: 15 – 30 %

Soil Data

Explanation of Terms (2 of 3)

martens consulting engineers

Symbols for Soils and Other

SOILS


COBBLES/BOULDERS


GRAVEL (GP OR GW)


SILTY GRAVEL (GM)


CLAYEY GRAVEL (GC)


SAND (SP OR SW)


SILTY SAND (SM)


CLAYEY SAND (SC)


SILT (ML OR MH)


ORGANIC SILT (OH)


CLAY (CL, CI OR CH)


SILTY CLAY


SANDY CLAY


PEAT


TOPSOIL

OTHER


FILL


TALUS


ASPHALT


CONCRETE

Unified Soil Classification Scheme (USCS)

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)					USCS	Primary Name
COARSE GRAINED SOILS More than 50 % of material less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 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 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of intermediate sizes missing.	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 50 % of material less than 63 mm is smaller than 0.075 mm	IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM					
	DRY STRENGTH (Crushing Characteristics)	DILATANCY	TOUGHNESS	DESCRIPTION	USCS	Primary Name
	None to Low	Quick to Slow	None	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	ML	Silt
	Medium to High	None	Medium	Inorganic clays of low to medium plasticity [1], gravely clays, sandy clays, silty clays, lean clays	CL [2]	Clay
	Low to Medium	Slow to Very Slow	Low	Organic slits and organic silty clays of low plasticity	OL	Organic Silt
	Low to Medium	Slow to Very Slow	Low to Medium	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH	Silt
	High	None	High	Inorganic clays of high plasticity, fat clays	CH	Clay
	Medium to High	None	Low to Medium	Organic clays of medium to high plasticity	OH	Organic Silt
HIGHLY ORGANIC SOILS	Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	Peat

Notes:

1. Low Plasticity – Liquid Limit W_L < 35 % Medium Plasticity – Liquid limit W_L 35 to 60 % High Plasticity - Liquid limit W_L > 60 %.
2. CI may be adopted for clay of medium plasticity to distinguish from clay of low plasticity.

Soil Data

Explanation of Terms (3 of 3)

Soil Agricultural Classification Scheme

In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions by Northcote, K.H. (1979) *The factual key for the recognition of Australian Soils*, Rellim Technical Publications, NSW, p 26 - 28.

Symbol	Field Texture Grade	Behaviour of moist bolus	Ribbon length	Clay content (%)
S	Sand	Coherence nil to very slight; cannot be moulded; single grains adhere to fingers	0 mm	< 5
LS	Loamy sand	Slight coherence; discolours fingers with dark organic stain	6.35 mm	5
CLS	Clayey sand	Slight coherence; sticky when wet; many sand grains stick to fingers; discolours fingers with clay stain	6.35mm - 1.3cm	5 - 10
SL	Sandy loam	Bolus just coherent but very sandy to touch; dominant sand grains are of medium size and are readily visible	1.3 - 2.5	10 - 15
FSL	Fine sandy loam	Bolus coherent; fine sand can be felt and heard	1.3 - 2.5	10 - 20
SCL$^-$	Light sandy clay loam	Bolus strongly coherent but sandy to touch, sand grains dominantly medium size and easily visible	2.0	15 - 20
L	Loam	Bolus coherent and rather spongy; smooth feel when manipulated but no obvious sandiness or silkiness; may be somewhat greasy to the touch if much organic matter present	2.5	25
Lfsy	Loam, fine sandy	Bolus coherent and slightly spongy; fine sand can be felt and heard when manipulated	2.5	25
SiL	Silt loam	Coherent bolus, very smooth to silky when manipulated	2.5	25 + > 25 silt
SCL	Sandy clay loam	Strongly coherent bolus sandy to touch; medium size sand grains visible in a finer matrix	2.5 - 3.8	20 - 30
CL	Clay loam	Coherent plastic bolus; smooth to manipulate	3.8 - 5.0	30 - 35
SiCL	Silty clay loam	Coherent smooth bolus; plastic and silky to touch	3.8 - 5.0	30- 35 + > 25 silt
FSCL	Fine sandy clay loam	Coherent bolus; fine sand can be felt and heard	3.8 - 5.0	30 - 35
SC	Sandy clay	Plastic bolus; fine to medium sized sands can be seen, felt or heard in a clayey matrix	5.0 - 7.5	35 - 40
SiC	Silty clay	Plastic bolus; smooth and silky	5.0 - 7.5	35 - 40 + > 25 silt
LC	Light clay	Plastic bolus; smooth to touch; slight resistance to shearing	5.0 - 7.5	35 - 40
LMC	Light medium clay	Plastic bolus; smooth to touch, slightly greater resistance to shearing than LC	7.5	40 - 45
MC	Medium clay	Smooth plastic bolus, handles like plasticine and can be moulded into rods without fracture, some resistance to shearing	> 7.5	45 - 55
HC	Heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; firm resistance to shearing	> 7.5	> 50

Rock Data

Explanation of Terms (1 of 2)

Symbols for Rock

SEDIMENTARY ROCK


BRECCIA


CONGLOMERATE


CONGLOMERATIC SANDSTONE


SANDSTONE/QUARTZITE


SILTSTONE


MUDSTONE/CLAYSTONE


SHALE


COAL


LIMESTONE


LITHIC TUFF

IGNEOUS ROCK


GRANITE


DOLERITE/BASALT

METAMORPHIC ROCK


SLATE, PHYLLITE, SCHIST


GNEISS


METASANDSTONE


METASILTSTONE


METAMUDSTONE

Definitions

Descriptive terms used for Rock by Martens are based on AS1726 and encompass rock substance, defects and mass.

Rock Substance In geotechnical engineering terms, rock substance is any naturally occurring aggregate of minerals and organic matter which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Rock substance is effectively homogeneous and may be isotropic or anisotropic.

Rock Defect Discontinuity or break in the continuity of a substance or substances.

Rock 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.

Degree of Weathering

Rock weathering is defined as the degree of decline in rock structure and grain property and can be determined in the field.

Term	Symbol	Definition
Residual soil[1]	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[1]	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly weathered[2]	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decrease compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original rock substance is no longer recognisable.
Moderately weathered[2]	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh	FR	Rock substance unaffected by weathering

Notes:
1 Rs and EW material is described using soil descriptive terms.
2. The term "Distinctly Weathered" (DW) may be used to cover the range of substance weathering between EW and SW

Rock Strength

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the loading. The test procedure is described by the International Society of Rock Mechanics.

Term	Is (50) MPa	Field Guide	Symbol
Very low	>0.03 ≤0.1	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VL
Low	>0.1 ≤0.3	A piece of core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	L
Medium	>0.3 ≤1.0	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	M
High	>1 ≤3	A piece of core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife.	H
Very high	>3 ≤10	A piece of core 150mm long x 50mm diameter may be broken readily with hand held hammer. Cannot be scratched with pen knife.	VH
Extremely high	>10	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	EH

Rock Data

Explanation of Terms (2 of 2)

Degree of Fracturing

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude fractures such as drilling breaks (DB) or handling breaks (HB).

Term	Description
Fragmented	The core is comprised primarily of fragments of length less than 20 mm, and mostly of width less than core diameter.
Highly fractured	Core lengths are generally less than 20 mm to 40 mm with occasional fragments.
Fractured	Core lengths are mainly 30 mm to 100 mm with occasional shorter and longer sections.
Slightly fractured	Core lengths are generally 300 mm to 1000 mm, with occasional longer sections and sections of 100 mm to 300 mm.
Unbroken	The core does not contain any fractures.

Rock Core Recovery

TCR = Total Core Recovery

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

SCR = Solid Core Recovery

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100\%$$

RQD = Rock Quality Designation

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

Rock Strength Tests

▼ Point load strength Index (Is50) - axial test (MPa)

▶ Point load strength Index (Is50) - diametral test (MPa)

● Unconfined compressive strength (UCS) (MPa)

Defect Type Abbreviations and Descriptions

Defect Type (with inclination given)

BP	Bedding plane parting
FL	Foliation
CL	Cleavage
JT	Joint
FC	Fracture
SZ/SS	Sheared zone/ seam (Fault)
CZ/CS	Crushed zone/ seam
DZ/DS	Decomposed zone/ seam
FZ	Fractured Zone
IS	Infilled seam
VN	Vein
CO	Contact
HB	Handling break
DB	Drilling break

Planarity

Pl	Planar
Cu	Curved
Un	Undulating
St	Stepped
Ir	Irregular
Dis	Discontinuous

Thickness

Zone	> 100 mm
Seam	> 2 mm < 100 mm
Plane	< 2 mm

Roughness

Pol	Polished
Sl	Slickensided
Sm	Smooth
Ro	Rough
VR	Very rough

Coating or Filling

Cn	Clean
Sn	Stain
Ct	Coating
Vnr	Veneer
Fe	Iron Oxide
X	Carbonaceous
Qz	Quartzite
MU	Unidentified mineral

Inclination

Inclination of defect is measured from perpendicular to and down the core axis.
Direction of defect is measured clockwise (looking down core) from magnetic north.

Test, Drill and Excavation Methods

Explanation of Terms (1 of 3)

martens consulting engineers

Sampling

Sampling is carried out during drilling or excavation to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling or excavation provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples may be taken by pushing a thin-walled sampling tube, e.g. U_{50} (50 mm internal diameter thin walled tube), into soils and withdrawing a soil sample in a relatively undisturbed state. Such samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Other sampling methods may be used. Details of the type and method of sampling are given in the report.

Drilling / Excavation Methods

The following is a brief summary of drilling and excavation methods currently adopted by the Company and some comments on their use and application.

Hand Excavation - in some situations, excavation using hand tools, such as mattock and spade, may be required due to limited site access or shallow soil profiles.

Hand Auger - the hole is advanced by pushing and rotating either a sand or clay auger, generally 75-100 mm in diameter, into the ground. The penetration depth is usually limited to the length of the auger pole; however extender pieces can be added to lengthen this.

Test Pits - these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils and, if it is safe to descend into the pit, collection of bulk disturbed samples. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (e.g. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling (Push Tube) - the hole is advanced by pushing a 50 - 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength *etc.* is only marginally affected.

Continuous Spiral Flight Augers - the hole is advanced using 90 - 115 mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface or, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling - similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling - a continuous core sample is obtained using a diamond tipped core barrel of usually 50 mm internal diameter. Provided full core recovery is achieved (not always possible in very weak or fractured rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

In-situ Testing and Interpretation

Cone Penetrometer Testing (CPT)

Cone penetrometer testing (sometimes referred to as Dutch Cone) described in this report has been carried out using an electrical friction cone penetrometer.

The test is described in AS 1289.6.5.1-1999 (R2013). In the test, a 35 mm diameter rod with a cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system.

Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the push rod centre to an amplifier and recorder unit mounted on the control truck. As penetration occurs (at a rate of approximately 20 mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records. The information provided on the charts comprises:

(i) Cone resistance (q_c) - the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa.

(ii) Sleeve friction (q_f) - the frictional force of the sleeve divided by the surface area, expressed in kPa.

(iii) Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower (A) scale (0 - 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main (B) scale (0 - 50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1 % - 2 % are commonly encountered in sands and very soft clays rising to 4 % - 10 % in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6)\ N \text{ (blows/300 mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:

$$q_c = (12 \text{ to } 18)\ C_u$$

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes *etc.* This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Standard Penetration Testing (SPT)

Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample.

The test procedure is described in AS 1289.6.3.1-2004. The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm penetration depth increments and the 'N' value is taken as the number of blows for the last two 150 mm depth increments (300 mm total penetration). In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued. The test results are reported in the following form:

(i) Where full 450 mm penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7 blows:

as 4, 6, 7
N = 13

(ii) Where the test is discontinued, short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm

as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

Dynamic Cone (Hand) Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods. Two relatively similar tests are used.

Perth sand penetrometer (PSP) - a 16 mm diameter flat ended rod is driven with a 9 kg hammer, dropping 600 mm. The test, described in AS 1289.6.3.3-1997 (R2013), was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

Cone penetrometer (DCP) - sometimes known as the Scala Penetrometer, a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm. The test, described in AS 1289.6.3.2-1997 (R2013), was developed initially for pavement sub-grade investigations, with correlations of the test results with California Bearing Ratio published by various Road Authorities.

Pocket Penetrometers

The pocket (hand) penetrometer (PP) is typically a light weight spring hand operated device with a stainless steel loading piston, used to estimate unconfined compressive strength, q_u, (UCS in kPa) of a fine grained soil in field conditions. In use, the free end of the piston is pressed into the soil at a uniform penetration rate until a line, engraved near the piston tip, reaches the soil surface level. The reading is taken from a gradation scale, which is attached to the piston via a built-in spring mechanism and calibrated to kilograms per square centimetre (kPa) UCS. The UCS measurements are used to evaluate consistency of the soil in the field moisture condition. The results may be used to assess the undrained shear strength, C_u, of fine grained soil using the approximate relationship:

$$q_u = 2 \times C_u.$$

It should be noted that accuracy of the results may be influenced by condition variations at selected test surfaces. Also, the readings obtained from the PP test are based on a small area of penetration and could give misleading results. They should not replace laboratory test results. The use of the results from this test is typically limited to an assessment of consistency of the soil in the field and not used directly for design of foundations.

Test Pit / Borehole Logs

Test pit / borehole log(s) presented herein are an engineering and / or geological interpretation of the subsurface conditions. Their reliability will depend to some extent on frequency of sampling and methods of excavation / drilling. Ideally, continuous undisturbed sampling or excavation / core drilling will provide the most reliable assessment but this is not always practicable, or possible to justify on economic grounds. In any case, the test pit / borehole logs represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of test pits / boreholes, the frequency of sampling and the possibility of other than 'straight line' variation between the test pits / boreholes.

Laboratory Testing

Laboratory testing is carried out in accordance with AS 1289 Methods of Testing Soil for Engineering Purposes. Details of the test procedure used are given on the individual report forms.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems:

- In low permeability soils, ground water although present, may enter the hole slowly, or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent prior weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

More reliable measurements can be made by installing standpipes, which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Test, Drill and Excavation Methods

Explanation of Terms (3 of 3)

DRILLING / EXCAVATION METHOD

HA	Hand Auger	RD	Rotary Blade or Drag Bit	NQ	Diamond Core - 47 mm
AD/V	Auger Drilling with V-bit	RT	Rotary Tricone bit	NMLC	Diamond Core – 51.9 mm
AD/T	Auger Drilling with TC-Bit	RAB	Rotary Air Blast	HQ	Diamond Core – 63.5 mm
AS	Auger Screwing	RC	Reverse Circulation	HMLC	Diamond Core – 63.5 mm
HSA	Hollow Stem Auger	CT	Cable Tool Rig	DT	Diatube Coring
S	Excavated by Hand Spade	PT	Push Tube	NDD	Non-destructive digging
BH	Tractor Mounted Backhoe	PC	Percussion	PQ	Diamond Core - 83 mm
JET	Jetting	E	Tracked Hydraulic Excavator	X	Existing Excavation

SUPPORT

Nil	No support	S	Shotcrete	RB	Rock Bolt
C	Casing	Sh	Shoring	SN	Soil Nail
WB	Wash bore with Blade or Bailer	WR	Wash bore with Roller	T	Timbering

WATER

▽ Water level at date shown ◁ Partial water loss

▷ Water inflow ◀ Complete water loss

GROUNDWATER NOT OBSERVED (NO)	The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.
GROUNDWATER NOT ENCOUNTERED (NX)	The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

PENETRATION / EXCAVATION RESISTANCE

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

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

SAMPLING

D	Small disturbed sample	W	Water Sample	C	Core sample
B	Bulk disturbed sample	G	Gas Sample	CONC	Concrete Core

U63 Thin walled tube sample - number indicates nominal undisturbed sample diameter in millimetres

TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11	4,7,11 = Blows per 150mm.
N=18	'N' = Recorded blows per 300mm penetration following 150mm seating
DCP	Dynamic Cone Penetration test to AS1289.6.3.2-1997. 'n' = Recorded blows per 150mm penetration

Notes:

RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB 30/80mm	Hammer double bouncing on anvil after 80 mm penetration
N=18	Where practical refusal occurs, report blows and penetration for that interval

CPT	Static cone penetration test
CPTu	CPT with pore pressure (u) measurement
PP	Pocket penetrometer test expressed as instrument reading (kPa)
FP	Field permeability test over section noted
VS	Field vane shear test expressed as uncorrected shear strength (sv = peak value, sr = residual value)
PM	Pressuremeter test over section noted
PID	Photoionisation Detector reading in ppm
WPT	Water pressure tests

SOIL DESCRIPTION

Density		Consistency		Moisture	
VL	Very loose	VS	Very soft	D	Dry
L	Loose	S	Soft	M	Moist
MD	Medium dense	F	Firm	W	Wet
D	Dense	St	Stiff	Wp	Plastic limit
VD	Very dense	VSt	Very stiff	Wl	Liquid limit
		H	Hard		

ROCK DESCRIPTION

Strength		Weathering	
VL	Very low	EW	Extremely weathered
L	Low	HW	Highly weathered
M	Medium	MW	Moderately weathered
H	High	SW	Slightly weathered
VH	Very high	FR	Fresh
EH	Extremely high		