PLANIX Projects
C/- Waterview

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

martens consulting engineers

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

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1 Overview

1.1 Background

This report provides the findings of a geotechnical and Acid Sulphate Soils assessment completed to support a development application (DA) to Pittwater Council for a proposed seniors living development at Cabbage Tree Road, Bayview, NSW. The investigation area comprises Lot 1 DP 662920 (north western part only) and Lot 1 DP 19161 ('the site'). The proposed development is to be located in the central part of Lot 1 DP 662920 ('the development area'). Refer to Attachment A, Figure 2 for the proposed development area. The objective of the assessment is to determine site geotechnical and hydrogeological conditions, including an assessment of potential presence of acid sulphate soils (ASS).

1.2 Relevant Guidelines/Standards

The assessment has been prepared in accordance with the following guidelines:

- Australian Geomechanics Society *Practice Note Guidelines for Landslide Risk Management* (2007).
- Australian Standard 1726 (1993) *Geotechnical Site Investigations.*
- Australian Standard 1289.6.3.2 (1997) *Determination of the penetration resistance of a soil – 9 kg dynamic cone penetrometer test.*
- Australian Standard 2870 (2011) *Residential slabs and footings – Construction.*
- Australian Standards 2159 (2009) *Piling-Design and Installation.*
- Pittwater Council (2009) Geotechnical Risk Management Policy for Pittwater.
- NSW Acid Sulfate Soil Management Advisory Committee, *Acid Sulfate Soil Manual.*

1.3 Development Proposal

We understand that the proposed development includes:

- Demolition of part of Bayview Golf Course (BGC).
- Construction of senior living apartments with basement car parking involving excavations of up to 10.0 m below ground level (bgl).

2 Site Description

2.1 Summary

A summarised site description is provided in Table 1. An aerial view of the site with indicative location of the development area is provided on Figure 2 in Attachment A.

Table 1: Site description summary.

Element	Description/Detail
Lot/DP	Lot 1 DP 662920 and Lot 1 DP 19161
Site area	8.93 ha
Development site area	1.99 ha
Existing site development	Site currently used as part of the Bayview Golf Course.
Aspect	South
Typical slopes	Slopes at 10 – 15 % to the south and 5 – 10 % to the south west. Near southern site boundary land at >35 % slopes down to site boundary and Cabbage Tree Road. Site elevations vary from 4 mAHD in the south west to 38 mAHD in the north east.
Vegetation	Grass and trees
Neighbouring environment	Bordered by Cabbage Tree Road to the south and residential properties or native bushland to the north, east and west.
Local Government Area (LGA)	Pittwater City Council
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	The Sydney 1:100,000 Geological Series Sheet 9130 (NSW Dept. of Mineral Resources, 1983) indicates the site as being underlain by Hawkesbury Sandstone, comprising medium to coarse grained quartz sandstone, very minor shale and laminate lenses.
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 floodplain draining the Hawkesbury Sandstone local relief.

3 Geotechnical Assessment

3.1 Field Investigations

Field investigations undertaken on May 20, 2014 included the following:

- Walkover inspection of the site to assess existing site conditions and local topography, geology, soil conditions and vegetation.
- Drilling of ten boreholes using a hydraulic auger to assess underlying soil horizons and depth to bedrock.
- Ten dynamic cone penetrometer (DCP) tests to complement borehole investigations and provide information relating to soil strength.
- Collection of soil samples for ASS assessment laboratory testing and future reference.

Locations of boreholes and DCP tests are shown on Figure 2 in Attachment A. Refer to Attachment B for borehole logs and Attachment C for DCP 'N' counts.

3.2 Pittwater Council Geotechnical Hazard Mapping

The southern portion of the site (adjacent to Cabbage Tree Road) and the west/north west portion of the site (refer to Figure 3 in Attachment A) are mapped as geotechnical hazard 'H1' in accordance with Pittwater Council's Geotechnical Hazard Map (2009).

3.3 Site Stability and Condition of Existing Structures

Field investigations revealed the following:

- Steep slopes (>35 %), where fill material has been placed to build up golf tees and greens, were observed near the southern boundary adjacent to Cabbage Tree Road.
- No evidence of recent gross slope instability on remainder of site or near to the site.

3.4 Sub-surface Conditions

Sub-surface investigations encountered typically silty sand fill between about 0.0 m and 0.6 mbgl overlying residual clays between about 0.3 m and 1.5 mbgl grading into extremely low strength sandstone. Deep fill (i.e. from 2.3 to 5.0 mbgl) was encountered along the southern site boundary (BH101 and BH107). Alluvial sediments were intercepted in BH101 to a depth of about 3.2 mbgl. Sub-surface conditions are described in detail in the completed borehole logs (Attachment B) and are summarised in Table 2.

Table 2: Summary of soil and rock profiles at borehole locations.

Layer[1]	Depth (mBGL)[2]									
	BH101	BH102	BH103	BH104	BH105	BH106	BH107	BH108	BH109	BH110
Gravelly SAND FILL: Varied Strengths	-	-	-	-	-	-	-	-	-	0.0 – 0.15
Silty SAND FILL: Varied Strengths	0.0 – 0.1	0.0 – 0.3	0.0 – 0.4	0.0 – 0.4	0.0 – 0.2	0.0 – 0.6	0.0 – 0.4	0.0 – 0.4	0.0 - 0.6	0.15 – 0.6
Sandy CLAY FILL: Varied Strengths	0.1 – 0.5	-	-	-	-	-	-	-	-	-
CLAY FILL: Varied Strengths	0.5 – 2.3	-	-	-	-	-	0.4 – 1.5	-	-	-
CLAY with Gravel FILL: Varied Strengths	2.3 – 3.2	-	-	-	-	-	-	-	-	-
Silty SAND FILL: Varied Strengths	-	-	-	-	-	-	1.5 – 5.0	-	-	-
Alluvial Silty CLAY	3.2 – 5.8	-	-	-	-	-	-	-	-	-
Residual CLAY with Sand/Sandy CLAY: Firm - Stiff	-	0.3 – 1.6	0.4 – 0.8	0.4 – 1.1	0.2 – 1.5	0.6 – 0.9	5.0 – 5.2	0.4 – 0.6	0.6 – 1.1	0.6 – 1.1
EL SANDSTONE: Extremely Weathered	5.8 – 6.2	1.6 – 2.0	0.8 – 1.8	1.1 – 2.4	1.5 – 2.5	0.9 – 1.1	5.2 – 5.5	0.6 – 0.9	1.1 – 1.5	1.1 – 1.6
VL SANDSTONE: Extremely - Highly Weathered	-	2.0 – 2.5	1.8 – 2.5	-	-	1.1 – 2.5	-	0.9 – 4.3	1.5 – 2.5	1.6 – 5.5
L SANDSTONE: Moderately Weathered	-	-	-	-	-	-	-	4.3 – 5.5	-	-

Notes:

[1] Based on visual assessment/drilling spoil. Refer to borehole logs (Attachment B) for more detailed descriptions. May vary between boreholes.

[2] Approximate depths in (m) below ground level.

[3] EL = Extremely low strength, VL = Very low strength, L = Low strength, M = Medium strength. Refer to borehole logs for material description details.

3.5 Preliminary Geotechnical Design Parameters

Preliminary geotechnical design parameters, estimated from visual assessment, DCP test results and rate of auger advancement (TC-bit) using our experience from similar developments in the area, are provided in Table 3. Rock coring and laboratory testing (i.e. point load) has not been completed due to the limited scope of work. If further detail is required for rock properties, then rock coring and point load testing will be required.

Table 3: Preliminary estimates of soil and rock strength properties.

Material Description [1]	γ_{insitu}[2] (kN/m³)	C_u[3] (kPa)	ϕ'[4] (°)	ASF [5] (kPa)	ABC [6] (kPa)
FILL: Varied Strengths	-	-	-	NA	NA
Residual CLAY/Silty CLAY: Firm - Stiff	18	50	-	15	100
EL SANDSTONE	19	-	27	50	450
VL SANDSTONE	22	-	30[7]	60	750
L SANDSTONE	23	-	32[7]	70	900

Notes:
[1] EL = Extremely low strength, VL = Very low strength, L = Low strength, M = Medium strength. Refer to borehole logs (Attachment B) for full soil description details.
[2] *In-situ* unit weight.
[3] Undrained shear strength.
[4] Effective friction angle.
[5] Allowable skin friction.
[6] Allowable end bearing pressure assuming square footing with $D_f/B < 0.5$ $D_f > 0.75$ and cleaned base.
[7] May be influenced by presence and condition of defects.

3.6 Retaining Wall Specification

Lateral earth pressure coefficients for retaining wall design and recommended maximum batter slopes are provided in Table 4.

Table 4: Lateral earth pressure coefficients and recommended maximum batter slopes.

Unit	k_a	k_p	Maximum Temporary Slope Batter[1]	Maximum Permanent Slope Batter[1]
FILL: Varied Strengths	0.20	2.4	1:2	NR[2]
CLAY: Firm - Stiff	0.35	2.60	1:1.5	1.2
EL SANDSTONE	0.70	3.00	1:1	1:2
VL SANDSTONE	0.80	3.20	Vertical[3]	Vertical[3]
L SANDSTONE	0.90	3.30	Vertical[3]	Vertical[3]

Notes:
[1] Maximum batter slopes (vertical: horizontal) for open excavation < 1 month.
[2] NR = Not recommended.
[3] Subject to further assessment during construction.

3.7 Hydrogeological Assessment

3.7.1 NSW Government Natural Resource Atlas

Groundwater information was collected from a review of local groundwater bore details from the NSW Natural Resource Atlas's website (www.nraltas.nsw.gov.au). Table 5 summarises groundwater conditions at four bores with available groundwater details found within 0.45 km of the site (Figure 1).

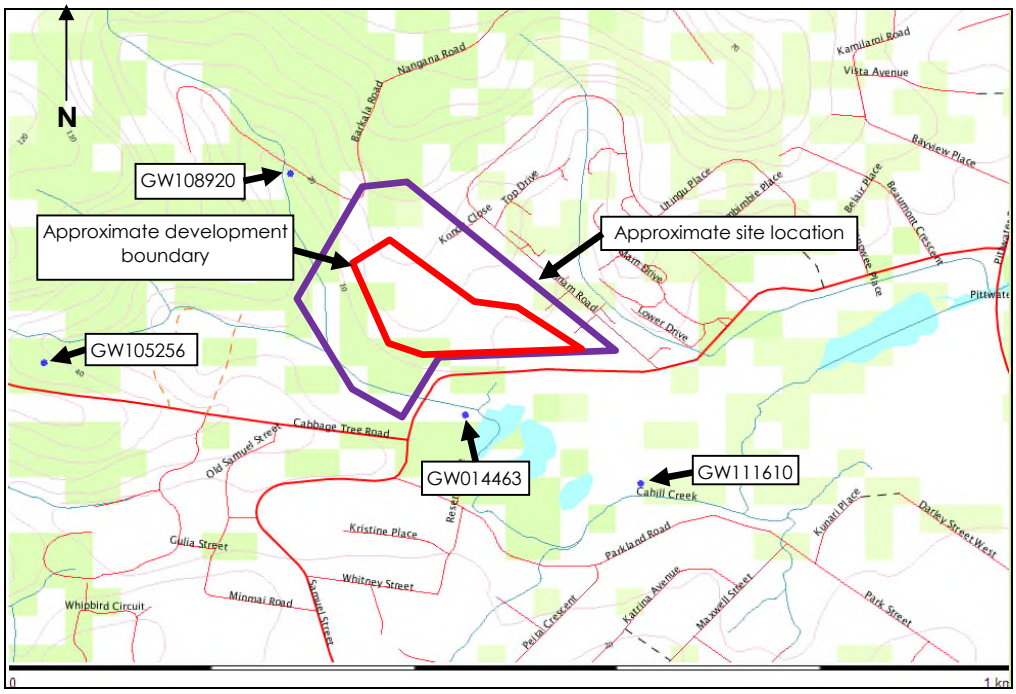


Figure 1: NSW Department of Natural Resources groundwater bore database search within 0.45km of the site.

Groundwater details of the NSW Department of Infrastructure Planning and Natural Resources (DIPNR) groundwater database for the four bores are summarised in Table 5.

Table 5: DIPNR groundwater bore details from database search results within 0.45km of the site.

Groundwater Bore Identification	Distance From Site (m)	Depth to Groundwater (mBGL)	Intended Use	Water Bearing Zone Substrate
GW014463	South, 55 m	ND [1]	Recreation (Groundwater)	ND [1]
GW111610	South west, 180 m	1.2	Recreation (Groundwater)	Silty sand black, fill
GW105256	West, 285 m	18.0	Domestic	Sandstone, light grey
GW108920	West, 440 m	49.5	Domestic stock	Sandstone, grey

Note:
[1] No Information given.

We note that the accuracy of information provided in these groundwater bores is not verified by DIPNR, who make the data available for use.

3.7.2 Geotechnical Borehole Observations

During drilling of BH101 (which reached a depth of 6.2 mbgl), groundwater was encountered at 5.0 mbgl. Based on a survey by Bee and Lethbridge (refer to Figure 4 in Appendix A) this water level is approximately 0.8 mAHD. BH101 is located on the lower slopes of the site (near Cabbage Tree Road) underlain by alluvial sediments (silty clay) to about 0.0 mAHD. All other boreholes were drilled in the residual landscape and remained dry during the one-day field investigation.

3.7.3 Conclusion

The proposed maximum excavation depth for the basement car park, (located in portions of the site with elevations >10.0 mAHD) is to a level of 6.0 mAHD. Therefore the development is unlikely to intercept the permanent groundwater table. However, further groundwater assessment is required to confirm groundwater characteristics, or groundwater inflow rates, if groundwater is encountered.

3.8 Site Classification

Based on preliminary field investigations, natural clays maintain a site classification of 'M' in accordance with AS 2870 (2011). Where footings are founded on sandstone bedrock a classification of 'A' is applicable.

3.9 Risk Assessment of Proposed Development Works

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 AGS (2007) guidelines and Pittwater Council's (2009) Geotechnical Risk Management Policy for Pittwater. 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, soil creep and gross instability (slide) are most likely to impact the proposed development. A summary for these hazards is presented in Table 6. The assessment is based on implementation of treatment measures, shown as a minimum. Risk evaluation calculations are provided as Attachment E.

Table 6: 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
Soil creep	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
Gross Instability (slide)	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.

Fill material has been placed along the southern boundary adjacent to Cabbage Tree Road to build up tees and greens for the golf course. This material is up to 5.0 m deep (based on borehole and DCP testing), has slopes with gradients >35 % and is therefore a potential stability risk. Part of the proposed development, including the driveway, will encroach onto this fill material. An inferred geological section is provided in Attachment D. A SLIDE model has been undertaken to assess the stability risk of the fill material to the proposed development.

3.9.1 Preliminary Slide Model Analysis

3.9.1.1 Modelling Methodology and Assumptions

A slope stability analysis was undertaken using the *SLIDE 6.0* modelling package 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 A, Figures 4 and 5). SLIDE modelling was carried out to assess the impact of 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 150kPa; and without loading.
- The majority of the existing soil overburden is fill overlying a thin layer of clay overlying weathered sandstone (based on borehole BH107). Additional test pitting or hand auguring is required to confirm soil characteristics downslope of the embankment.

3.9.1.2 Material Properties

A summary of strength properties used in the model is provided in Table 7. Soil strength parameters were estimated based on penetration test data. We have assumed that the fill generally consists of cohesive materials.

Table 7: Estimated strength properties of soil and rock used in *SLIDE 6.0* model.

Materials	γ_{dry}[1]	C_u (kPa)[2]	ϕ' (°)[3]
Soil Overburden: Fill/Clay	15	15	-
Natural Weathered sandstone	23[4]	-	32[4]

Notes:
[1] *In-situ* dry unit weight (±2).
[2] Assumed undrained cohesion (±5) assuming unconsolidated clays.
[3] Effective friction angle (±2) assuming drained conditions.
[4] Estimated rock strength properties based on refusal characteristics from hydraulic auguring during borehole investigations (BH107).

3.9.1.3 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 8. Slide modelling results are provided in Attachment A, Figures 5 and 6.

Table 8: 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

3.9.1.4 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 'facilities' building (assuming a typical design load of 150kPa) is likely to impact the underlying fill material resulting in a FOS of 0.70.
- We recommend all footings and foundations for the facilities building are taken through fill (where required) and founded on sound sandstone bedrock.

3.9.2 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 F.

3.10 Recommendations

Geotechnical recommendations for site development are provided below in Table 9.

Table 9: Geotechnical recommendations

Geotechnical Issue	Recommendations
Excavations and Vibrations	Excavations for the proposed basement car park (up to 10 mbgl) will encounter soil over predominantly low strength sandstone. There is a possibility that medium strong sandstone will be encountered at depths below 6.0 m. In light of this the following excavation techniques may be adapted: o Fill material and natural soils should be readily excavated using conventional earthmoving equipment. o Extremely weak to weak sandstone of extremely low to low strength should generally be readily excavated with a 'toothed' bucket or a ripping tyne (or similar) although progress may be slow in low strength sandstone. o Rock breaker of ripping tyne attachments may be required for excavation of medium strength sandstone or greater. All excavation work should be completed with reference to the Code of Practice 'Excavation Work', dated October 2013 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 sandstone is encountered) prior to the use of hydraulic hammer equipment to reduce noise and vibrations. It is expected that a temporary batter will be formed around the excavation to the top of the medium strong sandstone. Below this level the sandstone may be vertical cut to bulk excavation level subject to further assessment by a geotechnical engineer. If stability is not confirmed the batter will need to be continued to the final bulk excavation level with the batter remaining until the basement level structure is complete.
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 excavations into extremely low to low strength sandstone can be made at 1V:1H and 8V:1H for medium strong sandstone. Permanent excavations can be made at 1V:1H for low strength sandstone and 4V:1H for medium strong sandstone, provided there are no adversely oriented joints or defects in the rock. It is recommended that 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.

Geotechnical Issue	Recommendations
	Heavy Machinery Use of heavy machinery should be avoided, where possible, within 2 m of any open soil excavation to prevent excessive vibrations and undue settlement.
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). We recommend that stripping of organic topsoil or unsuitable sub-grades, such as uncontrolled fill, 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 DECC (2009) waste classification guidelines. All site earthworks should be undertaken in accordance with AS3798 (2007) and Aus-Spec 213 (2004).
Footings and Foundations	Footings of proposed buildings are to be designed by a suitably qualified and experienced structural or geotechnical engineer. Preliminary sub-surface soil and rock strength parameters are provided in Section 3.5 for footing design. 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 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. Depth to sandstone is predominantly <1.5 m across most of the site except for areas covered by fill at the eastern corner of the site. It is recommended that proposed buildings be founded within the sandstone bedrock to minimise potential foundation settlement and limit differential settlement across the building footprint. A piled footing system could be adopted to extend footings through the soil profile.

Geotechnical Issue	Recommendations
	Further geotechnical design advice will need to be provided once the design is progressed.
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 Section 3.6 and in accordance with further recommendations in our report. 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.
Groundwater	It is considered that the proposed excavations will unlikely intercept the groundwater table. Further groundwater assessment is recommended to confirm groundwater characteristics, and assess groundwater inflow rates if groundwater is encountered. Ephemeral groundwater is likely to be collected at the soil/rock interface after periods of substantial or prolonged rainfall. Sump and pump methods are considered to be appropriate for dewatering during construction. 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.
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.
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.

3.11 Further Investigations

- Further investigations including rock coring, point load testing and RQD evaluation for better assessment of rock conditions across the site and design parameters.
- Additional borehole in eastern corner to assess condition of alluvial soil profile and impact on proposed development and design parameters.
- Additional wells for further groundwater assessment to confirm groundwater characteristics, and assess groundwater inflow rates, if groundwater is encountered.

3.12 Monitoring Program

We recommend the following be monitored regularly (Table 10) (daily or otherwise) during site works.

Table 10: Recommended monitoring inspections during site works.

Inspection	Frequency/Duration	Who to Complete
Groundwater seepage	If encountered	Builder (notify MA if encountered)
Any constructed site retention structures – for efficient drainage	Daily	Builder
Sedimentation downslope of excavated areas	During and after rainfall events	Builder
Sediment and erosion control structures – for functioning condition and removal of built up spoil	After rainfall events	Builder

3.13 Inspection Schedule

We recommend the following geotechnical inspections (Table 11) are undertaken during construction works.

Table 11: Recommended geotechnical inpections during contruction works.

Inspection	Frequency/Duration	Who to Complete
Rock excavation faces	1 m depth increments	MA
Footings and foundations – to verify founding material	Prior to reinforcement set-up and concrete pouring	MA
Vibration monitoring	Where rock excavation via hammer occurs within 10 m of adjoining structures	MA
Proof roll	After subgrade compaction	MA

3.14 Further Design and Construction Verification Works

We recommend the following further investigations:

- Review of final design excavation plans by a geotechnical engineer to verify inclusion of recommendations presented in this report.
- Additional stress/strain dependent analysis during detailed design of retaining walls to further consider likely deformations and better model earth pressures and influence of excavations on nearby infrastructure and services.

3.15 Contingency Plan

In the event that the proposed development works cause an adverse impact on overall site stability or on neighbouring properties, works shall cease immediately. The nature of the impact shall be documented and the reason(s) for the adverse impact investigated. This might require site inspection by a qualified geotechnical or structural engineer. Contact Martens and Associates should conditions differ from those presented in this report.

4 Acid Sulfate Soils

4.1 Overview

A review of Pittwater Councils Acid Sulphate Soils Map (Figure 8 in Attachment A) indicates actual or potential ASS is likely present in the eastern corner of the site; therefore an ASS assessment was undertaken.

The objectives of the ASS assessment include detailing 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.

4.2 Sub-surface Conditions

Observations compiled during the site inspection and via aerial photography interpretation (API) were compared against various geomorphic characteristics outlined in ASSMAC (1998). Table 12 summarises possible ASS soil characteristics and their presence/absence at the site. The results indicate that AASS or PASS are likely present at the site.

Table 12: Geomorphic characteristics indicative of ASS and their presence or absence.

Geomorphic Characteristic	Presence on Site
Holocene sediments	Yes[1]
Soil horizons less than 5 m AHD	Yes[1]
Marine / estuarine sediments or tidal lakes	Yes[1]
Coastal wetland; backwater swamps; waterlogged or scaled areas; swales or coastal sand dunes.	No
Dominant vegetation is mangroves, reeds, rushes and other swamp or marine tolerant species.	No
Geologies containing sulfide bearing material	Yes[1]
Deep older (Pleistocene) estuarine sediments	Unknown

NOTES: [1] Geomorphic characteristics encountered only in the south eastern portion of the site.

4.3 Sampling Strategy

ASSMAC (1998) guidelines recommend up to 4 sampling points for an area of <1 ha , with soil sampling at 0.5 m intervals or major soil horizon changes, to a depth of 1.0 m below the limit of excavation. Due to the

nature of the excavation, ten borehole locations were considered adequate to assess the site.

4.4 sPOCAS Analysis

Laboratory test results/ASSMAC (1998) action criteria interpretation are summarised in Table 13. The laboratory certification is provided in Attachment G. Results are summarised as follows:

- Actual Acid Sulfate Soil (AASS) was found in two sandstone samples (BH102, depth 2.0 m and BH110, depth 3.0 m) and one clay sample (BH104, depth 0.5 m).
- Potential ASS (PASS) was found in four samples in BH101. Two samples are from fill (clay) and two samples from underlying alluvial sediments (organic silt).
- Neither PASS or ASS were found in the remaining fourteen samples.

Table 13: sPOCAS testing results.

Sample ID	Sample Depth (m)	Material Type [1]	pH_{KCL}[2]	pH_{OX}[3]	TPA (mol H+/t)[4]	TSA (mol H+/t)[5]	S_{POS} (%S oxidisable)[6]	Assessment [7]	Liming Rate (kg $CaCO_3$/t)
Assessment Criteria		(F) Fine grained. > 40 % clay.	< 4 = AASS	< 3.5 = PASS pHK_{CL}-pH_{OX}>1 = PASS	62	62	0.030	TPA, TSA, S_{POS} > criteria = PASS. Exposed soil >1000t, use coarse grained material criteria.	
		(M) Medium grained. 5-40 % clay.			36	36	0.060		
		(C) Coarse grained. < 5 % Clay.			18	18	0.100		
4179/101/0.5	0.50	F	6.3	6.3	5	5	0.010	NA	<0.75
4179/101/1.0	1.00	F	7.4	5.1	5	5	0.010	PASS	<0.75
4179/101/2.5	2.50	F	4.1	3.9	70	16	0.007	PASS	4.4
4179/101/3.5	3.50	F	5.1	4.9	92	51	0.050	PASS	5.6
4179/101/4.5	4.50	F	4.7	4.3	85	44	0.030	PASS	4.7
4179/102/1.0	1.00	F	4.5	4.4	20	5	0.007	NA	2.7
4179/102/2.0	2.00	C	3.9	3.7	57	9	0.005	AASS	3.8
4179/103/1.5	1.50	C	5.9	5.3	5	5	0.005	NA	<0.75
4179/103/2.0	2.00	C	4.2	4.6	17	5	0.006	NA	2
4179/104/0.5	0.50	F	3.8	3.5	150	56	0.009	NA	8
4179/105/1.0	1.00	F	4.1	3.7	90	11	0.006	NA	6.3
4179/106/0.5	0.50	M	4.6	3.9	5	5	0.010	NA	2.5
4179/106/1.5	1.50	C	4.2	4.3	26	5	0.005	NA	2.8

4179/107/1.0	1.00	F	4.2	4.3	32	5	0.005	NA	3.5
4179/107/1.5	1.50	M	6.0	6.0	5	5	0.006	NA	<0.75
4179/107/3.5	3.50	M	5.1	4.5	5	5	0.010	NA	1.7
4179/108/2.0	2.00	C	5.0	3.3	5	5	0.020	NA	4
4179/109/0.5	0.50	M	5.0	3.3	5	5	0.020	NA	2.4
4179/110/1.0	1.00	F	4.2	4.2	45	5	0.007	NA	5.1
4179/110/1.5	1.50	C	4.5	4.4	35	5	0.007	NA	3.4
4179/110/3.0	3.00	C	3.9	3.9	60	5	0.010	NA	5.5

Note:
[1] Material type based on field texture assessment or laboratory report.
[2] Laboratory pH.
[3] Post peroxide oxidation pH
[4] Total Potential Acidity
[5] Total Sulfidic Acidity
[6] Percentage oxidisable sulphur
[7] NA = not AASS or PASS, AASS = Actual Acid Sulfate Soil, PASS = Potential Acid Sulfate Soil

Soils exceeding the ASSMAC (1998) criteria for AASS and PASS are present at the site. If it is accepted that ASSMAC (1998) applies, then a detailed management plan is required.

Actual Acid Sulfate Soil (AASS) was found in two sandstone bedrock samples and one overlying clay sample. The origin of soil acidity is therefore likely to be related to geology.

Potential Acid Sulfate Soil (PASS) was found in fill material and underlying alluvial sediments in BH101, located in the south east corner of the site. Material at present is located in the aerobic zone of the soil profile. It is therefore unlikely that disturbance of this material will result in environmental impacts as a result of the presence of PASS. Underlying PASS alluvial sediments, at a depth of 3.2 mbgl, are unlikely to be disturbed during construction works (based on the current development proposal), as proposed buildings are predominantly located within the residual soil landscape.

We consider that excavation of residual soils, rock and fill materials (alluvial soils are located outside building works at a depth >3.2 m bgl), will unlikely lead to adverse impacts on the environment. We conclude that preparation of a management plan is not essential.

5 Limitations Statement

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Martens & Associates accept no responsibility whatsoever for the performance of the designs where recommendations are not implemented in full and properly tested, inspected and documented.

A site investigation cannot be considered a complete and exhaustive characterisation of a site. Occasionally sub-surface soil conditions in areas of the site not specifically tested may be found to be different from those expected. This is particularly the case on sites that have been filled. This can also occur with groundwater conditions, especially after climatic changes. Should, during site works, soil or water conditions be found to be significantly different to those detailed in this report, works shall cease immediately and the new conditions should be addressed by Martens & Associates to determine geotechnical implications before recommencement.

Also, in the event that there are any significant changes to the proposed development described in this report, then all recommendations should be reviewed by Martens & Associates.

6 References

Australian Geomechanics Society, Landslide Zoning Working Group (March 2007), *Guidelines for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning*, Australian Geomechanics Vol 42 No 1.

Australian Standard 1726 (1993) *Geotechnical Site Investigations.*

Australia Standard 1289.6.3.2 (1997), *Determination of the Penetration Resistance of a Soil using the 9kg Dynamic Cone Penetrometer.*

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

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

NSW Acid Sulfate Soils Management Advisory Committee (1998), *Acid Sulfate Soils Assessment Guidelines.*

NSW DECC (2009) *Waste Classification Guidelines Part 1: Classifying Waste.*

NSW Department of Mineral Resources (1983), Sydney Australia 1:100,000 Geological Series Sheet 9130.

Pittwater Council (2009) *Geotechnical Risk Management Policy for Pittwater.*

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

7 Attachment A – Figures

Key

- Site Boundary
- Development Area Boundary
- Borehole/DCP testing location
- Indicative area of fill
- Cross Sections (refer to Figures 9 and 10)

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GMT	**Borehole and DCP Testing Locations** **Source: Nearmap, 2014**	Drawing No: FIGURE 2
Approved:	GT		
Date:	23.05.2014		
Scale:	Not to Scale		Job No: P1404179JR03V01

PITTWATER COUNCIL

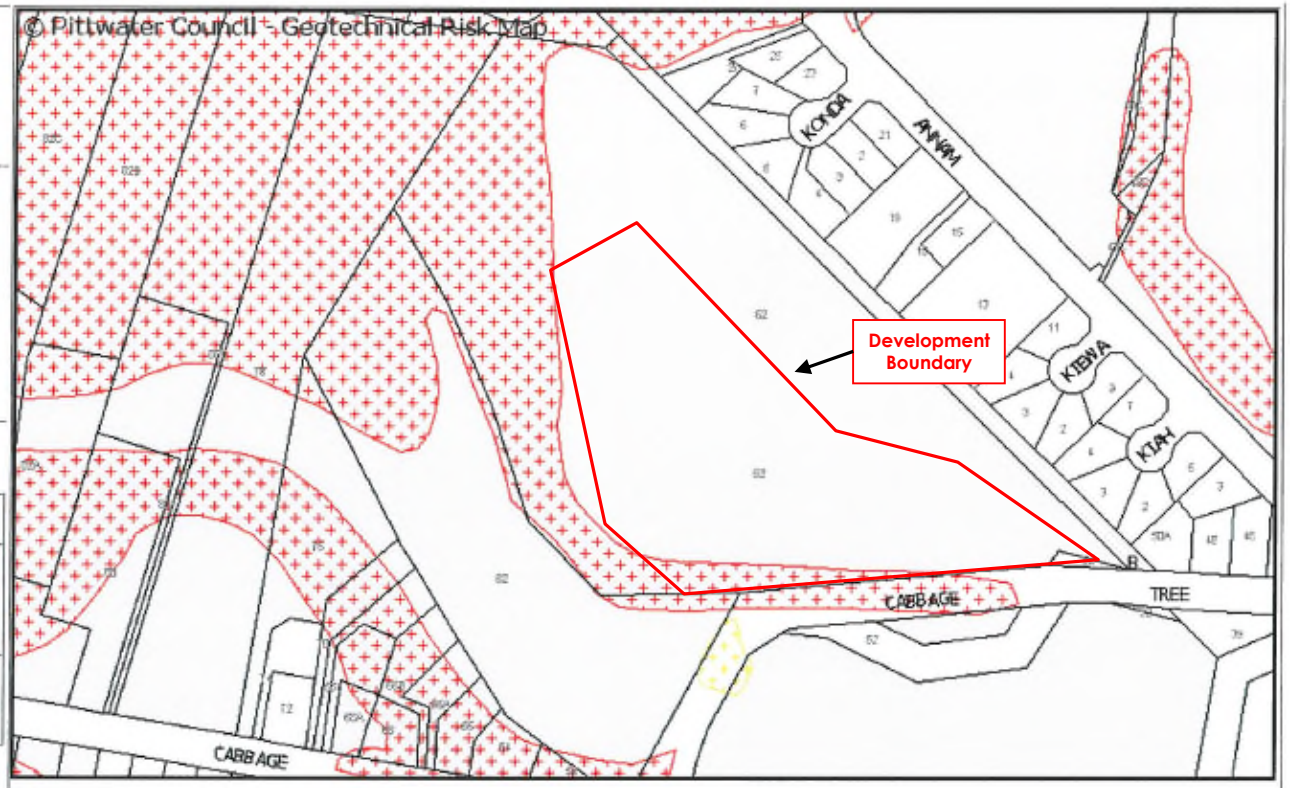
Date: Tuesday, 13 May 2014

Pittwater Council
Contact Details
1 Park Street
PO Box 882
MONA VALE NSW 1660
Ph: (02) 9970 1111
Fax: (02) 9970 7150
pittwater_council@pittwater.nsw.gov.au

Address

Slip
Geotechnical Hazard H1
Geotechnical Hazard H2

Slip Affected
See Geotechnical Risk Management Policy - 200



NORTH

Scale: 1:2,982

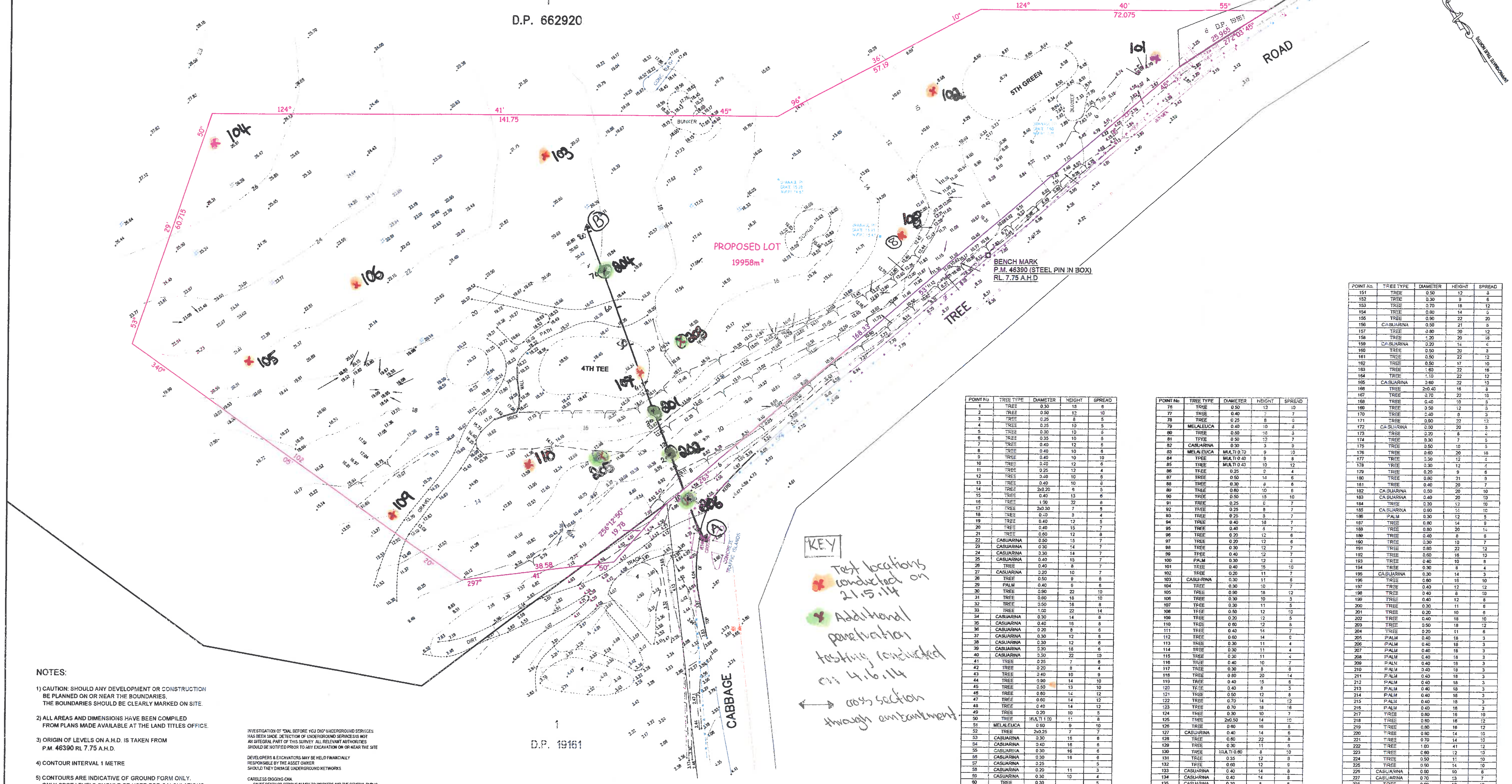
This data has been collated from a variety of sources and can neither be seen as absolute nor complete. Any errors or omissions can be forwarded to Council for review.

There are no selected items.

martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GMT	**Pittwater Council – Geotechnical Risk Map**	Drawing No: FIGURE 3
Approved:	GT		
Date:	23.05.2014		
Scale:	Not to Scale		Job No: P1404179JR03V01

Adopted cross section and additional testing locations: Martens 24.6.14 Figure 4



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 ON OR NEAR 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 DAMAGES CLAIMS
- CAUSE EXPENSIVE FINANCIAL LOSSES TO BUSINESS
- CUT OFF EMERGENCY SERVICES
- DELAY PROJECT COMPLETION TIMES WHILE THE DAMAGE IS REPAIRED

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DIAL 1100 BEFORE YOU DIG

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

POINT No	TREE TYPE	DIAMETER	HEIGHT	SPREAD
1	TREE	0.30	15	6
2	TREE	0.50	12	10
3	TREE	0.25	8	5
4	TREE	0.25	10	5
5	TREE	0.30	10	5
6	TREE	0.35	10	5
7	TREE	0.40	12	6
8	TREE	0.40	10	6
9	TREE	0.40	10	10
10	TREE	0.40	12	6
11	TREE	0.25	12	4
12	TREE	0.40	10	8
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	8
18	TREE	0.40	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	6
38	CASUARINA	0.30	12	6
39	CASUARINA	0.30	18	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	8
55	CASUARINA	0.30	16	6
56	CASUARINA	0.30	16	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	7	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	9	4
87	TREE	0.50	14	6
88	TREE	0.30	8	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	16	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	9
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	6
118	TREE	0.80	20	14
119	TREE	0.40	15	6
120	TREE	0.40	8	5
121	TREE	0.50	12	8
122	TREE	0.70	14	12
123	TREE	0.70	18	16
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	6
130	TREE	MULTI 0.60	8	10
131	TREE	0.35	12	8
132	TREE	0.60	12	9
133	CASUARINA	0.40	14	8
134	CASUARINA	0.40	14	8
135	CASUARINA	0.30	8	8
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	6	5
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

POINT No.	TREE TYPE	DIAMETER	HEIGHT	SPREAD
151	TREE	0.50	12	8
152	TREE	0.30	9	6
153	TREE	0.70	18	12
154	TREE	0.60	14	9
155	TREE	0.90	22	20
156	CASUARINA	0.50	21	5
157	TREE	0.80	20	12
158	TREE	1.20	20	16
159	CASUARINA	0.20	14	4
160	TREE	0.50	20	8
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	8
169	TREE	0.50	12	6
170	TREE	0.40	8	3
171	TREE	0.90	22	12
172	CASUARINA	0.30	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	16
177	TREE	0.30	12	4
178	TREE	0.30	12	4
179	TREE	0.20	9	6
180	TREE	0.80	21	8
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	0.60	14	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	16	10
218	TREE	0.80	16	12
219	TREE	0.80	16	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	0.60	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	0.90	14	12
231	TREE	0.50	7	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	0.90	16	15
238	CASUARINA	0.40	10	6
239	TREE	0.50	10	8
240	TREE	0.30	14	5
241	TREE	0.40	10	9
242	TREE	0.60	12	10
243	TREE	0.60	12	10

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Quality Surveying & Development Solutions
Bee & Lethbridge Pty Ltd
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PO Box. 330, Forestville, NSW 2087
Phone: 9451 6757 Fax: 9975 3535
Email: survey@beeleth.com.au
ABN: 13 003 194 447
www.beeleth.com.au

LEGEND
WIRE MESH FENCE
TOP OF BANK
BOTTOM OF BANK
TELSTRA LINES
WATER LINES
GAS LINES
TELSTRA PIT
WATER METER
SPRINKLER

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

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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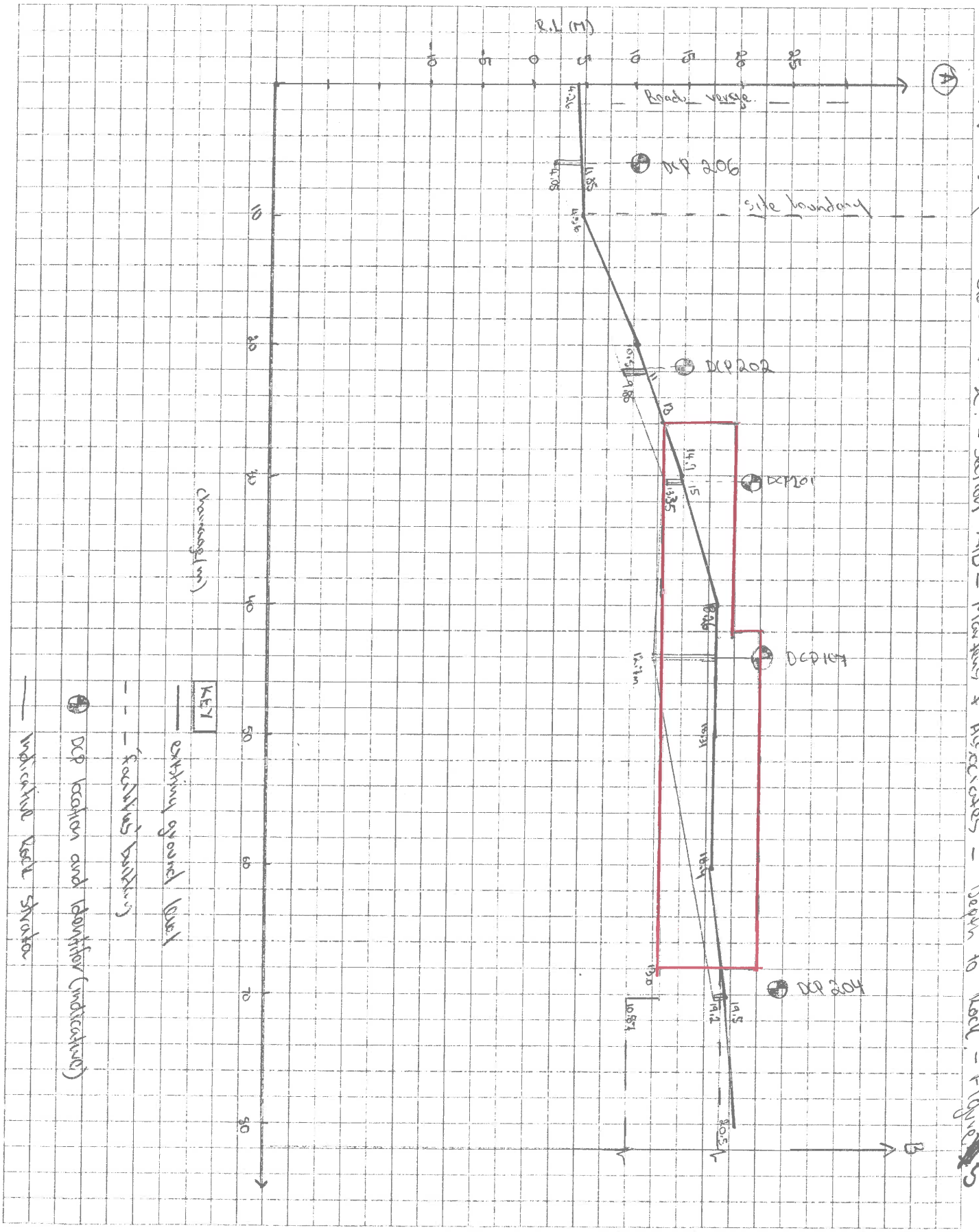
consulting engineers since 1989

System P5, Form 3 Issued 6/5/06

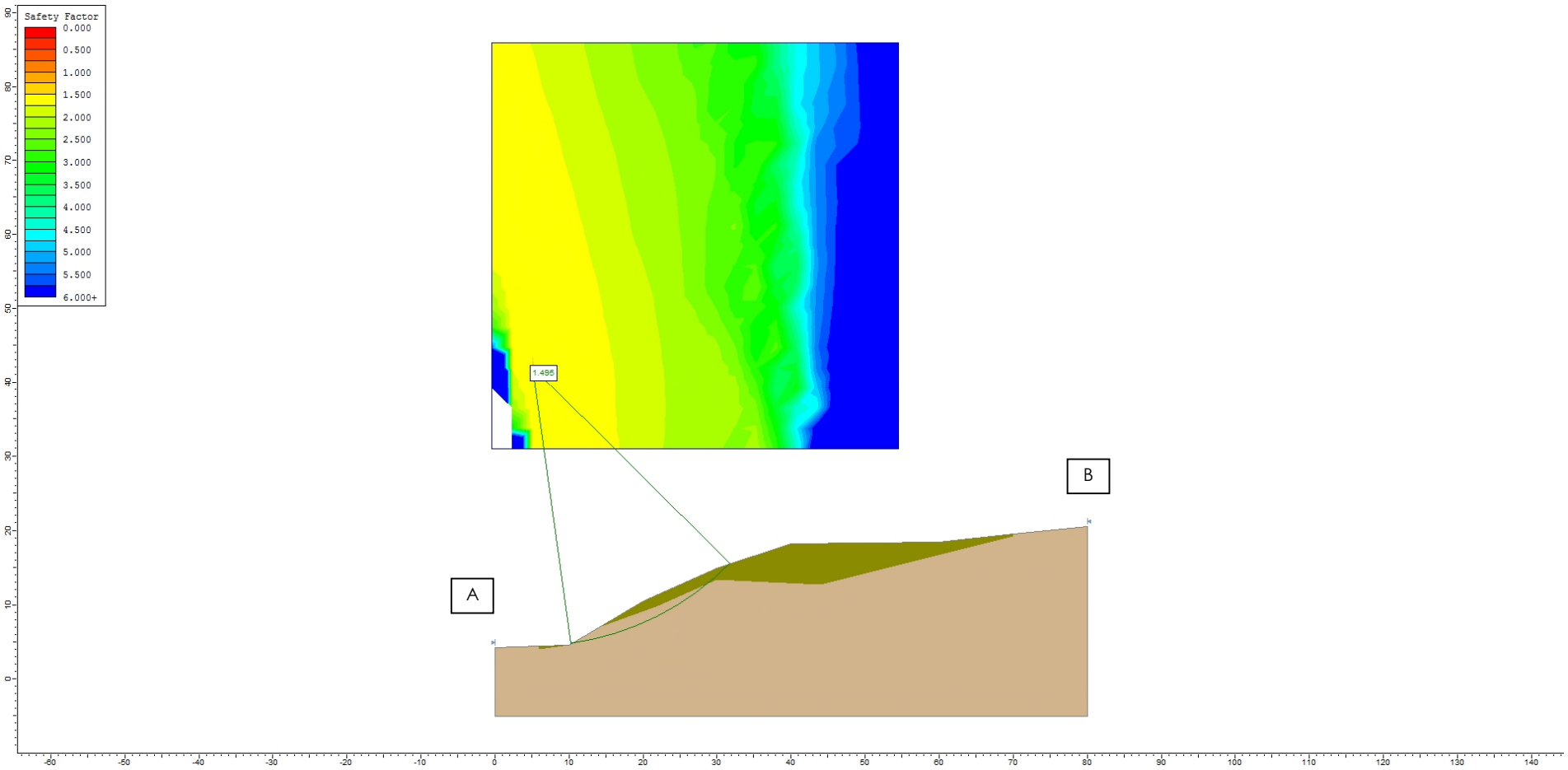
CALCULATION SHEET

REFERENCE NO. 4179

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



P1404179 - Bowling Club Cove. - Section A/B - Martens & Associates - Depth 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 6
Approved:	GT		
Date:	24.06.2014		
Scale:	Not to Scale		Job No: P1404179JR03V01

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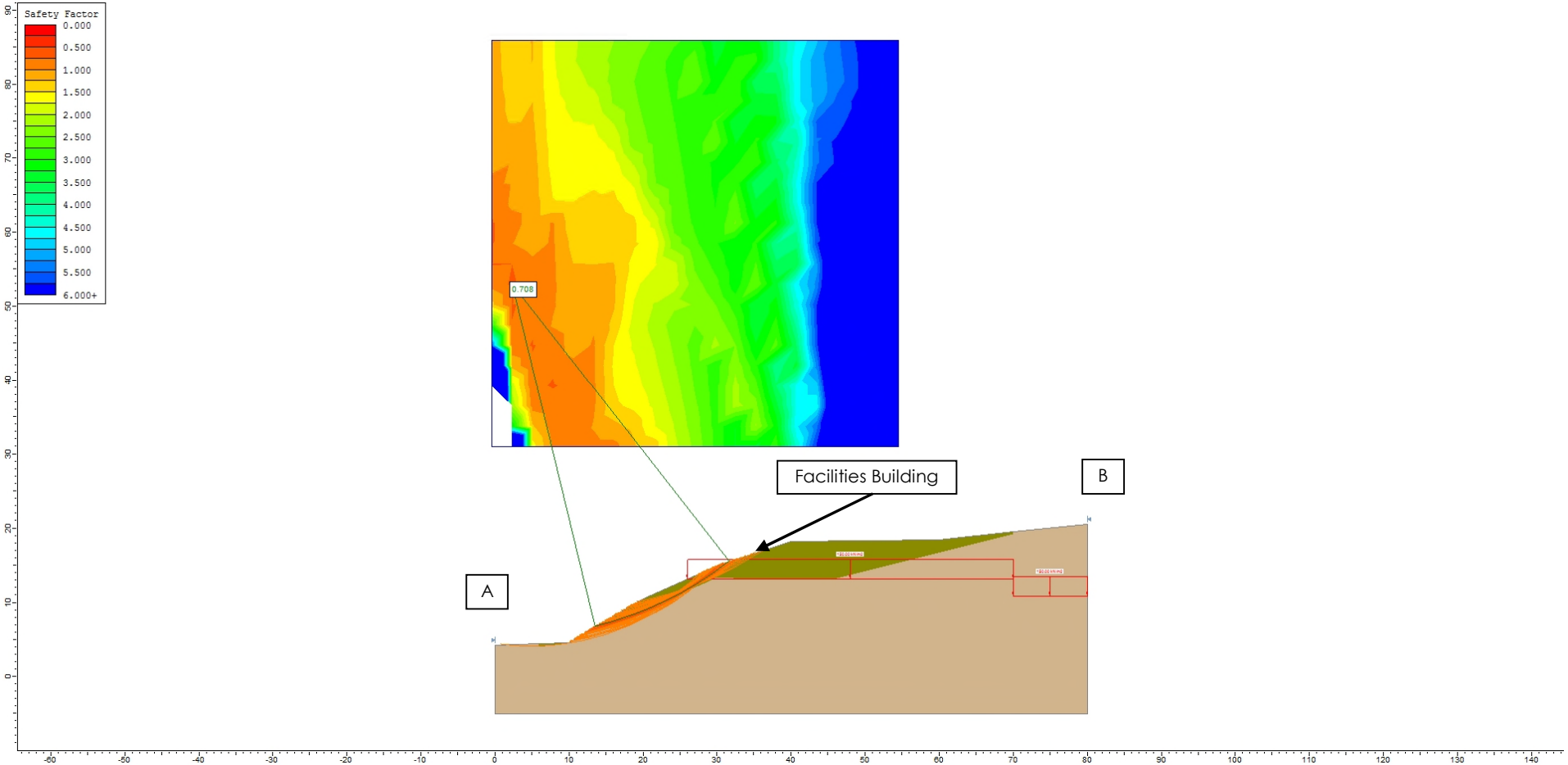

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	AB	**Slide Modeling v6:** **Bayview Golf Course, Bayview, NSW** **Existing Embankment With 150kPa Loading**	Drawing No: FIGURE 7
Approved:	GT		
Date:	24.06.2014		
Scale:	Not to Scale		Job No: P1404179JR03V01

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PITTWATER COUNCIL

Date: Tuesday, 13 May 2014

Pittwater Council
Contact Details
1 Park Street
PO Box 882
MONA VALE NSW 1660
Ph: (02) 9970 1111
Fax: (02) 9970 7150
pittwater_council@pittwater.nsw.gov.au

Address

Acid Sulphate

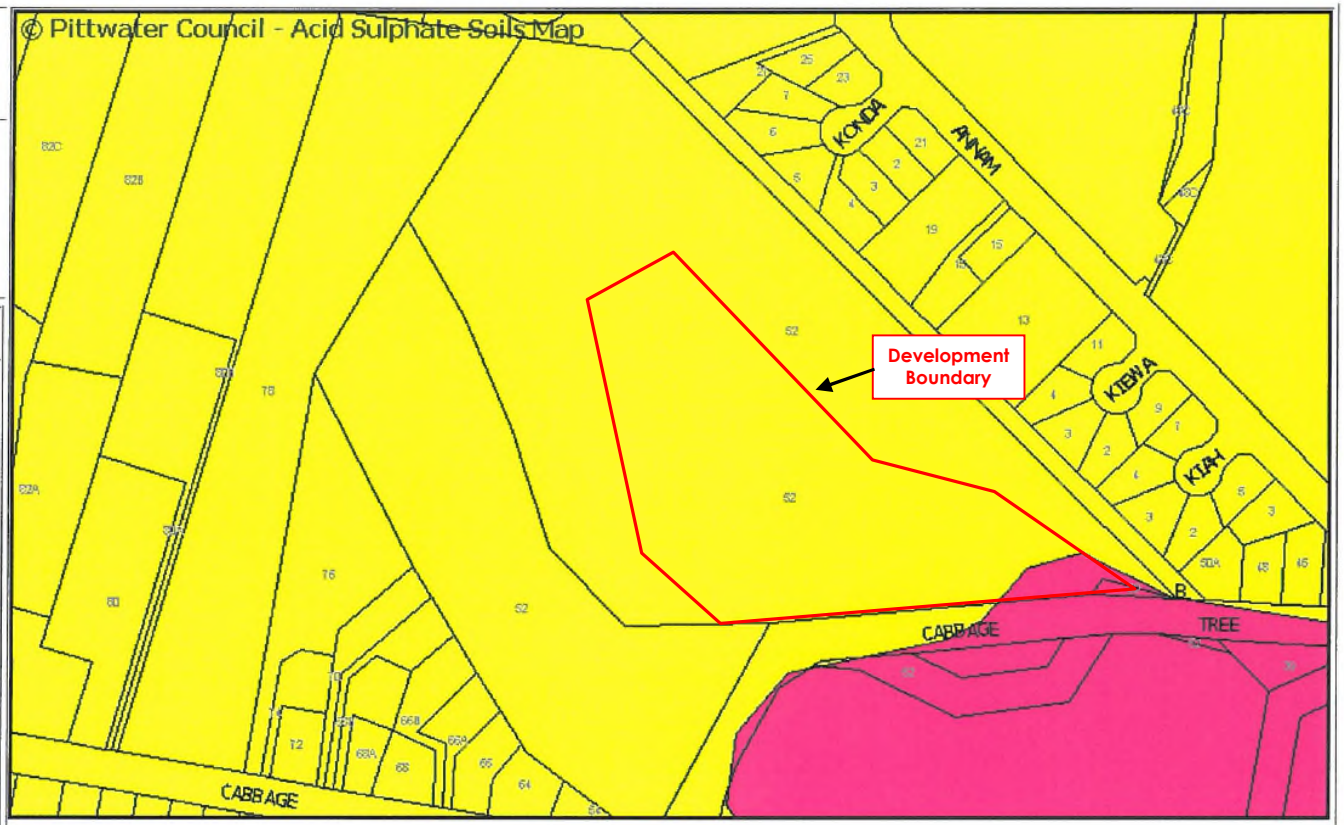
Class 1
- Any works involving the disturbance of soil or the change of groundwater levels.

Class 2
- Works below natural ground surface.
- Works by which the watertable is likely to be lowered.

Class 3
- Works beyond 1 metre below natural ground surface.
- Works by which the watertable is likely to be lowered beyond 1 metre below natural ground surface.

Class 4
- Works beyond 2 metres below natural ground surface.
- Works by which the watertable is likely to be lowered beyond 2 metres below natural ground surface.

Class 5
- Works within 500 metres of adjacent Class 1, 2, 3 or 4 land which are likely to lower the watertable below 1 metre AHD on adjacent Class 1, 2, 3 or 4 land.



martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	AB	**Pittwater Council – Acid Sulphate Soils Map**	Drawing No: FIGURE 8
Approved:	GT		
Date:	24.06.2014		
Scale:	Not to Scale		Job No: P1404179JR03V01

8 Attachment B – Borehole 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 2.0 2.3			Cl	CLAY - Medium plasticity, brown with light brown, red/orange mottles.			A A A	1.0 1.5 2.0	- FILL 4179/101/ 1.0 4179/101/ 1.5 4179/101/ 2.0
V	Nil	N	M	3.0 3.2			CL	CLAY - Medium plasticity, brown/orange, yellow, trace gravels (2-30mm, 5%).			A	2.5	- FILL 4179/101/ 2.5
V	Nil	N 5.0 Y	M W	4.0 5.0 5.8			CH	Silty CLAY - High plasticity, black, dark brown, minor organics.	F-St		A A A A	3.5 4.0 4.5 5.5	4179/101/ 3.5 4179/101/ 4.0 4179/101/ 4.5 4179/101/ 5.5
V	Nil	Y	W	6.0 6.2				SANDSTONE - Inferred extremely low strength, red/brown, fine to medium grained, extremely weathered.			A	6.0	4179/101/ 6.0 - V Bit refusal at 6.2m.
				7.0 8.0 9.0				V-bit refusal on inferred very low strength sandstone at 6.2m.					

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
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.
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.					

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 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.					2.0
				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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mail@martens.com.au WEB: http://www.martens.com.au

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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

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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 1.5			CL	CLAY - Low to medium plasticity, light brown/orange, with sand.	F-St		A A A	0.5 1.0 1.5	- RESIDUAL 4179/105/ 0.5 4179/105/ 1.0 1.0 4179/105/ 1.5 - V Bit refusal at 1.5m.
TC	Nil	N	M	2.0 2.5				SANDSTONE - Inferred extremely low strength, red/brown, extremely weathered.					2.0
				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	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 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	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 4179/107/ 4.5 4.0 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

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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 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
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- 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 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 3.0 2.0 4.0 5.0
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on Inferred 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

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Engineering Log - Borehole

9 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	8	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		6		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		1.55 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 @					19			
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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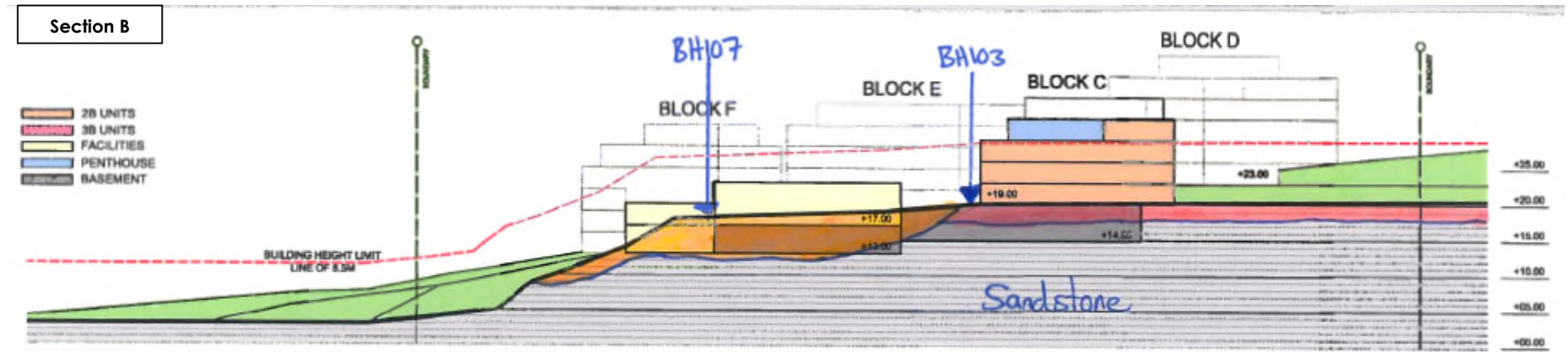
Site	Cabbage Tree Road, Bayview, NSW		
Client	PLANIX Projects		
Logged by	GMT/AB	**Date Logged**	4.6.14
Checked by	GT	**Date Checked**	24.6.14
Comments			

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									

10 Attachment D – Geological Site Sections



Key

Fill Material

Silty Sand overlying Clay

Sandstone

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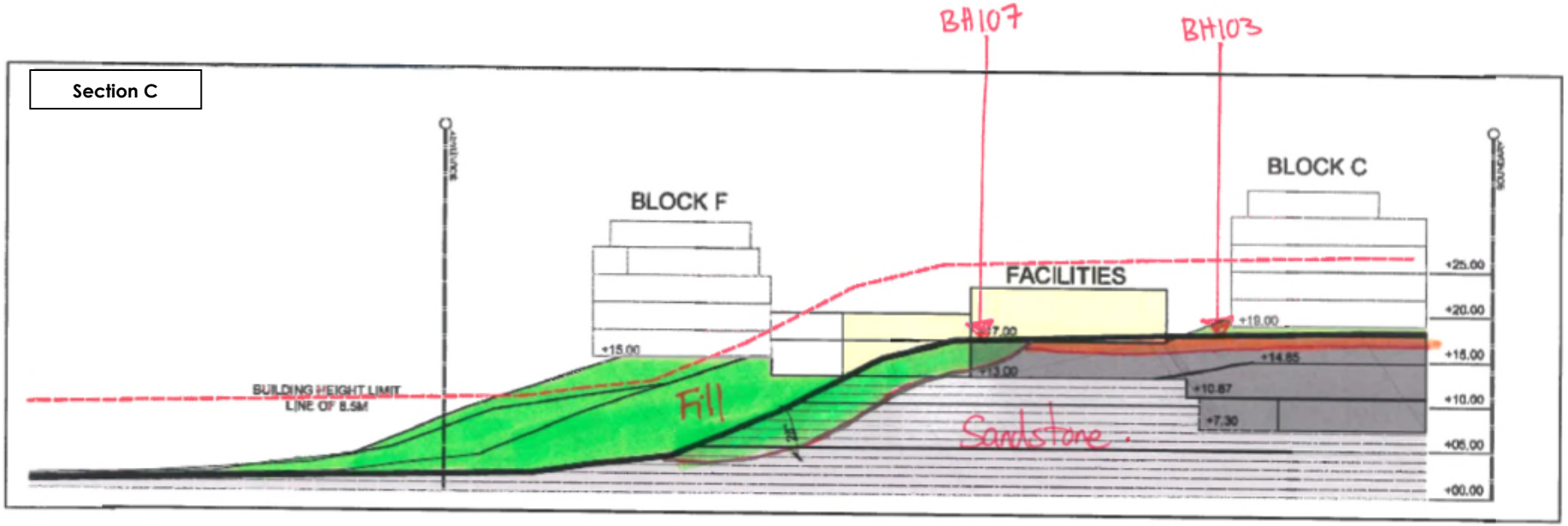
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GMT	**GEOLOGICAL CROSS SECTION** **Cabbage Tree Road, Bayview, NSW**	Drawing No: **Figure 9**
Approved:	GT		
Date:	05 June 2014		
Scale:	N.A.		Job No: P1404179



Key

Fill Material

Silty Sand overlying Clay

Sandstone.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GMT	**GEOLOGICAL CROSS SECTION** **Cabbage Tree Road, Bayview, NSW**	Drawing No: **Figure 10**
Approved:	GT		
Date:	05 June 2014		
Scale:	N.A.		Job No: P1404215

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11 Attachment E – Geotechnical Risk Calcuations

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

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PROJECT DETAILS

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

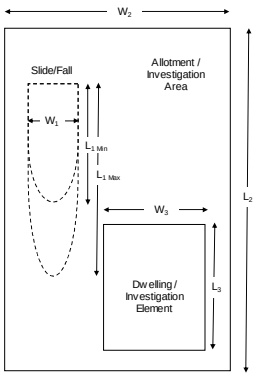
STEP 1 : ENTER SITE AND DESIGN DATA

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

$P_{(S:H)}$	Probablity 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_{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)	**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

martens

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

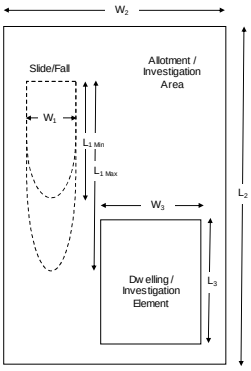
STEP 1 : ENTER SITE AND DESIGN DATA

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	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

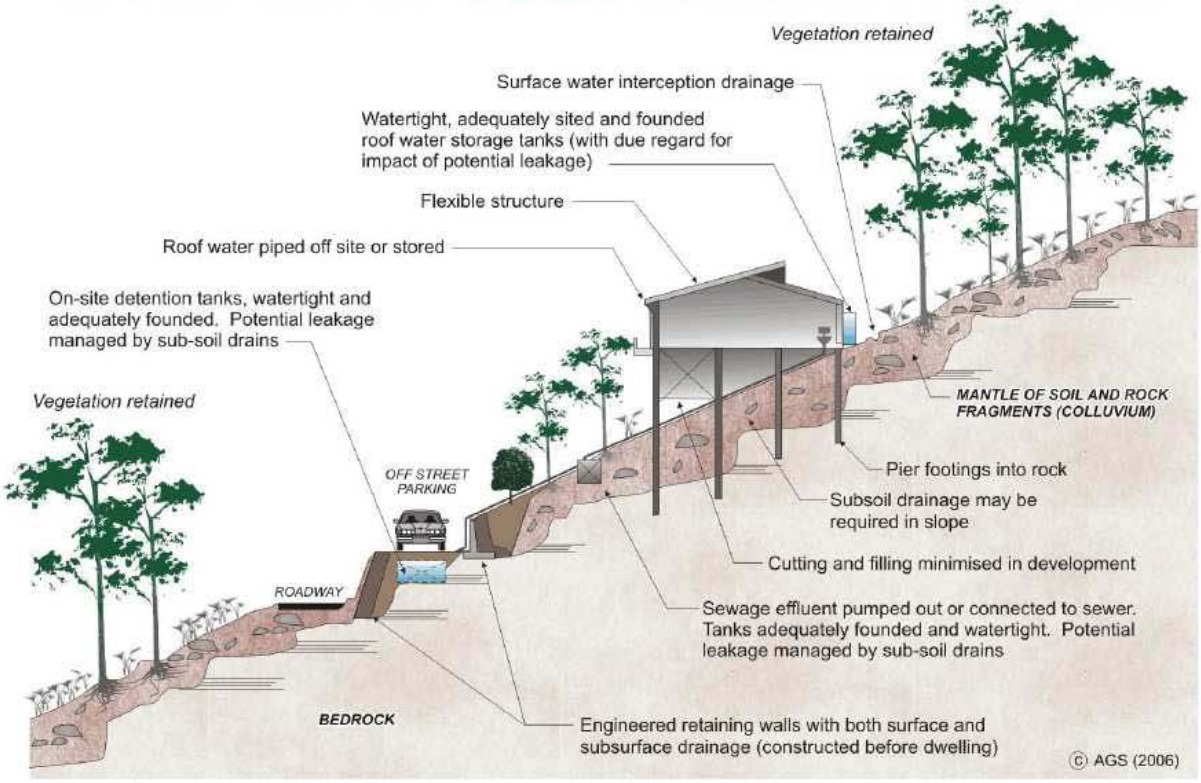
$V_{(D:T)}$	Risk (annual probability of loss of life of an individual)	**9.42E-07**
Risk Assessment		**Acceptable risk for loss of life for the person(s). Risk level suitable for new developments.**

Attachment F – Hillside Construction Guidelines (AGS, 2007)

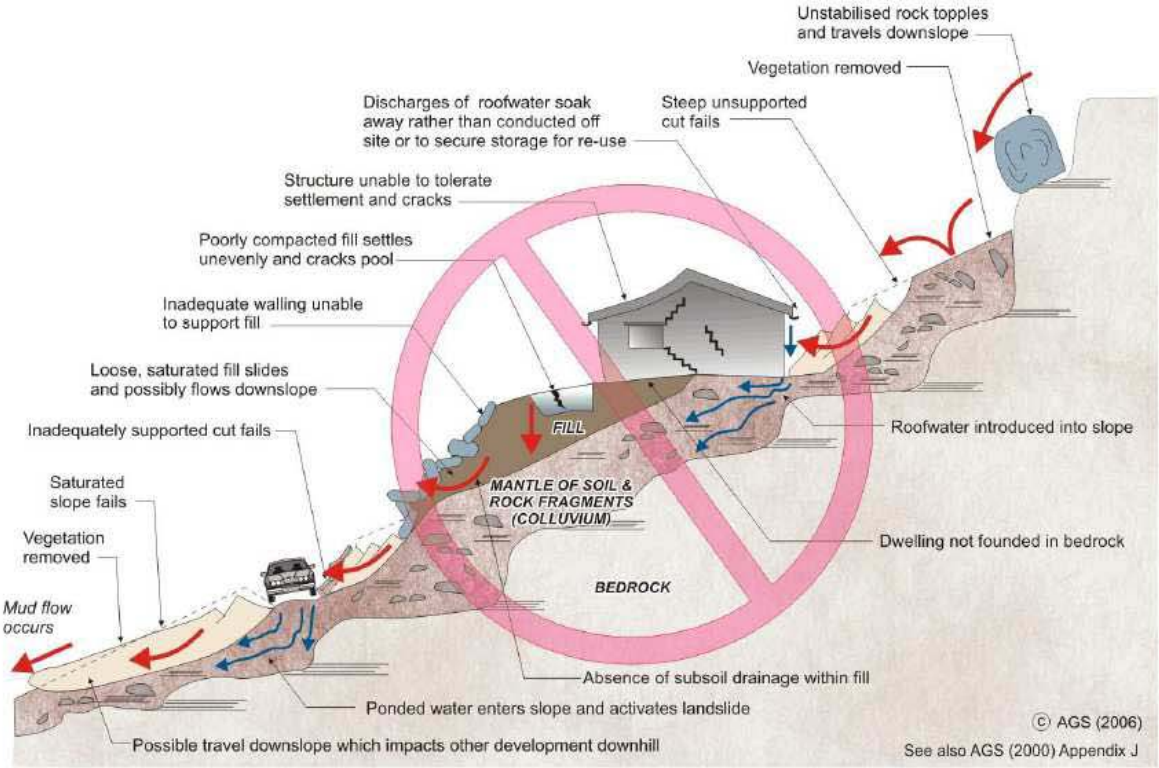
APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	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



EXAMPLES OF POOR HILLSIDE PRACTICE



Attachment G – Laboratory Results

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SOIL ANALYSIS CHAIN OF CUSTODY FORM

Additional Testing

Name	P1404179 – Bayview Golf Club										
Martens Contact Officer	Adam Budji				**Contact Email**	gtaylor@martens.com.au & abudji@martens.com.au					
Sampling and Shipping	**Sample Date**	20.5.14		**Dispatch Date**	21.5.14	**Turnaround Time**			standard		
	Our Reference	P1404179			**Shipping Method (X)**	**Hand**		**Post**		**Courier**	X
	On Ice (X)	X	**No Ice (X)**		**Other (X)**						

Laboratory

Name	EnviroLab							
Sample Delivery Address	12 Ashley Street, Chatswood							
Delivery Contact	**Name**	Aileen	**Phone**	9910 6200	**Fax**		**Email**	ahie@envirolabservices.com.au
Please Send Report By (X)	**Post**		**Fax**		**Email**	X	**Reporting Email Address**	gtaylor@martens.com.au & abudji@martens.com.au

Sample Number	Sample ID	sPOCUS
1	4179/101/0.5	X
2	4179/101/1.0	X
3	4179/101/2.5	X
4	4179/101/3.5	X
5	4179/101/4.5	X
6	4179/102/1.0	X
7	4179/102/2.0	X
8	4179/103/1.5	X
9	4179/103/2.0	X
10	4179/104/0.5	X
11	4179/105/1.0	X
12	4179/106/0.5	X
13	4179/106/1.5	X
14	4179/107/1.0	X
15	4179/107/1.5	X

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200

Job No: 110182
Date Received: 21/5/14
Time Received: 12:45
Received by: JYH
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

Head Office
Unit 6 / 37 Leighton Place
Hornsby NSW 2077, Australia
Ph 02 9476 9999 **Fax** 02 9476 8767

> mail@martens.com.au
> www.martens.com.au
MARTENS & ASSOCIATES P/L
ABN 85 070 240 890 ACN 070 240 890

SOIL ANALYSIS CHAIN OF CUSTODY

Sample Number	Sample ID	sPOCUS
110182 16	4179/107/3.5	X
17	4179/108/2.0	X
18	4179/109/0.5	X
19	4179/110/1.0	X
20	4179/110/1.5	X
21	4179/110/3.0	X

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

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

ACCREDITED FOR TECHNICAL COMPETENCE

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:	UNITS	110182-6	110182-7	110182-8	110182-9	110182-10
Your Reference	----------	4179/102	4179/102	4179/103	4179/103	4179/104
Depth	----------	1.0	2.0	1.5	2.0	0.5
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	4.5	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:	UNITS	110182-16	110182-17	110182-18	110182-19	110182-20
Your Reference	----------	4179/107	4179/108	4179/109	4179/110	4179/110
Depth	----------	3.5	2.0	0.5	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	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 II Duplicate II %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]
ANC_E	% $CaCO_3$	110182-11	<0.05 || <0.05	[NR]	[NR]
a-ANC_E	moles H^+/t	110182-11	<5 || <5	[NR]	[NR]
s-ANC_E	%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.

12 Attachment H – Notes about this Report

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1 – To be submitted with Development Application

Development Application for PLANIX Project
Name of Applicant

Address of site Cabbage Tree Rd. Bayview, NSW

Declaration made by geotechnical engineer or engineering geologist or coastal engineer (where applicable) as part of a geotechnical report

I, Daniel Martens on behalf of Martens and Associates
(Insert Name) (Trading or Company Name)

on this the _____ certify that I am a geotechnical engineer or engineering geologist or coastal engineer as defined by the Geotechnical Risk Management Policy for Pittwater and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least $2million.
I have:

Please mark appropriate box

☒ Prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Geotechnical Risk Management Guidelines and the Pittwater Council Policy

☒ Am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Geotechnical Risk Management Guidelines and the Pittwater Council Policy

☒ Have examined the site and the proposed development/alteration in detail and am of the opinion that the Development Application only involves Minor Development/Alterations that do not require a Detailed Geotechnical risk Assessment and hence my report is in accordance with the Policy requirements for Minor Development/Alterations.

☐ Provided the coastal process and coastal forces analysis for inclusion in the geotechnical report

Geotechnical Report Details:

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

Report Date: June, 2014

Author: Grant Taylor.

Documentation which relate to or are relied upon in report preparation:

Geotechnical Risk Management Policy for Pittwater 2009
Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007)

I am aware that the above geotechnical report, prepared for the abovementioned site is to be submitted in support of a Development Application for this site and will be relied on by Pittwater Council as the basis for ensuring that the geotechnical risk management aspects of the proposed development have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature .....

Name ..... Daniel Martens

Chartered Professional Status ..... CPENG, FIE Aust.

Membership No. ..... 2185379.

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1(a) - Checklist Of Requirements For Geotechnical Risk Management Report for Development Application or Part V assessment

Development Application for PLANIX Project.
Name of Applicant
Address of site Cabbage Tree Rd, Bayview, NSW

The following checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Geotechnical Report. This checklist is to accompany the Geotechnical Report and its certification (Form No. 1).

Geotechnical Report Details:

Report Title: Geotechnical and Acid Sulfate Soils Assessment: Proposed Seniors Living Development, Cabbage Tree Road, Bayview, NSW.
Report Date: June, 2014
Author: Grant Taylor.

Please mark appropriate box

- [x] Comprehensive site mapping conducted 20/05/14 (date)
- [ ] Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- [x] Subsurface investigation required
  - [ ] No Justification .....
  - [x] Yes Date conducted 20/05/14.
- [x] Geotechnical model developed and reported as an inferred subsurface type-section
- [x] Geotechnical hazards identified
  - [ ] Above the site
  - [x] On the site
  - [ ] Below the site
  - [ ] Beside the site
- [x] Geotechnical hazards described and reported
- [x] Risk assessment conducted in accordance with Council's Policy
  - [x] Consequence analysis
  - [x] Frequency analysis
- [x] Risk calculation
- [x] Risk assessment for property conducted in accordance with Council's Policy
- [x] Risk assessment for loss of life conducted in accordance with Council's Policy
- [x] Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater
- [x] Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
- [x] Design Life Adopted:
  - [x] 100 years
  - [ ] Other ..... specify
- [x] Development Conditions to be applied to all four phases as described in Pittwater Geotechnical Risk Management Policy have been specified
- [x] Additional action to remove risk where reasonable and practical have been identified and included in the report.

I am aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for ensuring that the geotechnical risk management aspects of the proposal have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated, and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature .....
Name Daniel Mantans
Chartered Professional Status CPENG, FIE Aust.
Membership No. 2185379.

Information

Important Information About Your Report

Subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all of course, are necessarily relevant to all reports, but are included as general reference.

Engineering Reports - Limitations

Geotechnical reports are based on information gained from limited sub-surface site testing and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Engineering Reports – Project Specific Criteria

Engineering reports are prepared by qualified personnel and are based on the 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 (eg. a three storey building), the information and interpretation may not be relative if the design proposal is changed (eg. 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 that 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 they are not consulted.

Engineering Reports – Recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced and 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 this investigation 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. Attention is drawn to the document 'Guidelines for the Provision of Geotechnical Information in Tender Documents', published by the Institution of Engineers, Australia.

The Company 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 the site assessment and the report 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) 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 the 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 as it relates 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 for 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 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, the Company will be pleased to assist with investigation or 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.

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, the Company 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 report, retain Martens to work with other project professionals who are 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 - Geoenvironmental 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 the Company's proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geoenvironmental 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

Geotechnical 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 recognize 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 is related. 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 based on Australian Standard 1726 and the S.A.A Site Investigation Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

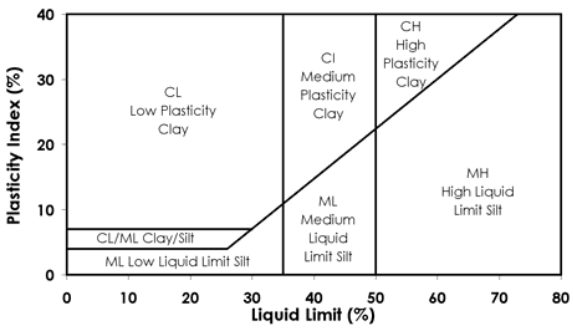
Particle Size

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

Division	Subdivision	Size
BOULDERS		>200 mm
COBBLES		60 to 200 mm
GRAVEL	Coarse	20 to 60 mm
	Medium	6 to 20 mm
	Fine	2 to 6 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties

Plasticity properties can be assessed either 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.
Soft	12 - 25	2 to 4	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail.
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 the results of standard penetration test (SPT) or Dutch cone penetrometer tests (CPT) 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

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, but soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5 % Fine grained soils: < 15 %
With some	Presence easily 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)

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

Soil Data

Explanation of Terms (3 of 3)

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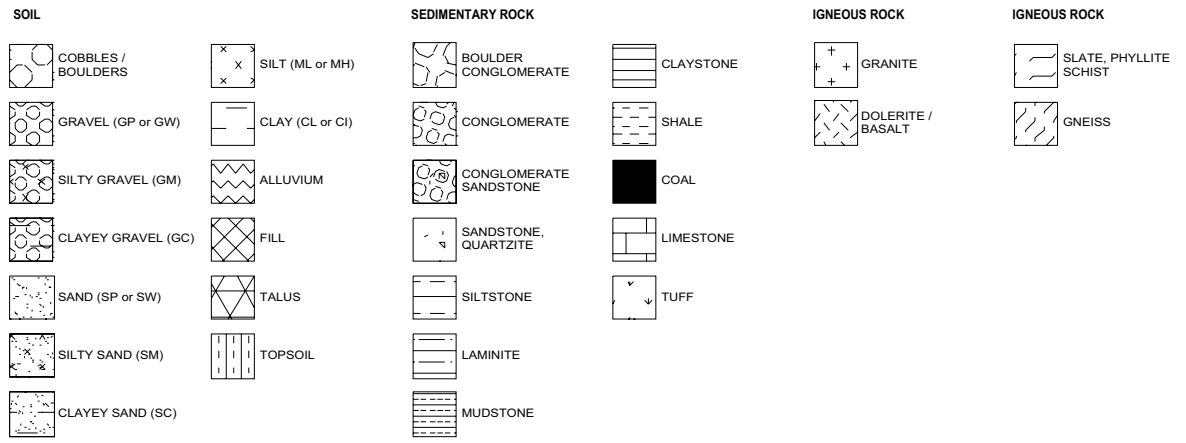
Symbols for Soil and Rock



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, gravely clays, sandy clays, silty clays, lean clays	CL	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

Low Plasticity – Liquid Limit W_L < 35 % Medium Plasticity – Liquid limit W_L 35 to 60 % High Plasticity - Liquid limit W_L > 60 %

Rock Data

Explanation of Terms (1 of 2)

martens consulting engineers

Definitions

Descriptive terms used for Rock by Martens are given below and include rock substance, rock defects and rock mass.

Rock Substance — In geotechnical engineering terms, rock substance is any naturally occurring aggregate of minerals and organic matter which cannot, unless extremely weathered, 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 in rock structure and grain property decline and can be readily determined in the field.

Term	Symbol	Definition
Residual Soil	Rs	Soil derived from the weathering of rock. The mass structure and substance fabric are no longer evident. There is a large change in volume but the soil has not been significantly transported.
Extremely weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - ie. 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	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	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

Rock Strength

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

Term	Is (50) MPa	Field Guide	Symbol
Extremely weak	< 0.03	Easily remoulded by hand to a material with soil properties.	EW
Very weak	0.03 - 0.1	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VW
Weak	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.	W
Medium strong	0.3 - 1	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	MS
Strong	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.	S
Very Strong	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.	VS
Extremely strong	> 10	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	ES

Rock Data

Explanation of Terms (2 of 2)

martens consulting engineers

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 excludes fractures such as drilling breaks.

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

Test Methods

Explanation of Terms (1 of 2)

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 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 sample tube into the 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 Methods

The following is a brief summary of drilling 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 75-100mm in diameter into the ground. The depth of penetration 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 if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) 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 - the hole is advanced by pushing a 100mm 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, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

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 Methods of Testing Soils for Engineering Purposes - Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

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

as 4, 6, 7
N = 13
(ii) In a case 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 50mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

CONE PENETROMETER TESTING AND INTERPRETATION

Cone penetrometer testing (sometimes referred to as Dutch Cone - abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in AS 1289 - Test F4.1.

In the test, a 35mm 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 separate 130mm long sleeve, immediately behind the cone. Tranducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output on continuous chart

Test Methods

Explanation of Terms (2 of 2)

recorders. The plotted results given in this report have been traced from the original records.

The information provided on the charts comprises:
Cone resistance - the actual end bearing force divided by the cross sectional area of the cone - expressed in MPA.
Sleeve friction - the frictional force of the sleeve divided by the surface area - expressed in kPa.
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 (Mpa) = (0.4 to 0.6) N (blows/300mm)

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

q_c = (12 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.

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 - a 16 mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS 1289 - Test F 3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
Cone penetrometer (sometimes known as the Scala Penetrometer) - a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289 - Test F 3.2). The test was developed initially for pavement sub-grade investigations, with correlations of the test results with California bearing ratio published by various Road Authorities.

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.

TEST PIT / BORE LOGS
The test pit / bore log(s) presented herein are an engineering and/or geological interpretation of the sub-surface conditions and their reliability will depend to some extent on frequency of sampling and the method 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 boreholes 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 boreholes, the frequency of sampling and the possibility of other than 'straight line' variation between the boreholes.

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.