Realty Realizations Pty Ltd

Water Cycle Management Report –

Mixed Use Subdivision; West Culburra, NSW

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1203365JR01V04
October 2013

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Head Office
6/37 Leighton Place
Hornsby, NSW 2077, Australia
ACN 070 240 890 ABN 85 070 240 890
Phone: +61-2-9476-9999
Fax: +61-2-9476-8767
Email: mail@martens.com.au
Web: www.martens.com.au

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Author(s)	Reviewer(s)	Project Manager	Signature
Megan Kovelis, Daniel Dhiacou	Andrew Norris	Andrew Norris	

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

Contents

Figures

Tables

1 Introduction

1.1 Overview

This report has been prepared to support a project Concept Approval, with NSW Department of Planning (DoP), for a mixed use subdivision located at Lot 61 DP 755971, and parts of Lots 5, 6 and 7 DP 1065111, Culburra Road, West Culburra, NSW.

It provides an assessment of the proposed development with respect to stormwater management, including water quality and quantity.

1.2 Scope

The scope of this assessment has been developed to address the requirements of the Director General's Environmental Assessment Requirements (DGEARs) with respect to stormwater management in consultation with Shoalhaven Council and NSW Office of Environment and Heritage (OEH).

This report provides:

- Documentation of results of a conceptual water quality assessment.
- Treatment train specification to achieve nominated water quality objectives.
- Assessment of on-site detention (OSD) and stormwater quantity control requirements for the site, including proposed measures to control discharge into adjacent mangrove environment.
- Assess potential impacts of the development on sensitive receiving environments including identified SEPP14 wetlands, seagrass beds and oyster leases.
- Statement of Commitments relating to stormwater management.

Water Quality Monitoring Plan including a Sediment and Erosion Control Plan has been prepared separate to this document (refer to Martens and Associates, October 2013. Ref: P1203365JR03V02).

1.3 Proposed Development

The proposed development includes the following landuses:

- Residential (including Torrens title lots, townhouses and 3-5 storey multiunit development)
- Commercial
- Industrial
- Tourist accommodation
- Retirement village
- Open space

A plan of the proposed development is provided in Attachment A.

1.4 Relevant Planning Controls and Design Principles

The following planning and engineering controls and design principles have been used:

- Shoalhaven City Council (2002) Development Control Plan 100 *Subdivision Code*
- Shoalhaven City Council (2012) Draft Sustainable Stormwater Management DCP
- Landcom (2004) *Soils and Construction 'Managing Urban Stormwater'*
- Neutral or beneficial effect (NorBE) design principle in determining minimum stormwater quality structure requirements

1.5 Agency Consultation

1.5.1 Initial Consultation

The following agencies were contacted as part of consultation completed as part of preparation of this assessment:

- Shoalhaven Council
- NSW Office of Water (NOW)
- NSW Office of Environment and Heritage (NSW OEH)
- DoPI (Fisheries)

Results of initial agency consultation are provided in Attachment H.

1.5.2 EA Submission Consultation

Subsequent to submission of the Environmental Assessment (EA) a number of agencies and stakeholders provided comments relevant to this assessment. These are summarised as:

- All development, including water quality treatment structures, is to be excluded from the 7(a) Environmental Protection zone.
- The water quality monitoring regime was considered inadequate.

A stakeholder meeting was held on August 13, 2013 and attended by:

- Local oyster farmers
- Australia's Oyster Coast Inc.
- NSW Food Authority
- Southern Rivers Catchment Management Authority (CMA)
- Shoalhaven Water
- Shoalhaven City Council (SCC)
- NSW Environmental Protection Authority (EPA)
- NSW Fisheries
- NSW Office of Environment and Heritage (OEH)

- The applicant, Martens and Associates, and Allen Price and Associates representatives.

Outcomes from the stakeholder meeting resulted in a layout redesign and subsequent remodelling of various aspects of the proposed development, particularly water quality modelling. The Water Quality Monitoring Plan and Sediment and Erosion Control Plan are now part of a seperate document (Martens and Associates, 2013 P1203365JR03V02) that provides a detailed outline of monitoring requirement pre, during and post construction.

1.5.3 Ongoing Consultation

During the August stakeholder meeting, the 'Culburra Development-Stakeholder Liaison Group' was formed and it was resolved that subsequent meetings would be held to facilitate additional stakeholder and agency comment and input into various aspects of the proposed development.

During the September meeting of the Group, the draft Water Quality Monitoring Plan was reviewed and discussed. Comments relating to monitoring and water quality treatment requirements were incorporated into project design and documentation.

2 Site Description

2.1 Location and Existing Landuse

The study area is located on the northern side of Culburra Road, West Culburra, within the Shoalhaven City Council local government area (LGA). The study area consists of the following lots:

- Lot 61 DP 755971
- Part Lot 5 DP 1065111
- Part Lot 6 DP 1065111
- Part Lot 7 DP 1065111

The study area covers an area of approximately 109 ha and consists of undeveloped vegetated land and some agricultural areas in Lot 5 DP 1065111 and Lot 61 DP 755971 (Figure 1).

2.2 Physiography and Hydrology

Majority of the site is elevated >5 mAHD above the Crookhaven River estuary. Immediate foreshore areas are moderately steep and transitional between the subject site and the estuary. Relief across the site is approximately 20 m. The landscape is gently undulating with slopes ranging between 2.5 – 6.0 %, with some areas of localised over steepening typically associated with drainage lines.

The site of the proposed subdivision lies on a ridgeline and associated northern side slopes discussed above, except for an area of Lot 5 which lies on the southern side of the ridge line.

Site drainage ranges from good to poor across the site, with poor draining areas characteristically associated with lower points of elevation within the landscape. Site drainage likely consists of both infiltration and overland flow (sheet and concentrated).

2.3 Lithology and Soil Landscapes

Reference to the 1:250,000 Wollongong Geological Series Sheet indicates the site lies upon Wandrawandian Siltstone, a member of the Shoalhaven Group. Wandrawandian Siltstone is dominated by siltstone and silty sandstone lithologies, and is pebbly in parts. Immediate foreshore areas of the site, adjacent to Crookhaven River Estuary consist of Quaternary sedimentary units of gravel, sands, silts, and clays

of marine to freshwater environments, and likely overlie Wandrawandian Siltstone in these areas.

Hazelton (1992) indicates that soils within the investigation area belong predominantly to the Greenwell Point Soil Landscape Group. Soils are primarily derived from *in-situ* weathering of the underlying Wandrawandian Siltstone. Soils are characteristically shallow (<50 cm) to moderately deep (50-100 cm) Loams to Yellow Podzolic Soils or Red Solodic Soils.

Soil mapping completed by Hazelton (1992) suggests that the eastern periphery of the site may contain the Seven Mile Soil Landscape group. This soil landscape group is estuarine, and comprises deep (> 1.5 m) Siliceous Sands, Acid Peats, and Humus Podzols. This landscape was not observed during field investigations (November 22, 2010).

2.4 Hydrogeology

Groundwater was observed during intrusive investigations at the site (November 22, 2010). More detailed investigation of groundwater is presented in Section 3.

3 Groundwater Assessment

3.1 Overview

This assessment has been prepared to satisfy issue 7.5 of the Director General Requirements (DGRs) (NSW DoP, 27.05.2010). It documents aquifer characteristics, assesses likely impacts associated with site development, and assesses the requirement for mitigation measures that aim to prevent adverse groundwater impacts.

3.2 Field Investigations

Field investigations for the Groundwater Assessment were undertaken between 22.11.2010 and 26.11.2010 and included the following:

- Site walkover.
- Completion of 26 boreholes with a truck mounted hydraulic auger.
- Completion of 8 of the 24 boreholes as Groundwater Monitoring Bores (GMBs).
- Monitoring of groundwater levels within GMBs.
- Rising/falling head tests to estimate hydraulic conductivity (k) at 7 of the 8 GMBs.
- Collection of 3 groundwater samples for laboratory analysis.

3.3 Groundwater Conditions

3.3.1 Water Bearing Strata

Aquifer layers are broadly classed as follows:

1. Residual clay:
    - Comprised of clay that extends from near natural surface level (typically 0.3 mBGL) to depths generally of the order of 1.3 mBGL.
    - Characterised by low hydraulic conductivity (K).
    - Generally unconfined.

- Base of layer comprises extremely weathered siltstone.
- Permanent groundwater is likely to only exist in areas with relatively low grades. Other areas may contain ephemeral groundwater (non-permanent) or remain generally unsaturated.
- The majority of boreholes within this stratum were drilled dry. We note that drilling works were undertaken in late November, 2010 and that this month had above average rainfall.
- Flow vectors are expected to generally mimic the surface topography.
- During fieldworks groundwater levels varied from approximately 0.15 mBGL to dry.

2. Siltstone:

- Water bearing zones in the aquifer were observed at weathered siltstone from 3.2 to 4.2 mBGL (BH1), 6.5 to 7.0 mBGL (BH2) and 3.3 to 6.5 mBGL (BH6). We note that shallow GMBs installed immediately adjacent to GMB1 and GMB2 verify that this aquifer layer is confined.
- Characterised by low hydraulic conductivity (K).
- During field works groundwater head levels for this layer varied from 1.41 to 0.62 mBGL.
- Confinement at GMB2 is likely to be associated with geological bedding in the vicinity of the GMB as this GMB was drilled on-top of a knoll and still displayed evidence of confinement.

3.3.2 Hydraulic Conductivity (K)

Site K testing to date (Table 1)indicates that the aquifer(s) are of low permeability. Refer to Figure 2 for GMB locations.

Table 1: Summary of aquifer K testing results.

GMB	Test Medium	Estimated K (m/d)
1	Clay/Extremely Weathered Siltstone	0.057
1a	Clay	0.035
2	Clay/Extremely Weathered Siltstone	0.043
3	Clay/Extremely Weathered Siltstone	0.004
4	Clay/Extremely Weathered Siltstone	0.004
5	Extremely Weathered Siltstone	0.008
6	Clay/Extremely Weathered Siltstone	0.007
Geometric mean	Clay/Extremely Weathered Siltstone	0.013
Median		0.008
Mean		0.023

Notes:

1. Results based on Martens and Associates testing completed on 22.11.2010 and 23.10.2010.

2. Test type = rising head for GMB1, GMB1a, GMB2 and GMB6. Falling head for GMB3, GMB4 and GMB5 as these GMBs were dry. All data analysed using the Hvorslev (1981) method.

3.3.3 Groundwater Level Measurements

Manual groundwater level measurements taken to date are summarised in Table 2.

Table 2: Manual groundwater level measurements.

		Groundwater Levels (mAHD) Recorded by Martens and Associates				
			23.11.2010 [2]	24.11.2010 [2]	25.11.2010 [2]	26.11.2010 [2]
GMB ID	Aquifer Layer [1]	GMB Surface Level	mAHD	mAHD	mAHD	mAHD
1	Siltstone (confined)	6	5.38	5.38	5.34	5.31
1a	Residual clay (unconfined)	6	-	4.84	4.93	4.97
2	Siltstone (confined)	22	20.8	20.71	20.63	20.59
2a		22	-	Dry	Dry	Dry
3		15	Dry	Dry	Dry	Dry
4		8	Dry	Dry	Dry	Dry
5		8	Dry	Dry	Dry	Dry
6	Siltstone (confined)	5	-	-	4.87	4.86

Note:

[1] GMB – groundwater monitoring bore.

[2] Level approximate mAHD based on Allen, Price and Associates survey (Ref: 25405-02)

3.3.4 Groundwater Quality

Groundwater quality samples were taken from GMB1, GMB2 and GMB6. Results for key analytes are summarised (Table 3) with full laboratory report in Attachment G. Results indicate:

- Groundwater is acidic.
- Groundwater is fresh at GMB2, brackish at GMB1 and saline at GMB6.
- Nutrient levels are low.

Table 3: Preliminary groundwater quality results.

GMB ID	Date Sampled	pH	EC	TDS (grav)	Total Nitrogen	Total Phosphorus
		pH Units	µS/cm	mg/L	mg/L	mg/L
1	**25.11.2010**	5.2	4,900	2,900	0.7	<0.5
2	**25.11.2010**	5.1	250	180	0.4	<0.5
6	**26.11.2010**	5.6	18,000	13,000	0.3	<0.5

3.3.5 Groundwater/Surface Water Interaction

Interaction of groundwater from the upper unconfined aquifer with surface water is expected to be minimal given the majority of site boreholes and GMBs did not encounter water.

3.3.6 Groundwater Dependent Ecosystems (GDEs)

GDE mapping is outside the scope of this assessment. It is understood that the site's ecological consultant (SLR Consulting) is addressing GDE distribution.

3.4 Groundwater Impact Assessment

3.4.1 Resource Use

Review of the NSW Natural Resource Atlas (Figure 3) indicates that there are no licensed bores in the vicinity (3km) of the site.

3.4.2 Potential Impacts

1. Altered groundwater recharge

The proposed-development has the potential to alter groundwater flow to downslope areas which may contain GDEs. The groundwater flow regime has the potential to be altered as follows:

- Impervious areas shall increase resulting in reduced groundwater recharge.
- Land currently occupied by forest/woodland vegetation shall be cleared and replaced by a landscape predominantly comprised of grass in pervious areas and no vegetation in impervious areas. Grass vegetation shall exhibit lower evapotranspiration (ET) than the ET

associated with the existing forest/woodland vegetation. This reduction in ET has the potential to increase groundwater recharge rates.

- The balance of the above effects will determine if groundwater recharge is increased or reduced due to the proposed development.

2. Groundwater quality

Groundwater quality is not expected to be adversely impacted by surface water run-off from the proposed development provided discharge waters (derived from site surface water run-off) have undergone an appropriate level of treatment.

3. Potential acid sulfate soils (PASS)

SPOCUS testing indicates that site soils are acidic and that they do not increase in acidity once oxidised. Based on the above, and given that site soils are residual (i.e. not estuarine sediments associated with ASS), risks associated with PASS or ASS soils are low.

3.4.3 CLASS-U3M-1D (Unsaturated Moisture Movement Model)

3.4.3.1 Overview

The CLASS soil moisture model developed by eWater Cooperative Research Centre (CRC) is used to assess site groundwater recharge for existing and developed conditions. The model utilises site rainfall and evaporation data together with soil profile properties to assess the net recharge to groundwater.

In consultation with eWater Cooperative Research Centre it was confirmed that the CLASS model was appropriate for this application as follows:

- Groundwater flow is ephemeral and therefore not suited to modelling with conventional groundwater models such as MODFLOW.

- The conceptual hydrogeological model is suited to CLASS as the soil/rock interface layer has low slope and soil stratigraphy is not overly complex.

- Long-term climate data is considered important for the model simulation and CLASS is run using a long-term daily climate file.

- Catchment and soil science experts of the eWater Cooperative Research Centre previously indicated that the model was suitable for a site with a similar hydrogeological setting (Mundamia Urban Release area).

3.4.3.2 Inputs

Input parameters used in the model are summarised in Table 4.

Table 4: CLASS input parameters.

Element	Input
Soil Layers	2
Soil Layer Depth (mBGL)	Layer 1 – sandy loam (0 – 0.3), Layer 2 – clay (0.3 – 1.3)
Soil Parameters	CLASS default soil catalogue parameters for nominated soil types
Soil K (m/d)	Layer 1 – 1.061, Layer 2 – 0.048
Ksub (m/d) [1]	0.048
Climate file	Daily 50 yr rain and evaporation file derived from NOWRA RAN BOM station
Vegetation	Tree (CLASS default properties) for existing conditions, pasture (CLASS default properties)

Notes:

[1]. A Ksub value of 0.048 m/d was assigned so that flux out of the bottom soil layer could be considered as seepage.

3.4.3.3 Results

Total seepage flux (Table 5) determined by the CLASS modelling system indicates a groundwater recharge rate of 48 mm/year for existing conditions. When forest is replaced by grass, this increases to 112 mm/year. Considering recharge doesn't occur beneath impervious surfaces and pervious 'grassed' surface shall be 60% of the developed site the overall groundwater recharge for developed conditions is estimated at 67 mm/year (60% x 112 mm/year).

Whilst results indicate a minor increase to groundwater recharge we note that CLASS modelling for developed conditions assumed uniform grass cover. Whist developed pervious areas shall be dominated by grass, a small proportion of trees shall remain or be planted. Consequently, ET in the developed condition is likely to be slightly higher than modelled value and therefore changes to groundwater recharge due to the proposed development are likely to be negligible.

Table 5: CLASS results summary.

	Forest CLASS model result	Grassed CLASS model result	Developed conditions CLASS model accounting for impervious surfaces
Average annual groundwater recharge (mm/yr)	48	112	67

3.4.3.4 Impact Assessment

Results indicate that groundwater recharge will not be significantly altered due to the proposed development. Consequently, no mitigation measure is required to address changes to groundwater recharge.

3.5 Conclusions and Recommendations

- The site contains two low permeability aquifers, being an unconfined shallow clay aquifer and a deeper confined aquifer in rock.
- The shallow clay aquifer was observed in 1 of the site's 8 GMBs within approximately 1 m of the land surface in a low lying area of the site. Consequently, it is anticipated that shallow ephemeral aquifers shall exist in local drainage depressions.
- The deeper confined aquifer was observed in 3 of the site's 8 GMBs. This aquifer is confined by siltstone which typically occurs at a depth of approximately 1.3 mBGL. The water bearing zones for this aquifer are thought to comprise extremely weathered siltstone or clay seams. Water bearing zones were considered to be from 3.2 to 4.2 mBGL (BH1), 6.5 to 7 mBGL (BH2) and 3.3 to 6.5 mBGL (BH6).
- Groundwater was not observed within 4 of the site's 8 GMBs.
- Shallow aquifer(s) beneath the site are likely to be ephemeral (i.e non-permanent) in some areas, non-existent in others and permanent in low lying areas and areas with low grades.
- If shallow excavations (road pavements, service trenches and shallow footings) are proposed it is likely that works may intersect the shallow unconfined aquifer. This is to be assessed and managed through future construction works.

- The aquifers beneath the site are of low value to stakeholders (ecological and anthropogenic) given their low yield, limited distribution and ephemeral nature.

- Groundwater recharge will not be significantly altered due to the proposed development. Consequently, no mitigation is required to address changes to groundwater recharge which may impact downslope vegetation.

- In principle, groundwater is not expected to constrain site development. However, from a geotechnical perspective it is recommended that the findings in this report are considered for site engineering purposes.

4 Water Quality Assessment

4.1 Overview

This water quality assessment determines treatment measures required to achieve adopted water quality objectives. It allows for a general specification of water quality structures, and will require refinement at detailed design stage.

Given the site's location and the sensitive nature of downstream ecosystems, this assessment shall ensure compliance with water quality objectives at the following receiving environments (Figure 1):

- SEPP 14 Wetlands between Billy's Island and the site
- Seagrass and oyster leases fringing the foreshore to the north east and north west of the site
- Curleys Bay
- Crookhaven River
- Lake Wollumboola

4.2 Water Quality Objectives

Element RE12 '*Water Quality Management*' of Shoalhaven Council's DCP 100 (2002) requires that proposals aim to ensure:

> *'existing downstream environments are not adversely affected and no net increase in pollution levels discharging from the development'*.

During consultation with Shoalhaven Council's subdivision engineer (March 14, 2012), it was noted that a draft '*Sustainable Stormwater Management DCP'* was being prepared. If adopted the following pollutant retention (i.e. treated versus untreated) objectives would apply:

- 90% of gross pollutants
- 85% of total suspended solids (TSS)
- 65% of total phosphorus (TP)
- 45% of total nitrogen (TN)

- 90% of total hydrocarbons

Based on consultation with Shoalhaven Council and NSW OEH, project water quality objectives are adopted as follows:

- NorBE (neutral or beneficial) - pollutant loads in the post development scenario that are equal to or less than those currently generated from the site.

- Treatment train effectiveness will be designed to achieve the draft DCP (2012) requirements for pollutant retention.

Water quality objectives are adopted for all receiving environments (Section 4.1).

4.3 Modelling Methodology

4.3.1 Overview

The Model for Urban Stormwater Improvement Conceptualisation (*MUSIC*, Version 5.1) developed by the CRC for Catchment Hydrology was utilised to evaluate pre and post development pollutant loads from the site.

Modelling has been undertaken in accordance with *Draft NSW MUSIC Modelling Guidelines* (BMT WBM, 2010).

The following modelling scenarios were considered:

1. Pre Development – the existing site.

2. Post Development (untreated) - the developed site without water quality structures.

3. Post Development (treated) – the developed site with water quality structures included to achieve adopted objectives.

Pre and post development MUSIC model layouts are provided on Sheet 4 and 5 of Attachment A.

4.3.2 Approach

An iterative approach was used for post development modelling to determine appropriate types, sizes and locations of stormwater treatment devices for the site to achieve adopted objectives.

4.3.3 Climate Data

Rainfall data was sourced from Nowra RAN from 1964 – 1970 in accordance with the NSW MUSIC guidelines. Average monthly areal potential evapotranspiration (PET) was sourced from *'Climatic Atlas of Australia – Evapotranspiration'* (Bureau of Meteorology, 2001).

4.3.4 Input Parameters

Input parameters for source and treatment nodes are consistent with the *Draft NSW MUSIC Modelling Guidelines* (BMT WBM, 2010). Attachment B summarises input parameters.

4.3.5 Catchment Areas

Pre and post development catchment areas and pervious/impervious areas of each catchment are provided in Attachment D. A ridge forming the catchment boundary between Lake Wollumboula and the Crookhaven River runs along the southern edge of the development area.

The following should be noted with regards to catchment areas:

- Development north of the ridgeline discharges north to the Crookhaven River as with existing hydrology.
- Where development occurs south of the ridgeline (small portion of the collector road, the industrial subdivision in the site's east and residential development in the site's east), runoff shall be directed to the Crookhaven River by road drainage networks.
- Only the proposed oval (Catchment C4) and the proposed new roundabout intersection along Culburra Road shall discharge south to Lake Wollumboula. They are therefore modelled and assessed separately to ensure water quality objectives are met for each receiving environment.
- The catchment area draining to the SEPP14 wetlands between Billys Island and the site was determined for the post development based on maintaining wetland hydrology (Section 5.4).
- This wetland outlet was assessed independently and as part of the total Crookhaven River catchment, to assess water quality impacts on the wetlands.

- Outlets into the Crookhaven River, excluding the wetland outlet, were assessed to determine the impacts on fringing seagrass and oyster leases.

- The Curleys Bay outlet was assessed independently due to its identified significance by NSW DoPI (Fisheries).

- For both the industrial and the roundabout area, results were compared to an equivalent area of pre-development 'forest' area to ensure that water quality objectives are met by these individual catchments (see Section 4.4.7).

- All residential/accommodation development catchments have been split into 'roof', 'road' and 'remaining' sub-catchments. The cumulative areas of each of these sub-catchments are based on the catchment area, the proposed landuse and the proposed site coverage (Attachment A).

4.3.6 Model Parameters

Event Mean Concentration (EMC) inputs were derived from Sydney Metropolitan Catchment Management Authority (SMCMA) (2010) *'Draft NSW MUSIC Modelling Guidelines'*

Table 6: Adopted EMCs for source nodes.

		Base Flow (mg/L)		Storm Flow (mg/L)	
Land Use	**Parameter**	**Log (mean)**	**Log (stdev)**	**Log (mean)**	**Log (stdev)**
Roof	TN	na	na	0.300	0.190
	TP	na	na	-0.890	0.250
	SS	na	na	1.300	0.320
Agricultural	TN	0.040	0.130	0.480	0.260
	TP	-1.050	0.130	-0.220	0.300
	SS	1.300	0.130	2.150	0.310
Residential	TN	0.110	0.120	0.300	0.190
	TP	-0.850	0.190	0.600	0.250
	SS	1.200	0.170	2.150	0.320
Forest	TN	-0.520	0.130	-0.050	0.240
	TP	-1.520	0.130	-1.100	0.220
	SS	0.780	0.130	1.600	0.200
Commercial	TN	0.110	0.120	0.300	0.190
	TP	-0.850	0.190	-0.600	0.250
	SS	1.200	0.170	2.150	0.320
Sealed roads	TN	0.110	0.120	0.340	0.190
	TP	-0.850	0.190	-0.300	0.250
	SS	1.200	0.170	2.430	0.320
Industrial	TN	0.110	0.120	0.300	0.190
	TP	-0.850	0.190	-0.600	0.250
	SS	1.200	0.170	2.150	0.320

Land use parameters for each catchment node are provided in Attachment D.

4.4 Treatment Train Philosophy

The preferred stormwater treatment strategy for the site utilises stormwater reuse, at source controls, and end of line controls to ensure treatment objectives are satisfied. Individual SQIDs are outlined in the following sub-sections.

4.4.1 Rainwater Tanks

Rainwater tanks shall be utilised across the site to reuse rainwater to satisfy toilet flushing and laundry demands. The following tank sizes were assumed:

- 3 KL per dwelling for freestanding dwellings
- 3 – 5KL per dwelling for tourist facilities
- 3 KL per unit for multi-unit buildings
- 10 KL per industrial 'lot'

Water usage demands were based on figures provided by Shoalhaven Water (16 November, 2012):

- 1 ET for dwellings and units
- 15 ET/gross ha/yr for light industrial

where 1 ET = 200KL/yr.

According to NSW Department of Water and Energy (DWE) (2008) '*NSW Guidelines for Greywater Reuse in Sewered, Single Household Residential Premises*', toilet flushing and laundry uses account for 44% of total internal water demands. Therefore, total rainwater tank demands have been calculated based on 0.274 KL/day/dwelling (ET).

The total number of dwellings (and hence the cumulative tank volume and cumulative demand) was based on the sub catchment area and the proposed lot sizes within the sub-catchment. A single 'roof' node and 'tank' node was created to model each sub catchment.

4.4.2 SPEL '*Stormceptor*' Treatment Device

All road, tank overflow and pervious lot runoff areas shall pass through a '*Stormceptor*' (produced by SPEL) unit to remove gross pollutants, suspended solids and nutrients from stormwater runoff. The node (with treatment efficiencies) utilised in modelling was supplied by the manufacturer. Based on additional information from the supplier, high flow bypass for each unit is based on the 90th percentile of daily maxima inflow from the catchment.

Devices to be used onsite shall be confirmed at detailed design stage. If different devices are proposed, treatment removal efficiencies should meet or exceed those used in this assessment.

4.4.3 Bioretention Swales

Road side bioretention swales ('bioswales') are proposed to provide at source treatment of developed areas.

Bioswales provide treatment through media filtration, biological uptake of nutrients, evapotranspiration and detention. Assumed infiltration for modelling of proposed filter media is 50% of the specified design figure to account for reduced infiltration capacity of the swales over their life.

All flow is directed to the bioswales from upslope catchments.

Bioswale input parameters are provided in Attachment B. Typical bioswale design is provided in Attachment F.

4.4.4 Bioretention Basins

Bioretention basins are proposed to treat runoff discharging from 'Catchment 7' (proposed unit block development) and from the industrial zone ('Catchment 8').

Bioretention basins provide treatment through filtration, biological uptake of nutrients, infiltration, evapotranspiration and detention. Overflow outlets of the proposed basins will include baffles to retain floating pollutants such as gross pollutants and hydrocarbons.

Individual basin input parameters are provided in Attachment E with typical basin sections in Attachment F.

4.4.5 Wetlands

Two different wetlands are proposed as part of the proposed development. These are discussed in the following sections. Typical wetland sections are provided in Attachment F with wetland input parameters in Attachment E.

4.4.5.1 Foreshore Wetlands

A number of 'foreshore' wetlands, including a continuous wetland in the vicinity of the inlet between Billys Island and the site, are required to achieve water quality outcomes. Catchment runoff will discharge into the foreshore wetlands which will detain and treat runoff through biological uptake of nutrients, evapotranspiration and detention and discharge immediately upslope of the 7(a) zone boundary. Wetlands shall be designed and vegetated to complement the existing estuarine environment.

Wetlands shall spill either via an energy dissipater to the River or, in the case of the continuous wetland, spill evenly along it's length to promote even dispersal of flow and controlled discharge during major events.

In some areas wetland sections are connected (e.g. Wetland 5) by a 2m wide vegetated swale or similar providing additional treatment and to mimic site hydrology.

4.4.5.2 Parkland Wetland

A wetland is proposed in Catchment C4 (proposed oval and parkland). Inclusion of a wetland here, as opposed to a bioretention basin, allows detained water to be reused for irrigation on the oval. A reuse demand of 6 ML/ha/yr was assumed based on typical irrigation rates for playing fields.

4.4.6 CDS GPT

CDS GPT units (produced by Rocla) are proposed to treat runoff from C16 (proposed electrical substation) to remove gross pollutants and some nutrients. In reality, minimal gross pollutants are expected from this area given staff will only be present periodically.

Devices to be used onsite shall be confirmed at detailed design stage. If different devices are proposed, performance should be adequate to achieve outcomes detailed in this assessment. Unit is to include hydrocarbon removal.

4.4.7 Industrial Zone and Proposed Roundabout Treatment

The industrial zone presents a point source of potentially high pollution generation. As discussed earlier, treatment in this area includes:

- Rainwater tanks
- A bioretention basin

Additionally it is recommended that approximately 10% of individual industrial lot areas be dedicated to bioretention basin to provide at source treatment of runoff.

The proposed roundabout and intersection with Culburra Road naturally discharges to Lake Wollumboula via Wattle Creek. To achieve acceptable water quality impacts at receiving environments a bioretention swale is proposed to treat road runoff. Final design of the proposed intersection will refine the size of bio-swale area required to achieve a neutral or beneficial water quality outcome.

For both the industrial and roundabout areas, results were compared to an equivalent area of pre-development 'forest' area to ensure that water quality objectives are met by these individual catchments.

4.4.8 7(a) Protection Zone Buffer

An area zoned '7(a) Environmental Protection' lies downslope of the development footprint. No development, excluding a passive recreational walk/cycleway, is proposed in this area in an effort to maintain a vegetated buffer between the development and the receiving estuarine environment.

The design of the MUSIC model ensures runoff is of a suitable water quality prior to entering this protected zone. This area would then naturally provide additional treatment to runoff from the upslope catchment through evapotranspiration, infiltration and filtration. As it has not been included in the water quality model, the beneficial effect of the 7(a) zone is not included therefore, final water quality of runoff discharging to the estuary will be better than that reported within this document.

4.5 MUSIC Results

4.5.1 NORBE Assessment

Assessment of the effect of the development is completed and tabulated in Table 7 to Table 11 for each catchment considered. Catchment description refers to the receiving environment.

Table 7: MUSIC results - NORBE assessment – Crookhaven River

Parameter	Pre-Development	Post-Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	13600.0	10800.0	21%	Y
TP (kg/year)	33.9	28.7	15%	Y
TN (kg/year)	252.0	223.0	12%	Y
Gross Pollutants	899.0	899.0	0%	Y

Table 8: MUSIC results - NORBE assessment – Lake Wollumboula

Parameter	Pre-Development	Post-Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	262.0	260.0	1%	Y
TP (kg/year)	0.8	0.7	5%	Y
TN (kg/year)	8.1	7.4	9%	Y
Gross Pollutants	0.0	0.0	0%	Y

Table 9: MUSIC results - NORBE assessment – Billys Island inlet (SEPP 14 Wetlands)

Parameter	Pre-Development	Post-Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	1560	787.0	50%	Y
TP (kg/year)	4.69	4.34	7%	Y
TN (kg/year)	50.1	46.9	6%	Y
Gross Pollutants	0.0	0.0	0%	Y

Table 10: MUSIC results - NORBE assessment – Seagrass and Oyster Leases

Parameter	Pre-Development	Post-Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	12000	9980	17%	Y
TP (kg/year)	29.2	24.3	17%	Y
TN (kg/year)	202.0	176.0	13%	Y
Gross Pollutants	899.0	899.0	0%	Y

Table 11: MUSIC results - NORBE assessment – Curleys Bay

Parameter	Pre-Development	Post-Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	9170.0	8930.0	3%	Y
TP (kg/year)	18.2	16.40	10%	Y
TN (kg/year)	114.0	105.0	8%	Y
Gross Pollutants	899.0	899	0%	Y

4.5.2 Treatment Train Effectiveness

Table 12 to Table 16 provide assessment of the treatment train effectiveness (i.e. post development untreated versus post development with treatment) for receiving environments.

Table 12: MUSIC results - treatment train effectiveness – Crookhaven River

Parameter	Sources	Residual	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	46710.0	1224.3	97%	Y
TP (kg/year)	101.2	10.6	90%	Y
TN (kg/year)	750.1	101.9	86%	Y
Gross Pollutants	8415.0	0.0	100%	Y

Table 13: MUSIC results - treatment train effectiveness – Lake Wollumboula

Parameter	Sources	Residual	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	2240.0	260.0	88%	Y
TP (kg/year)	4.8	0.7	85%	Y
TN (kg/year)	28.4	7.4	74%	Y
Gross Pollutants	152.0	0.0	100%	Y

Table 14: MUSIC results - treatment train effectiveness – Billys Island Inlet (SEPP 14 Wetlands)

Parameter	Sources	Residual	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	12400.0	480.0	96%	Y
TP (kg/year)	30.7	3.4	89%	Y
TN (kg/year)	251.0	37.1	85%	Y
Gross Pollutants	2800.0	0.0	100%	Y

Table 15: MUSIC results - treatment train effectiveness – Seagrass and Oyster Leases

Parameter	Sources	Residual	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	34310.0	744.3	98%	Y
TP (kg/year)	70.5	7.2	90%	Y
TN (kg/year)	499.1	64.8	87%	Y
Gross Pollutants	5615.0	0.0	100%	Y

Table 16: MUSIC results - treatment train effectiveness – Curleys Bay

Parameter	Sources	Residual	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	3620.0	94.1	97%	Y
TP (kg/year)	7.2	0.4	94%	Y
TN (kg/year)	55.4	6.8	88%	Y
Gross Pollutants	565.0	0.0	100%	Y

4.5.3 Proposed Industrial Zone and Roundabout

Table 17 and Table 18 provide assessment of water quality results when Catchment 8 (proposed industrial zone) and Catchment C8r (proposed roundabout) were isolated and tested for compliance against NorBe objectives. Results suggest that proposed treatment measures treat water quality from these areas effectively.

Table 17: MUSIC results - NORBE assessment – Industrial Zone

Parameter	Pre-Development	Post-Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	333.0	41.2	88%	Y
TP (kg/year)	1.0	0.8	20%	Y
TN (kg/year)	10.3	6.9	33%	Y
Gross Pollutants	0.0	0.0	0%	Y

Table 18: MUSIC results - NORBE assessment – Proposed Roundabout Intersection

Parameter	Pre-Development	Post-Development	Achieved Reduction (%)	Complies (Y/N)
TSS (kg/year)	30.0	2.9	90%	Y
TP (kg/year)	0.1	0.1	4%	Y
TN (kg/year)	1.0	0.6	35%	Y
Gross Pollutants	0.0	0.0	0%	Y

4.6 Water Quality Impacts on Sensitive Ecosystems

4.6.1 SEPP 14 Wetlands

MUSIC modelling demonstrates that water quality discharged into the Billys Island inlet will be of better quality than that currently being discharged. The proposed outlet structures shall be designed (at CC stage) to provide for controlled and dispersed flow that does not result in localised scour and disturbance of mangrove species. It is therefore considered that the proposed development shall have a negligible local impact.

4.6.2 Seagrass

MUSIC modelling demonstrates that water quality discharged into areas where seagrass is mapped will be of better quality than that currently being discharged. Although the development will result in an

increased volume of fresh water discharged to these areas, it is anticipated that due to stratification, freshwater 'plumes' will float above saltwater strata (in which seagrass exist) along foreshore areas until mixing occurs within deeper parts of the Crookhaven River and Curleys Bay. Therefore impacts on seagrass resulting from increased freshwater discharge are anticipated to be negligible.

4.6.3 Oyster Leases

MUSIC modelling demonstrates that water quality discharged into areas with oyster leases will be of better quality than that currently being discharged.

The importance of faecal coliform impacts on oyster leases is acknowledged and considered in the design of water quality treatment devices, although not able to be modelled as the MUSIC software package only considers nutrients, suspended sediments and gross pollutants. The outlet structures of proposed treatment wetlands and basins are conceptually designed to provide for approximately 72 hours residence time to allow for the breakdown of faecal coliforms. Wetland and basin planting shall increase the rate of this breakdown.

It is noted that the proposed development shall be sewered and no onsite effluent disposal is proposed which reduces the risk of release of human pathogens to stormwater. A Sewage Management Regime (Allen Price & Associates, 2013) has been prepared to outline design measures and emergency procedures to mitigate the impacts of sewage spills/leaks on the water quality within the estuary.

Therefore impacts on oyster leases resulting from reduced water quality are anticipated to be negligible.

4.6.4 Lake Wollumboula

Excluding the proposed oval and the proposed new round about intersection on Culburra Road, no development area is proposed to drain to Lake Wollumboula.

Through capture, treatment and, where possible, reuse for irrigation, the water quality of runoff discharged from these areas is of a better water quality than existing runoff. The impact on Lake Wollumboula is therefore considered negligible if not beneficial.

4.7 Conclusions

Results indicate that post development water quality objectives will be met by the proposed stormwater treatment train.

It is noted that further refinement of the model at the detailed design stage of the development may alter the sizes of proposed treatment structures, however, performance outcomes of final design are to achieve specification provided in this report.

4.8 Water Quality Monitoring

In response to agency comments (June 21, 2013) (in particular NSW Fisheries, NSW OEH and submissions supplied by representatives of the oyster aquaculture industry) a Water Quality Monitoring Plan for the development has been prepared (Martens and Associates, 2013. Ref: P1203365JR03V02). It has been prepared in consultation with NSW Food Authority, NSW Fisheries, NSW Oyster Coast Inc, local oyster farmers and other stakeholders and with reference to relevant policy such as SEPP 62 and NSW Oyster Industry Sustainable Aquaculture Strategy (OISAS) (2006).

This program has been designed to ensure that the specified water quality objectives are met and treatment train components are operating effectively throughout the construction and operational phase of the proposed development. In turn, this will help to ensure the ongoing health of sensitive ecosystems and maintenance of the local oyster industry.

5 Water Quantity Assessment

5.1 Overview

This water quantity assessment discusses the impact of the proposed development on the flow regime leaving the site, and recommends management measures to control this discharge and mitigate impacts on the receiving wetland ecosystem.

5.2 OSD Requirements

Shoalhaven Council generally require OSD be provided within developments in its local government area. However, Council's Subdivision Engineer (I. Dollery, February 21, 2012) confirms that, given the site discharge is near the outlet of the catchment and in close proximity to the ocean, OSD is not necessary. Where the site discharges to wetland areas measures are proposed to protect the receiving environments from increased localised flows resulting from increased impervious area runoff.

5.3 Objectives

The objective of this assessment is to determine management measures required to, as far as feasible, mimic the hydrological regime in the wetland areas within the Billy Island inlet (Figure 1).

5.4 Hydrological Assessment

5.4.1 Approach

DRAINS hydraulic modelling software was utilised to calculate pre and post development flow rates leaving the site for the 1 in 2, 10, 20 and 100 year ARI storm events. Iterative modelling was utilised to determine the post development catchment area required to achieve flow rates in the wetland that mimic, as nearly as possible, pre development flow rates.

The assessed catchment area of 34.9 ha for the receiving wetlands is identified in Attachment A.

5.4.2 Results

Table 19 provides the pre and post development catchment areas and flow rates for each storm event.

Table 19: Hydrological modelling results.

Scenario	Catchment Area (ha)	Impervious Area (%)	Pervious Area (%)	Flow Rates (m^3/s)			
				1:2yr	1:10yr	1:20yr	1:100yr
Pre Development	45.5	0%	100%	5.07	9.7	11.8	16.4
Post Development [1]	34.9	33%	67%	4.93	8.54	10.3	13.9

Notes:

[1] Post development catchment modified to mimic pre development wetland flow regime.

Results of iterative modelling conclude that the developed catchment area discharging to the wetland needs to be limited to approximately 34.9 ha to mimic the pre-development hydrological regime and minimise the risk of negative impacts from increased flow rates.

5.5 Management Recommendations

The following measures are recommended as part of the proposed development to maintain the hydrological regime in the receiving wetland ecosystem:

- Catchment areas outside the 34.9 ha area that would otherwise discharge into the wetlands (Attachment A) shall be diverted, after treatment, and discharged to open water in the Crookhaven River. MUSIC modelling suggests that water quality objectives are met under these conditions.

- Proposed bioretention basins and wetlands (Sections 4.4.4 and 4.4.5) are to include an outlet structure appropriately designed to achieve dispersed flow into the SEPP14 Wetland and mitigate impacts such as localised scour. Outlet structures are to include rip-rap and vegetation tolerant of freshwater inflows.

- The proposed bioretention basins and wetlands include a maximum of 0.5 and 0.4 m detention depth respectively. This storage will provide a degree of onsite detention of flow during rain events and shall mimic natural baseflow and groundwater flow.

6 Statement of Commitments

With regards to management of stormwater onsite during construction and operation of the proposed development, the following commitments are made by the applicant:

- Water quality treatment devices shall be installed to achieve post development nutrient loads that reflect existing loads at the Crookhaven River, Lake Wollumboola, Curleys Bay and Billys Island inlet.

- The proposed treatment train shall comply with Shoalhaven City Council's Draft *Sustainable Stormwater Management* DCP (2012) and achieve NorBE at receiving environments.

- To mimic the hydrological regime in the wetland areas, the catchment area discharging into the wetlands shall be reduced to ensure post development flows to these areas are comparable to pre development flow.

- All discharge points shall include outlet structures appropriately designed to achieve dispersed flow into the wetland to mitigate impacts such as localised scour.

- Water quality monitoring shall be undertaken in accordance with the project Water Quality Monitoring Plan (Martens and Associates, 2013), which has been prepared with the input from various stakeholders, to ensure the development continues to comply with site water quality objectives. This plan shall undergo continual review and modification to address project progress and results.

- Impacts on downstream receiving environments during the construction phase shall be mitigated by implementation of the project SECP (Martens and Associates, 2013) which has been prepared in accordance with Landcom (2004) and best management practices.

7 References

Allen Price & Associates (2013) *Proposed Sewage Management Regime for New Development Areas within the Crookhaven River Catchment*

Martens and Associates, (2013) *Water Quality Monitoring Plan* (P1203365JR03V02)

Shoalhaven City Council (2002) '*Development Control Plan 100: Subdivision Code'*

Shoalhaven City Council (2012) '*DRAFT: Sustainable Stormwater Management DCP'*

Soil Landscapes of the Kiama 1:100 000 sheet. Soil Conservation Service of NSW, Sydney.

Sydney Metropolitan Catchment Management Authority (SMCMA) (2010) *'Draft NSW MUSIC Modelling Guidelines'*

Wollongong 1:250,000 Geological Sheet; New South Wales Dept of Mines, 1970.

8 Attachment A – Planset

COVER SHEET

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6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999
Fax: (02) 9476 8767
Email: mail@martens.com.au
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TITLE
COVER SHEET
MIXED USE SUBDIVISION - WEST CULBURRA, NSW

PROJECT MANAGER: ANDREW NORRIS
DRAWING NUMBER: P1203365JD01V06

DESIGNED: MLK	DATUM: mAHD	SHEET	
DRAWN: MLK	HORIZONTAL RATIO: NA	SK200	
REVIEWED: AN	VERTICAL RATIO: NA	PAPER SIZE: A1 / A3	

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CLIENT/ PROJECT: REALITY REALIZATIONS

TITLE: PROPOSED SUBDIVISION INDICATIVE LAYOUT AND SITE COVERAGE

MIXED USE SUBDIVISION – WEST CULBURRA, NSW

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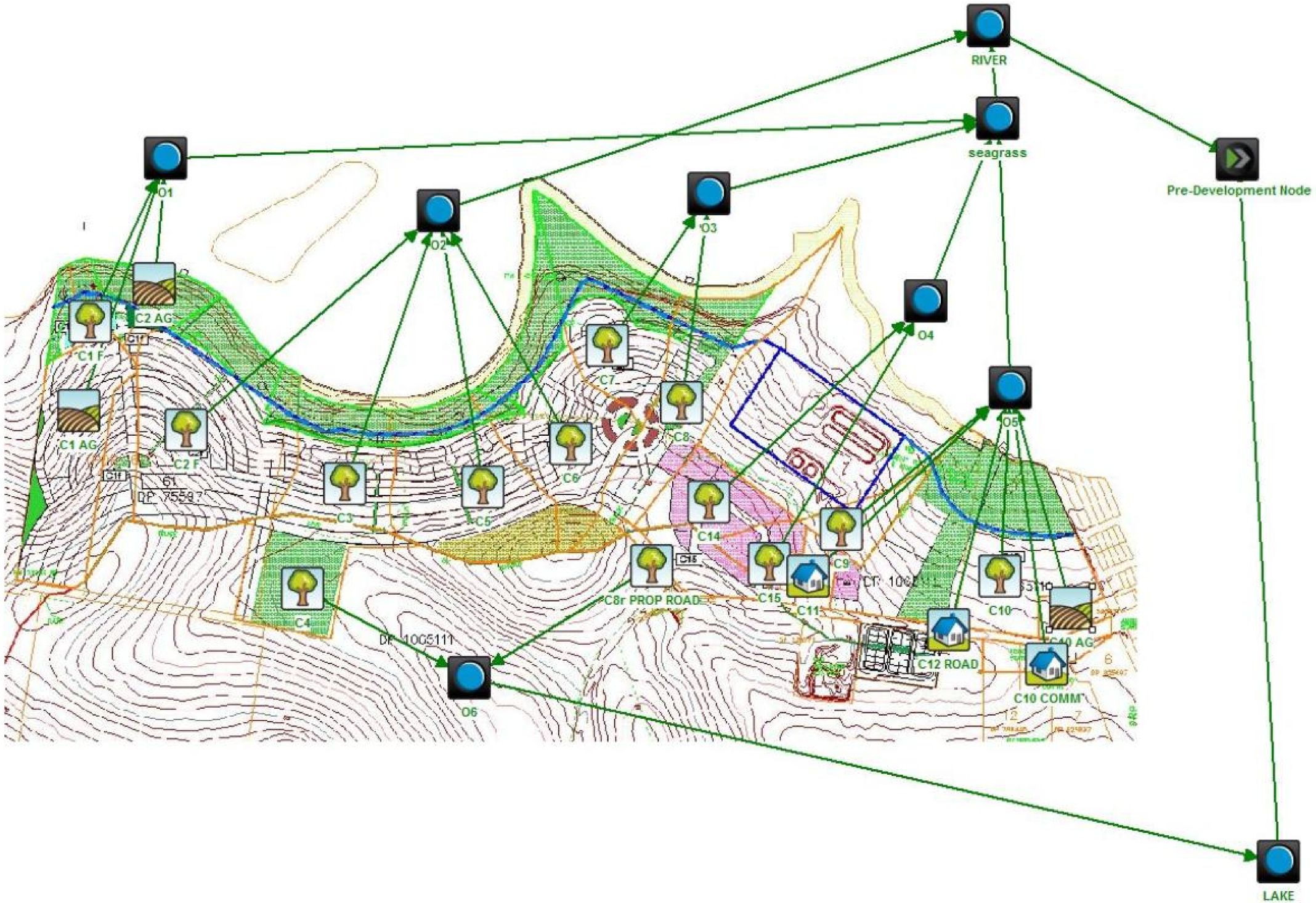

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TITLE
PRE-DEVELOPMENT MUSIC MODEL LAYOUT
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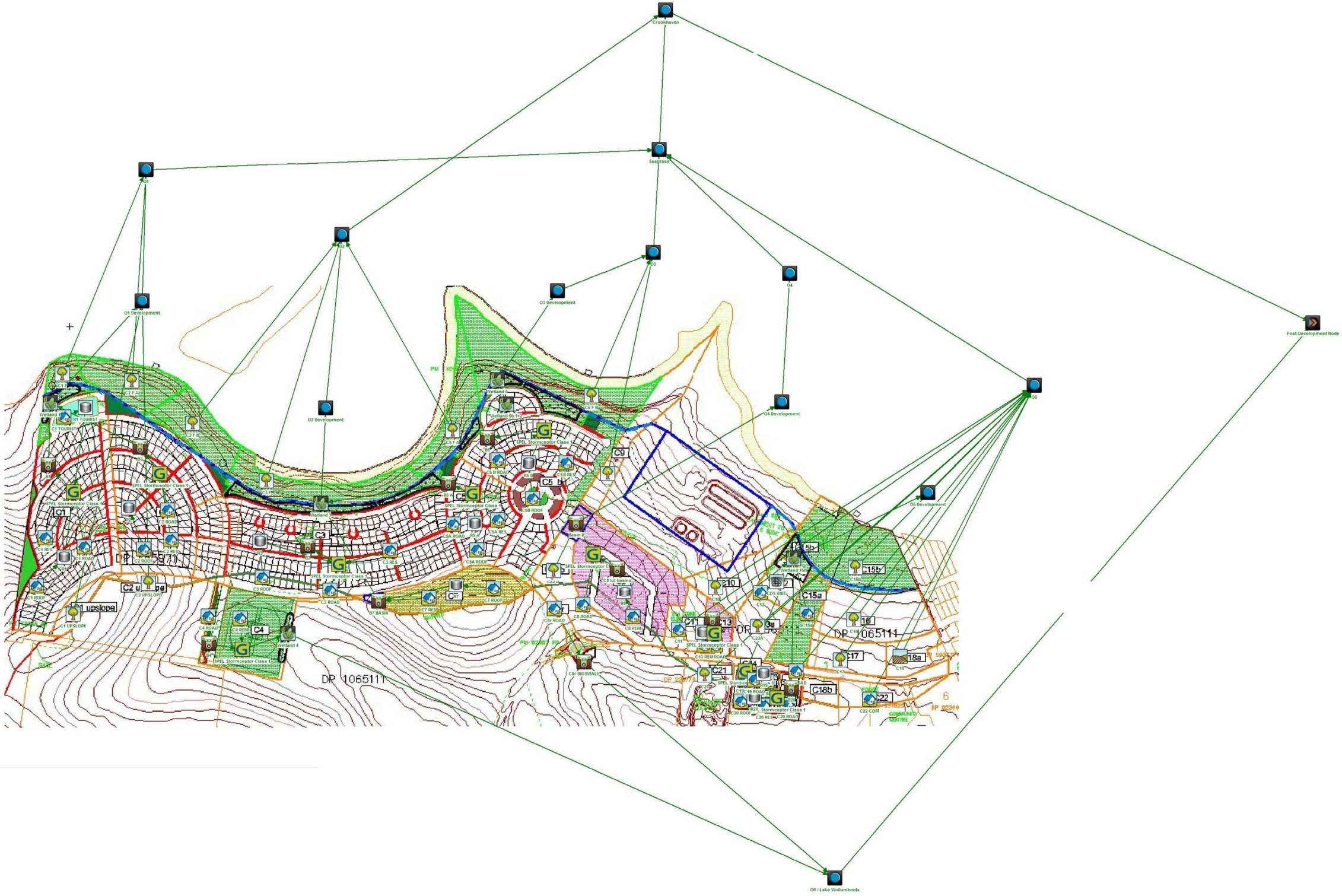

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Hornsby, NSW 2077 Australia
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POST-DEVELOPMENT MUSIC MODEL LAYOUT
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KEY

WETLAND HYDROLOGIC CATCHMENT

AREAS TO BE DIVERTED TO OPEN WATER FORMERLY DRAINING TO WETLAND

APPROX SEPP14 WETLAND EXTENT

CROOKHAVEN ESTUARY

BILLYS ISLAND

CURLEYS BAY

N

W E

S

5

EASEMENT

PM 73997 FD

GATE

PM 74006 FD

TRACK

16

DRAIN

(VIDE DP 631825)

6 WIDE

(POR. 61)

28

61

DP 755971

SEWAGE

TRACK

LINE

RIDGE

20

TRACK

TRACK

25

BY SURVEY

PM 73996 FD

PAGE BAR SCALE

0 40 80 120 160 200

UNITS – METRES

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KEY

PROPOSED BIORETENTION SWALE

PROPOSED TREATMENT WETLAND LOCATION

PROPOSED BIORETENTION BASIN LOCATION

APPROX SEPP14 WETLAND EXTENT

7(a) ZONE BOUNDARY

BILLYS ISLAND

CURLEYS BAY

61
DP 755971

DP 1065111

7

81

PAGE BAR SCALE

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Element	Basin A	Basin B	Basin C	Basin D
Storage Zone Volume (soil) (m^3)	1804	1721	384	422
Settling Zone Volume (water) (m^3)	6861	6275	2955	4542
Basin Total Volume (m^3)	8665	7996	3339	4964

BASIN CAPACITIES NOMINATED ASSUME NO STAGING OF DEVELOPMENT. FINAL BASIN CONFIGURATION AND SIZE LIKELY TO REDUCE WITH STAGED SITE DISTURBANCE

N
W E
S

CROOKHAVEN ESTUARY

BILLYS ISLAND

7(a) ZONE BOUNDARY

SEDIMENT BASIN LOCATION (SIZE INDICATIVE ONLY)

SEDIMENT FENCE

EARTH DIVERSION BUND

STABILISED SITE ACCESS

ENERGY DISSIPATER

APPROX SEPP14 WETLAND EXTENT

BASIN A

BASIN B

BASIN C

BASIN D

DP 755971

DP 1065111

DP 788445

DP 825697

DP 631825

DP 223279

RETIREMENT VILLAGE

COMMUNITY CENTRE

POLICE STATION

CULBURRA BOWLING CLUB

CULBURRA ROAD

PAGE BAR SCALE

0 80 160 240 320 400

UNITS – METRES

SCALE – 1:4000 @ A1 1:8000 @ A3

martens
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999
Fax: (02) 9476 8767
Email: mail@martens.com.au
Internet: http://www.martens.com.au

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CLIENT/ PROJECT
REALITY REALIZATIONS

TITLE
SEDIMENT AND EROSION CONTROL PLAN
MIXED USE SUBDIVISION – WEST CULBURRA, NSW

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in mm unless otherwise specified.

PROJECT MANAGER: ANDREW NORRIS

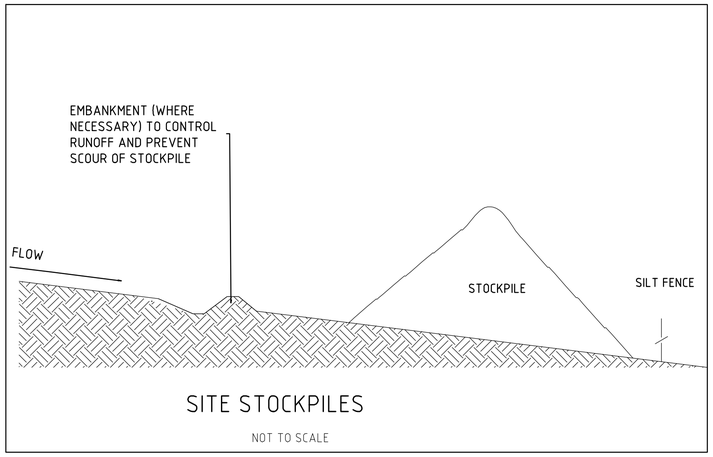
DRAWING NUMBER: P1203365JD01V07

DESIGNED: MLK
DRAWN: MLK
REVIEWED: AN

DATUM: mAHD
HORIZONTAL RATIO: 1:4000 @ A1, 1:8000 @ A3
VERTICAL RATIO: 1:4000 @ A1, 1:8000 @ A3

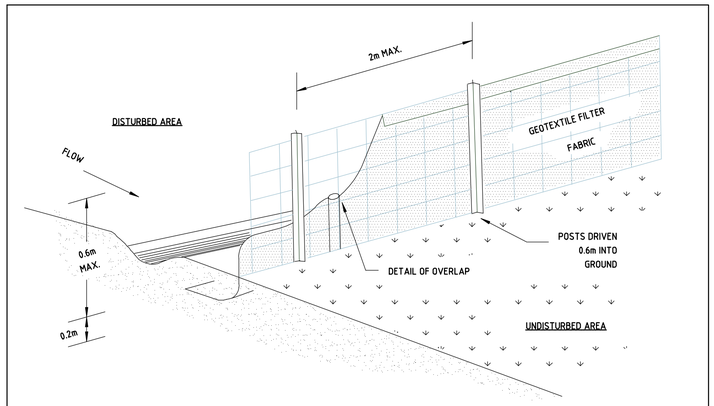
SHEET: SK207
PAPER SIZE: A1 / A3

REV.	DESCRIPTION	DATE	ISSUED
1	FINAL	09.10.2013	AN



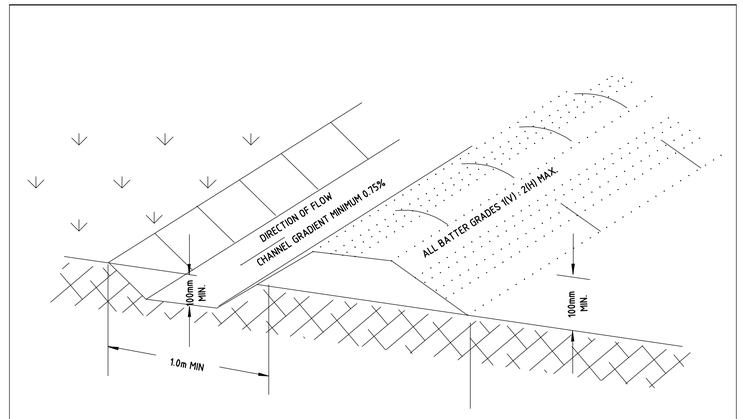
SITE STOCKPILES

NOT TO SCALE



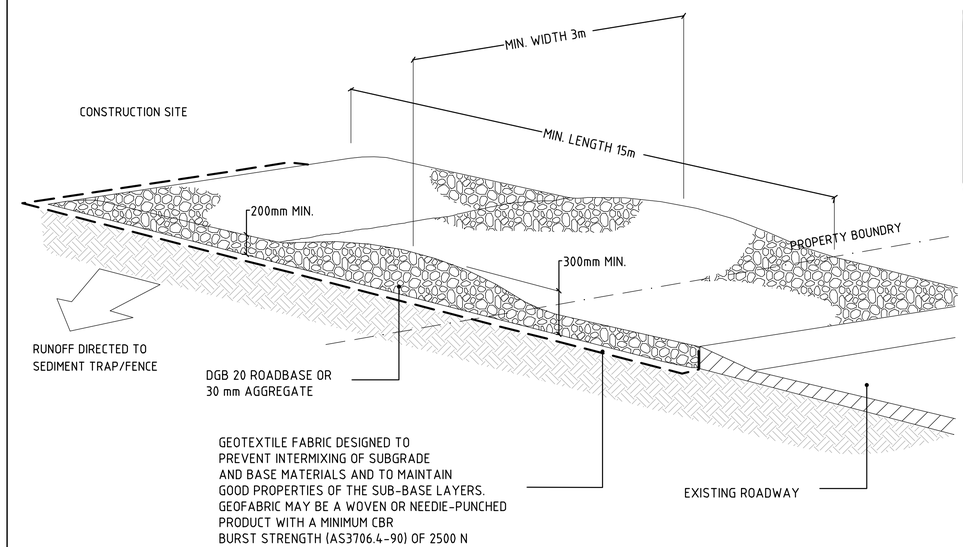
SEDIMENT CONTROL FENCE

NOT TO SCALE



EARTH CHANNEL

NOT TO SCALE

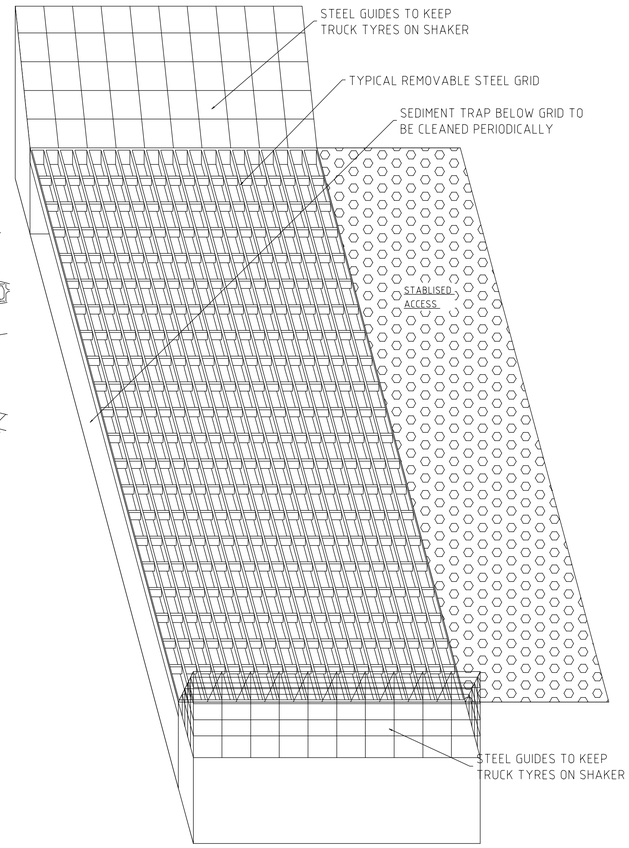


CONSTRUCTION NOTES

1. STRIP THE TOPSOIL, LEVEL THE SITE AND COMPACT THE SUBGRADE.
2. COVER THE AREA WITH NEEDLE-PUNCHED GEOTEXTILE.
3. CONSTRUCT A 200-mm THICK PAD OVER THE GEOTEXTILE USING ROAD BASE OR 30-mm AGGREGATE.
4. ENSURE THE STRUCTURE IS ATLEAST 15 METRES LONG OR TO BUILDING ALIGNMENT AND AT LEAST 3 METRES WIDE.
5. WHERE A SEDIMENT FENCE JOINS ONTO THE STABILISED ACCESS, CONSTRUCT A HUMP IN THE STABILISED ACCESS TO DIVERT WATER TO THE SEDIMENT FENCE

STABILISED SITE ACCESS SD 6-14

NOT TO SCALE



TYPICAL SEDIMENT SHAKER

NOT TO SCALE

martens
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999
Fax: (02) 9476 8767
Email: mail@martens.com.au
Internet: http://www.martens.com.au

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CLIENT/ PROJECT: REALITY REALIZATIONS

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All measurements in mm unless otherwise specified.

TITLE: SEDIMENT AND EROSION CONTROL SPECIFICATIONS
MIXED USE SUBDIVISION - WEST CULBURRA, NSW

PROJECT MANAGER: ANDREW NORRIS
DRAWING NUMBER: P1203365JD01V06

DESIGNED:	MLK
DRAWN:	MLK
REVIEWED:	AN
DATUM:	mAHD
HORIZONTAL RATIO:	1:4000 @ A1 1:8000 @ A3
VERTICAL RATIO:	1:4000 @ A1 1:8000 @ A3
SHEET	SK208
PAPER SIZE:	A1 / A3

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6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999
Fax: (02) 9476 8767
Email: mail@martens.com.au
Internet: http://www.martens.com.au

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CLIENT/ PROJECT: REALITY REALIZATIONS

TITLE: WATER QUALITY MONITORING PLAN
MIXED USE SUBDIVISION - WEST CULBURRA, NSW

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in mm unless otherwise specified.

PROJECT MANAGER: ANDREW NORRIS

DRAWING NUMBER: P1203365JD01V07

DESIGNED:	DATUM:	SHEET
MLK	mAHD	SK210
DRAWN: MLK	HORIZONTAL RATIO: 1:4000 @ A1 1:8000 @ A3	
REVIEWED: AN	VERTICAL RATIO: 1:4000 @ A1 1:8000 @ A3	PAPER SIZE: A1 / A3

REV.	DESCRIPTION	DATE	ISSUED
1	FINAL	09.10.2013	AN

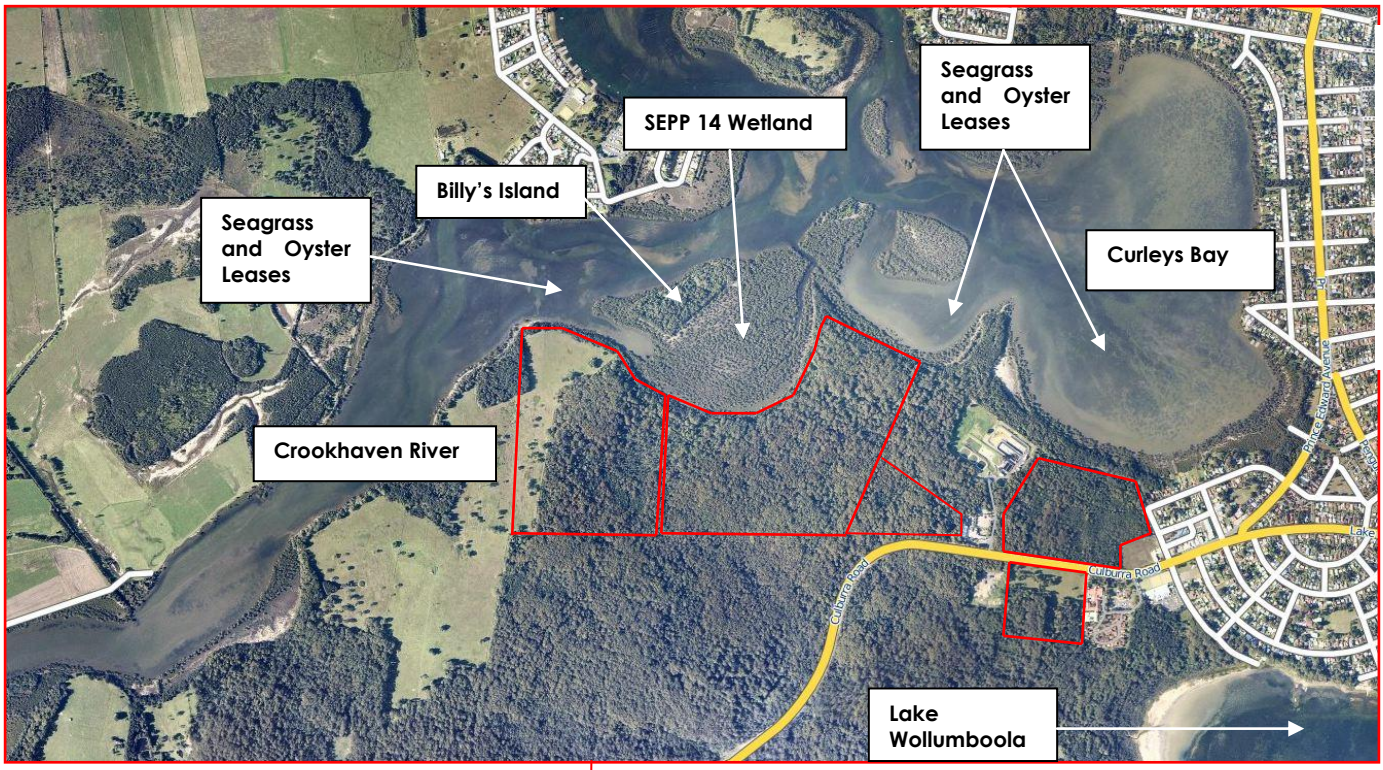
9 Attachment B – Summary of MUSIC Input Parameters

Attachment B: MUSIC modelling input parameter values and source.

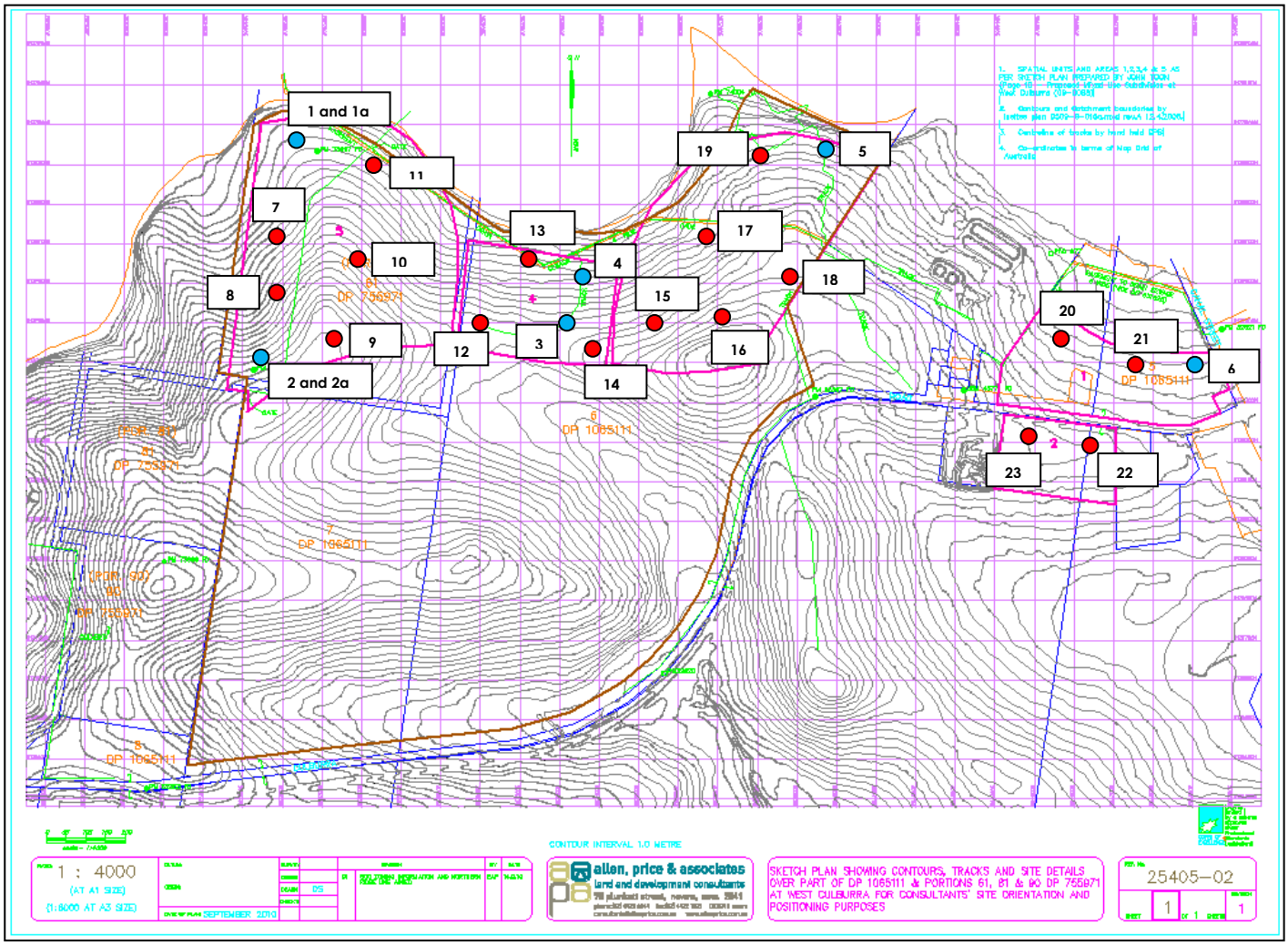
Element	Factor	Input	Source
Setup	Climate File	Climate file (mlb file) from Nowra RAN from 26/11/1992 - 26/11/1997	BOM
Source Nodes	Node Type	The existing site will be a mixture of agricultual and forested nodes, depending on location across the site. Proposed will be a mixture of roof, road and residential nodes plus forest for undeveloped forest areas.	As per WBM (2010) and development layout
	Roof Area	As per proposed site coverage (ranges from 40% - 60%)	As per development layout
	Road Area	Area per lot layout. Area to be summed for each subcatchment.	As per development layout
	Residential	Remaining lot area (catchment area less road and roof area). Given driveways are not considered 'effective impervious areas' and laybacks are, residential nodes are generally 99% pervious	Assumed based on 'typical' lot layouts
	Rainfall Threshold	Based on land use type or surface type as specified in Table 3.6 of WBM (2010)	WBM (2010) guidelines
	Pervious Area Parameters	Based on soils within the top 0.5m of existing soil profile = Clayey Sand	Soil properties based on WBM (2010) Table 3-7 and 3-8 and site geotechnical testing by Martens (2010) of 24 boreholes.
	EMC's	As per WBM (2010) for Urban and Forest landuse	WBM (2010) guidelines
	Estimation Method	Stochastically generated	WBM (2010) guidelines
Bioretention Basin	Low Flow By-Pass	0 m^3/s	WBM (2010) guidelines
	High Flow Bypass	100 m^3/s	Online so no bypass (excluding Catchment C15a basin = 50% 1yr ARI)
	Extended Detention depth	Typically 0.5m	By design
	Surface area	Surface area at half the detention depth	WBM (2010) guidelines
	Filter area	By design.	Design of proposed basin
	Unlined filter media	Equal to square root of surface area (actual) multiplied by 4	WBM (2010) guidelines
	Saturated Hydraulic Conductivity	90 mm/hr	MUSIC model help guidelines (ewater) recommend a hydraulic conductibity of 180 mm/hr be used for sands. 50% of this value has been used in modelling as a conservative estimate of realistic long-term hydraulic conductivity of system (ewater).
	Fiter Depth	0.4 - 0.6m	Design of proposed basin
	TN content of filter media	500 mg/kg	Based on previous discussions with T. Weber (WBM) for other sites (Riverside development September 7, 2012).
	Orthophosphate content of filter media	40 mg/kg	Based on previous discussions with T. Weber (WBM) for other sites (Riverside development September 7, 2012) and product data sheet from RiverSands P/L for typical sand filter media (attached)
	Exfiltration rate	3.6 mm/hr	Based on medium clay subsoils
	Is based lined?	No	Basins shall not be lined
	Vegetation Properties	With effective nutrient removal plants	Landscaping of basins will include deep rooted vegetation.
	Oveflow weir width	varies	Basin design
	Underdrain present	Yes	Basin design
	Submerged zone with carbon present	Yes; 0.0 - 0.2m	Basin design
	Low Flow By-Pass	0 m^3/s	WBM (2010) guidelines
	High Flow Bypass	100 m^3/s	No Bypass
	Extended Detention depth	0.25m	By design
	Surface area	Surface area at half the detention depth	WBM (2010) guidelines
	Filter area	By design.	Design of proposed basin
	Unlined filter media	Equal to square root of surface area (actual) multiplied by 4	WBM (2010) guidelines
	Saturated Hydraulic Conductivity	90 mm/hr	MUSIC model help guidelines (ewater) recommend a hydraulic conductibity of 180 mm/hr be used for sands. 50% of this value has been used in modelling as a conservative estimate of realistic long-term hydraulic conductivity of system (ewater).
	Fiter Depth	0.6m	Design of proposed basin

Bioretention Swales	TN content of filter media	500 mg/kg	Based on previous discussions with T. Weber (WBM) for other sites (Riverside development September 7, 2012).
	Orthophosphate content of filter media	40 mg/kg	Based on previous discussions with T. Weber (WBM) for other sites (Riverside development September 7, 2012) and product data sheet from RiverSands P/L for typical sand filter media (attached)
	Exfiltration rate	3.6 mm/hr	Based on medium clay subsoils
	Is based lined?	No	Swales shall not be lined
	Vegetation Properties	With effective nutrient removal plants	Landscaping of basins will include deep rooted vegetation.
	Oveflow weir width	varies	Basin design
	Underdrain present	Yes	Basin design
	Submerged zone with carbon present	Yes; 0.2m	Basin design
Wetlands	Low Flow By-Pass	0 m^3/s	WBM (2010) guidelines
	High Flow Bypass	100 m^3/s	Online so no bypass (excluding Catchment C15a basin = 50% 1yr ARI)
	Inlet Pond Volume	Varies	By design
	Surface area	Surface area at half the detention depth	WBM (2010) guidelines
	Extended Detention depth	0.4 - 0.5m	Design of proposed wetlands
	Permanent Pool Volume	Varies	Design of proposed wetlands
	Exfiltration rate	3.6 mm/hr	Based on medium clay subsoils
	Equivalent Pipe Diameter	Varies	Adjusted to achieve an approximate detention time of 72 hrs as per 3.8.3.1 of WBM (2010) guidelines
	Weir width	Varies	Design of proposed wetlands
	Reuse	Where used based on 6ML/ha/yr	Typical irrigation rate for golf course grade landscaping
GPT (CDS GPT)	Low Flow By-Pass	0 m3/s	WBM (2010) guidelines
	High Flow Bypass	Varies - Q (3month)	As per manufactures specification (Rocla) and catchment area
	TSS (mg/L)	Input 1075 Ouput 376.7	As per manufactures specification (Rocla)
	TN (mg/L)	Input 50 Ouput 50	As per manufactures specification (Rocla)
	TP (mg/L)	Input 10 Ouput 7	As per manufactures specification (Rocla)
	GP (kg/ML)	Input 100 Ouput 2	As per manufactures specification (Rocla)
GPT (SPEL Stormceptor)	Low Flow By-Pass	0 m3/s	WBM (2010) guidelines
	High Flow Bypass	Varies	As per manufactures specification (SPEL) 90% of daily maxima inflow
	TSS (mg/L)	Input 1000 Ouput 30	As per manufactures specification (SPEL)
	TN (mg/L)	Input 50 Ouput 35	As per manufactures specification (SPEL)
	TP (mg/L)	Input 5 Ouput 3.5	As per manufactures specification (SPEL)
	GP (kg/ML)	Input 15 Ouput 0	As per manufactures specification (SPEL)
Rainwater Tank	Low Flow By-Pass	0 m3/s	WBM (2010) guidelines
	High Flow Bypass	0.005 m3/s per dwelling (for free standing houses, townhouses, retirement and tourist accomodation). 100mm/hr for unit blocks by assumed roof perimeter	WBM (2010) guidelines
	Volume below overflow	Based on 3KL/dwelling or 3KL/tenement. A volume of 80% of total tank volume is assumed	Development design. As per WBM (2010) MUSIC modelling guidelines
	Depth above overflow	0.2m	By design
	Surface area	Cumulative surface area	By design
	Overflow pipe diameter	100mm	WBM (2010) guidelines
	Reuse	274L/day/ET	Shoalhaven Water

10 Attachment C - Figures



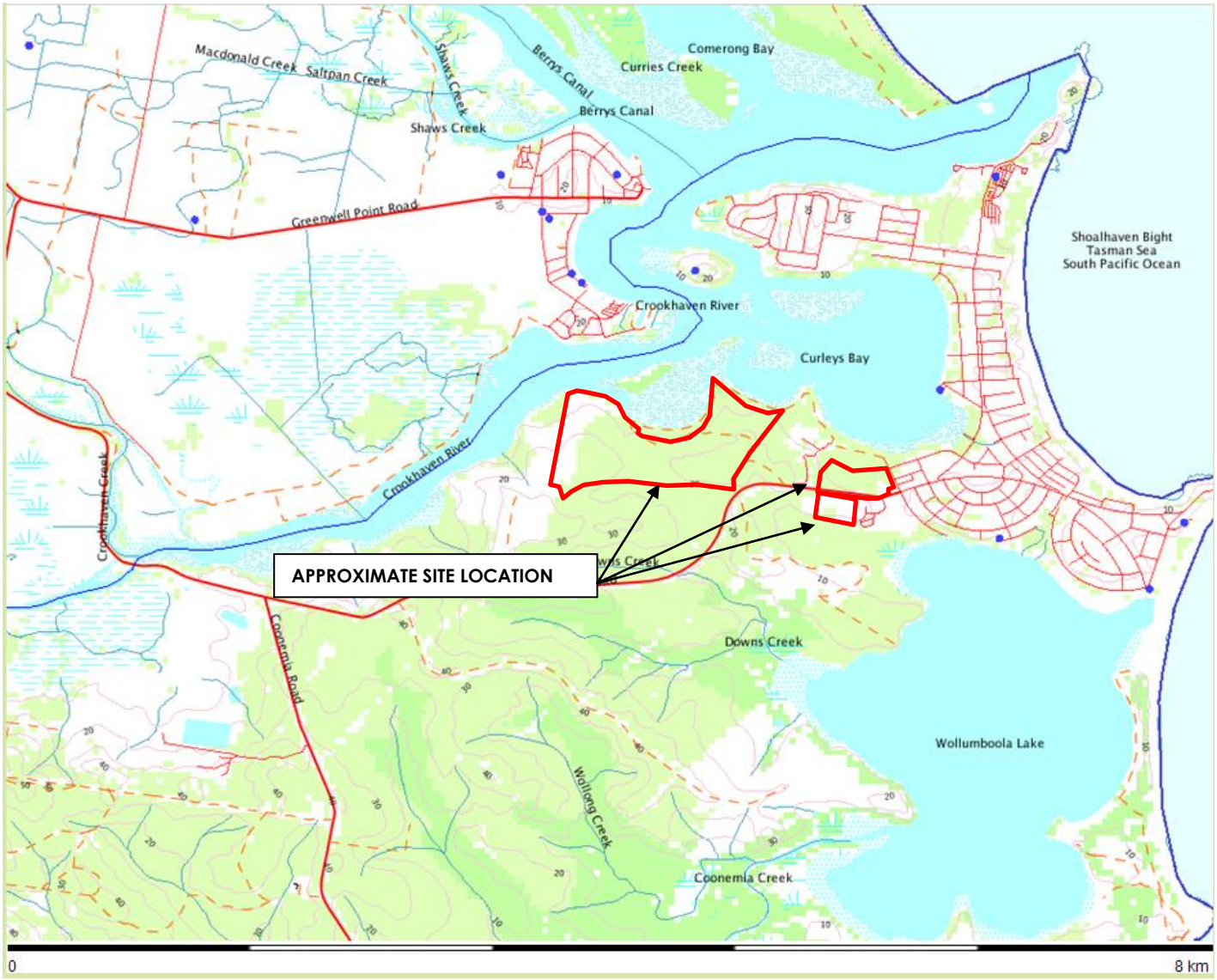
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MLK	**Site Locality and Regional Context**	**Figure 1**
Approved:	AN		**SK301**
Date:	01.03.2013		
Scale:	NA		Job No: P1203365



Key:

- **Approx borehole location and I.D**
- **Approximate GMB location and I.D**

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MLK	**Borehole and GMB Locations**	**Figure 2** **SK302**
Approved:	AN		
Date:	01.03.2013		
Scale:	NA		Job No: P1203365



Notes:

1. **Source (NSW Natural Resource Atlas).**
2. **Site location is approximate only.**
3. **Licensed bores = purple dots.**

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MLK	**Site and Surrounding Licensed Bores**	**Figure 3**
Approved:	AN		**SK303**
Date:	01.03.2013		
Scale:	NA		Job No: P1203365

11 Attachment D – MUSIC Model Catchment Areas

SOIL TYPES

Soil Types in top 0.5m - Real Data								Inputs for MUSIC					
Layer 1	Depth	SSC (MUSIC guidelines)	FC (MUSIC Guidelines)	Layer 2	Depth	SSC (MUSIC guidelines)	FC (MUSIC Guidelines)	Weighted average SSC	Weighted average FC	Inf a	Inf b	DRR (%)	DBR (%)
LOAMY SAND	0.3	139	69	CLAY	0.2	93	68	120.6	68.6	270	1.9	64	34

PRE DEVELOPMENT CATCHMENT AREAS

RECEIVING NODE	CATCHMENT ID	TOTAL AREA (HA)	IMPERVIOUS AREA (HA)	%	PERVIOUS AREA (HA)	%	EMC CATEGORY
O1	C1 AG	10.52	0.0	0%	10.5	100%	AGRICULTURAL
	C1 FOREST	4.39	0.0	0%	4.4	100%	FOREST
	C2 AG	3.38	0.0	0%	3.4	100%	AGRICULTURAL
O2	C2 FOREST	16.73	0.0	0%	16.7	100%	FOREST
	C3	6.54	0.0	0%	6.5	100%	FOREST
	C5	11.21	0.0	0%	11.2	100%	FOREST
	C6	11.52	0.0	0%	11.5	100%	FOREST
O6	C8r	0.887	0.0	0%	0.9	100%	FOREST
	C4	6.67	0.0	0%	6.7	100%	FOREST
O3	C7	8.88	0.0	0%	8.9	100%	FOREST
	C8	10.40	0.0	0%	10.4	100%	FOREST
O4	C14	3.99	0.0	0%	4.0	100%	FOREST
	C15	2.90	0.0	0%	2.9	100%	FOREST
O5	C9	4.38	0.0	0%	4.4	100%	FOREST
	C10	18.47	0.0	0%	18.5	100%	FOREST
	C10ag	4.44	0.0	0%	4.4	100%	AGRICULTURAL
	C10comm	1.49	0.6	40%	0.9	60%	COMMERCIAL
	C11	1.72	1.7	100%	0.0	0%	INDUSTRIAL
	C12	1.77	1.8	100%	0.0	0%	ROAD
	TOTAL	**130**					

POST DEVELOPMENT CATCHMENT AREA NB: Roads are 50% Pervious 50% Impervious based on DCP100 pg 24 Table 3 and using a 'local street'

RECEIVING NODE	CATCHMENT	Total Area	Bioswale Area	Road Area	%Pervious Road*	House Area	Residential Node	% Impervious (Res)	%Pervious (Res)	NODE
	C1 FOREST	1.06						0%	100%	FOREST
	WETLAND 1	0.3474								
	C1	12.36	0.4201	4.35	0.41	2.96	4.63	1%	99%	RESIDENTIAL
O1	C1 Tourist	0.62					0.6	90%	10%	
	C2 FOREST A	2.66						0%	100%	FOREST
	C2	10.19	0.3291	2.40	0.38	2.91	4.55	1%	99%	RESIDENTIAL
	C2 UPSLOPE	0.55								
	C1 UPSLOPE	0.87								
	TOTAL	**28.65**								
	C2 Forest b	2.58						0%	100%	FOREST
	C3 FOREST	3.67						0%	100%	FOREST
	C3	16.80	0.4331	4.87	0.42	4.77	6.73	1%	99%	RESIDENTIAL
	WETLAND 3	0.7981								
O2	C5 FOREST A	2.78						0%	100%	FOREST
	WETLAND5(b1)	0.1403								
	C5 WETLAND5(a)	0.3419								
	C5 A	4.33	0.0895	1.12	0.42	1.07	2.05	1%	99%	RESIDENTIAL
	C7	3.47		0.0		2.08	1.39	0%	100%	RESIDENTIAL
	BASIN B7	0.1211								
	TOTAL	**35.03**								
	C8r	0.89		0.89	0.50					ROAD
O6	C4	4.99	0.0625	0.22	0.28		4.71	0%	100%	RESIDENTIAL
	WETLAND 4	0.2497								
	C5 FOREST B	5.30						0%	100%	FOREST
	Wetland 5	0.2234								
	WETLAND5(b2)	0.5077								
O3	C5 B	11.55	0.3856	4.16	0.41	2.80	4.21	1%	99%	RESIDENTIAL
	C9	2.67						0%	100%	FOREST
	TOTAL	**20.24**								
	C23b	2.63						0%	100%	FOREST
O4	C8	6.86	0.6863	1.50	0.50	0.0	4.68	100%	0%	INDUSTRIAL
	BASIN C8	0.3991								
	TOTAL	**9.89**								
	C10	2.45						0%	100%	FOREST
	C11	1.72					1.7	100%	0%	INDUSTRIAL
	C15a	2.13					2.1	0%	100%	RESIDENTIAL
	WETLAND 15B	0.6646								
	C15b	5.41						0%	100%	FOREST
	C12	1.01					1.0	90%	10%	RESIDENTIAL
	C13	0.84	0.0296	0.17	0.50		0.64	100%	0%	INDUSTRIAL
O5	C14	1.77		1.8				100%	0%	ROAD
	C16	3.97						0%	100%	FOREST
	C17	1.89						0%	100%	FOREST
	C18	1.99						0%	100%	AGRICULTURAL
	C19	0.62	0.0000	0.2	0.5	0.153	0.32	0%	100%	RESIDENTIAL
	C20	1.82	0.0954	0.3	0.5	0.430	0.95	0%	100%	RESIDENTIAL
	C21	0.60		0.0				0%	100%	FOREST
	C22	1.49					1.5	40%	60%	COMMERCIAL
	C23a	1.96						0%	100%	FOREST
	TOTAL	**30.3**								
	TOTAL	**130**								

* where bioswales are on road then pervious area cannot be 50%

12 Attachment E – Bioretention Basin and Wetland MUSIC Input Parameters

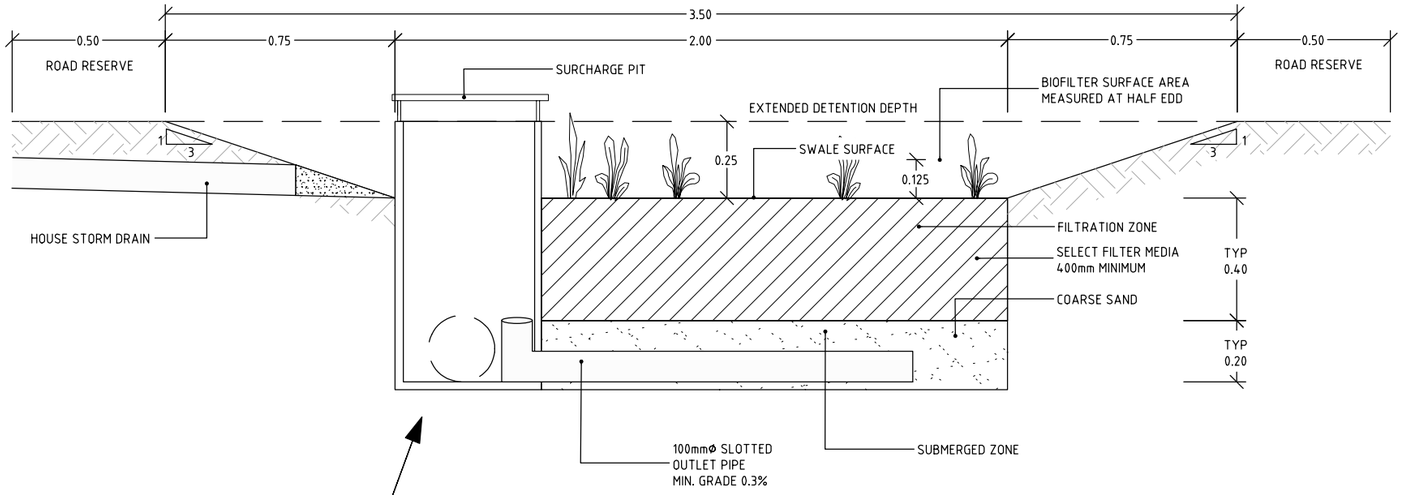
WETLAND INPUT PARAMETERS

Node Name	Wetland 3	Wetland 4	Wetland 5b 1+2	Wetland 1	Wetland 5	Wetland 15B	
Inlet Properties - Low Flow By-pass (cubic metres per sec)	0	0	0	0	0	0	{cubic metres per sec}
Inlet Properties - High Flow By-pass (cubic metres per sec)	100	100	100	100	100	100	{cubic metres per sec}
Inlet Properties - Inlet Pond Volume (cubic metres)	0	0	0	0	0	0	{cubic metres}
Storage Properties - Surface Area (square metres)	10869	2423	6236	3311	2053	6471	{square metres}
Storage Properties - Extended Detention Depth (metres)	0.4	0.5	0.4	0.5	0.5	0.5	{metres}
Storage Properties - Permanent Pool Volume (cubic metres)	820	200	570	260	74.2	510	{cubic metres}
Storage Properties - Exfiltration Rate (mm/hr)	3.6	3.6	3.6	3.6	3.6	3.6	{mm/hr}
Storage Properties - Evaporative Loss as % of PET	125	125	125	125	125	125	
Outlet Properties - Equivalent Pipe Diameter (mm)	110	55	90	65	40	90	{mm}
Outlet Properties - Overflow Weir Width (metres)	660	20	10	20	10	10	{metres}
Outlet Properties - Notional Detention Time (hrs)	67.7	67.5	58.0	66.1	108.2	67.3	{hrs}

BASIN INPUT PARAMETERS

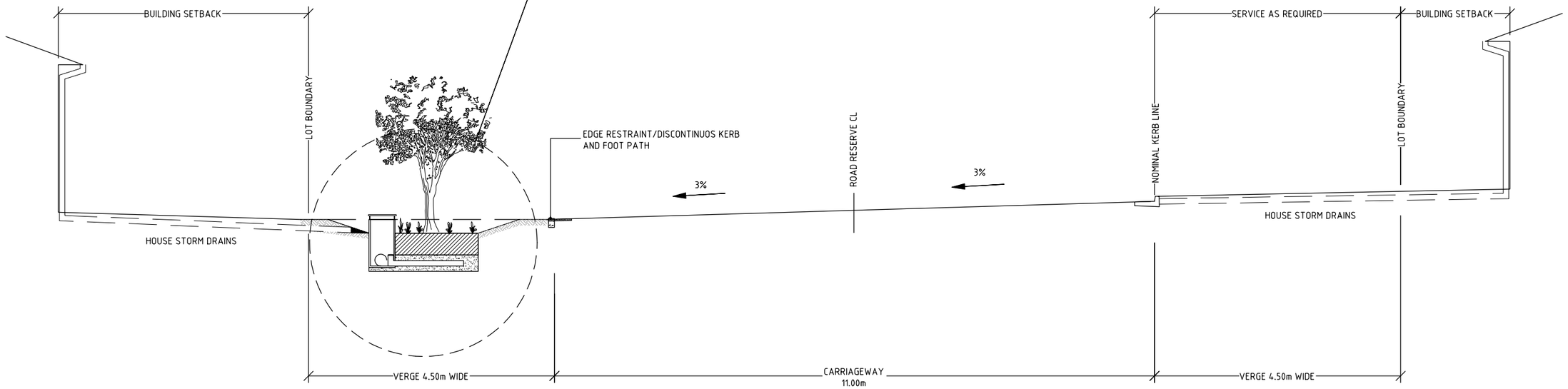
Node Name	B7 BASIN	Basin 8	
Inlet Properties - Low Flow By-pass (cubic metres per sec)	0	0	{cubic metres per sec}
Inlet Properties - High Flow By-pass (cubic metres per sec)	100	100	{cubic metres per sec}
Storage Properties - Extended Detention Depth (metres)	0.5	0.5	{metres}
Storage Properties - Surface Area (square metres)	1211	3991	{square metres}
Filter and Media Properties - Filter Area (square metres)	1099	3991	{square metres}
Filter and Media Properties - Unlined Filter Media Perimeter (metres)	140	252	{metres}
Filter and Media Properties - Saturated Hydraulic Conductivity (mm/hr)	90	90	{mm/hr}
Filter and Media Properties - Filter Depth (metres)	0.4	0.65	{metres}
Filter and Media Properties - TN Content of Filter Media (mg/kg)	500	500	{mg/kg}
Filter and Media Properties - Orthophosphate Content of Filter Media (mg/kg)	40	40	{mg/kg}
Infiltration Properties - Exfiltration Rate (mm/hr)	3.6	3.6	{mm/hr}
Outlet Properties - Overflow Weir Width (metres)	35	7	{metres}
Outlet Properties - Submerged Zone Depth (metres)	0.2	0	{metres}

13 Attachment F – Typical Bioretention Swale, Basin and Wetland Design



TYPICAL BIOSWALE SECTION

SCALE 1:20 @ A3



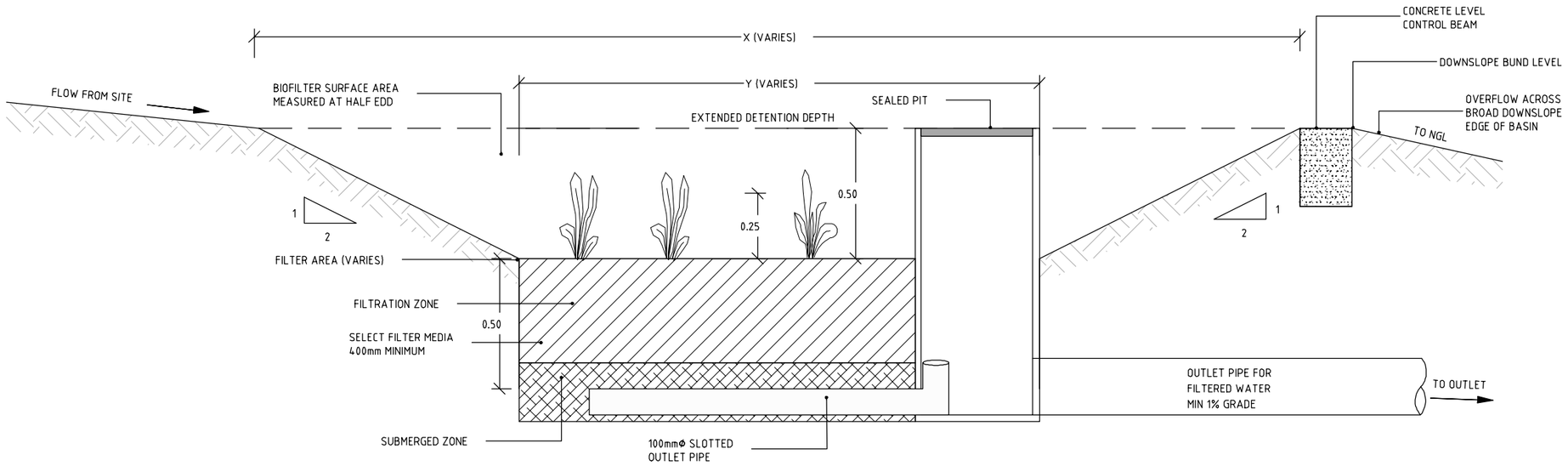
TYPICAL SECTION
ROAD 20m WIDE

SCALE 1:80 @ A3

0 0.2 0.4 0.6 0.8 1.0

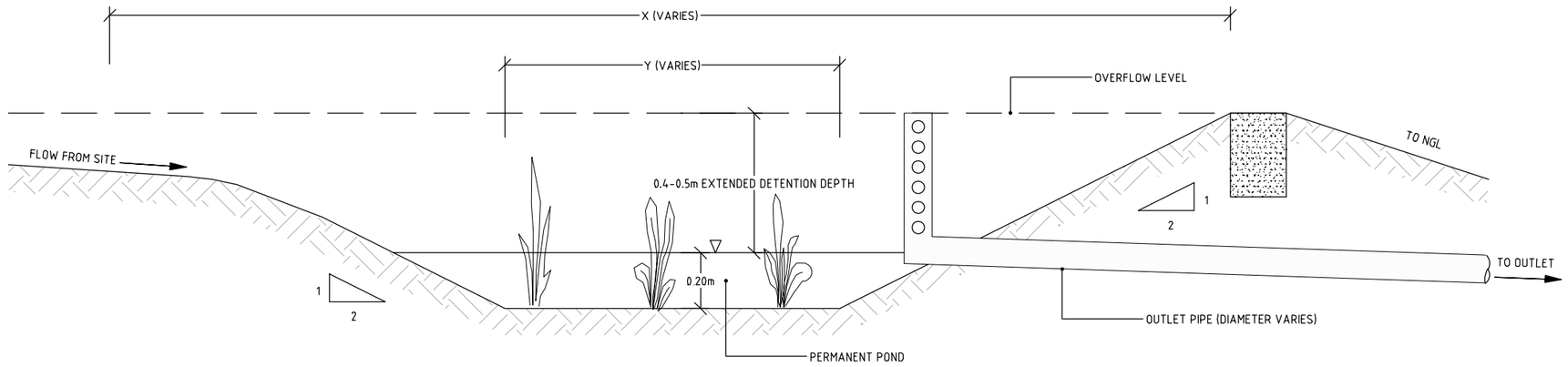
UNITS - METRES

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**		
Drawn:	KT	**TYPICAL BIOSWALE SECTION CULBURRA WEST, NSW MIXED USE SUBDIVISION**	Drawing No./ID: **SK001**	
Approved:	AN			
Date:	01.03.2013			
Scale @A3:	1:20	6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 Email: mail@martens.com.au Internet: http://www.martens.com.au	Project: P1203365 / File: JD02V01 / Revision: A	



TYPICAL BIOREMEDIATION BASIN SECTION

SCALE 1:20 @ A3



TYPICAL WETLAND SECTION

SCALE 1:20 @ A3

0 0.2 0.4 0.6 0.8 1.0

UNITS - METRES

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**			
Drawn:	KT	**TYPICAL BIOREMEDIATION BASIN SECTION AND TYPICAL WETLAND SECTION CULBURRA WEST, NSW MIXED USE SUBDIVISION**	Drawing No./ID: **SK002**		
Approved:	AN				
Date:	10.10.2013				
Scale @A3:	1:20	6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 Email: mail@martens.com.au Internet: http://www.martens.com.au	Project: P1203365	File: JD02V02	Revision: A

14 Attachment G – Groundwater Quality Laboratory Results

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 48959

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

Attention: Ben Rose

Sample log in details:

Your Reference:	**P1002842JC01V01, Culburra**
No. of samples:	3 Waters, 60 Soils
Date samples received:	30/11/10
Date completed instructions received:	30/11/10

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:	7/12/10
Date of Preliminary Report:	01/12/2010
Issue Date:	7/12/10

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This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.
Tests not covered by NATA are denoted with *.

Results Approved By:

Kasjan Paciuszkiewicz
Chemist

Nick Sarlamis
Inorganics Supervisor

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-4	48959-5	48959-6	48959-7	48959-8
Your Reference	----------	2842/1	2842/1	2842/1	2842/2	2842/2
Depth	----------	0.5	1.0	1.5	0.2	0.5
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	5.1	5.0	8.1	5.5	4.7
Electrical Conductivity 1:5 soil:water	µS/cm	57	97	80	23	43

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-9	48959-10	48959-11	48959-12	48959-13
Your Reference	----------	2842/2	2842/24	2842/24	2842/24	2842/24
Depth	----------	1.5	0.2	1.0	1.5	2.0
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	5.0	5.3	4.8	4.8	4.9
Electrical Conductivity 1:5 soil:water	µS/cm	23	21	55	58	58

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-14	48959-15	48959-16	48959-17	48959-18
Your Reference	----------	2842/13	2842/13	2842/13	2842/3	2842/3
Depth	----------	0.2	0.5	1.0	0.2	0.5
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	5.1	5.5	5.2	5.3	5.2
Electrical Conductivity 1:5 soil:water	µS/cm	33	24	66	35	56

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-19	48959-20	48959-21	48959-22	48959-23
Your Reference	----------	2842/3	2842/4	2842/4	2842/4	2842/18
Depth	----------	1.0	1.0	1.5	2.0	0.2
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	4.9	4.8	4.7	4.6	5.3
Electrical Conductivity 1:5 soil:water	µS/cm	52	63	68	76	18

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-24	48959-25	48959-26	48959-27	48959-28
Your Reference	----------	2842/18	2842/18	2842/19	2842/19	2842/19
Depth	----------	0.5	1.0	0.2	0.5	1.5
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	5.1	4.9	5.5	4.9	4.7
Electrical Conductivity 1:5 soil:water	µS/cm	34	44	30	51	83

Miscellaneous Inorg - soil						
Our Reference:	UNITS	48959-29	48959-30	48959-31	48959-32	48959-33
Your Reference	----------	2842/22	2842/22	2842/6	2842/6	2842/6
Depth	----------	0.2	0.5	0.2	0.5	2.5
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
Date analysed	-	6/12/2010	6/12/2010	6/12/2010	6/12/2010	6/12/2010
pH 1:5 soil:water	pH Units	5.7	5.3	4.7	4.5	6.1
Electrical Conductivity 1:5 soil:water	µS/cm	21	58	480	1,200	710

sPOCAS field test						
Our Reference:	UNITS	48959-34	48959-35	48959-36	48959-37	48959-38
Your Reference	----------	2842/1	2842/1	2842/1	2842/11	2842/11
Depth	----------	0.5	1.0	1.5	0.5	1.0
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	5.4	5.1	5.1	5.3	4.7
pH_{FOX} (field peroxide test)*	pH Units	4.5	4.1	4.2	4.4	3.8
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference:	UNITS	48959-39	48959-40	48959-41	48959-42	48959-43
Your Reference	----------	2842/24	2842/24	2842/24	2842/24	2842/13
Depth	----------	0.5	1.0	1.5	2.0	0.5
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	5.1	5.0	5.1	5.2	5.3
pH_{FOX} (field peroxide test)*	pH Units	4.0	4.0	4.1	4.2	4.2
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference:	UNITS	48959-44	48959-45	48959-46	48959-47	48959-48
Your Reference	----------	2842/13	2842/4	2842/4	2842/4	2842/4
Depth	----------	1.0	0.5	1.0	1.5	2.0
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	5.4	5.3	4.9	4.8	4.9
pH_{FOX} (field peroxide test)*	pH Units	4.4	4.3	4.0	4.0	4.0
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference:	UNITS	48959-49	48959-50	48959-51	48959-52	48959-53
Your Reference	----------	2842/4	2842/19	2842/19	2842/19	2842/5
Depth	----------	2.5	0.5	1.0	1.5	0.5
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	4.5	5.1	4.8	4.9	5.5
pH_{FOX} (field peroxide test)*	pH Units	3.8	4.2	3.9	3.9	4.5
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference:	UNITS	48959-54	48959-55	48959-56	48959-57	48959-58
Your Reference	----------	2842/5	2842/6	2842/6	2842/6	2842/6
Depth	----------	1.0	0.5	1.0	1.5	2.0
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	5.2	4.5	4.7	5.0	5.2
pH_{FOX} (field peroxide test)*	pH Units	4.1	3.6	4.0	4.5	4.4
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference:	UNITS	48959-59	48959-60	48959-61	48959-62	48959-63
Your Reference	----------	2842/6	2842/6	2842/21	2842/21	2842/20
Depth	----------	2.5	3.0	0.5	1.0	1.5
Type of sample		Soil	Soil	Soil	Soil	Soil
pH_F (field pH test)*	pH Units	5.8	5.6	5.2	5.3	5.0
pH_{FOX} (field peroxide test)*	pH Units	5.7	5.3	4.1	4.7	4.2
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

Miscellaneous Inorganics				
Our Reference:	UNITS	48959-1	48959-2	48959-3
Your Reference	----------	2842/GMB01/ 25.11.2010	2842/GMB02/ 25.11.2010	2842/GMB06/ 26.11.2010
Depth	----------	-	-	-
Type of sample		Water	Water	Water
Date prepared	-	30/11/2010	30/11/2010	30/11/2010
Date analysed	-	30/11/2010	30/11/2010	30/11/2010
Electrical Conductivity	µS/cm	4,900	250	18,000
Total Dissolved Solids (grav)	mg/L	2,900	180	13,000
pH	pH Units	5.2	5.1	5.6
Nitrate as N in water	mg/L	0.01	0.1	<0.005
Hardness	mg$CaCO_3$ /L	280	8	2,600
NOx as N in water	mg/L	0.02	0.1	0.007
Ammonia as N in water	mg/L	0.3	0.02	0.1
Total Nitrogen in water	mg/L	0.7	0.4	0.3
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05
Phosphate as P in water	mg/L	<0.05	<0.05	<0.05
Silicon*- Dissolved	mg/L	36	36	15
Strontium - Dissolved	mg/L	0.2	<0.01	1.2
Titanium - Dissolved	mg/L	<0.02	<0.02	<0.02

Ion Balance Our Reference: Your Reference Depth Type of sample	UNITS ---------- ----------	48959-1 2842/GMB01/ 25.11.2010 - Water	48959-2 2842/GMB02/ 25.11.2010 - Water	48959-3 2842/GMB06/ 26.11.2010 - Water
Date prepared	-	30/11/2010	30/11/2010	30/11/2010
Date analysed	-	30/11/2010	30/11/2010	30/11/2010
Calcium - Dissolved	mg/L	10	0.6	130
Potassium - Dissolved	mg/L	8.0	0.6	13
Sodium - Dissolved	mg/L	950	38	3,400
Magnesium - Dissolved	mg/L	62	1.6	560
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<0.1	<0.1	<0.1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	23	7	46
Carbonate Alkalinity as $CaCO_3$	mg/L	<0.1	<0.1	<0.1
Total Alkalinity as $CaCO_3$	mg/L	23	7	46
Sulphate, SO4	mg/L	330	22	720
Chloride, Cl	mg/L	1,300	40	6,000
Ionic Balance	%	3.5	3.1	3.9

All metals in water-dissolved				
Our Reference:	UNITS	48959-1	48959-2	48959-3
Your Reference	----------	2842/GMB01/ 25.11.2010	2842/GMB02/ 25.11.2010	2842/GMB06/ 26.11.2010
Depth	----------	-	-	-
Type of sample		Water	Water	Water
Date prepared	-	2/12/2010	2/12/2010	2/12/2010
Date analysed	-	2/12/2010	2/12/2010	2/12/2010
Aluminium-Dissolved	µg/L	260	39	210
Boron-Dissolved	µg/L	200	70	40
Barium-Dissolved	µg/L	71	7	93
Beryllium-Dissolved	µg/L	<0.5	<0.5	0.6
Cadmium-Dissolved	µg/L	1.9	1	3.2
Cobalt-Dissolved	µg/L	52	<1	67
Chromium-Dissolved	µg/L	<1	<1	<1
Copper-Dissolved	µg/L	3	<1	7
Iron-Dissolved	µg/L	1,800	11	13
Manganese-Dissolved	µg/L	950	7	1,100
Molybdenum-Dissolved	µg/L	<1	<1	<1
Nickel-Dissolved	µg/L	38	<1	67
Vanadium-Dissolved	µg/L	<1	<1	<1
Zinc-Dissolved	µg/L	100	42	140
Arsenic-Dissolved	µg/L	2	<1	9
Mercury-Dissolved	µg/L	<0.4	<0.4	<0.4
Lead-Dissolved	µg/L	15	<1	3
Selenium-Dissolved	µg/L	<1	<1	<1

Method ID	Methodology Summary
LAB.1	pH - Measured using pH meter and electrode in accordance with APHA 20th ED, 4500-H+.
LAB.2	Conductivity and Salinity - measured using a conductivity cell and dedicated meter, in accordance with APHA2510 20th ED and Rayment & Higginson.
LAB.63	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. Based on section H, Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.
LAB.18	Total Dissolved Solids - determined gravimetrically by drying the sample, in accordance with APHA 20th ED, 2540-C.
LAB.55	Nitrate - determined colourimetrically based on EPA353.2. Soils are analysed following a water extraction.
Metals.20 ICP-AES	Determination of various metals by ICP-AES.
LAB.57	Ammonia - determined colourimetrically based on EPA350.1, Soils are analysed following a water extraction.
LAB.66	Total Nitrogen - Calculation sum of TKN and oxidised Nitrogen.
LAB.60	Phosphate water extractable - determined colourimetrically based on EPA365.1
LAB.6	Alkalinity - determined titrimetrically in accordance with APHA 20th ED, 2320-B.
LAB.81	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 21st ED, 4110-B.
LAB.41	Gravimetric determination of the total solids content of water.
Metals.22 ICP-MS	Determination of various metals by ICP-MS.
Metals.21 CV-AAS	Determination of Mercury by Cold Vapour AAS.

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			6/12/2010	48959-4	6/12/2010 || 6/12/2010	LCS-1	6/12/2010
Date analysed	-			6/12/2010	48959-4	6/12/2010 || 6/12/2010	LCS-1	6/12/2010
pH 1:5 soil:water	pH Units		LAB.1	[NT]	48959-4	5.1 || 5.1 || RPD: 0	LCS-1	100%
Electrical Conductivity 1:5 soil:water	µS/cm	1	LAB.2	<1.0	48959-4	57 || 53 || RPD: 7	LCS-1	107%

QUALITY CONTROL sPOCAS field test	UNITS	PQL	METHOD	Blank
pH_F (field pH test)*	pH Units		LAB.63	[NT]
pH_{FOX} (field peroxide test)*	pH Units		LAB.63	[NT]

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			30/11/2010	[NT]	[NT]	LCS-W1	30/11/2010
Date analysed	-			30/11/2010	[NT]	[NT]	LCS-W1	2/12/2010
Electrical Conductivity	µS/cm	1	LAB.2	<1.0	[NT]	[NT]	LCS-W1	104%
Total Dissolved Solids (grav)	mg/L	5	LAB.18	<5	[NT]	[NT]	LCS-W1	106%
pH	pH Units		LAB.1	[NT]	[NT]	[NT]	LCS-W1	102%
Nitrate as N in water	mg/L	0.005	LAB.55	<0.005	[NT]	[NT]	LCS-W1	91%
Hardness	$mgCaCO_3/L$	3	Metals.20 ICP-AES	<3	[NT]	[NT]	[NR]	[NR]
NOx as N in water	mg/L	0.005	LAB.55	<0.005	[NT]	[NT]	LCS-W1	91%
Ammonia as N in water	mg/L	0.005	LAB.57	<0.005	[NT]	[NT]	LCS-W1	93%
Total Nitrogen in water	mg/L	0.1	LAB.66	<0.1	[NT]	[NT]	LCS-W1	86%
Phosphorus - Total	mg/L	0.05	Metals.20 ICP-AES	<0.05	[NT]	[NT]	LCS-W1	97%
Phosphate as P in water	mg/L	0.005	LAB.60	<0.005	[NT]	[NT]	LCS-W1	101%
Silicon*- Dissolved	mg/L	0.2	Metals.20 ICP-AES	<0.2	[NT]	[NT]	LCS-W1	100%
Strontium - Dissolved	mg/L	0.01	Metals.20 ICP-AES	<0.01	[NT]	[NT]	LCS-W1	90%
Titanium - Dissolved	mg/L	0.02	Metals.20 ICP-AES	<0.02	[NT]	[NT]	LCS-W1	96%

QUALITY CONTROL Ion Balance	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			30/11/2010	[NT]	[NT]	LCS-W1	30/11/2010
Date analysed	-			30/11/2010	[NT]	[NT]	LCS-W1	30/11/2010
Calcium - Dissolved	mg/L	0.5	Metals.20 ICP-AES	<0.5	[NT]	[NT]	LCS-W1	91%
Potassium - Dissolved	mg/L	0.5	Metals.20 ICP-AES	<0.5	[NT]	[NT]	LCS-W1	103%
Sodium - Dissolved	mg/L	0.5	Metals.20 ICP-AES	<0.5	[NT]	[NT]	LCS-W1	100%
Magnesium - Dissolved	mg/L	0.5	Metals.20 ICP-AES	<0.5	[NT]	[NT]	LCS-W1	92%
Bicarbonate Alkalinity as $CaCO_3$	mg/L	0.1	LAB.6	<0.1	[NT]	[NT]	LCS-W1	104%
Carbonate Alkalinity as $CaCO_3$	mg/L	0.1	LAB.6	<0.1	[NT]	[NT]	[NR]	[NR]
Total Alkalinity as $CaCO_3$	mg/L	0.1	LAB.6	<0.1	[NT]	[NT]	LCS-W1	104%
Sulphate, SO4	mg/L	1	LAB.81	<1.0	[NT]	[NT]	LCS-W1	108%
Chloride, Cl	mg/L	1	LAB.81	<1.0	[NT]	[NT]	LCS-W1	94%
Ionic Balance	%		LAB.41	[NT]	[NT]	[NT]	[NR]	[NR]

QUALITY CONTROL All metals in water-dissolved	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			2/12/2010	48959-1	2/12/2010 || 2/12/2010	LCS-W1	02/12/2010
Date analysed	-			2/12/2010	48959-1	2/12/2010 || 2/12/2010	LCS-W1	02/12/2010
Aluminium-Dissolved	µg/L	10	Metals.22 ICP-MS	<10	48959-1	260 || 260 || RPD: 0	LCS-W1	103%
Boron-Dissolved	µg/L	5	Metals.22 ICP-MS	<5	48959-1	200 || 190 || RPD: 5	LCS-W1	83%
Barium-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	71 || 67 || RPD: 6	LCS-W1	99%
Beryllium-Dissolved	µg/L	0.5	Metals.22 ICP-MS	<0.5	48959-1	<0.5 || <0.5	LCS-W1	80%
Cadmium-Dissolved	µg/L	0.1	Metals.22 ICP-MS	<0.1	48959-1	1.9 || 2.0 || RPD: 5	LCS-W1	100%
Cobalt-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	52 || 52 || RPD: 0	LCS-W1	96%
Chromium-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	<1 || <1	LCS-W1	95%
Copper-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	3 || 3 || RPD: 0	LCS-W1	91%
Iron-Dissolved	µg/L	10	Metals.22 ICP-MS	<10	48959-1	1800 || 1800 || RPD: 0	LCS-W1	91%
Manganese-Dissolved	µg/L	5	Metals.22 ICP-MS	<5	48959-1	950 || 950 || RPD: 0	LCS-W1	91%

QUALITY CONTROL All metals in water-dissolved	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Molybdenum-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	<1 || <1	LCS-W1	99%
Nickel-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	38 || 38 || RPD: 0	LCS-W1	89%
Vanadium-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	<1 || <1	LCS-W1	95%
Zinc-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	100 || 100 || RPD: 0	LCS-W1	95%
Arsenic-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	2 || 2 || RPD: 0	LCS-W1	90%
Mercury-Dissolved	µg/L	0.4	Metals.21 CV-AAS	<0.4	48959-1	<0.4 || <0.4	LCS-W1	100%
Lead-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	15 || 15 || RPD: 0	LCS-W1	96%
Selenium-Dissolved	µg/L	1	Metals.22 ICP-MS	<1	48959-1	<1 || <1	LCS-W1	92%

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	48959-14	6/12/2010 || 6/12/2010	LCS-2	6/12/2010
Date analysed	-	48959-14	6/12/2010 || 6/12/2010	LCS-2	6/12/2010
pH 1:5 soil:water	pH Units	48959-14	5.1 || 5.0 || RPD: 2	LCS-2	100%
Electrical Conductivity 1:5 soil:water	µS/cm	48959-14	33 || 34 || RPD: 3	LCS-2	106%

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	48959-25	6/12/2010 || 6/12/2010
Date analysed	-	48959-25	6/12/2010 || 6/12/2010
pH 1:5 soil:water	pH Units	48959-25	4.9 || 5.0 || RPD: 2
Electrical Conductivity 1:5 soil:water	µS/cm	48959-25	44 || 54 || RPD: 20

Report Comments:
Phosphate:PQL raised due to sample matrix.

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job
Asbestos counting was analysed by Approved Counter:	@ERROR
Asbestos counting was authorised by Approved Signatory:	@ERROR

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 batched of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

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

15 Attachment H – Agency Consultation

Megan Kovelis

From: Dollery, Ian <dolleryi@shoalhaven.nsw.gov.au>
Sent: Thursday, 15 March 2012 8:52 AM
To: Megan Kovelis
Subject: RE: West Culburra subdivision

Megan

At this point in time I can't foresee any problem with doing so. Without the policy and the development coming direct to council, we would probably place conditions on a consent requiring similar outcomes.

Regards

Ian Dollery
Subdivision Engineer
Shoalhaven City Council

☎02 4429 3308 | 02 4429 3178
dolleryi@shoalhaven.nsw.gov.au
http://shoalhaven.nsw.gov.au

From: Megan Kovelis [mailto:mkovelis@martens.com.au]
Sent: Wednesday, 14 March 2012 4:12 PM
To: Dollery, Ian
Cc: Andrew Norris
Subject: RE: West Culburra subdivision

Ian,

Thank you for sending that information through. As discussed, our current MUSIC modelling approach is to achieve a 'neutral or beneficial impact' when comparing the pre- and post-development scenarios. Based on the information provided, we will also consider the pollutant objectives in Table 5.2 of the draft DCP.

Do you anticipate that Council would be happy with this modelling approach?

Kind Regards,

Martens & Associates Pty Ltd

Megan Kovelis
Environmental Scientist
BEnvSc (Hons1)

Martens & Associates Pty Ltd
Unit 6/37 Leighton Place
Hornsby, NSW 2077
P + 61 2 9476 9999
F + 61 2 9476 8767

From: Dollery, Ian [mailto:dolleryi@shoalhaven.nsw.gov.au]
Sent: Tuesday, 13 March 2012 4:36 PM
To: Megan Kovelis
Subject: West Culburra subdivision

Megan

Hope this helps!

Regards

Ian Dollery
Subdivision Engineer
Shoalhaven City Council

☎02 4429 3308 | 02 4429 3178
dolleryi@shoalhaven.nsw.gov.au
http://shoalhaven.nsw.gov.au

This message may contain both confidential and privileged information intended only for the addressee named above.
If you have received this email in error, please notify the sender immediately then destroy the original message.

Megan Kovelis

From: allan.lugg@dpi.nsw.gov.au
Sent: Thursday, 14 February 2013 12:25 PM
To: Megan Kovelis
Cc: trevor.daly@dpi.nsw.gov.au
Subject: MP09_0088 West Culburra Urban Expansion - Stormwater Modelling

Hi Megan,

as discussed, I can confirm that we have discussed the modelling approach being undertaken for the proposed West Culburra subdivision by Martens and Associates.

From our discussion, I understand that the modelling will compare pre-development conditions with post-development conditions and aim to achieve a Neutral or Beneficial Impact upon Curleys Bay and the Crookhaven River estuary (where there are numerous oyster farms) with respect to suspended sediment, nitrogen and phosphorus. I believe that is a reasonable approach.

As discussed, I also recommend that you give some consideration to the potential impacts upon bacterial levels and the potential implications for oyster farming.

Regards Allan

Allan Lugg | Senior Fisheries Conservation Manager
NSW Department of Primary Industries
4 Woollamia Road | PO Box 97 | HUSKISSON NSW 2540
T: 02 4428 3401 | F: 02 4441 8961 | M: 0409 912 686 | E: Allan.Lugg@dpi.nsw.gov.au
W: http://www.dpi.nsw.gov.au/fisheries

Megan Kovelis

From: Miles Boak <Miles.Boak@environment.nsw.gov.au>
Sent: Friday, 8 February 2013 2:11 PM
To: Megan Kovelis
Subject: FW: West Culburra Proposed Subdivision - Water Quality Modelling
Attachments: DOC10-22366 DECCW DG-EARs & Attachments 24 May 2010.pdf; ATT00001..txt; ATT00002..htm

Hi Megan

OEH are happy with the approach taken for water quality assessment - of applying MUSIC modelling guidelines with a view to achieving neutral and beneficial impact on water quality. OEH provided comments in this regard on the West Culburra DGRs in May 2010 (attached) which provide more detail.

Cheers
Miles Boak

Miles Boak
Conservation Planner - Regional Operations
Office of Environment and Heritage
NSW Department of Premier and Cabinet
PO Box 733, Queanbeyan, NSW 2620
T: 02 62297095 M: 0427919192
W: www.environment.nsw.gov.au

From: Megan Kovelis [mailto:mkovelis@martens.com.au]
Sent: Wednesday, 14 March 2012 12:28 PM
To: Thompson Julian
Cc: Andrew Norris
Subject: West Culburra Proposed Subdivision - Water Quality Modelling

Julian,

I appreciate your time this morning. As discussed, based on Council DCP water quality requirements and NSW OEH requirements for the nearby West Culburra Golf Course, we are undertaking our MUSIC modelling to achieve neutral or beneficial impacts (pre development versus post development) for the proposed subdivision development.

MUSIC inputs (EMC's, pervious area parameters etc) are based on NSW CMA (2010) '*Sydney Metropolitan: Draft NSW MUSIC Modelling Guidelines*'.

I trust that OEH agree with this modelling approach.

Kind Regards,

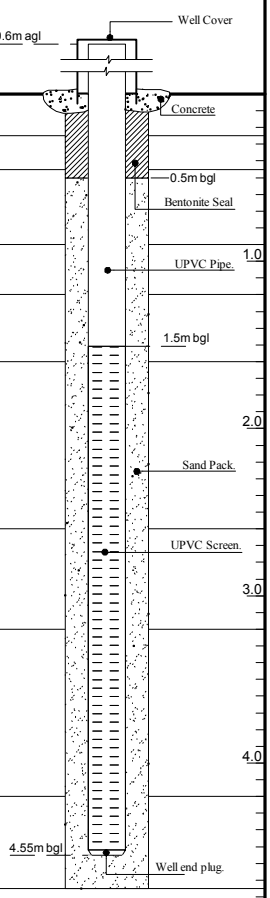
Martens & Associates Pty Ltd

Megan Kovelis
Environmental Scientist
BEnvSc (Hons1)

16 Attachment I - Borelogs

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	22.11.10	**COMPLETED**	22.11.10	**REF**	**BH1**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 4.75m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

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)	WATER WELL DETAILS
A	Nil	N	M	0.25			SC	SILTY CLAYEY SAND – Dark brown, fine grained sands.		L	A	0.2	2842/1/0.2
A	Nil	N	M	0.45			SC	SILTY CLAYEY SAND – Light grey, fine grained sands, minor gravels.		L	A	0.4	2842/1/0.4
A	Nil	N	M	0.6 0.9			CL	SILTY CLAY - Brown/orange, gravels (1-15mm, 35%), tending to clay with gravels decreasing.	F St		A	0.5	2842/1/0.5
A	Nil	N	M	1.0 1.2			CH	CLAY - Grey/orange/red mottled.	VSt		A	1.0	2842/1/1.0
A	Nil	N	M	1.6			CL	SANDY CLAY/EXTREMELY WEATHERED SILTSTONE - Light grey, yellow, cream bands, gravels (approx 5-50mm).	VSt	MD	A	1.5	2842/1/1.5
A	Nil	N	D	2.0 2.6			EW HW	EXTREMELY TO HIGHLY WEATHERED SILTSTONE.		MD D	A A	2.0 2.5	2842/1/2.0 2842/1/2.5
A	Nil	N	D	3.0 3.2			MW	MODERATELY WEATHERED SILTSTONE GRAVELLY CLAY.					
A	Nil	N	M	4.0 4.2			CL EW	CLAY/EXTREMELY WEATHERED SILTSTONE - Grey.	F St		A	3.5	2842/1/3.5
A	Nil	N	D	4.75			MW	MODERATELY WEATHERED SILTSTONE.		D	A	4.5	2842/1/4.5
				5.0 6.0 7.0 8.0 9.0				Borehole terminated at 4.75m on moderately to slightly weathered siltstone.					



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

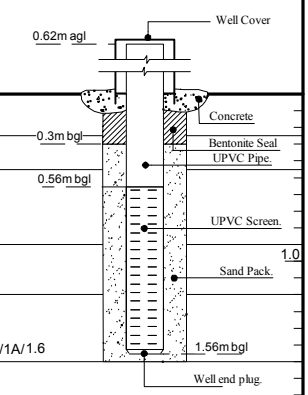
Quality Sheet No. 4

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	23.11.10	**COMPLETED**	23.11.10	**REF**	**BH1A**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 1.6m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

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)	WATER WELL DETAILS
A	Nil	N	M	0.25			SC	SILTY CLAYEY SAND – Dark brown, fine grained sands.		L			
A	Nil	N	M	0.45			SC	SILTY CLAYEY SAND – Light grey, fine grained sands, minor gravels.		L			
A	Nil	N	M	0.6 0.9			CL	SILTY CLAY - Brown/orange, gravels (1-15mm, 35%), tending to clay with gravels decreasing.	F St				
A	Nil	N	M	1.0 1.2			CH	CLAY - Grey/orange/red mottled.	VSt				
A	Nil	N	M	1.6			CL	SANDY CLAY/EXTREMELY WEATHERED SILTSTONE - Light grey, yellow, cream bands, gravels (approx 5-50mm).	VSt	MD	A	1.6	2842/1A/1.6
								Borehole terminated at 1.6m on clay/extremely weathered siltstone.					



2.0 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
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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

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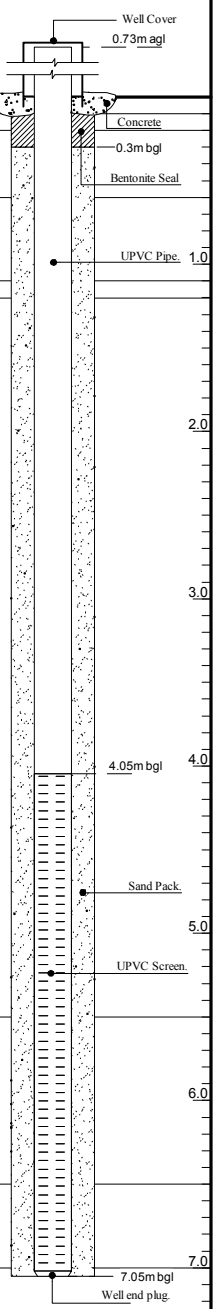
martens

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	22.11.10	**COMPLETED**	22.11.10	**REF**	**BH2**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 7.0m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	3-4%

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)	WATER WELL DETAILS
A	Nil	N	M	0.1			OL	ORGANIC SILTY CLAY – Dark grey/black.	S				
A	Nil	N	M	0.2			CL	SILTY CLAY – Brown/light brown.	S		A	0.2	2842/2/0.2+B
A	Nil	N	M	0.6			CL	CLAY – Red, moderately plastic, with light brown/grey mottles increassing with depth.	F		A	0.5	2842/2/0.5+Att
A	Nil	N	M	1.0 1.1			CH	CLAY – Red, medium plasticity, grey/brown mottles.	St		A	1.0	2842/2/1.0
A	Nil	N	M	1.2			CH	CLAY - Grey with minor red/brown mottles.	VSt		A	1.2	2842/2/1.2
A	Nil	N	D M	2.0 3.0 4.0 5.0 5.5			CL EW	CLAY - EXTREMELY WEATHERED SILTSTONE - Clay to sandy clay, weathered gravels, grey/red/brown.	VSt		A A A A	1.5 2.0 2.5 4.5	2842/2/1.5 2842/2/2.0 2842/2/2.5 2842/2/4.5
A	Nil	N	M	6.0 6.5			CL	SILTSTONE CLAY - Brown/dark grey, minor gravels, highly weathered siltstone.	St		A	6.0	2842/2/6.0
A	Nil	N	W	7.0			CL EW	CLAY - Dark grey/brown, clay/extremely weathered siltstone.	VSt		A	7.0	2842/2/7.0
				8.0 9.0				Borehole terminated at 7.0m on clays.					



EQUIPMENT / METHOD
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RB Rock Bolts
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WATER
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Water level
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Water inflow

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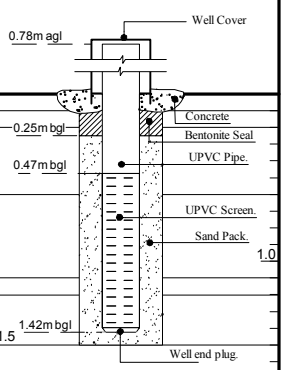
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	23.11.10	**COMPLETED**	23.11.10	**REF**	**BH2A**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grasses	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 1.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	3-4%

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)	WATER WELL DETAILS
A	Nil	N	M	0.1			OL	ORGANIC SILTY CLAY – Dark grey/black.	S				
A	Nil	N	M	0.2			CL	SILTY CLAY – Brown/light brown.	S				
A	Nil	N	M	0.6			CL	CLAY – Red, moderately plastic, with light brown/grey mottles increassing with depth.	F				
A	Nil	N	M	1.0 1.1			CH	CLAY – Red, medium plasticity, grey/brown mottles.	St				
A	Nil	N	M	1.2			CH	CLAY - Grey with minor red/brown mottles.	VSt				
A	Nil	N	D M	1.5			CL EW	CLAY TO EXTREMELY WEATHERED SILTSTONE - Clay to sandy clay, weathered gravels, grey/red/brown.	VSt		A	1.5	2842/2A/1.5
								Borehole terminated at 1.5m on extremely weathered siltstone.					



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Water level
Water outflow
Water inflow

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Wl Liquid limit

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

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martens

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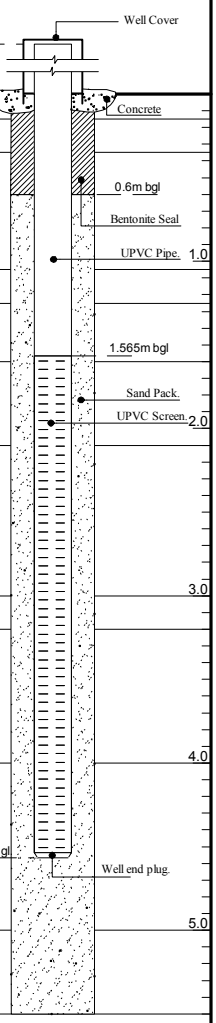
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	23.11.10	**COMPLETED**	23.11.10	**REF**	**BH3**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 5.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

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)	WATER WELL DETAILS
A	Nil	N	M	0.15			SM	SILTY SAND – Brown/dark brown, minor gravels.		L	A	0.2	2842/3/0.2
A	Nil	N	M	0.35			SP	SAND – Light brown/brown, medium grained sands, gravels (1-5mm, approx 10%).		L			
A	Nil	N	M	0.8 1.0 1.05			CL	CLAY - Yellow/brown/orange, red weathered siltstone bands increasing with depth.	F St		A A	0.5 1.0	2842/3/0.5 2842/3/1.0
A	Nil	N	M	1.25			CL/ HW	SANDY CLAY/HIGHLY WEATHERED SILTSTONE - Orange/grey.	VSt		A	1.2	2842/3/1.2
A	Nil	N	M	1.6			CL HW	CLAY - HIGHLY WEATHERED SILTSTONE - Grey with red/orange mottles, siltstone bands/gravels.	VSt		A	1.5	2842/3/1.5
A	Nil	N	M	2.0 2.1			CL MW EW	CLAY - MODERATELY TO EXTREMELY WEATHERED SILTSTONE - Grey with red/pink mottles.	VSt		A	2.0	2842/3/2.0
A	Nil	N	D	3.0			SC EW	CLAYEY SAND/EXTREMELY WEATHERED SILTSTONE - Grey/pink/red, fine to medium grained sands.	VSt		A	2.5	2842/3/2.5
A	Nil	N	D	3.2			MW	MODERATELY WEATHERED SILTSTONE - Orange brown.					
A	Nil	N	D	4.0			HW/ EW	HIGHLY/EXTREMELY WEATHERED SILTSTONE.			B	4.0	2842/3/4.0
A	Nil	N	D	5.0			MW/ SW	MODERATELY/SLIGHTLY WEATHERED SILTSTONE.					
A	Nil	N	D	5.5			EW/ MW	EXTREMELY/MODERATELY WEATHERED SILTSTONE.					
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on moderately weathered siltstone.					



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

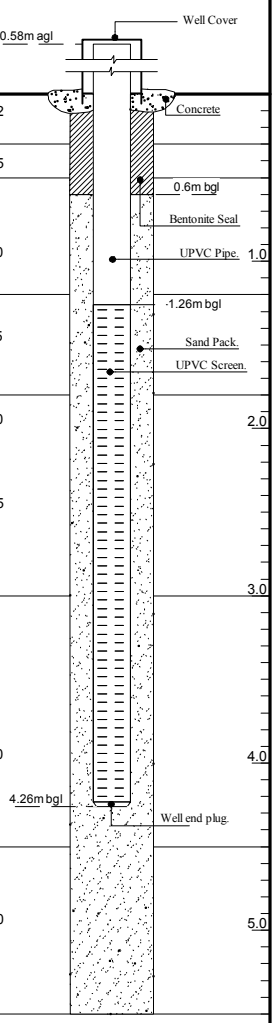
Quality Sheet No. 4

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	23.11.10	**COMPLETED**	23.11.10	**REF**	**BH4**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 5.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

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)	WATER WELL DETAILS
A	Nil	N	M	0.3			SM	SILTY SAND – Brown, gravels (1-10mm, approx 10%).		L	A	0.2	2842/4/0.2
A	Nil	N	M	0.5			CL	CLAY - Brown/orange, mottles increasing with depth, gravels (1-10mm, approx 10%).	S		A	0.5	2842/4/0.5
A	Nil	N	M	1.0 1.2			CL	CLAY - Grey/brown/red mottles, minor gravels.		F	A	1.0	2842/4/1.0
A	Nil	N	M	1.8			CL HW	CLAY - HIGHLY WEATHERED SILTSTONE - Grey with red/orange mottles, siltstone bands/gravels.	VSt		A	1.5	2842/4/1.5
A	Nil	N	M	2.0 3.0			CL MW EW	CLAY - MODERATELY TO EXTREMELY WEATHERED SILTSTONE - Grey with red/pink mottles.	VSt		A A	2.0 2.5	2842/4/2.0 2842/4/2.5
A	Nil	N	D	4.0 4.5			SC EW	CLAYEY SAND/EXTREMELY WEATHERED SILTSTONE - Grey/pink/red/orange, fine to medium grained sands.	VSt		B	4.0	2842/4/4.0
A	Nil	N	D	5.0 5.5			EW/ MW	EXTREMELY/MODERATELY WEATHERED SILTSTONE - Grey/red/pink/orange.			A	5.0	2842/4/5.0
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on extremely/moderately weathered siltstone.					



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
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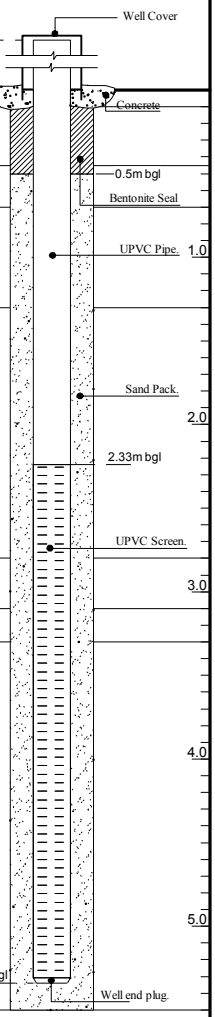
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	23.11.10	**COMPLETED**	23.11.10	**REF**	**BH6**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.1mØ X 5.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	1-2%

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)	WATER WELL DETAILS
A	Nil	N	M	0.1			CL	SILTY SANDY CLAY – Dark grey/brown.	S				
A	Nil	N	M	0.45			CL	SILTY SAND CLAY – Brown/light brown.	S		A A	0.2 0.5	2842/6/0.2 2842/6/0.5
A	Nil	N	M	0.7			CL	CLAY - Red/orange with light brown mottles increasing with depth, minor gravels (1-10mm, approx 5%).	St				
A	Nil	N	M	1.0 1.3			CH	CLAY - Grey/cream with red/brown mottles, moderately plastic, gravels (1-5mm, approx 20%).	St		A	1.0	2842/6/1.0
A	Nil	N	M	2.0 2.8			CL HW	CLAY - HIGHLY WEATHERED SILTSTONE - Light grey with red mottles, siltstone gravels bands increasing with depth.	VSt		A A A	1.5 2.0 2.5	2842/6/1.5 2842/6/2.0 2842/6/2.5
A	Nil	N	M	3.0 3.1			CL MW	SANDY CLAY - MODERATELY WEATHERED SILTSTONE - Light brown, gravels (1-50mm, approx 15%).	VSt		B	3.0	2842/6/3.0
A	Nil	N	D	3.3			CL/ HW	CLAY/HIGHLY WEATHERED SILTSTONE - Light grey.	VSt				
A	Nil	N	W	4.0 5.0 5.5			CL EW	CLAY - EXTREMELY WEATHERED SILTSTONE - Dark brown/dark grey with bands of grey clay.	VSt		A B A	3.5 4.5 5.5	2842/6/3.5 2842/6/4.5 2842/6/5.5
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on extremely weathered siltstone.					



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP9**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.5m depth	**NORTHING**	NA	**ASPECT**	Sourth	**SLOPE**	2-3%

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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.35			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/9/0.2
BH	Nil	N	M	0.6 0.9			CL	CLAY - Orange/brown mottled, moderately plastic.	F St		B	0.5	2842/9/0.5
BH	Nil	N	M	1.0 1.4			CL	CLAY - Grey/red/orange mottled, moderately plastic.	VSt		B	1.0	2842/9/1.0 1.0
BH	Nil	N	M	2.0			CL/HW	CLAY/HIGHLY WEATHERED SILTSTONE - Grey/pink/red/orange, siltstone gravels bands, tending to extremely weathered siltstone at 1.8m.	VSt		B B	1.5 2.0	2842/9/1.5 2842/9/2.0 2.0
BH	Nil	N	M	2.5			MW	MODERATELY WEATHERED SILTSTONE - With grey/orange/red mottling.	VSt				
				3.0				Test pit terminated at 2.5m on moderately weathered siltstone.					3.0
				4.0									4.0
				5.0									5.0
				6.0									6.0
				7.0									7.0
				8.0									8.0
				9.0									9.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

martens

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP10**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.0m depth	**NORTHING**	NA	**ASPECT**	North West	**SLOPE**	2-3%

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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.3			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/10/ 0.2
BH	Nil	N	M	0.5			CL	CLAY - Orange/brown mottled, moderately plastic.	F St		B	0.5	2842/10/ 0.5
BH	Nil	N	M	0.8 1.0			CL	CLAY - Grey/red/orange mottled, moderately plastic.	VSt		B	1.0	2842/10/ 1.0 1.0
BH	Nil	N	M	1.3 2.0			CL/EW	CLAY/EXTREMELY WEATHERED SILTSTONE - Grey minor mottles, moderately weathered siltstone bands, tending to moderately weathered siltstone.	VSt		B B	1.5 2.0	2842/10/ 1.5 2842/10/ 2.0 2.0
				3.0				Test pit terminated at 2.0m on moderately/slightly weathered siltstone.					3.0
				4.0									4.0
				5.0									5.0
				6.0									6.0
				7.0									7.0
				8.0									8.0
				9.0									9.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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 - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP12**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.2m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.3			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/12/ 0.2
BH	Nil	N	M	0.5			CL	CLAY - Orange/brown mottled, moderately plastic.	F St		B	0.5	2842/12/ 0.5
BH	Nil	N	M	0.7 1.0			CL	CLAY - Grey/red/orange mottled, moderately plastic.	VSt		B	1.0	2842/12/ 1.0
BH	Nil	N	M	1.3			CL/ EW	CLAY/EXTREMELY WEATHERED SILTSTONE - Grey minor mottles, moderately weathered siltstone bands, tending to moderately weathered siltstone.	VSt		B	1.5	2842/12/ 1.5
				2.0 2.2				Test pit terminated at 2.2m on moderately weathered siltstone.					
				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
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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

Engineering Log - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP14**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 1.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.25			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/14/ 0.2
BH	Nil	N	M	0.35			CL	CLAY - Orange/brown mottled, moderately plastic.	F St		B	0.5	2842/14/ 0.5
BH	Nil	N	M	0.8			CL	CLAY - Light grey/grey with brown/orange mottled.	VSt				
BH	Nil	N	M	1.0			EW	EXTREMELY WEATHERED SILTSTONE BANDS.	VSt		B	1.0	2842/14/ 1.0
BH	Nil	N	M	1.5			MW	MODERATELY WEATHERED SILTSTONE - Grey, minor mottles.	VSt		B B	1.2 1.5	2842/14/ 1.2 2842/14/ 1.5
				2.0				Test pit terminated at 1.5m on moderately weathered siltstone.					
				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
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

martens

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP15**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.7m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	1-2%

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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.2			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/15/ 0.2
BH	Nil	N	M	0.6			CL	CLAY - Orange/brown mottled, moderately plastic.	F St		B	0.5	2842/15/ 0.5
BH	Nil	N	M	1.0			CL	CLAY - Grey/red/orange mottled, moderately plastic.	VSt		B B	1.0 1.5	2842/15/ 1.0 2842/15/ 1.5
BH	Nil	N	M	2.0			CL/ HW	CLAY/HIGHLY WEATHERED SILTSTONE - Grey/pink/red, siltstone gravels bands, tending to extremely weathered siltstone past 2.3m.	VSt		B B B	2.0 2.5 2.6	2842/15/ 2.0 2842/15/ 2.5 2842/15/ 2.6
				2.7				Test pit terminated at 2.7m on extremely weathered siltstone.					
				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
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP16**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.4m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

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
BH	Nil	N	M	0.1			SM	ORGANIC SILTY SAND – Dark grey/brown.		L			
BH	Nil	N	M	0.4			SM	SILTY SAND – Light grey/grey, gravels (1-5mm, 10%).		L	B	0.2	2842/16/ 0.2
BH	Nil	N	M	0.6 0.9			CL	CLAY - Light brown/grey mottles, moderately plastic.	F St		B	0.5	2842/16/ 0.5
BH	Nil	N	M	1.0 1.2			CL	CLAY - Grey with minor red/orange mottles, minor gravels, moderately plastic, mottles increasing with depth.	VSt		B	1.0	2842/16/ 1.0 1.0
BH	Nil	N	M	2.0 2.4			CL HW	CLAY - HIGHLY WEATHERED SILTSTONE - Grey with minor red/orange mottles, minor gravels, moderately plastic, mottles increasing with depth, siltstone bands/gravels (1-10mm, approx 20%), tending to extremely weathered siltstone.	VSt		B B B	1.5 2.0 2.4	2842/16/ 1.5 2842/16/ 2.0 2.0 2842/16/ 2.4
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Test pit terminated at 2.4m on extremely weathered siltstone.					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
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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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6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP20**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.2m depth	**NORTHING**	NA	**ASPECT**	North West	**SLOPE**	1-2%

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
BH	Nil	N	M	0.2			SM	SILTY SAND – Dark grey/grey.		L	B	0.2	2842/20/ 0.2
BH	Nil	Y	W	0.35			SM	SILTY CLAYEY SAND – Brown/light brown.		L			
BH	Nil	Y	W	0.45 0.55			CL	CLAY - Orange/brown, minor gravels, moderately plastic.	F St		B	0.5	2842/20/ 0.5
BH	Nil	N	M	1.0			CH	CLAY - Red/grey, minor gravels, orange mottled, moderately to highly plastic.	VSt		B B B	1.0 1.5 2.0	2842/20/ 1.0 2842/20/ 1.5 2842/20/ 2.0
				2.2				Test pit terminated at 2.2m on clays.					
				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
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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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6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Excavation

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**TP21**
PROJECT	Engineering Services	**LOGGED**	GT	**CHECKED**	AN	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	None	**PROJECT NO.**	P1002842
EQUIPMENT	Backhoe	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.4m X 2.0m X 2.6m depth	**NORTHING**	NA	**ASPECT**	North West	**SLOPE**	1-2%

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
BH	Nil	N	M	0.12			CL	SILTY SANDY CLAY – Dark grey/brown.	S				
BH	Nil	N	M	0.5			CL	SILTY SAND CLAY – Brown/light brown.	S		B B	0.2 0.5	2842/20/ 0.2 2842/20/ 0.5
BH	Nil	N	M	0.8			CL	CLAY - Red/orange with light brown mottles increasing with depth, minor gravels (1-10mm, approx 5%).	St				
BH	Nil	N	M	1.0 1.6			CH	CLAY - Grey/cream with red/brown mottles, moderately plastic, gravels (1-5mm, approx 20%).	St		B B	1.0 1.5	2842/20/ 1.0 2842/20/ 1.5
BH	Nil	N	M	2.0 2.6			CL HW	CLAY - HIGHLY WEATHERED SILTSTONE - Light grey with red mottles, siltstone gravels bands increasing with depth.	VSt		B B	2.0 2.6	2842/20/ 2.0 2842/20/ 2.6
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Test pit terminated at 2.6m on moderately weathered siltstone.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

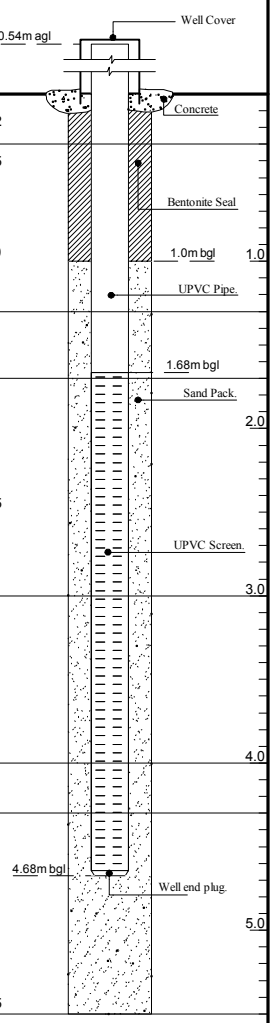
martens

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Excavation

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH5**
PROJECT	**Engineering Services**	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 5.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	5%

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)	WATER WELL DETAILS
A	Nil	N	M	0.3			OL	ORGANIC SANDY SILT – Dark brown.	S		A	0.2	2842/5/ 0.2
A	Nil	N	M	1.0 1.3			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F-St		A A	0.5 1.0	2842/5/ 0.5 2842/5/ 1.0
A	Nil	N	D	1.7			EW	EXTREMELY WEATHERED SILTSTONE - Orange/grey mottled, dry.			A	1.5	2842/5/ 1.5
A	Nil	N	D	2.0 3.0			MW	MODERATELY WEATHERED SILTSTONE - Orange/grey mottled, dry.			A	2.5	2842/5/ 2.5
A	Nil	N	D	4.0			EW	EXTREMELY WEATHERED SILTSTONE - Orange/grey mottled, dry.					
A	Nil	N	D	4.3			SW	SLIGHTLY WEATHERED SILTSTONE.					
A	Nil	N	D	5.0 5.5			MW	MODERATELY WEATHERED WITH EXTREMELY WEATHERED SILTSTONE BANDS.			B	5.5	2842/5/ 5.5
				6.0 7.0 8.0 9.0				Borehole terminated at 5.5m on moderately weathered siltstone.					



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH7**
PROJECT	Engineering Services	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North West	**SLOPE**	4%

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
A	Nil	N	M	0.1			OL	ORGANIC SANDY SILT – Dark brown.	S				
A	Nil	N	M	0.3			SC	CLAYEY SAND - Brown, moist (almost wet), loose.		L	A	0.2	2842/7/0.2
A	Nil	N	M	1.0 1.2			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F		A A	0.5 1.0	2842/7/0.5 2842/7/1.0
A	Nil	N	D	1.6			EW	EXTREMELY WEATHERED SILTSTONE - Grey, clay like properties.			A	1.5	2842/7/1.5
A	Nil	N	D	2.0 2.5			MW	MODERATELY WEATHERED WITH EXTREMELY WEATHERED SILTSTONE BANDS.					Borehole left open and checked 2 hours after drillinh and found dry.
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Borehole terminated at 2.5m on moderately weathered siltstone.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

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MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH8**
PROJECT	Engineering Services	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North West	**SLOPE**	5%

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
A	Nil	N	M	0.1			OL	ORGANIC SANDY SILT – Dark brown.	S				
A	Nil	N	M	0.3			SC	CLAYEY SAND - Brown, moist (almost wet), loose.		L	A	0.2	2842/7/0.2
A	Nil	N	M	1.0 1.3			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F		A A	0.5 1.0	2842/7/0.5 2842/7/1.0
A	Nil	N	D	1.6			EW	EXTREMELY WEATHERED SILTSTONE - Grey, red mottles, clay like properties.			A	1.5	2842/7/1.5
A	Nil	N	D	1.9			EW	EXTREMELY WEATHERED SILTSTONE - Orange, clay like properties.					
A	Nil	N	D	2.0 2.5			MW	MODERATELY WEATHERED SILTSTONE - Grey.			A	2.0	2842/7/2.0 Borehole dry after 2 hours.
								Borehole terminated at 2.5m on moderately weathered siltstone.					

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
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH11**
PROJECT	**Engineering Services**	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.0m depth	**NORTHING**	NA	**ASPECT**	North East	**SLOPE**	4%

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
A	Nil	N	M	0.2			OL	ORGANIC SANDY SILT – Dark brown.	S		A	0.2	2842/11/ 0.2
A	Nil	N	M	1.0 1.3			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F-St		A A	0.5 1.0	2842/11/ 0.5 2842/11/ 1.0
A	Nil	N	D	1.8			EW	EXTREMELY WEATHERED SILTSTONE - Grey with mottled.			A	1.5	2842/11/ 1.5
A	Nil	N	D	2.0			MW	MODERATELY WEATHERED SILTSTONE - Grey with mottled.					
								Borehole terminated at 2.0m on moderately weathered siltstone.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH13**
PROJECT	Engineering Services	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	6%

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
A	Nil	N	M	0.25			ML	ORGANIC SILTY/CLAYEY SAND - Dark brown, moist.	S		A	0.2	2842/13/ 0.2
A	Nil	0.4 ▽ N	M	0.4			CL	SANDY CLAY - Light brown, moist.	F				
A	Nil		W	0.7			CL	GRAVELLY CLAY - Brown, wet (perched), gravels (5- 10mm, 10-40%), minor sand.	S-F		A	0.5	2842/13/ 0.5
A	Nil	N	M	1.0 1.3			CL	CLAY - Brown and orange mottled, firm to stiff, moist.	F-St		A	1.0	2842/13/ 1.0
A	Nil	N	M	1.7			EW	EXTREMELY WEATHERED SILTSTONE - Brown/grey mottled, dry side of moist.			A	1.5	2842/13/ 1.5
A	Nil	N	M	2.0 2.5			MW	MODERATELY WEATHERED SILTSTONE - Light grey.			A	2.0	2842/13/ 2.0
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Borehole terminated at 2.5m on moderately weathered siltstone.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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

martens
MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH17**
PROJECT	Engineering Services	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North West	**SLOPE**	5%

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
A	Nil	N	M	0.3			ML	ORGANIC SILTY/CLAYEY SAND - Dark brown, moist.		L	A	0.2	2842/17/ 0.2
A	Nil	N	M	1.0			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F		A A	0.5 1.0	2842/17/ 0.5 2842/17/ 1.0
A	Nil	N	M	1.4 2.0			CL	CLAY - Grey with minor red mottled, firm to stiff, moist, sand in profile from 1.8m, grades to SANDY CLAY - Grey, with red mottles, moist, stiff.	St		A A	1.5 2.0	2842/17/ 1.5 2842/17/ 2.0
				2.5							A	2.5	2842/17/ 2.5
								Borehole terminated at 2.5m on sandy clay.					
				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
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

martens

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH18**
PROJECT	**Engineering Services**	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	1-2%

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
A	Nil	N	M	0.3			OL	ORGANIC SANDY SILT – Dark brown.	S		A	0.2	2842/18/ 0.2
A	Nil	N	M	1.0			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F-St		A A A	0.5 1.0 1.5	2842/18/ 0.5 2842/18/ 1.0 2842/18/ 1.5
A	Nil	N	D	2.0			EW	EXTREMELY WEATHERED SILTSTONE - Clay like properties, grey with red mottles, stiff to very stiff.	St-VSt		A	2.0	2842/18/ 2.0
A	Nil	N	D	2.5			MW	MODERATELY WEATHERED SILTSTONE - Grey.			A	2.5	2842/18/ 2.5
				3.0				Borehole terminated at 2.5m on moderately weathered siltstone.					
				4.0									
				5.0									
				6.0									
				7.0									
				8.0									
				9.0									

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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

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Engineering Log - Borehole

CLIENT	**Allen Price & Associates Pty Ltd**	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH19**
PROJECT	**Engineering Services**	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	**1 of 1**
SITE	**Cullburra Road, West Cullburra**	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North	**SLOPE**	2-3%

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
A	Nil	N	M	0.1		x x x	OL	ORGANIC SANDY SILT – Dark brown.	S				
											A	0.2	2842/19/ 0.2
											A	0.5	2842/19/ 0.5
A	Nil	N	M	1.0			CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	F-St		A	1.0	2842/19/ 1.0 1.0
				1.6							A	1.5	2842/19/ 1.5
A	Nil	N	D	2.0			EW	EXTREMELY WEATHERED SILTSTONE - Red and grey mottles, clay like properties, highly weathered layers from 2.0m.			A	2.0	2842/19/ 2.0 2.0
				2.5							A	2.5	2842/19/ 2.5
								Borehole terminated at 2.5m on moderately weathered siltstone.					
				3.0									3.0
				4.0									4.0
				5.0									5.0
				6.0									6.0
				7.0									7.0
				8.0									8.0
				9.0									9.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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

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6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH22**
PROJECT	Engineering Services	**LOGGED**	BR	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.5m depth	**NORTHING**	NA	**ASPECT**	North East	**SLOPE**	1-2%

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
A	Nil	N	M	0.3			OL	ORGANIC SILT – Dark brown, gravels (5-10mm, 30%).	S		A	0.2	2842/22/ 0.2
A	Nil	N	M	0.8			CL	CLAY - Variable colours (grey, red, yellow, brown).	F		A	0.5	2842/22/ 0.5
A	Nil	N	D	1.0 1.2			EW	EXTREMELY WEATHERED FINE GRAINED SILTSTONE - Reddish brown.			A	1.0	2842/22/ 1.0
A	Nil	N	D	1.9			EW	EXTREMELY WEATHERED FINE GRAINED SILTSTONE - Grey.			A	1.5	2842/22/ 1.5
A	Nil	N	D	2.0 2.5			EW	EXTREMELY WEATHERED FINE GRAINED SILTSTONE - Grey, strength decreasing.			A A	2.0 2.5	2842/22/ 2.0 2842/22/ 2.5
				3.0 4.0 5.0 6.0 7.0 8.0 9.0				Borehole terminated at 2.5m on extremely weathered siltstone.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

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

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

PENETRATION
L Low
M Moderate
H High
R Refusal

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

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

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

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

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

martens

MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH23**
PROJECT	Engineering Services	**LOGGED**	BR	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 1.0m depth	**NORTHING**	NA	**ASPECT**	North East	**SLOPE**	1-2%

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
A	Nil	N	M	0.2			OL	ORGANIC SILT – Dark brown, gravels (5-10mm, 30%).	S		A	0.2	2842/23/ 0.2
A	Nil	N	M	0.3			CL	CLAY - Grey.	S				
A	Nil	N	M	0.9			CL	CLAY - Variable colours (grey, red, yellow, brown).	S		A	0.5	2842/23/ 0.5
A	Nil	N	D	1.0			EW	EXTREMELY WEATHERED FINE GRAINED SILTSTONE - Reddish brown. Borehole terminated at 1.0m on extremely weathered siltstone.			A	1.0	2842/23/ 1.0

2.0 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
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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

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Engineering Log - Borehole

CLIENT	Allen Price & Associates Pty Ltd	**COMMENCED**	24.11.10	**COMPLETED**	24.11.10	**REF**	**BH24**
PROJECT	Engineering Services	**LOGGED**	JSF	**CHECKED**	GT	**Sheet**	1 of 1
SITE	Cullburra Road, West Cullburra	**GEOLOGY**	Siltstone	**VEGETATION**	Eucalypts	**PROJECT NO.**	P1002842
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	0.95mØ X 2.6m depth	**NORTHING**	NA	**ASPECT**	North East	**SLOPE**	5%

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
A	Nil	N	M	0.2			OL	ORGANIC SANDY SILT – Dark brown.	S		A	0.2	2842/24/ 0.2
											A	0.5	2842/24/ 0.5
				1.0							A	1.0	2842/24/ 1.0
A	Nil	N	M				CL	CLAY - Orange/brown mottles, firm grading stiff, tending grey with minor brown and red mottles at depth.	St-VSt				
											A	1.5	2842/24/ 1.5
				2.0							A	2.0	2842/24/ 2.0
				2.3									
A	Nil	N	D	2.6			EW	EXTREMELY WEATHERED SILTSTONE - Grey with red mottles, clay like properties.			A	2.5	2842/24/ 2.5
								Borehole terminated at 2.6m on extremely weathered siltstone.					
				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
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

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
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