Crighton Properties Pty Ltd

Concept Integrated Water Cycle Management Strategy (Revised) Riverside, Tea Gardens, NSW

martens consulting engineers

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

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

Executive Summary

Overview

This report has been prepared to support a Concept Proposal Application under Part 3a of the EP&A Act (1979) for the Riverside Development at Tea Gardens, NSW. It presents a revised approach to the management of ground and surface waters in response to a long history of consultation with State and Local Government agencies.

Specifically, the strategy has been revised to address concerns expressed by the NSW Department of Planning and Infrastructure (DoPI), NSW Office of Water (NOW) and Great Lakes Council over the previously prepared strategy by Cardno (2012).

Site Hydrology – Drainage and Flood Management

A drainage and flood study (Tattersall Lander P/L, 2012) was completed to investigate impacts of the proposed development, adjacent properties and downstream receiving environments. Detailed flood modelling concludes:

- Provision of storage and low flow discharge structures ensure environmental flows into the wetland buffer are maintained.
- Proposed level spreader ensures the development will not increase flow velocities during rare events.
- Existing flood levels remain unaffected.
- All lots remain flood free to the design 100yr event as a result of provision of floodways and site filling.
- The safety of future residents is catered for in the peak PMF event.

Water Quality

Detailed water quality modelling has been undertaken in accordance with Sydney Metro CMA *'Draft NSW MUSIC Modelling Guidelines'* (2010) to determine treatment measures required to achieve a Neutral or Beneficial Effect (NorBE) for post development water quality conditions, as well as satisfying Great Lakes Council Draft DCP (2012) Chapter 11 (previously DCP 54) requirements.

Treatment measures include a combination of 'at source' (bioretention swales, buffers) and end of line (constructed wetlands) structures (where needed) to achieve these objectives. Water quality modelling concludes:

- NorBE test is satisfied.
- WSUD, including distributed and 'at-source' management measures will be effective in mitigating against any water quality impacts on receiving wetlands, river and groundwater system.

Groundwater

The groundwater assessment quantifies existing groundwater conditions and potential hydrologic and water quality impacts on adjacent SEPP 14 wetlands. A conceptual groundwater management plan has been prepared to outline potential risks resulting from the development on the aquifer and risk management methodology.

Outcomes from the groundwater assessment conclude that the proposed development will result in:

- No discernible impact from the proposed development on SEPP 14 wetland groundwater levels and water budgets
- No discernible impact on water quality and levels in existing brackish lake (J Lake)
- NorBE on groundwater resources for the site and surrounding areas.
- Largely unchanged groundwater regime from existing conditions. This is due to the distributed WSUD approach to water quality management and recharge where possible in the catchment.

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1 Introduction

1.1 Background

This concept integrated water cycle management strategy (IWCMS or the 'strategy') has been prepared by Martens & Associates to support a Concept Proposal Application under Part 3a of the EP&A Act (1979) for the Riverside Development at Tea Gardens NSW. The report presents a revised approach to the management of ground water and surface waters on the site in response to a long history of consultation with State and Local Government agencies.

Specifically, the strategy has been revised to address concerns expressed by the NSW Department of Planning and Infrastructure (DoPI), NSW Office of Water (NOW) and Great Lakes Council over the previously prepared strategy by Cardno (2012).

The revised strategy has been formulated with the principle objective of ensuring Neutral or Beneficial Effect (NorBE) from the development on receiving groundwater and surface water systems to protect receiving waters and critical ecosystems including groundwater dependant ecosystems (GDEs). The strategy focuses on the use of 'at source' (i.e. 'distributed') stormwater treatment measures allowing preservation (to the extent possible) of existing ground water recharge mechanisms and surface water hydrology, such that there would be no significant impact on receiving waters and adjoining GDEs.

1.2 Site Development History

The following overviews of the history of the Riverside at Tea Gardens site and project description are drawn from ERM, 2011.

In 1991 Crighton Properties bought the 230 hectare site currently known as 'Riverside at Tea Gardens' (formerly 'Myall Quays') which lies immediately to the west of the Myall River and to the east of Myall Road (the main road linking Tea Gardens / Hawks Nest with the Pacific Highway). The location of the Riverside at Tea Gardens site is shown as Attachment 1A.

The Riverside at Tea Gardens Estate is currently being developed and comprises a range of residential, retail/commercial, recreation and tourist development. The part of the site remaining to be developed and covered by the concept plan comprises Lot 40 and Lot 10 DP270100.

An Environmental Assessment Report was prepared and placed on public exhibition for a period of 30 days from 19 February 2009 to 20 March 2009.

The Department of Planning and Infrastructure (DoPI) appointed an Independent Hearing and Assessment Panel (IHAP), which was subsequently modified to a Planning and Assessment Commission (PAC), to undertake an expert review of the proposed development. The terms of reference of the PAC were focused on the review on two main areas: the ecological constraints of the site and the hydrological issues associated with groundwater, the SEPP 14 wetland and flooding.

In a letter dated 22 October 2009, the DoPI raised a number of concerns regarding the concept plan and project application including that the proponent had not adequately established that the surface and groundwater flows to the adjoining SEPP 14 Wetland would remain unaltered.

Prior to the Minister for Planning making a determination on the concept plan and project application Crighton Properties withdrew the application. The application was withdrawn to enable additional information and studies to be undertaken to address issues raised by the PAC, DoPI and other government agencies. These additional investigations resulted in the preparation of the *Integrated Water Management Main Report* (Cardno, December 2011). This report accompanied a revised concept plan application which was exhibited from 8 February to 9 March 2012.

In response to exhibition of the revised concept plan, Council, DoPI and NOW provided comments on the report and subsequent meetings were held between the Applicant and the agencies. Significantly, the major outcome of the 15th June 2012 meeting between the Applicant, NOW and the DoPI, was that a revised strategy should be formulated to:

- Remove proposed freshwater ponds/ window lakes from the stormwater treatment train.
- Establish a new system of water quality management focusing on the use of 'at source' bio-filtration measures to achieve water quality targets.
- Utilise opportunities for 'at source' ground water recharge in conjunction with bio-filters (ensure sufficient treatment of surface waters prior to contact with groundwater) to preserve (as far as possible) groundwater recharge patterns across the development site.

- Maintain existing surface water hydrology, including flows, discharge patterns and outlet locations (as far as possible) to receiving environments.

1.3 Site Description

The Riverside at Tea Gardens site is bounded by Myall River to the east and Myall Road to the west (Attachment 1A). The Shearwater Residential Estate lies to the north of the site and residential development of Tea Gardens is to the south. The site has approximately a one kilometre frontage to Myall Road and two kilometre frontage to the Myall River. State Environmental Planning Policy No. 14 – Coastal Wetlands (SEPP 14) applies to wetlands within a portion of the eastern boundary of the site adjacent to the Myall River. These wetlands have been clearly identified along with a buffer to the wetlands and zoned accordingly when the site was rezoned in 2000. The remainder of the site is available for urban development and zoned accordingly.

The site is flat with generally sandy soils. There is a slight fall to the south east. The site ranges in height from approximately 0.6m Australian Height Datum (AHD) (along the foreshore of the Myall River) to 20m AHD (at the northern end of the site adjacent to Shearwater Estate). However, most of the site varies in height from between 1.6m AHD to 5.0m AHD.

The majority of the site was previously used for a pine plantation and has been substantially cleared of native vegetation. Some scattered isolated occurrences of both pines and natives currently exist on the site. The current land use on the site is cattle grazing.

1.4 Project Description

The Riverside at Tea Gardens site is already zoned 2(f) – Mixed Residential – Commercial for urban development. The concept plan for the development of the Riverside at Tea Gardens site consists of a residential / mixed use precinct proposed for the majority of the site and a tourist and larger lot component located in the NE corner of the site. Substantial areas of the 2(f) zoned land are proposed to be protected and enhanced as open space / wildlife movement corridors, over and above those already protected within the 7(a) and 7(b) zones.

The current proposal differs from that previously lodged with the DoPI in several key respects. Changes have been made to address concerns raised by the PAC and DoPI. Key changes include the following:

i) Residential development of the site now focused over a much smaller development footprint, including the potential to create approximately 945 dwellings comprising 880 residential (variety of lots), 50 lodges and 15 houses in a Tourist Precinct.

ii) A biodiversity offsetting package is proposed which will consist of both on-site and off-site offsets as part of an offsetting package.

iii) A new water cycle management strategy as documented within this study.

The amended development concept plan is provided in Attachment 1B, while the diagrammatic stormwater concept plan is given in Attachment 1A.

1.5 Previous Investigations

A number of studies have been previously undertaken at the site in respect of water cycle management. These have been broadly summarised by Cardno in the IWMM report (2011). This study does not intend to further review or summarise previous works, apart from utilising historic groundwater and water quality data as summarised within the relevant study element of this report, as the water cycle management strategy has been completely revised.

1.6 Past Comments on Water Cycle Management

Over the past 4-5 years, a number of comments have been raised by various agencies, Council and their representatives. The following sections broadly summarise these comments:

1.6.1 NSW Planning & Assessment Commission (PAC)

In summary, PAC majority report (2009) noted three key areas requiring further resolution in regards to hydrological impacts of the proposed project in its 2009 form.

i) Baseline groundwater information was lacking.

ii) Proposed stormwater management approach was strongly opposed by all key government agencies and Council. Principally regarding extensive interception of groundwater aquifers, direct injection of untreated stormwater into groundwater, expansion of saline lake and access to the Myall River, and potential impacts on the SEPP 14 wetland and its adjacent buffer.

iii) Flooding under climate change scenarios has not been adequately addressed.

1.6.2 NSW Department of Planning

The DoPI utilises BMT WBM as their peer reviewer for the surface water and groundwater management aspects of the project.

BMT WBM (2012) review, undertaken as commissioned by DoPI in respect of the revised concept plan application which contained the Cardno (2011) report, produced the following recommendations:

Recommendation 1
It is recommended that the pond and lake systems be removed from the development proposal or at the very least, considered as receiving environments and not part of the water quality treatment system.

Recommendation 2
If freshwater lake systems are deemed a necessary part of the development, suitable treatment measures should be put in place for their protection, and a more sophisticated assessment of their performance be undertaken. If lakes are deemed necessary, they should be assessed independently of the treatment train and considered only as receiving waters.

Recommendation 3
Revise the existing and developed case MUSIC models to be consistent with the NSW MUSIC Modelling Guidelines.

Recommendation 4
Revise the existing and developed case MUSIC models to have parameters which are both justified and consistent with the NSW MUSIC modelling guidelines.

Recommendation 5
The deep seepage parameter should not be used in any MUSIC models of the site.

Recommendation 6
The groundwater contributions of the site, using the outputs of the MUSIC model and other models, need to be better assessed to quantify the hydrologic and water quality impacts on the adjacent SEPP 14 wetlands.

Recommendation 7
Appropriate parameters to represent nutrients likely to be present in rainfall are to be used where direct rainfall onto lakes are being modelled.

Recommendation 8
Revise the existing case MUSIC model source nodes to better reflect both the "agricultural" and "forested" conditions of the existing site and to include specific nodes reflecting the commercial areas in the existing site.

Recommendation 9
Clarify the WBD nodes and whether the existing commercial areas have been properly accounted for in the future case model.

Recommendation 10
Use a sub-daily timestep through both the existing and developed case models, either 6 or 12 minute.

Recommendation 11
The model warmup should be turned on in any future models of the site, or the first year of results not included in the analysis of model outputs.

Recommendation 12
Wetland nodes, where used, should be configured both within the model and in design drawings to contain a high flow bypass, and a sediment forebay to remove coarse sediment. Also the configuration of the wetlands should be revised so as to provide reasonable (24-48 hour) detention times and consistent extended detention depths.

Recommendation 13
Any measures included in the water quality management regime should be designed such that treatment occurs prior to any interaction with the groundwater.

Recommendation 14
Reconfigure the swale nodes to be consistent with the NSW guidelines.

Recommendation 15
The treatment system should be revised (using revised MUSIC models) to achieve NorBE prior to any discharge to receiving waters including any proposed freshwater lakes and the existing saline lake.

Recommendation 16
It is recommended that an approach which treats and then infiltrates surface water, and reuses as much surface water as possible through rainwater and stormwater harvesting would be a far better approach for the site. Such a system would use biofiltration systems designed to infiltrate to the shallow groundwater, distributed throughout the development, perhaps coupled to well-designed wetlands that had provision for stormwater harvesting. This approach would be far more consistent with a WSUD philosophy and also result in better outcomes for the SEPP 14 wetlands, but at a reduced capital and operational cost to the developer. This obviously has not been assessed as part of this review but suggested as a possible revised treatment system.

Recommendation 17
Assessment of both the surface and groundwater impacts to the SEPP 14 wetlands be considered in further revisions of the Integrated Water Management Plan with a view to minimising hydrologic changes consistent with the requirements of the SEPP 14 and the Great Lakes Council DCP 54 Water Sensitive Design.

The recommendations, together with comments received from the various other State agencies and Council resulted in a change of strategy, the basis of this report. In formulating the revised strategy, Martens & Associates have liaised closely with BMT WBM, the outcomes of which are discussed further Section 1.7.

1.6.3 NSW Office of Water

NOW review of the Cardno (2011) report concluded that it did not support the strategy as it did not reflect the PAC recommendations and more specifically:

- Construction of "window lakes".
- Extension of the existing brackish lake.
- Use of the existing brackish lake as a water quality management device (sediment and nutrient sink).
- Increasing the connection between lake and Myall River.
- Potential activation of Potential Acid Sulphate Soils (PASS) due to lake construction activities.
- Lowering of groundwater levels as a result of lake construction.

1.6.4 Great Lakes Council

In their comments relating to Cardno (2011) report, Council, have noted that they are unable to comment on water quality modelling in qualified detail as it normally relies on the assistance of experts in that field (normally BMT WBM). General comments/concerns raised by Council include:

- MUSIC model software and model assumptions may not be consistent with current modelling guidelines.
- The model may be yielding an inaccurate assessment of the proposed scheme performance (in particular overstating pre-development nutrient exports and understating post development nutrient exports which could understate the need for water quality performance).
- There is an overreliance on treatment by the existing brackish lake system to achieve water quality objectives. This reliance would be better placed upon primary treatment measures located closer to the source of pollutants.
- Reliance on the brackish lakes has potential for impact upon the (currently) efficient operation of the existing system, which could have impacts upon the recreational, health amenity values of this waterway.

1.7 Revised Strategy Formulation

Martens & Associates prepared a "MA *Concept Outline of Revised Water Management Strategy, Riverside, Tea Gardens, NSW*" in July 2012. The report reviewed past correspondence from various surface water management proposals for the development and provided recommendations for an amended water management strategy for the current development.

BMT WBM were engaged by DPI to review the recommendations. Overall, their findings were supportive of the revised strategy and specific details regarding the proposed objectives were noted. Importantly, it was recommended that:

"*…. biofilters which discharge into the underlying sand dominated regions of the site be maximised to ensure sufficient treatment of surface water occurs before infiltration into groundwater. This may be in conflict with the Office of Water's requirements to line all systems, however it is felt that using biofilters should be sufficient to protect groundwater quality, though this will need to be confirmed through modelling.*"

The use of biofilters to enable "at-source" recharge across the site to maintain (as far as practical) existing groundwater regimes formed a key element of the revised strategy presented in this report.

NOW also provided comment on the concept outline and were generally supportive of the revised strategy. They suggested recharge beds specifically designed to discharge to the groundwater may lead to difficulties in achieving NorBE objectives. This consideration has been resolved by ensuring sufficient treatment is provided within biofilters prior to groundwater recharge. It is discussed further in the water quality section of this report.

1.8 Strategy Elements

Elements forming part of the revised integrated strategy include:

i) Site hydrology – drainage and flood management

An updated stormwater drainage concept plan and supporting hydrological model including flood assessment has been developed by Tattersall Lander Pty Ltd.

The concept drainage plan was developed in coordination with the water quality and groundwater management strategies. Key to this was the preservation of surface water hydrology on

receiving environments including the adjacent SEPP 14 Wetlands.

As part of the works, Tattersall Lander prepared a detailed post-development site terrain or 'surface' which was used for water quality and groundwater modelling.

The scope of the flood study was formulated from feedback received from various agencies including DoPI, Council (and BMT WBM) and OEH.

ii) Surface water quality

A revised stormwater management system has been formulated by Martens & Associates using current best practice WSUD philosophies for water quality tailored to the site. This includes compliance with:

- Great Lakes Council Draft DCP (2012) Chapter 11 (previously DCP 54) requirements.
- DoPI's peer reviewer feedback (BMT WBM). Council also utilise BMT WBM as peer reviewers.
- NOW feedback.
- Draft NSW MUSIC Modelling Guidelines (BMT WBM, 2010).

The revised water quality management concept relies on "at-source" treatment structures and elimination of proposed "window lakes" and is integrated with groundwater and surface water management strategies for the development.

iii) Groundwater

An updated groundwater model and groundwater management strategy has been formulated by Martens & Associates. The revised model utilises additional groundwater data, including increased data coverage, and addresses concerns raised by various assessment agencies.

The groundwater management strategy integrates closely with the stormwater management strategy utilising 'at source' recharge mechanisms to ensure NorBE impacts on groundwater patterns and conditions particularly in relation to impact on critical receiving waters and GDEs.

2 Site Hydrology – Drainage and Flood Management

2.1 Overview

Tattersall Lander P/L (2012) have completed a concept drainage layout design and flood assessment (Attachment 5) to investigate the impacts of flooding on the proposed development, adjacent properties and downstream receiving environments. It has been completed in accordance with Great Lakes Council requirements and the Floodplain Management Manual (NSW Government, 2005).

2.2 Site Hydrology Objectives

The objectives of the flood study were to:

1. Determine appropriate floodway designs, and the required fill levels within the proposed development.

2. Design a drainage system to mitigate any potential post development impacts on receiving downstream environments.

3. Assess the impact of the proposed development on adjacent development and environmental lands.

2.3 Conclusions

The Tattersall Lander study demonstrates that the proposed development will not have an adverse impact on flood behaviour on or around the site. Specifically it concludes:

1 The combination of provided storage and low flow discharge structures ensure environmental flows into the wetland buffer area are maintained once the site is developed.

2 The proposed level spreader designed for high flow discharge ensures the development will not result in an increase in flow velocities during rare events that would otherwise cause damage to downstream environments.

3 Existing flood levels remain unaffected by the proposal.

4 Proposed filling works plus floodway capacities ensure all lots remain flood free to the design 100yr event.

5 The proposed development design caters for the safety of future residents in the peak PMF event.

3 Water Quality Management

3.1 Overview

This water quality assessment determines treatment measures required to achieve adopted water quality objectives thereby protecting downstream receiving environments.

This assessment allows for a general specification of water quality structures, and will require refinement at detailed design stage.

3.2 Water Quality Objectives

Chapter 11 of Great Lakes Council's Draft Development Control Plan (DCP) 2012 requires the following water quality performance targets be achieved for development of greenfields sites within their LGA:

- 90% reduction of gross pollutants (GPs) relative to pollution generation from development without treatment.
- Neutral or Beneficial Effect of total suspended solids (TSS).
- Neutral or Beneficial Effect of total phosphorus (TP).
- Neutral or Beneficial Effect of total nitrogen (TN).

The draft DCP 2012 defines 'Neutral or Beneficial Effect' (NorBE) as *'loads of pollutants from future development must be equivalent to or less than land use prior to development'*.

The draft DCP (2012) also requires stormwater management to incorporate the principles of Water Sensitive Urban Design (WSUD) whereby treatment structures form a 'treatment train' rather than single 'end of line' structures.

3.3 Reference Documents

Table 1 provides a summary of relevant past documentation and how these have been utilised in preparation of this assessment.

Table 1: Reference documentation summary

Document	Comment
BMT WBM (2010) '*Draft NSW MUSIC Modelling Guidelines*' prepared for Sydney Metropolitan CMA	These guidelines were recommended by BMT WBM (2012) to be used for water quality modelling for the proposed development. As such, this revised assessment has been prepared in accordance with these guidelines.
BMT WBM (June, 2012) '*Review of Water Quality Management for the Proposed Riverside at Tea Gardens Development – Final Report*'	Review of previous surface water management assessment undertaken on behalf of NSW Department of Planning for the proposed development
Martens and Associates (2012) '*Concept Outline of Revised Water Management Strategy; Riverside, Tea Gardens, NSW*'	Prepared to provide a review of correspondence relating to previous surface water management proposals for the development and to provide recommendations for an amended water management strategy. Forms the basis for this assessment.
BMT WBM (July, 2012) '*Riverside at Tea Gardens Residential Subdivision Revised Concept Plan*'	A review of Martens and Associates (2012) concept outline for water management at the site. Provides additional recommendations to BMT WBM (June, 2012).

3.4 Modelling Aims

For the purposes of water quality modelling, 4 receiving environments were noted as being potentially affected by development at the site:

1. Myall Creek
2. SEPP 14 wetlands
3. Existing 'J' Lake
4. Site groundwater system and groundwater dependant ecosystems (GDEs)

The groundwater element is considered in Section 4. Given the existing site has a number of drainage outlets into the wetlands, the wetlands were further spilt into 3 separate receiving 'nodes' ('Wetland 1', 'Wetland 2' and 'Wetland 3')to ensure water quality compliance along its entire length.

The aim of this assessment is therefore to achieve the water quality objectives for each of the 5 identified downstream surface water receiving environments.

Receiving environments ('nodes') are shown in Attachment 3A (Figure 1 and 2) and Attachment 3C.

3.5 Modelling Methodology

3.5.1 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.

The following modelling scenarios were considered:

1. Pre Development – the existing site was modelled to determine baseline pollutant generation rates for TSS, TN and TP.

2. Post Development (untreated) – the developed site was modelled without water quality structures to determine baseline gross pollutant generation rates.

3. Post Development (treated) – the developed site was modelled with water quality structures included to achieve adopted objectives for nutrients and gross pollutants.

Pre and post development (with treatment nodes) MUSIC model layouts are provided in Attachment 3A.

3.5.2 Climate Data

Base rainfall data was sourced from Williamtown RAAF from 1997 – 2007. In accordance with BMT WBM (June, 2012) the rainfall data file was adjusted using Hawks Nest data to make an allowance for the increased rainfall experienced at the site. The conversion factor between the annual averages for the 2 stations was calculated to be 1.2 (i.e. Hawks Nest rainfall data approximately 120% higher than Williamtown RAAF at the time of analysis).

Average monthly areal potential evapotranspiration (PET) was sourced from '*Climatic Atlas of Australia – Evapotranspiration'* (Bureau of Meteorology, 2001). Inputs are summarised in Table 2.

Table 2: PET inputs – Hawks Nest (BOM, 2001).

Month	PET (mm)
January	180
February	135
March	135
April	90
May	70
June	50
July	50
August	70
September	95
October	135
November	150
December	175

A 6 minute timestep was adopted for the water quality analysis.

3.5.3 Model Input Parameters

Input parameters for pre and post development MUSIC modelling are in accordance with SMCMA (2010) MUSIC modelling guidelines and based on development design by Tattersall Lander P/L and recommendations within BMT WBM reviews (June and July, 2012).

A summary of input parameters and their source is provided in Attachment 3B.

3.5.4 Catchment Areas

3.5.4.1 Pre Development

Pre development catchment areas were identified based on the following process:

- Upslope catchments affecting the site were provided by Tattersall Lander P/L.

- SEPP14 wetland buffer area was calculated based on aerial photography interpretation and site investigations.
- The site was split into 5 catchments based on site hydrology, recent site aerial and 0.1m contours. The 5 catchments were directed into 5 separate receiving environments ("receiving nodes"):
    - J Lake
    - Wetland 3 (southern extent of SEPP 14 wetland)
    - Wetland 2 (middle of SEPP 14 wetland)
    - Wetland 1 (northern extent of SEPP 14 wetland)
    - Myall Creek
- Catchments land use was defined as 'forest' or 'agricultural' source nodes based on aerial interpretation and detailed site investigations (inspections, walkovers and geotechnical testing).
- Each catchment was split into subcatchments based on soil type(s) within upper 0.5m of the ground surface (Attachment 3C) to dictate pervious input parameters (Attachment 3D). Soil types were based on the findings of intrusive geotechnical testing (49 boreholes) undertaken by Coffey (2008) and Martens and Associates (2009 and 2012). Site testing plan is provided in Attachment 3H.
- Across the site seven soil landscape were identified :
    - Sandy clay
    - Clayey sand
    - Clayey sand overlying sandy clay
    - Sand overlying sandy clay
    - Loamy sand
    - Loamy sand overlying sand
    - Sandy clay overlying clay

  Borelogs are provided in Attachment 3I.

- Soil landscape for upslope catchments was taken to be sandy clay loam based on the Port Stephens Soil Landscapes 1:100 000 sheet (Department of Land and Water Conservation, 1995).

- Soil landscape for wetland buffer areas was assumed to be clayey sand.

3.5.4.2 Post Development

Post development catchment areas were defined based on the following process:

- Upslope areas affecting the site and wetland buffer areas remained consistent with the pre development model.

- The site was split into 5 catchments to be consistent with the pre development model and to allow assessment of water quality impacts at discrete receiving environments. However, due to proposed site drainage, sub catchment areas differed somewhat from the pre development model. Total modelled site catchment area is consistent with pre development (Attachment 3D).

- Proposed residential/development areas within each catchment were split into smaller subcatchments by Tattersall Lander according to proposed site drainage.

- Individual sub-catchments were further split into roof, road, bioretention swale and residential areas ('nodes') by Tattersall Lander (Attachment 3D). 'Residential' nodes included driveway, footpath and pervious lot areas (such as landscaping and lawns).

- Proposed floodway areas were calculated based on proposed development layout provided by Tattersall Lander. These areas were assigned the 'urban' node.

- The 'Myall Creek' catchment floodway includes re-forested corridor 20m wide and 330m long leading down to the proposed wetland (Section 3.6.2) and the discharge point into Myall Creek.

- Re-forestation areas were calculated based on proposed development layout provided by Tattersall Lander. Re-forestation areas include both areas to be planted out (i.e. actively revegetated) and areas to remain undeveloped that are assumed will regenerate naturally once agricultural practices cease. These areas were assigned the 'forest' node.

- Based on advice from the Client, we understand the majority of the site is to be filled by varying amounts to achieve flood levels. We understand soil type for the post developed site is 100mm loamy sand topsoil overlying sand. This soil type was utilised for pervious input parameters for all post development source nodes within the development footprint (Attachment 3D).

- Upslope areas, wetland buffers and onsite retained forest areas had soil landscapes properties consistent with the pre development model.

3.6 Treatment Train Philosophy

The preferred stormwater treatment strategy for the site is based on the principles of WSUD. It utilises 'at source' controls and some end of line structures (where required) to provide a treatment train that ensures treatment objectives are satisfied and the integrity of downstream receiving environments are maintained. Individual stormwater quality improvement devices (SQIDs) are outlined in the following sub sections. A conceptual layout of the proposed treatment train is provided in Attachment 3E.

3.6.1 Bioretention Swales

Road side bioretention swales ('bioswales') are proposed to provide 'at source' treatment of developed areas. Approximately 2% in standard residential streets and up to 4-5% in areas of open space will be utilised for bioswales to achieve water quality outcomes.

Bioswales provide treatment through media filtration, biological uptake of nutrients, evapotranspiration and detention. Although infiltration is also a feature of these structures that provides treatment, this feature has been set to 0mm/hr to ensure sufficient water quality treatment is provided prior to infiltration in an effort to protect downslope receiving environments that are reliant on groundwater quality (Section 3.7).

On advice from BMT WBM (October 3, 2012) the highflow bypass was set to 100m^3/s (i.e. all flow is directed to the bioswales) to allow the bioswales to also act as gross pollutant traps (GPTs). Maintenance of the bioswales will therefore require regular removal of gross pollutants captured.

Bioswale input parameters are provided in Attachment 3B. Proposed bioswale design is provided in Attachment 3F.

3.6.2 Buffer Areas

Buffer areas have been utilised in:

- The northern precinct to treat runoff from road areas
- In the eco-resort to treat runoff from the service road and pool decking.
- To treat runoff prior to collection and treatment in bioswales. Buffer areas will take the form of 1m wide grass strips that runoff will sheet flow over.

3.6.3 Wetland

A wetland is required within the 'Myall Creek' catchment (the proposed northern precinct) to reduce nitrogen and phosphorus levels prior to discharge into Myall Creek. Modelling indicates the following preliminary specifications are required to achieve water quality objectives:

- Surface area of 4, 468 m^2
- Batter slopes of 1(V):3(H)
- Extended detention depth of 0.35m
- Total depth of 0.75m
- Permanent pool volume of 668 m^3
- 0 mm/hr exfiltration (i.e. the wetland will be lined)
- Outlet pipe diameter of 85mm and overflow weir width of 3.0m (preliminary design factors)

The wetland shall be located offline to the east of the main northern precinct development footprint (Attachment 3A). A highflow bypass channel shall be located within the northern precinct floodway to carry flows exceeding 0.7 m^3/s (the peak Q_{3mth} inflow into the floodway as provided by Tattersall Lander P/L) through the floodway and directly to Myall Creek.

3.7 MUSIC Model Run Types ('Modes')

The post development model was run in two 'modes'

Mode 1: Infiltration capacity of bioswales was 'switched off' by setting exfiltration to 0mm/hr. This mode was used for water quality assessment.

Mode 2: infiltration capacity of bioswales was 'switched on' by setting exfiltration rate to a suitable value. This mode was used to determine site water balances.

3.8 MUSIC Results

3.8.1 Suspended Solids and Nutrient Loads

Modelling results achieved are summarised in Table 3. These demonstrate that the WSUD approach results in the NorBE test being satisfied.

Table 3: MUSIC results - NorBE assessment.

Receiving Environment	Parameter	Pre Development (kg/y)	Post Development (kg/y)	Achieved Reduction (%)	Complies (Y/N)
Myall Creek	TSS	4570	2240	51	Y
	TP	17.1	16.7	2	Y
	TN	181.0	155	14	Y
Wetland 1	TSS	3650	1310	64	Y
	TP	12.9	9.74	24	Y
	TN	123.0	75.9	38	Y
Wetland 2	TSS	54000	25600	53	Y
	TP	207.0	106	49	Y
	TN	1360	826	39	Y
Wetland 3	TSS	8860	3800	57	Y
	TP	36.7	29.50	20	Y
	TN	242.0	209	14	Y
J Lake	TSS	3750.0	811	78	Y
	TP	15.9	9.88	38	Y

	TN	104.0	70.40	32	Y
	TSS	66600.0	33700	49	Y
Total	TP	260.0	172	34	Y
	TN	1710.0	1340	22	Y

3.8.2 Gross Pollutant Loads

Table 4 provides an assessment of the treatment train effectiveness for gross pollutant loads generated from the site. This demonstrates that pollutant load reductions are met.

Table 4: MUSIC results - treatment train effectiveness – gross pollutants.

Receiving Environment	Untreated (kg/yr)	Treated (kg/yr)	Achieved Reduction (%)	Complies (Y/N)
Myall Creek	2190	31	99	Y
Wetland 1	1000	0	100	Y
Wetland 2	6350	140	98	Y
Wetland 3	3040	53.3	98	Y
J Lake	1000	0	100	Y
Total	13 580	224.3	98	Y

3.8.3 Nutrient Concentrations In Treated Stormwater

Table 5 provides median concentrations of nutrients in stormwater following treatment. These are used for comparison to existing groundwater quality data at the site.

Table 5: Nutrient concentrations.

Receiving Environment	TSS (mg/L)	TP (mg/L)	TN (mg/L)
Myall Creek	5.81	0.0604	0.600
Wetland 1	2.92	0.084	0.572
Wetland 2	6.38	0.097	0.598
Wetland 3	6.59	0.104	0.641
J Lake	2.80	0.107	0.600

3.8.4 Conclusion

The proposed treatment train achieves site water quality objectives outlined in Section 3.2 and will have a beneficial impact on stormwater quality discharging to downstream sensitive receiving environments.

Treatment devices assumed no infiltration (despite this occurring in reality) to ensure water quality targets were being achieved prior to any infiltration into the groundwater table. The proposed treatment train therefore also protects the integrity of the groundwater quality, which downstream SEPP 14 wetland environments rely on.

3.9 Groundwater Recharge Assessment

Using the MUSIC node water balance feature, the following factors were extracted:

1. Total rainfall inflow
2. Evapotranspiration loss
3. Baseflow losses for source nodes
4. Infiltration loss for treatment nodes
5. Total storm outflow

In order to estimate the volume of water which could conceivably *reach* the groundwater system, the following method was used to estimate areal 'net infiltration' rates:

Net infiltration rate = (Source node baseflow + treatment node infiltration)/(total source and treatment node area)

Whilst the above method may result in some overestimation of infiltration, it provides a convenient means of comparing infiltration rates between different parts of the study area. We note that MUSIC is not a distributed groundwater model and not capable of the same level of modelling sophistication as MODFLOW.

The above approach therefore provides a means of scaling MUSIC model outcomes to the calibrated MODFLOW recharge rates for existing conditions. The same scaling factor can then be used to estimate MODFLOW recharge rates under developed conditions using MUSIC model water balance results data for developed conditions.

Section 4 covers the above in more detail.

3.10 Compliance with BMT WBM Recommendations

BMT WBM's (June, 2012) review of previously undertaken stormwater management assessment provides a number of recommendations for improving water quality modelling, producing a model consistent with modelling guidelines and creating a management system which protects downstream receiving environments. Demonstration of this revised assessment's consistency with this review is provided in Table 6.

Table 6: Compliance with BMT WBM (2012)

Element	Recommendation	Comment
Model setup	Revise the existing and development case MUSIC model to be consistent with NSW MUSIC Modelling Guidelines.	As shown in Attachment 3B, MUSIC modelling is consistent with the guidelines.
	Revise the existing and development case to have parameters which are both justified and consistent with NSW MUSIC Modelling Guidelines.	As shown in Attachment 3B, MUSIC modelling is consistent with the guidelines. Each input parameter has been justified.
	Revise the existing MUSIC model source nodes to better reflect both the 'agricultural' and 'forested' conditions of the existing site and to include specific nodes reflecting the commercial areas in the existing site.	Aerial interpretation and site investigations have been utilised to delineate between forest and agricultural areas both on the site and in upslope catchments. No commercial areas occur onsite.
	Clarify the WBD nodes.	This has been removed from modelling.
	Use a sub-daily timestep through both the existing and developed case models, either 6 or 12 minute.	1997 – 2007 6 minute pluviograph rainfall data from Williamtown RAAF was utilised for MUSIC modelling. Rainfall data was adjusted using Hawks Nest data to account for increased rainfall at the site compared with Williamtown.
	The model warmup should be turned on, or the first year of results not included in the analysis of model outputs.	The 'catchment warmup' feature was switched on for MUSIC modelling.
Input parameters	The deep seepage parameter should not be used in MUSIC modelling.	Daily Deep Seepage Rates (DSR) for all source nodes has been set to 0% in accordance with Table 3-8 of the NSW Music Modelling Guidelines.
	Appropriate parameters to represent nutrients likely to be present in rainfall are to be used where direct rainfall onto lakes are modelled.	Lakes have been removed from the proposed development.

Element	Recommendation	Comment
	Wetland nodes, where used, should be configured to contain high flow bypass, sediment forebay to remove coarse sediment and reasonable detention times (24 – 48hrs) and detention depths.	The Myall Creek wetland has been designed with a high flow bypass (equivalent to Q_{3mth} of flow entering floodway) and sediment inlet pond in accordance with NSW Music Modelling Guidelines. Detention time is 42 hrs and extended detention depth is 0.35m (total depth 0.75m).
	Reconfigure swale nodes to be consistent with NSW guidelines.	No swales are proposed in the treatment train.
Proposed treatment train	Pond and lake system be removed from the development or considered as receiving environments and not part of the water quality treatment system.	Previous pond and window lakes have been removed from the stormwater management system.
	If freshwater lakes are deemed necessary, treatment measures shall be put in place for their protection. They should be considered receiving waters and independent of the treatment train.	Freshwater lakes have been removed from the proposed development.
	The treatment system should be revised to achieve NorBE prior to any discharge to receiving waters.	As shown in Table 3, NorBE is achieved by the proposed treatment train prior to any discharge/infiltration into receiving environments.

Element	Recommendation	Comment
	An approach which treats and then infiltrates surface water, and reuses as much surface water as possible through rainwater and stormwater harvesting would be a far better approach.	The proposed treatment train treats stormwater prior to any infiltration (Table 3). We understand the developer has an agreement with Midcoast Water to use treated effluent from the Hawkes Nest STP for external uses (such as irrigation) at the site. No additional reuse/stormwater harvesting is therefore proposed.
Reporting	Assessment of both the surface and groundwater impacts to the SEPP 14 wetlands be considered in revisions of the Integrated Water Management Plan with a view to minimise hydrological changes.	Groundwater infiltration and recharge rates have been calculated for the pre and post development site using MUSIC modelling. This information has been used to calibrate detailed groundwater modelling (Section 4.4) and assess the impacts to the SEPP 14 wetlands. Water quality modelling suggests the proposed treatment train will result in a neutral or beneficial impact on water quality of surface water. This will assist in protecting downstream environments including the SEPP 14 wetlands.

3.11 Conclusions and Recommendations

The revised stormwater management system and MUSIC model is consistent with both the NSW MUSIC modelling guidelines (BMT WBM 2010) and the BMT WBM reviews (June and July, 2012). Results of MUSIC modelling indicate that water quality objectives will be met by the proposed stormwater treatment train.

The proposed management system is consistent with the principles of Water Sensitive Urban Design (WSUD) as the proposed treatment strategy utilises 'at source' controls and a 'treatment train' rather than relying solely on large end of line structures. This approach is considered the most appropriate for the site and will provide the best outcome for receiving environments

We note that further refinement of the model at the detailed design stage may alter the sizes of proposed treatment structures.

4 Groundwater Assessment

4.1 Overview

As part of the revision of the integrated water cycle management strategy, the previous groundwater assessment has been fully revised to address the following:

- PAC (2009):
  - Lack of baseline groundwater information.
  - Inappropriate use of a steady state model instead of transient model and poor calibration of the model.
  - Potential for saline intrusion from the existing detention lake.
  - Assessment of groundwater flux at shoreline to assess potential impacts to tidal wetland ecosystem.
- NoW submission to DoPI (2012)
  - Use of a steady state model rather than a dynamic model incorporating a representative period of climatic variability.
  - Underestimation of the effect of the averaging of drawdown over time (it believes this average drawdown will then be compounded by natural fluctuations rather than offset by them).
- DoPI (BMT WBM (2012) review) recommended:
  - Groundwater contributions of the site be better assessed to quantify hydrologic and water quality impacts on adjacent wetlands.
  - Implementation of biofiltration systems to promote 'at source' recharge of treated stormwater to groundwater throughout the development (and assessment of resulting surface and groundwater impacts on the SEPP 14 wetlands).

The revised groundwater assessment has included:

1. Review of site previous hydrogeological investigations and collation of key data.

2. Collection of additional site groundwater data including:

   - Groundwater level measurement at existing site bores and at newly installed bores in areas lacking data coverage.

   - Groundwater quality sampling.

   - Soil permeability testing.

3. Revision of numerical groundwater models for the existing and developed site conditions incorporating:

   - Additional collected groundwater data.

   - Revised strategy of 'at source' recharge for the developed site model.

4.2 Groundwater Objectives

The principle objectives of the strategy with regard to groundwater are:

1. Preserve Water Quality
   Existing groundwater quality to be preserved or improved.

2. Preserve Groundwater Levels
   Ensure groundwater levels critical for GDEs (i.e. SEPP 14 wetland) are not disturbed.

3. Preserve Flow Patterns and Water Balance
   Maintain existing groundwater flow patterns and flow budgets to critical ecosystems (SEPP 14 wetlands and the existing saltwater (J) lake).

4.3 Existing Groundwater Conditions

4.3.1 Conceptualisation of Aquifer System

Groundwater is confined within a shallow to medium depth marine sand deposit (with some areas of clay deposit) that sits at or above sea level and adjoins a bed rock controlled hill in the north and north west of the site. The aquifer is bounded by Myall River to the east and Port Stephens associated bays and creeks to the south/west.

Water table depths are frequently shallow and typically less than 1-2m below existing ground level. Groundwater depth variation is minimal spatially across the majority of the site in response to minimum site grades. Water levels within the aquifer are significantly dependant on

incident rainfall and sea level rather than other catchment processes such as run-on.

A number of existing small incised man-made channels drain surface water and intermittent shallow groundwater to the lower lying heath and wetland areas to the site's east.

4.3.2 Available Data

4.3.2.1 Previous investigations

This assessment draws from a number of previous groundwater investigations conducted on the site. More specifically, groundwater level data, water quality results and geotechnical information has been utilised from:

- Coffey Partners International (February, 1996), Myall Quays Development Groundwater and Surface Water Study.
- Coffey Geotechnics (October, 2007), Groundwater Assessment Riverside Development, Tea Gardens.
- Martens & Associates (December, 2011) Preliminary Hydrogeological Study and Concept Groundwater Management Plan, Riverside, Tea Gardens, NSW.

4.3.2.2 Additional Investigations

Additional site investigations were conducted for this assessment in early (3rd -4th) and late (25th – 26th) September 2012. These included:

- Installation of three new GMBs (GMB201, GMB202 and 203).
- Groundwater level measurement at all existing site bores and at newly installed bores.
- Groundwater quality sampling (GMB3, GMB4, GMB5, GMB6, GMB7, GMB8, GMB9, GMB10, GMB25, Lake, GMB201, GMB202 and GMB 203).
- Hydraulic conductivity testing at all existing site bores and at newly installed bores.

4.3.2.3 Site Groundwater Monitoring Bores (GMBs)

A total of 19 GMBs exist across the site including three recently constructed bores (GMB201, GMB202 and GMB203) and 16 remaining

bores from previous investigations. Bore locations are indicated on Figure 3 (Attachment 4A).

4.3.2.4 Geotechnical

Aquifer material generally comprises fine to medium grained sands with some cemented layers (coffee rock). However, variations in soil landscape (Section 3.5.4) do exist across the site resulting in variations in hydraulic conductivity and recharge capacity.

4.3.2.5 Hydraulic Conductivity

In-situ Hydraulic conductivity (K) testing (Table 7) was undertaken in September 2012 utilising single bore slug tests (Hvorslev method, 1981) on all existing site bores. Calculation sheets are provided in Attachment 4D. The site was categorised into zones of equivalent hydraulic conductivity for groundwater modelling purposes (Figure 16, Attachment 4A).

Table 7: Measured in-situ hydraulic conductivity.

GMB	K (m/d)	K Zone (Figure 16)	Adopted K (m/d)
GMB1Aa	6.5	1	4.5
GMB3	11.7	2	10
GMB4	13.1	2	10
GMB5	18.4	5	16
GMB6	17.0	5	16
GMB7	4.4	1	4.5
GMB8	3.5	1	4.5
GMB9	4.5	1	4.5
GMB10	16.6	5	16
GMB11	3.1	1	4.5
GMB12	4.8	1	4.5
GMB21	9.8	2	10
GMB22	6.7	2	10
GMB23	8.6	2	10
GMB24	8.9	2	10
GMB25	3.6	7	3.5
GMB201	4.8	1	4.5
GMB202	16.3	5	16
GMB203	4.0	1	4.5

4.3.2.6 Specific Yield

Specific Yield (S_y) is likely to be of the order of 0.1 to 0.15 based on review of Coffey (February, 1996) and our experience with similar aquifers.

4.3.2.7 Water Level Data

Historical groundwater level measurements at established GMBs are collated in Attachment 4B. The data includes a long history of instantaneous dipped levels and also some periods of continuous monitoring with data loggers. It is considered that the data set is satisfactory for the purposes of steady groundwater modelling for the concept stage assessment.

Continuous monitoring undertaken in July 2009 is presented in Figure 4 (Attachment 4A) to illustrate response to tidal and rainfall variation.

The following comments are made based on review of site groundwater level data:

1. Groundwater levels are generally shallow.

2. Groundwater resurfaced at times at GMBs 7 and 23 during the Martens and Associates (July, 2009) continuous data logging period.

3. Short-term groundwater level fluctuations are typically <1m and can occur within hours of heavy rainfall.

4. Lake levels are consistently lower than groundwater levels suggesting that groundwater discharges to the lake in the vicinity of the existing GMBs. Discharge of groundwater to the lake is expected to occur around the majority of the lake based on likely groundwater gradients.

5. Groundwater response to rainfall is shown to be rapid, occurring within 1-2 days of incident rainfall. Groundwater responses appear more substantial at higher ground elevations.

4.3.2.8 Groundwater Quality

Historical groundwater quality data at established GMBs are collated in Attachment 4C and summarised in Table 8 with site data grouped and compared against lake data.

Table 8: Summarised groundwater quality data.

Analyte	Site GMB Median [1]	Site GMB Mean [1]	Lake Median [1,2]
pH	5.6	5.6	6.1
TDS (mg/L)	200	1653	5565
Chloride (mg/L)	65	847	2919
Sulphate (mg/L)	16	125	431
Magnesium (mg/L)	6.1	60.2	181.5
Calcium (mg/L)	3.6	19.7	59.0
EC (us/cm)	264	2151	7091
TN (mg/L)	2.5	46.6	0.7
TP (mg/L)	0.41	4.35	0.07

Notes:

[1.] Laboratory detection limit used where result below detection limit. [2] Median and Mean results equal as based on 2 data points

Continuous monitoring of groundwater and lake EC concentrations was undertaken concurrently with groundwater level monitoring by Martens and Associates (July, 2009) for GMB 1A, 2A, 25 and 26 (lake). Results are summarised in Table 9 and plotted in Figure 5 (Attachment 4A). Results indicate saline/brackish lake water does not migrate from lake to local groundwater system. This is expected given the groundwater gradient is towards the lake.

Table 9: Summary of continuous groundwater EC (µS/cm) monitoring.

GMB	1A [1]	2A [1]	25 [1]	26 (lake) [1]
Mean	255	155	229	10285
Minimum	240	140	180	7830
Maximum	260	150	380	13150
Range	20	10	200	5320

Notes:

[1.] Martens and Associates (July, 2009) continuous data logging (04/06/2009 to 06/07/2009) at 0.5 hr logging frequency.

The following comments are made based on review of site groundwater quality data:

1. Groundwater quality is not of sufficient standard to satisfy potable use requirements in accordance with Australian Drinking Water Guidelines (NHMRC, 2004), primarily on the basis of acid levels, variable salinity and elevated concentrations of a range of analytes (Martens and Associates, April, 2009).

2. The most significant beneficial uses for groundwater in some locations of the site are for irrigation and ecosystem maintenance (Coffey, October, 2007).

3. Median EC and TDS concentrations within the lake are higher than in GMBs and are indicative of saline water. This is expected as the lake's drain invert level is approximately 0.66 mAHD (Coffey, October, 2007). Based on review of Fort Denison tidal data such an elevation can be expected to be breached by tides approximately 25 days per year.

4. Median EC and TDS concentrations within GMBs are indicative of fresh water.

5. Monitoring data indicates that lake nutrient concentrations are lower than those observed in nearby GMBs.

4.3.2.9 Summary

GMB coverage and the extensive historical levels data record are considered well suited for the purposes of groundwater modelling for concept stage assessment.

4.4 Groundwater Modelling

4.4.1 Steady state or Transient Modelling

Based on our review of groundwater data, we are of the view that a steady state modelling approach is appropriate to the concept phase application because:

- Groundwater is consistently high.
- Response to rainfall is rapid and in the range of 0.5-2 days therefore a transient model would require a similar time step. We do not consider this adds much to the analysis.

In balancing the two approaches of steady state as opposed to transient, we have undertaken analysis for both the mean rainfall conditions as well as 'wet' year conditions (refer to Section 4.4.4). 'Dry' year conditions were not analysed because it was considered irrelevant to operation of the drainage system since removal of the window lakes from the proposal meant that there is no risk of groundwater 'flow reversal'.

4.4.2 Modelling Approach

A series of preliminary steady state groundwater models have been developed to assess the likely changes of the proposed development on existing groundwater levels, flow patterns and water balances on receiving environments. Modelling works extended a concept model previously prepared by Coffey (October, 2007 and August, 2009) and Martens & Associates (December, 2011) and incorporated the following major developments:

- Additional GMB calibration data – additional groundwater levels for all site GMBs;
- Additional GMBs (GMB201, GMB202 and GMB203) – extended GMB coverage to include the Monkey Jacket area, improving spatial calibration.
- Establishment of hydraulic conductivity zones based on field testing results.
- Revised recharge zones based on land form, drainage pattern and soil types and iteratively adjusted during model calibration.
- Inclusion of drainage cells with calculated drainage conductance to better reflect existing site drainage features.

- Addition of 'mean' and 'wet' year scenarios.
- Addition of sea level rise scenario.
- Developed site model established utilising developed site terrain and recharge rates adjusted according to stormwater modelling (MUSIC) water balance results.

The following models were developed.

M0: Calibration model - Existing terrain and conditions
Using available site geotechnical data and GMB level data, a calibrated single layer steady state model was developed.

M1a: Existing terrain, mean rainfall conditions
Recharge zone values derived in M0 factored to account for difference between average rainfall experienced during groundwater level data collection and mean rainfall conditions experienced on site.

M1b: Existing terrain, wet rainfall conditions
As per M1a with recharge values factored for wet conditions.

M1c: Existing terrain, mean rainfall conditions, sea level rise
As per M1a with boundary conditions changed to reflect potential climate change induced sea level rise of 0.9m (increased from 0.045m AHD to 0.9m AHD).

M1d: Existing terrain, wet rainfall conditions, sea level rise
As per M1b with sea level rise boundary conditions.

M2a: Developed terrain, mean rainfall conditions
M1a terrain replaced with developed site terrain including proposed drainage systems. Recharge zone values adjusted with "MUSIC to MODFLOW" conversion factor.

M2b: Developed terrain, wet rainfall conditions
As per M2a with additional adjustment of recharge values for wet conditions.

M2c: Developed terrain, mean rainfall conditions, sea level rise
As per M2a with boundary conditions changed to reflect potential climate change induced sea level rise of 0.9m (increased from 0.045m AHD to 0.9m AHD).

M2d: Developed terrain, wet rainfall conditions, sea level rise
As per M2b with sea level rise boundary conditions.

4.4.3 Model Setup

Modelling was undertaken with Visual Modflow Version 4.6.0.161 utilising single layer, steady state modelling and with background (constant) properties as summarised in Table 10.

Table 10: Summary of groundwater model properties.

Property	Value/Detail	Comment
Grid cell size	25m x 25m	-
Existing Terrain	DTM from Tattersall Lander	06.11.2012
Developed Terrain	DTM from Tattersall Lander	14.11.2012
Cell Base	DTM produced from rock level contours	Coffey (2007)
Head observation wells	Mean GMB observations from data record for 19 GMBs	Attachment 4B
Boundary Conditions	Constant Head: Myall River = 0.045m AHD J Lake = 0.7m AHD Monkey Jacket upper slopes = 4.45-4.6m	-
Boundary Conditions – Sea Level Rise	Constant Head: Myall River = 0.9m AHD J Lake = 0.9m AHD Monkey Jacket Upper slopes = 4.45-4.6m	Myall River and J Lake constant head heights increased to 0.9m (DECCW, 2009, benchmark for sea level rise planning = 0.9 by 2100).
Water Balance Zones	Refer to Figure 15 (Attachment 4A)	Assigned to existing condition and developed condition models to allow comparison of water movement between zones and total zone budgets between models.
Hydraulic Conductivity – K	Refer to Figure 16 (Attachment 4A)	Site divided into K zones based on field K testing results.

4.4.4 Existing Conditions Modelling

4.4.4.1 Calibration Model

A calibration model (M0) was developed to establish base recharge values for existing site conditions and involved:

- Definition of hydraulic conductivity (K) zones across the site based on field testing results (Figure 16, Attachment 4A; Attachment 4D).
- Definition of recharge zones across the site based on site landform, vegetation type and drainage conditions (Figure 17, Attachment 4A).
- Calibration of head equipotentials against observed heads (at GMBs) by iterative adjustment of recharge zones values whilst keeping K values constant. Calibrated recharge values are summarised in Table 11.

Calibration results are depicted in Figure 6 (Attachment 4A) showing a normalised RMS of 4.27%, comparing favourably with the typical industry accepted upper threshold of 10%. A calibrated residual mean of -0.066m indicates suitable prediction of mean groundwater head.

4.4.4.2 Mean and Wet Year

'Mean' and 'wet' year versions of the existing conditions groundwater model (M1a and M1b respectively) were developed as follows:

- Assessment of average monthly rainfall experienced during site observations (R_{obs}). Average monthly rainfall was used rather than average annual rainfall due to the lack of complete annual groundwater monitoring records.
- Assessment of 'mean' (R_{mean}) and 'wet' (R_{wet}) (90^{th} percentile) average monthly rainfall for the site based on rainfall records (Nelson Bay BOM Station Number 61054).
- Calculation of recharge adjustment factors by the following method:

  'Mean' = R_{mean} / R_{obs}

  'Wet' = R_{wet} / R_{obs}

- Calculation of 'mean' and 'wet' year recharge values (Table 12) for use in the model scenarios by multiplying calibrated recharge values by the adjustment factors (Table 11).

Table 11: 'Mean' and 'Wet' year recharge adjustment factors.

	R_{obs}	R_{mean}	R_{wet}
Rainfall mm/month	104.2	112.4	158.1
Recharge Adjustment Factor	1	1.08	1.52

Table 12: Summary of adopted recharge values (existing site conditions).

	Recharge rate (mm/year)		
Zone	**Calibrated Model**	**Mean Year**	**Wet Year**
Industrial	40	43	61
Residential	100	108	152
Quarry	40	43	61
Coastal saltmarsh/mangrove	40	43	61
Dense heath/wetland	80	86	121
Forested slopes	70	75	106
Cleared clay soils	30	32	46
Cleared poorly drained	150	162	228
Cleared sandy soils	250	270	379

4.4.5 Developed Conditions Model

4.4.5.1 Terrain file and Drains

The concept design surface DTM (from Tattersalls Lander) was utilised in the developed conditions modelling. The DTM incorporated drain invert levels including the invert of proposed roadside biofilters. This is an important consideration as it allowed evaluation of groundwater levels against drainage structures function to ensure structures are not "drowned out" and that stormwater treatment within biofilters is undertaken prior to interception of groundwater.

Drain layout is depicted in Figure 15, Attachment 4A.

4.4.5.2 Recharge Adjustment and Zonation

Recharge rates derived in calibrating the existing conditions model were compared against infiltration rates derived from water quality (MUSIC) modelling (Section 3.9).

Developed condition recharge rates were developed based on the outcomes of MUSIC modelling. MUSIC water balance results provided values for 'infiltration losses'. These were compared to the calibrated recharge rates for the 'mean' groundwater level model. A direct adoption of MUSIC infiltration rates could not be used as the 2 models use different algorithms to model groundwater (MODFLOW is a distributed model).

MUSIC to MODFLOW recharge conversion factors were then calculated by dividing the MODFLOW recharge rate for a particular recharge zone by the MUSIC derived infiltration rates for the equivalent site location. Conversion factors were determined for all recharge zones.

As the majority of the site shall be filled with loamy sands overlying sand loams (Section 3.5.4), the recharge factor determined for the pre development area comprising similar soil conditions of loamy sand over sandy loam profile was deemed appropriate to utilise across the total developable site footprint. This factor was calculated to be 0.5 (MODFLOW recharge rate of 250mm/yr divided by MUSIC infiltration rate of approximately 500mm/yr).

Similar results were achieved for the proposed revegetated slope and revegetated low lying areas of the site, thus a conversion factor of 0.5 was applied uniformly across the total area of the site to be developed or rehabilitated. Conversions rates were not applied to areas of the site remaining unchanged as a result of the development such as the dense heath/wetland area, coastal saltmarsh and forested slopes west of the site.

The conversion factor was applied to post development MUSIC water balance figures to derive relative recharge values for the MODFLOW developed model (Table 13). Recharge zones were also redefined into five new zones to reflect developed conditions including residential areas, eco-tourism area, revegetated low lying area and revegetated slopes (Figure 17, Attachment 4A).

Table 13: MUSIC to MODFLOW Recharge conversion for developed conditions.

Area	Description	MUSIC Infiltration (mm/yr)	Conversion Factor	MODFLOW Recharge (mm/yr)
A	Residential (Main)	292	0.5	146
B	Residential (Monkey Jacket)	302	0.5	151
C	Eco-tourism	403	0.5	202
D	Revegetated Low Lying	524	0.5	262
E	Revegetated Slopes	320	0.5	64

4.4.6 Modelling Results

4.4.6.1 Head Equipotential Plots

Head equipotentials plots are presented in Figures 7-10 (Attachment 4A). These represent groundwater contours at a 0.1m contour interval.

4.4.6.2 Drawdown Comparisons

Drawdown comparisons (Figures 11-14) present the difference in groundwater levels between model scenarios as drawdown contours (0.05m interval).

Effect of development – no sea level rise
Figure 11 demonstrates that under mean rainfall conditions, proposed development will have insignificant effects on groundwater across the majority of the site, including within and adjacent to all wetland areas (GDEs) south of the Monkey Jacket area. However, groundwater levels primarily in the more undulating areas in the site's west will be reduced. This is as a result of design surface interception with groundwater particularly west of GMB9 and GMB201 (Monkey Jacket area) and at the upper ends of the main drainage line near GMB7 and GMB11.

Effect of development – with sea level rise
Figure 13 demonstrates very similar results to Figure 11, demonstrating that sea level rise has no discernible impact on the relationship between the developed site groundwater levels and the existing site's groundwater levels.

Effect of 'wet' year
Figure 12 demonstrates minor water table rises within the upper areas of the site under 'wet' conditions compared to 'mean' conditions for

the developed site without sea level rise. There is no discernible difference in the eastern (GDE) areas of the site.

Effect of sea level rise

Figure 14 demonstrates that sea level has an effect on groundwater levels in the eastern (GDE) parts of the site but no significant effect in the higher areas in the site's west.

4.4.6.3 Water Balance to Receiving Environments

A water balance assessment was conducted for:

1 Myall Creek catchment area

2 Rehabilitation and SEPP 14 wetland area

3 J lake

Total in-flow to these areas (sum of groundwater and drain contributions) was determined (Table 14). Results indicate:

- Water balances to the rehabilitation area and SEPP 14 wetland are maintained.
- Discharges to Myall Creek will increase. This is primarily due to increased drain flows which shall be discharged directly to the Myall River (following proposed water quality wetland treatment) and will not impact on GDEs.

Table 14: Water balance summaries.

	Existing Conditions			Developed Conditions			Difference	
Receiving Node	Flow In (m^3/day)	Upslope Drains (m^3/day)	Total flow In (m^3/day)	Flow In (m^3/day)	Upslope Drains (m^3/day)	Total flow In (m^3/day)	Total flow in m^3/day	%
Myall Creek	97.0	0.0	97.0	86.7	293.2	379.9	282.9	292%
Rehab Area & SEPP 14 Wetland	484.2	614.8	1099.0	327.5	739.0	1066.5	-32.6	-3%
J Lake	491.7	0.0	491.7	468.1	0.0	468.1	-23.6	-5%

4.4.6.4 Groundwater Interception Plot

A comparison of the concept design surface DTM and the M2a surface is presented in Figure 18. This indicates design surface areas (developed site contours) that intercept the modelled groundwater level (M2a) under mean rainfall conditions. Red and pink coloured areas indicate groundwater being intercepted. We note that the design surface DTM is based on drain invert levels including the invert of proposed roadside biofilters as opposed to finished ground surface levels in these areas.

The main areas where interception would occur are within the Western Branch and Monkey Jacket drainage corridors. Other areas of likely interception include the higher western slopes of the Monkey Jacket area and the invert level of roadside biofilters in a number of locations across the site.

Concept results indicate interception over the majority of depicted interception areas is typically less than 0.1m. More detailed design and modelling at the DA stage may void these minor interceptions altogether.

More significant interception occurs within the Monkey Jacket higher slope areas where approximately 1.5m interception is indicated. This would result in local lowering of the groundwater within this immediate area through subsurface road drainage. The drawdown plots suggest the spatial influence of the drawdown is relatively focused and does not extend to influence downslope wetland areas. This area of the site is not flanked by GDE's. In reality, a very minor area of the development site (approximately 1%) is affected by this. We would recommend that design levels within this area could be re-evaluated at a more detailed design stage in the project, with further consideration to water table levels, supported with additional data.

Modelling results suggests that the extent of groundwater interception likely as a result of the proposed design levels will have negligible impact on GDE's. We therefore recommend that this finding bear no real significance on concept approval of the proposal. If deemed by authorities to be an issue, the areas of groundwater interception can be managed in either one of two ways in moving forward with the future design stages of the development: The management options include:

1 Minor amendments to the design levels in the affected areas of the site during more detailed design stage of the application (DA stage). It is appreciated that raising levels in stormwater storage and receiving areas of the site may result in

considerable overall volumes (and hence expense) of fill being required extending to other areas requiring fall to allow drainage.

2 Acceptance that a slight lowering of the groundwater will occur in the areas of interception. Groundwater modelling suggests that slight lowering the groundwater table in such areas will have negligible impact on levels within the surrounding GDE areas.

Both options could be supported by additional geotechnical/groundwater investigations if deemed required particularly in the Monkey Jacket area of the site where current modelling has relied on one piezometer. Greater coverage should be included to allow more detailed assessment, to accompany a DA application for that area.

4.4.7 Transient Groundwater Levels

The modelling undertaken has provided a range of mean groundwater level scenarios. We make the following specific comments in relation to transient or 'day to day' groundwater level variations.

1. On a daily basis, groundwater levels may fluctuate considerably across the site in response to incident rainfall. During periods of heavy rainfall, for example, groundwater can locally rise within a few hours in the order of 0.1-0.5 m (depending on location). This groundwater response is generally short lived due to the sandy permeable nature of the aquifer.

2. In some locations within the development site (under the preliminary proposed developed terrain surface) surface drains and inverts of some road side swales may capture a small proportion of these intermittently high groundwater levels.

3. We note that the site already maintains a number of drainage channels which achieve the same effect as that described above (i.e. they remove the higher groundwater levels to surface drains). However, these are generally at a lower level than that to be constructed for the developed site.

4. It is our view that whilst drain interception of intermittently elevated groundwater levels is not ideal, that the placement of fill at the site and broadly higher elevation of the proposed site drainage system compared with the existing conditions, will not result in any significant change to the capture of higher

groundwater levels at the critical ecosystem boundaries than is presently the case.

4.4.8 Uncertainty Analysis and Model Limitations

In accordance with Australian groundwater modelling guidelines (June, 2012), the model is considered to generally represent a 'Class 2' model confidence-level classification.

A 'Class 2' classification is justified on the basis of the following:

- Geotechnical and groundwater data coverage are high for the entire model domain.
- The conceptual model is relatively simple and therefore inherently exhibits a relatively lower degree of uncertainty compared to other more complex hydrogeological systems.
- Digital elevation models (DEM) for terrain surfaces are high quality.
- Model is a steady state and single layer.

Model limitations:

- Temporal head data coverage is considered reasonable but insufficient to permit transient calibration verification. We do not consider this a significant limitation as discussed in Section 4.4.1.
- Dry-cells developed in the model within the higher slopes of the northern site area (west of GMB201). This is considered to be an effect of relatively sharp ground steepening area and was offset by assigning constant head boundary conditions in this area. Lack of variation in head equipotentials in the area for the various model scenarios is a consequence. We do not consider this a significant limitation as:
  1) GMB data in this area allows confidence in the assigning of constant head values in this area.
  2) This area is not adjacent to critical receiving waters or GDEs.

In spite of these limitations the model's target confidence level is deemed fit for purposes of concept stage assessment.

4.5 Effects of Development on Groundwater

4.5.1 Groundwater Levels

From groundwater modelling results it is concluded that the proposed development would result in no discernible impact on groundwater levels within or adjacent to the critical ecosystems (i.e. SEPP 14 wetland and J lake) of the site. The development's impact on groundwater would be limited to the higher western portions of the site and the Monkey Jacket area with the zone of impact being relatively confined and not extending to downslope critical ecosystems.

4.5.2 Water Balance to Wetland

The water balance analysis demonstrates that existing groundwater flow patterns and water budgets to critical ecosystems (SEPP 14 wetlands and J lake) are maintained for the proposed development.

4.5.3 Groundwater Quality

Water quality modelling results (Section 3.7) demonstrates that proposed surface water treatment strategy will produce concentrations of key pollutants (TP and TN) that are considerably below existing groundwater concentrations found on site (Table 15). Hence, a NorBE groundwater quality result is achieved.

Table 15: Comparison of water quality modelling results with existing groundwater quality.

Pollutant	Stormwater Pollutant Concentration[1]	Existing Groundwater[1]
TP mg/L	0.084	0.41
TN mg/L	0.082	2.5

Notes:

[1]. Median values (see Table 8).

4.6 Preliminary Concept Groundwater Management Plan

4.6.1 Overview

This preliminary concept groundwater management plan provides advice on the following:

1. Existing aquifer characteristics
2. Potential aquifer risks
3. Risk management objectives
4. Risk management methods
5. Further investigation requirements

4.6.2 General Aquifer Characteristics

Based on preliminary investigations and modelling of the aquifer, the following characteristics define the Riverside site aquifer:

1. The aquifer is sand-dominated, of a relatively low gradient and highly permeable.
2. The groundwater system is coupled with the Port Stephens estuary/Myall River and is responsive to tidal fluctuations.
3. The aquifer is highly responsive to recharge events. Reasonably rapid groundwater level fluctuations of the order of 500 mm to 1000 mm can occur in response to rainfall.
4. Aquifer recharge is local and is predominantly controlled by incident rainfall.
5. Based on available groundwater quality data, groundwater is likely to be of a low-value resource due to TDS, pH, chloride, sodium and ammonia concentrations which exceed Australian Drinking Water Guidelines (NHRMC, 2004).

4.6.3 Primary Risk Identification

The following broad scale potential risks are identified in association with the release of urban land.

1. Untreated stormwater discharge to groundwater resulting in groundwater contamination.

2. Changes to groundwater level which come about through modifications to surface infiltration and recharge properties at the site.

3. Changes to groundwater flow direction which come about through modifications to surface infiltration and recharge properties at the site.

4. Significant modifications to groundwater flow budgets to GDEs and receiving waters.

5. Locally increasing groundwater levels though excessive recharge resulting in surface water losses from the groundwater system.

4.6.4 Risk Management Objectives

On the basis of identified risks, the following risk management objectives are provided:

1. Development is to be undertaken in such a way so as to ensure that groundwater table drawdown is minimised.

2. Development should not result in a degradation of the existing aquifer water quality.

3. Development should not significantly alter the flow directions of ground water at the site.

4. Development water and groundwater management strategies should be integrate and ensure surface water and groundwater systems are managed such that the integrity of GDEs is preserved or enhanced.

4.6.5 Risk Management Methods

The following methods are provided in order that the risk management objectives can be met:

1. All stormwater management systems treat stormwater to a level equal to or better than existing groundwater quality prior to discharge to any groundwater body.

2. No direct permanent connection to groundwater.

3. Minimised (as far as practical) exposure of groundwater to surface water systems.

4. Recharge treated stormwater throughout the site in such a way so as to enable distributed recharge rather than single point recharge. This ensures that groundwater flow gradients, levels and directions are maintained at/close to pre-development levels. It is noted that that current proposal features a recharge swale that buffers the SEPP 14 wetland.

4.6.6 Groundwater pH Management

Existing groundwater pH levels at the site are variable and may typically range between say 5.0 and 6.5 depending on specific location, local soil and geology, and antecedent rainfall conditions. Samples from GMB returned the lowest pH value of 3.99.

Rainfall pH levels for coastal NSW are generally acidic due to the disassociation of CO_2 to form carbonic acid and may range between say 5.5 and 7.0. Lower levels [to say pH of 4.5] can be experienced in coastal areas near larger urban centres or closer to industrial centres (such as Newcastle in the case of this site) (Bridgman, 1989).

Contrasting the depressed pH of rainfall, urban runoff, notably from concrete and other pavement surfaces, has the potential to maintain a slightly elevated pH of say 6.5 – 7.5. In the case of this development, we do not expect any changes to background groundwater pH levels at the fringing wetlands for the following reasons:

1. There will be minimal concrete pavements / surfaces within the development relative to other surfaces (ie. pervious surfaces and roofs) and therefore limited potential for significant production of alkaline urban runoff.

2. Rainwater will remain the primary source of acidity within urban runoff and there will continue to be significant opportunity within the

development footprint and within the proposed surface drainage system for contact between rainwater and *in-situ* soil prior to percolation to the groundwater system.

3. Local soils within and adjoining the fringing wetlands have a significant capacity to maintain stable pH levels given the high levels of organic matter and buffering capacity of local soils (Murphy, 1995).

4.6.7 Recycled Water Usage

We provide the following preliminary comments in relation to the risks that any potential irrigation of recycled water over the site would pose.

1. Indicative nutrient concentrations in recycled water would be 6 mg/L TN and 2.2 mg/L TP. These values are comparable to existing groundwater conditions, particularly nitrogen levels. We note there may be scope to reduce these concentrations with additional water treatment.

2. On the basis that lots will be of the order of 600 m^2 with irrigated garden beds and/or lawns being in approximately 200 m^2, a maximum of some 90-100 KL/ET/year (say 100 KL/dwelling/year) of recycled water could be expected to be used for outdoor purposes (assuming a total water consumption rate of 210 KL/ET/year).

3. Irrigation nutrient loads to the yard areas will therefore be of the order of 0.60 kg/year TN and 0.22 kg/year TP. It is important to note that these loads would be irrigated during dry times and generally onto unsaturated soils and not directly into the groundwater system. During times of high groundwater, there would be no need to provide additional irrigation water. Risks of direct recharge are therefore negligible.

4. Broad acre nutrient consumption rates for lawns and landscaped gardens are of the order of 200 kg/ha/year and 15 kg/ha/year phosphorus. On this basis, demand for nutrients in irrigated yard and landscaped areas will be of the order of 4 kg/year TN and 0.3 kg/year TP.

5. The above demonstrates that demand for nutrients in garden areas alone far outstrips that which can be supplied by the recycled water. In the case of nitrogen, demand is 660 % of expected supply, and in the case of phosphorus, demand is 136 % of expected supply. In the case of phosphorus, these preliminary estimates do not account for the significant sorption of phosphorous that would occur within soils.

6. The preliminary calculations are conservative as they do not account for the opportunity for nutrient uptake in areas outside those being irrigated, nor do they account for nutrient transformation which will occur within the unsaturated and saturated portions of the soil (e.g. denitrification losses).

4.6.8 Beneficial Use of Site Groundwater Resource

The proposed development, together with the integrated water management strategy in place will have NorBE on the potential for beneficial use of the site's groundwater resource given the findings of NorBE on surface water and groundwater assessments determined in this study.

It is noted from Section 4.3.2 that existing groundwater quality is not suited for potable use.

Potential risk from future domestic use of groundwater for irrigation has not been assessed in detail but there is no likely need for such use given the agreement in place with Midcoast Water for the re-use of recycled water for irrigation on individual lots and in public spaces throughout the development.

Any proposed extraction point for irrigation would require conditional licence approval from the NSW Office of Water and be subject to similar rigorous impact assessment on GDEs.

Use of groundwater for GDE maintenance represents the most suitable potential use of the site's groundwater resource.

4.7 Compliance with Previous Review Feedback

Table 16: Compliance with Review Feedback

Assessor	Issue	Comment
PAC (2009)	Lack of baseline groundwater information.	**Addressed**: Additional information gathered and utilised – Additional GW level recordings, GMB locations, hydraulic conductivity assessment (Section 4.3.2)
	Inappropriate use of a steady state model instead of transient model and poor calibration of the model.	**Addressed**: Steady state justified (Section 4.4.1); improved and appropriate Model calibration results (Section4.4.4);
	Potential for saline intrusion from the existing detention lake.	**Addressed:** Drawdown risk eliminated by revision of water cycle management strategy including removal of window lakes. No likelihood of flow reversal from the J lake (Section 4.4.1);
	Assessment of groundwater flux at shoreline to assess potential impacts to tidal wetland ecosystem.	**Not applicable**: tidal wetland ecosystem groundwater flux totally dependent on tidal fluctuations. Removed from any conceivable impact from development given distance from development to natural shoreline ecosystem and no discernible impact shown groundwater levels and flow balances on other side of wetland closets to development.
Now (2012)	Use of a steady state model rather than a dynamic model incorporating a representative period of climatic variability	**Addressed**: Steady state justified, climate variability incorporated with 'wet' and 'mean' year modelling (Section 4.4.1);
	Underestimation of the effect of the averaging of drawdown over time (it believes this average drawdown will then be compounded by natural fluctuations rather than offset by them)	**Addressed**: Model calibration improved (Section4.4.4); Climate variability incorporated into modelling (Section 4.4.1).
DoPI (2012)	Groundwater contributions of the site be better assessed to quantify hydrologic and water quality impacts on adjacent wetlands.	**Addressed**: Totally revised model, improved data, calibration, climate variability incorporation.
	Implementation of biofiltration systems to promote 'at source' recharge of treated stormwater to groundwater throughout the development (and assessment of resulting surface and groundwater impacts on the SEPP 14 wetlands).	**Addressed**: Totally revised WSUD approach incorporating biofilters for water quality treatment and 'at source' recharge to maintain groundwater regimes and minimise risk of impacts on GDEs.

5 Conclusions and Recommendations

This report presents a revised approach to the management of ground and surface waters associated with the development of land at the "Riverside" site at Tea Gardens, NSW from cattle grazing to residential and tourism purposes. It has been prepared to support a Concept Proposal Application under Part 3a of the EP&A Act (1979).

The revised strategy has been carefully formulated from a long history of consultation with State and Local Government agencies and specifically addresses concerns expressed by the NSW Department of Planning and Infrastructure (DoPI), NSW Office of Water (NOW) and Great Lakes Council over the previously prepared strategy by Cardno (2012).

The revised strategy has been formulated with the principle objective of ensuring Neutral or Beneficial Effect (NorBE) from the development on receiving groundwater and surface water systems to protect receiving waters and critical ecosystems including groundwater dependant ecosystems (GDEs). The strategy focuses on the use of 'at source' (i.e. 'distributed') stormwater treatment measures allowing preservation (to the extent possible) of existing ground water recharge mechanisms and surface water hydrology, such that there would be no significant impact on receiving waters and adjoining GDEs.

5.1 General Conclusions

Concluding remarks for three main elements that form part of the integrated strategy are summarised as follows:

i) Site hydrology – drainage and flood management

Undertaken by Tattersall Lander Pty Ltd, the updated stormwater drainage concept plan and supporting hydrological model including flood assessment was developed in coordination with the water quality and groundwater management strategies.

The assessment demonstrates that the proposed development will not have an adverse impact on flood behaviour on or around the site. Specifically it concludes:

- The combination of provided storage and low flow discharge structures ensure environmental flows into the wetland buffer area are maintained once the site is developed.

- The proposed level spreader designed for high flow discharge ensures the development will not result in an increase in flow velocities during rare events that would otherwise cause damage to downstream environments.

- Existing flood levels remain unaffected by the proposal.

- Proposed filling works plus floodway capacities ensure all lots remain flood free to the design 100yr event.

- The proposed development design caters for the safety of future residents in the peak PMF event.

ii) Surface water quality

The revised stormwater management system, formulated by Martens & Associates, uses current best practice WSUD philosophies for water quality tailored to the site. The revised surface water quality management concept relies on "at-source" treatment structures and elimination of proposed "window lakes" and is integrated with groundwater and surface water management strategies for the development.

Detailed water quality modelling has been undertaken in accordance with Sydney Metro CMA 'Draft NSW MUSIC Modelling Guidelines' (2010) to determine treatment measures required to achieve a Neutral or Beneficial Effect (NorBE) for post development water quality conditions, as well as satisfying Great Lakes Council Draft DCP (2012) Chapter 11 (previously DCP 54) requirements.

Treatment measures include a combination of 'at source' (bioretention swales, buffers) and end of line (constructed wetlands) structures (where needed) to achieve these objectives. Water quality modelling concludes:

- NorBE test is satisfied.

- WSUD, including distributed and 'at-source' management measures will be effective in mitigating against any water quality impacts on receiving wetlands, river and groundwater system.

iii) Groundwater

The revised groundwater model and groundwater management strategy, formulated by Martens & Associates, utilises additional

groundwater data, including increased data coverage, and address' concerns raised by various assessment agencies.

The groundwater management strategy integrates closely with the stormwater management strategy utilising 'at source' recharge mechanisms to ensure NorBE impacts on groundwater patterns and conditions particularly in relation to impact on critical receiving waters and GDEs.

Groundwater assessment outcomes conclude:

- Modelling shows minor areas of groundwater interception within the development footprint. However, no discernible impact from the proposed development is likely on SEPP 14 wetland groundwater levels and water budgets.
- No discernible impact on water quality and levels in existing brackish lake (J Lake).
- NorBE on groundwater resources for the site and surrounding areas.
- Largely unchanged groundwater regime from existing conditions. This is due to the distributed WSUD approach to water quality management and recharge where possible in the catchment.

5.2 Recommended Commitments

The following recommendations are made for developer commitments in progression of the project.

Detailed design for the development shall be consistent with the integrated approach to water cycle management as outlined in this strategy. Additionally, it shall include provision for ongoing monitoring and reporting to ensure water cycle management objectives are being met.

Recommended commitments include:

i) Site hydrology – drainage and flood management

- Proposed drainage storages, low flow discharge structures and level spreaders shall be designed and constructed to ensure environmental flows into the wetland buffer area are maintained to predevelopment conditions and will not result in a significant increase in flow velocities during rare events

that would otherwise cause damage to downstream environments.

- The proposed development including filling works will ensure all lots remain flood free to the design 100yr event and that existing flood levels (including for neighbouring areas) remain unaffected by the development.

- The proposed development design will cater for the safety of future residents in all reasonably considered flooding scenarios including the peak PMF event.

ii) Surface water quality

- The proposed stormwater treatment train shall be implemented at the site to ensure that water quality objectives are met.

- Proposed treatment train is to combine 'at source' and end of line controls in accordance with principles of Water Sensitive Urban Design and to avoid reliance on large end of line structures.

- The development shall have a neutral or beneficial effect on water quality in order to protect receiving environments, including SEPP14 wetlands, existing brackish lake, Myall Creek and the groundwater table.

i) Groundwater

- Proposed 'at source' water quality treatment mechanisms incorporate groundwater recharge mechanisms are to ensure distributed recharge and NorBE impacts on groundwater patterns and conditions across the development site.

- Proposed development is to have no significant impact on SEPP 14 wetland groundwater levels and water budgets.

- Proposed development to have no significant impact on water quality and levels in existing brackish lake (J Lake).

- Proposed development to be designed so that minimal groundwater interception will occur. Any areas of interception are to be approved in consultation and subject to approval of NOW (and any other relevant Government agencies).

6 References

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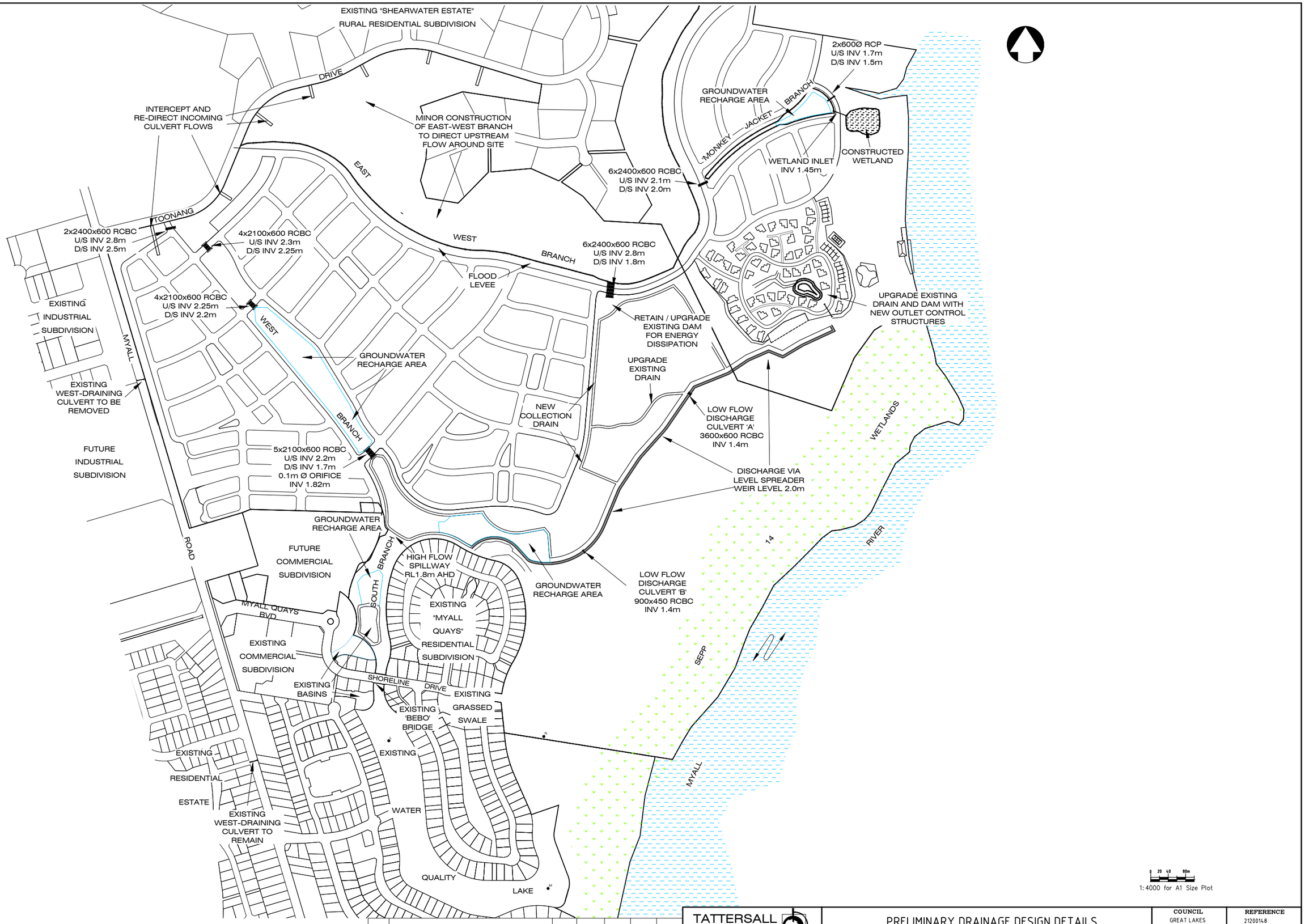
7 Attachment 1A – Preliminary Drainage Details Plan



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PRELIMINARY DRAINAGE DESIGN DETAILS

PROPOSED RESIDENTIAL DEVELOPMENT
RIVERSIDE ESTATE, TEA GARDENS

COUNCIL: GREAT LAKES	REFERENCE: 21200148
PARISH	SHEET SIZE: A1
SCALE: 1:4000	SHEET No.: 16
DATE : Plotted 09:26 14/11/12	

CLIENT: CRIGHTON PROPERTIES | JOB No.: 201479 | COMPUTER FILE : S:\projects\Myall Quays\dwg\STG9\Riverside DA Inundation Plans.dwg

8 Attachment 1B – Amended Concept Development Plan

Item	Description	Ha	%	Approx. Yield
	Extent of concept plan area 'Riverside' at Tea Gardens.	222.5 Ha %	100 %	
	Conservation	116.1 Ha	52.2%	
	Existing Lakes	6.7 Ha	3.0 %	
	Open Space / Water Management	15.4 Ha	6.9 %	
	Low Density Residential	64.8 Ha	29.1 %	780 Dw
	Low - Medium Density Residential Home business	7.7 Ha	3.5 %	100 Dw
	Eco Lodge / Tourist Accomodation / Foreshore Precinct	10.4 Ha	4.7 %	65 Dw
	Public Woodland Park for Active Recreation	1.4 Ha	0.6 %	
	Future precinct Facilities			
	Existing house.			
	Location of known midden & buffer.			
	Existing drain outlet to Myall River.			
	Developing Town Centre (Not part of this application)			
	Future connecting road			

Riverside
Tea Gardens Australia

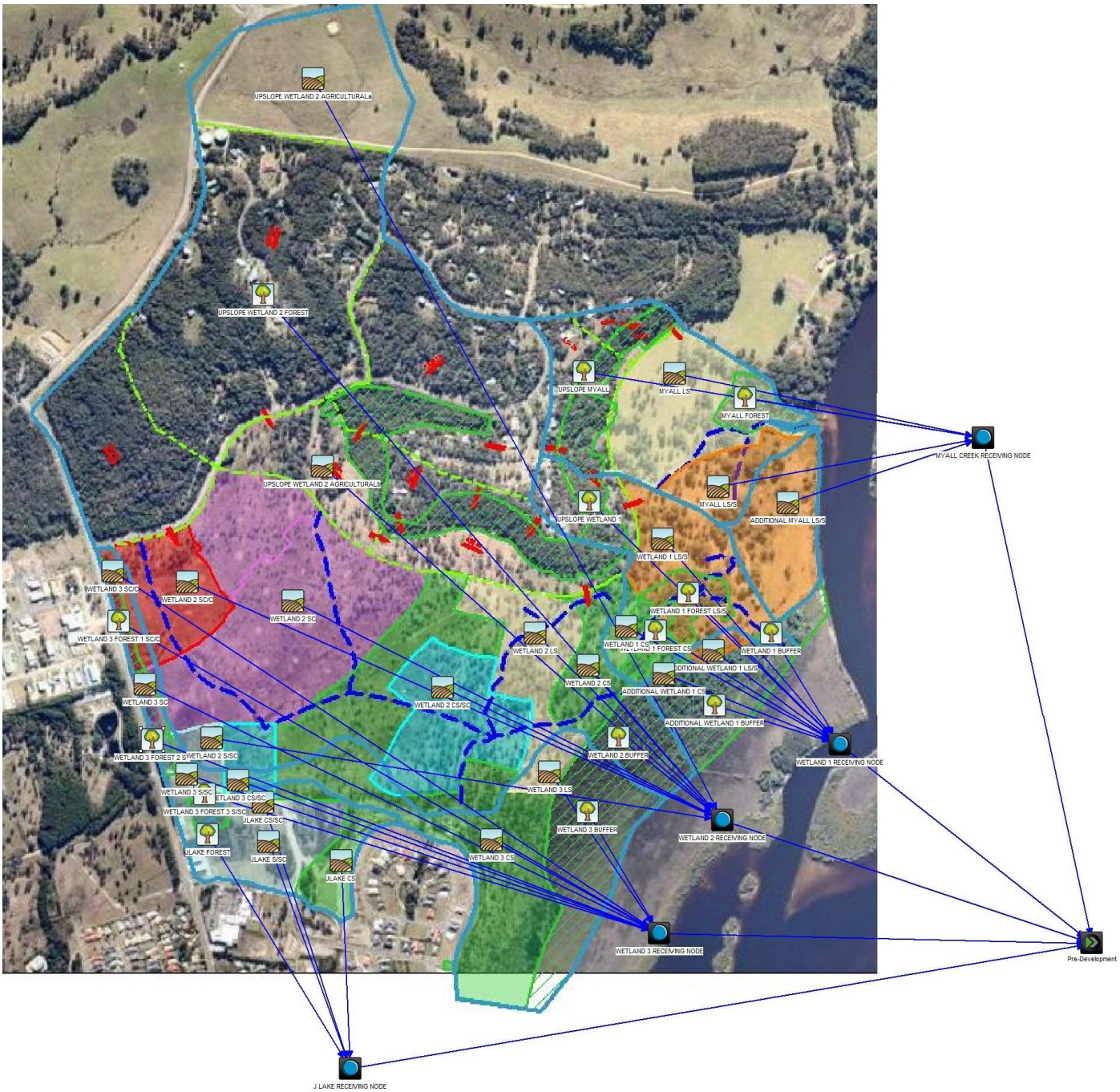
DRAWING TITLE
CONCEPT PLAN

0m 500m

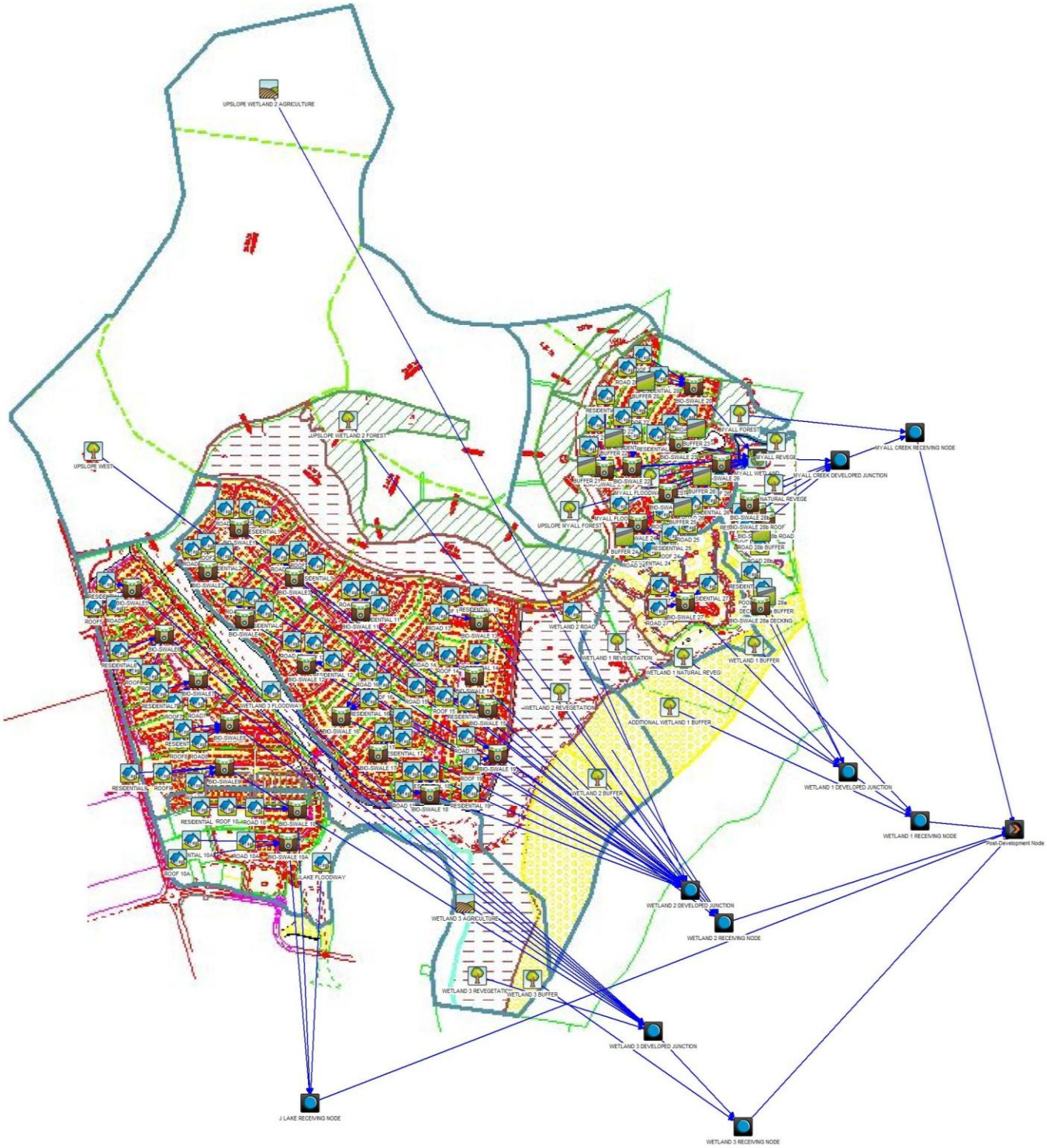
APPLICATION			
Part 3a Submission to N.S.W. D.O.P.			
DATE	SCALE	DRAWING No.	REVISION
October 2012	1:5000 @ A1	R.C. -03	O

CRIGHTON PROPERTIES

9 Attachment 3A – Pre and Post Development MUSIC layouts



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MLK	**Pre Development MUSIC model layout Riverside development at Tea Gardens**	**Figure 1**
Approved:	DM		
Date:	06.11.2012		
Scale:	NA		Job No: P0902346



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MLK	**Post Development MUSIC model layout Riverside development at Tea Gardens**	**Figure 2**
Approved:	DM		
Date:	07.11.2012		
Scale:	NA		Job No: P0902346

10 Attachment 3B – MUSIC Input Parameters

Attachment 3B: MUSIC modelling input parameter values and source.

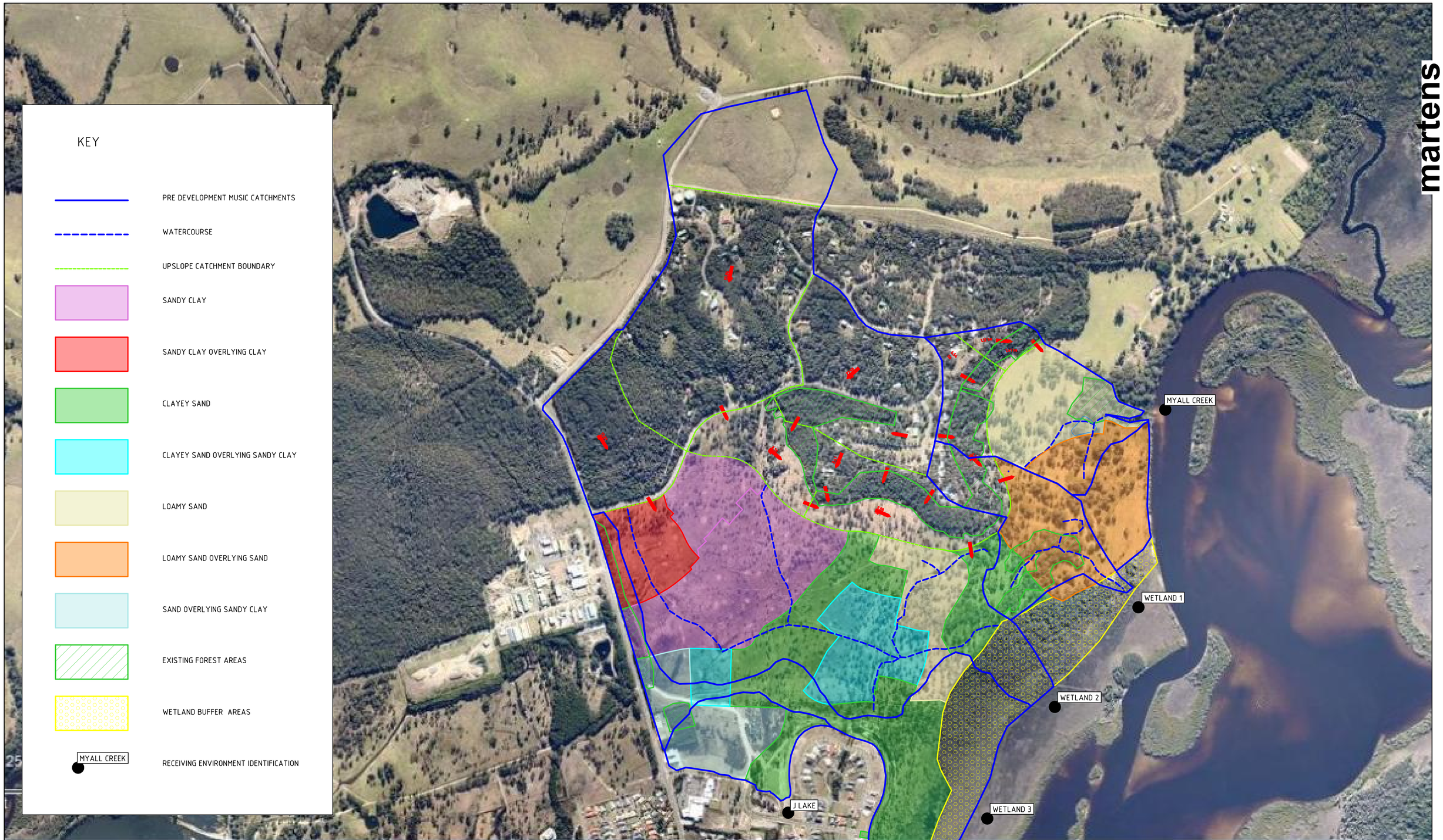
Element	Factor	Input	Source
Setup	Climate File	Rainfall: Hawks Nest adjusted Williamtown RAAF 6min pluvio 1/1/1997 - 31/12/2006 PET: Monthly averages as per BOM 'Climatic Atlas of Australia'	WBM (2012a) requires Williamtown to be used with a 6min timestep. WBM (2010) MUSIC guidelines suggests 1/1/2002 - 31/12/2006 is used for this climate file in Table 3-1. Discussion with T. Weber (Sept 4, 2012) confirmed the climate file should also include 5 years prior to 2002 (i.e. 1/1/1997 - 31/12/2006). PET as per advice from T Weber on Oct 3, 2012.
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 reforestation areas and agricultural for pre=post areas.	As recommended in WBM (2012a)
	Roof Area	Roof area assumed to be 40% of total lot area in accordance with Great Lakes requirement for floor space ratio.	Area supplied by Tattersall Lander.
	Road Area	Based on proposed lot layout.	Area supplied by Tattersall Lander.
	Residential - Impervious area	Includes effective impervious area (EIA) only in accordance with WBM (2010). EIA for site (excluding roads and roofs which are modelled separately) are footpaths and the driveway area from road to front boundary.	EIA as per WBM (2010). Footpath and driveway area provided by Tattersall Lander
	Residential - Pervious area	Total lot area minus total roof. Includes driveway area on each lot as not considered EIA.	Area supplied by Tattersall Lander.
	Rainfall Threshold	Based on land use type or surface type	As recommended in WBM (2010) Table 3-6
	Pervious Area Parameters	Existing site - based on soils within the top 0.5m of existing soil profile Catchment 1: SCC, FC and rainfall-runoff parameters based on WBM (2010) for sandy clay soils. Catchment 16: SSC, FC and rainfall runoff parameters based on a weighted average of values in WBM (2010) based on clayey sand (0.3m) overlying sand (0.2m).	Average soil properties based on WBM (2010) Table 3-7 and 3-8 and site geotechnical testing by Coffey (2008) and Martens (2009) of 49 boreholes.
		Proposed site - the site will be filled with sand and then 100mm of loamy sand growing media to achieve FFL's consistent with flood requirements. SCC, FC and rainfall-runoff parameters based on a weighted average of values in WBM (2010) for top 0.5m - where 0.4m is sand and 0.1m is loamy sand.	
	EMC's	As per WBM (2010)	WBM (2012b) requires that the proponent should use site calibrated parameters or the MUSIC guidelines. In the absense of site specific data we are using the EMCs specified within the WBM (2010) guidelines which are taken from Fletcher *et al* 2004.
	Estimation Method	Stochastically generated	As per WBM (2010) MUSIC modelling guidelines
BioSwale	Low Flow By-Pass	0 m3/s	As per WBM (2010) MUSIC modelling guidelines
	High Flow Bypass	100 m3/s	As per advice from T Weber (October 3, 2012)
	Extended Detention depth	0.25m	Design of proposed swales. Design provided by Tattersall Lander (attached).
	Surface area	Surface area (combined surface area for subcatchment) at half the detention depth	As per WBM (2010) MUSIC modelling guidelines. Area provided by Tattersall Lander.
	Filter area	By design. Total area within subcatchment.	Design of proposed swales. Design provided by Tattersall Lander (attached).
	Unlined filter media	Equal to square root of surface area (actual) multiplied by 4	As per WBM (2010) MUSIC modelling guidelines
	Saturated Hydraulic Conductivity	180 mm/hr	MUSIC model help guidelines (ewater) recommend a hydraulic conductibity of 360 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).
	Filter Depth	0.4m	Design of proposed swales. Design provided by Tattersall Lander (attached).
	TN content of filter media	500 mg/kg	As per direction from T. Weber c/o Stuart Withington in correspondance dated September 7, 2012.
	Orthophosphate content of filter media	50 mg/kg	
	Exfiltration rate	0mm/hr	Although some exfiltration is expected, the system is being designed such that treatment occurs prior to surface water being lost to the system. A second model run with exfiltration 'turned on' will be utilised to provide data for groundwater modelling.
	Is based lined?	Yes	Although system will not be lined, system has been modelled to not allow water to be lost from the system prior to treatment.
	Vegetation Properties	With effective nutrient removal plants	Landscaping of Bioswales will include deep rooted vegetation.
	Oveflow weir width	Driveway is weir for each swale (3.5m). Total weir is used in modelling (i.e. 3.5 x number of swales).	Design of proposed swales. Design provided by Tattersall Lander (attached).
	Underdrain present	Yes	Design of proposed swales. Design provided by Tattersall Lander (attached).
	Submerged zone with carbon present	No	Design of proposed swales. Design provided by Tattersall Lander (attached).
Buffer	Percentage of upstream area buffered (%)	By design	Provided by Tattersall Lander and as per WBM (2010) MUSIC modelling guidelines
	Buffer area (%)	By design	Provided by Tattersall Lander and as per WBM (2010) MUSIC modelling guidelines
	Exfiltration rate	0mm/hr	No infiltration assumed
Wetland	Low Flow By-Pass	0 m3/s	As per WBM (2010) MUSIC modelling guidelines
	High Flow Bypass	50% of 1 year ARI based on total subcatchment area and AR&R results for Nelson Bay	As per WBM (2010) MUSIC modelling guidelines
	Inlet pond Volume	0 m3	Bioswales provide pre treatment include gross pollutant capture and so an inlet pond is not required as per WBM (2010) MUSIC modelling guidelines
	Surface area	Surface area (4321 m2) at half the detention depth (0.05m)	By design and as per WBM (2010) MUSIC modelling guidelines
	Extended Detention depth	0.35m	By design
	Permanent pool volume	668 m3	Based on a surface area of 3185 m2 at 0.4m depth (permanent pool depth). Volume then multiplied by a factor of 0.4 to accommodate typical 1:3 side batters
	Exfiltration rate	0mm/hr	Wetland shall be lined
	Equivalent pipe diameter	85 mm	adjusted to achieve detention time of 40 hrs as per WBM (June, 2012)

NB:
WBM (2010) ***'Sydney Metro CMA: Draft NSW MUSIC Modelling Guidelines'***

WBM (2012a) ***'Review of Water Quality Management for the Porposed Riverside at Tea Gardens Development: Final Report'***

WBM (2012b) ***'Riverside at Tea Gardens Residential Subdivision Revised Concept Plan'***

11 Attachment 3C – Soil Landscapes Mapping



martens

NOTE
AERIAL SOURCE: TATTERSALL LANDER P/L

PAGE BAR SCALE
0 120 240 360 480 600
UNITS – METRES
SCALE – 1:6000 @ A1 1:12000 @ A3

N
W E
S

Martens & Associates Pty Ltd ABN 85 070 240 890	**Environment | Water | Wastewater | Geotechnical | Civil | Management**
Drawn: KT	**SOIL LANDSCAPES - EXISTING SITE** **RIVERSIDE DEVELOPMENT AT TEA GARDENS, NSW**
Approved: DM	Drawing No./ID: **D100**
Date: 10.10.2012	
Scale @ A1: 1:6000	

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:	File:	Revision:
P0902346	JD07V03	A

12 Attachment 3D – Catchment Areas

PRE DEVELOPMENT CATCHMENT AREAS

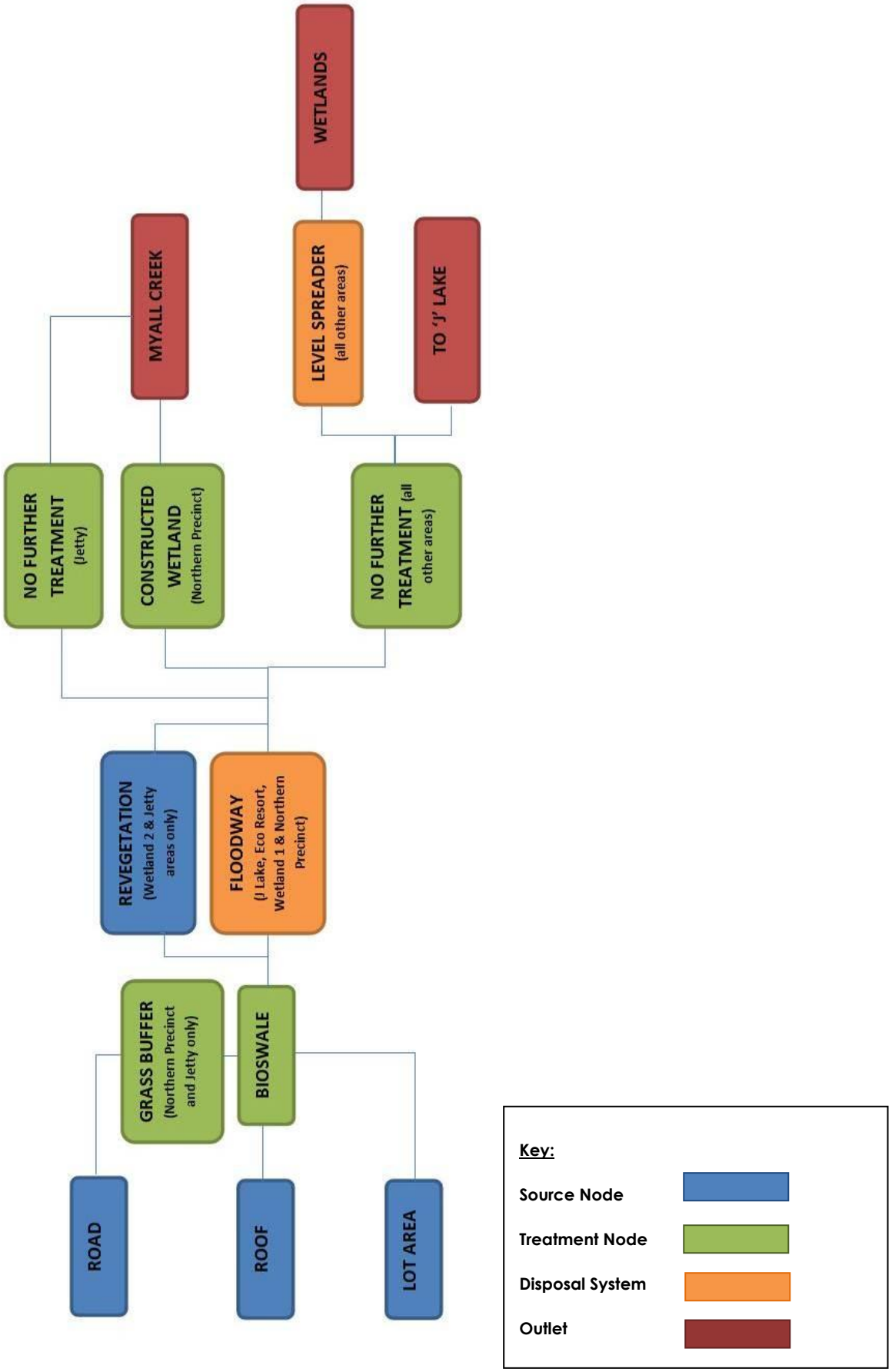
								PERVIOUS INPUT PARAMTERS						
RECEIVING NODE	**CATCHMENT ID**	**TOTAL AREA (HA)**	**IMPERVIOUS AREA (HA)**	**%**	**PERVIOUS AREA (HA)**	**%**	**EMC CATEGORY**	**SOIL TYPE**	**SSC**	**FC**	**INF A**	**INF B**	**DDR (%)**	**DBR (%)**
J-LAKE	JLAKE FOREST	0.2	0	0%	0.2	100%	FOREST	SAND/SANDY CLAY	161.8	82	288	1.5	70	40
	JLAKE S/SC	6.97	0.45	6%	6.52	94%	AGRICULTURAL	SAND/SANDY CLAY	161.8	82	288	1.5	70	40
	JLAKE CS	3.66	0	0%	3.66	100%	AGRICULTURAL	CLAYEY SAND	107	75	250	1.3	60	45
	JLAKE CS/SC	0.27	0.09	33%	0.18	67%	AGRICULTURAL	CLAYEY SAND/SANDY CLAY	128	86.4	208	2.32	39	33
		11.1												
MYALL CREEK	MYALL FOREST	2.32	0	0%	2.32	100%	FOREST	LOAMY SAND	139	69	360	0.5	100	50
	MYALL LS/S	3.83	0	0%	3.83	100%	AGRICULTURAL	LOAMY SAND/SAND	168	73	360	0.5	100	50
	MYALL LS	9.73	0	0%	9.73	100%	AGRICULTURAL	LOAMY SAND	139	69	360	0.5	100	50
	UPSLOPE MYALL	9.14	0.914	10%	8.226	90%	FOREST	SANDY CLAY LOAM	108	73	250	1.3	60	45
	ADDITIONAL MYALL LS/S	7.47	0	0%	7.47	100%	AGRICULTURAL	LOAMY SAND/SAND	168	73	360	0.5	100	50
		32.5												
WETLAND 1	WETLAND 1 FOREST LS/S	2.3	0	0%	2.3	100%	FOREST	LOAMY SAND/SAND	168	73	360	0.5	100	50
	WETLAND 1 FOREST CS	1.04	0	0%	1.04	100%	FOREST	CLAYEY SAND	107	75	250	1.3	60	45
	WETLAND 1 LS/S	7.28	0	0%	7.28	100%	AGRICULTURAL	LOAMY SAND/SAND	168	73	360	0.5	100	50
	WETLAND 1 CS	2.03	0	0%	2.03	100%	AGRICULTURAL	CLAYEY SAND	107	75	250	1.3	60	45
	UPSLOPE WETLAND 1	4.8	0.48	10%	4.32	90%	FOREST	SANDY CLAY LOAM	108	73	250	1.3	60	45
	WETLAND 1 BUFFER	0.4	0	0%	0.4	100%	FOREST	CLAYEY SAND	107	75	250	1.3	60	45
	ADDITIONAL WETLAND 1 BUFFER	7.73	0	0%	7.73	100%	FOREST	CLAYEY SAND	107	75	250	1.3	60	45
	ADDITIONAL WETLAND 1 LS/S	0.69	0	0%	0.69	100%	AGRICULTURAL	LOAMY SAND/SAND	168	73	360	0.5	100	50
	ADDITIONAL WETLAND 1 CS	0.15	0	0%	0.15	100%	AGRICULTURAL	CLAYEY SAND	107	75	250	1.3	60	45
		26.4												
WETLAND 2	UPSLOPE WETLAND 2 AGRICULTURAL	27.38	0.91	3%	26.47	97%	AGRICULTURAL	SANDY CLAY LOAM	108	73	250	1.3	60	45
	UPSLOPE WETLAND 2 FOREST	86.28	8.628	10%	77.652	90%	FOREST	SANDY CLAY LOAM	108	73	250	1.3	60	45
	WETLAND 2 SC/C	6.22	0	0%	6.22	100%	AGRICULTURAL	SANDY CLAY/CLAY	107.7	75.8	148.5	3.7	14.5	14.5
	WETLAND 2 SC	27.03	0	0%	27.03	100%	AGRICULTURAL	SANDY CLAY	142	94	180	3	25	25
	WETLAND 2 S/SC	1.02	0	0%	1.02	100%	AGRICULTURAL	SAND/SANDY CLAY	161.8	82	288	1.5	70	40
	WETLAND 2 CS/SC	11.58	0	0%	11.58	100%	AGRICULTURAL	CLAYEY SAND/SANDY CLAY	128	86.4	208	2.32	39	33
	WETLAND 2 CS	15.96	0	0%	15.96	100%	AGRICULTURAL	CLAYEY SAND	107	75	250	1.3	60	45
	WETLAND 2 LS	7.09	0	0%	7.09	100%	AGRICULTURAL	LOAMY SAND	139	69	360	0.5	100	50
	WETLAND 2 BUFFER	4.12	0	0%	4.12	100%	FOREST	CLAYEY SAND	107	75	250	1.3	60	45
		186.7												
WETLAND 3	WETLAND 3 FOREST 1	0.8	0	0%	0.8	100%	FOREST	SANDY CLAY/CLAY	107.7	75.8	148.5	3.7	14.5	14.5
	WETLAND 3 FOREST 2	0.77	0	0%	0.77	100%	FOREST	SANDY CLAY	142	94	180	3	25	25
	WETLAND 3 FOREST 3	0.96	0	0%	0.96	100%	FOREST	SAND/SANDY CLAY	161.8	82	288	1.5	70	40
	WETLAND 3 SC/C	1.07	0	0%	1.07	100%	AGRICULTURAL	SANDY CLAY/CLAY	107.7	75.8	148.5	3.7	14.5	14.5
	WETLAND 3 SC	0.28	0	0%	0.28	100%	AGRICULTURAL	SANDY CLAY	142	94	180	3	25	25
	WETLAND 3 S/SC	1.88	0	0%	1.88	100%	AGRICULTURAL	SAND/SANDY CLAY	161.8	82	288	1.5	70	40
	WETLAND 3 CS/SC	1.03	0	0%	1.03	100%	AGRICULTURAL	CLAYEY SAND/SANDY CLAY	128	86.4	208	2.32	39	33
	WETLAND 3 CS	15.15	0	0%	15.15	100%	AGRICULTURAL	CLAYEY SAND	107	75	250	1.3	60	45
	WETLAND 3 LS	1.65	0	0%	1.65	100%	AGRICULTURAL	LOAMY SAND	139	69	360	0.5	100	50
	WETLAND 3 BUFFER	10.01	0	0%	10.01	100%	FOREST	CLAYEY SAND	107	75	250	1.3	60	45
		33.6												
	Total Catchment Area	**290**	**ha**											

POST DEVELOPMENT CATCHMENT AREAS

NB ALL POST DEVELOPMENT CATCHMENTS ARE 100MM LOAMY SAND/400MM SAND SOIL TYPE
ALL OTHER CATCHMENTS ARE BASED ON PRE DEVELOPMENT SOIL TYPES

														PERVIOUS INPUT PARAMTERS -ONLY APPLIES TO PRE-POST NODES AND UPSLOPE NODES						
RECEIVING NODE	**CATCHMENT**	**Total Area**	**Biofilter Area**	**1/2 DD Area**	**Road Area**	**Driveway Area**	**Footpath Area**	**Lot Area**	**House Area**	**Residential Node**	**% Impervious (Res)**	**%Pervious (Res)**	**NODE**	**SOIL TYPE**	**SSC**	**FC**	**INF A**	**INF B**	**DDR (%)**	**DBR (%)**
JLAKE	JLAKE FLOODWAY	3.59									18%	82%	URBAN	LOAMY SAND/SAND	168	73	360	0.5	100	50
	10	3.97	0.07	0.11	0.63	0.01	0.12	2.09	0.83	1.38	9%	91%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	10a	4.61	0.05	0.08	1.15	0.04	0.07	2.45	0.98	1.58	7%	93%		LOAMY SAND/SAND	168	73	360	0.5	100	50
		12.18																		
Wetland 3	5	3.76	0.09	0.14	0.59	0.05	0.12	1.53	0.61	1.09	15%	85%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	6	3.93	0.09	0.14	0.62	0.06	0.19	2.38	0.95	1.68	15%	85%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	7	3.67	0.12	0.17	0.63	0.06	0.06	2.32	0.93	1.51	8%	92%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	8	4.57	0.23	0.23	0.89	0.07	0.14	2.49	1.00	1.70	12%	88%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	9	4.98	0.12	0.18	1.20	0.00	0.10	2.41	0.96	1.55	6%	94%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	WETLAND 3 AGRICULTURE	2.54									0%	100%	AGRICULTURE	CLAYEY SAND	107	75	250	1.3	60	45
	WETLAND 3 REVEGETATION	5.88									0%	100%	FOREST	CLAYEY SAND	107	75	250	1.3	60	45
	WETLAND 3 BUFFER	1.66									0%	100%	FOREST	CLAYEY SAND	107	75	250	1.3	60	45
	WETLAND 3 FLOODWAYS	8.96									3%	97%	URBAN							
	Total	**39.95**																		
WETLAND 2	1	3.20	0.07	0.12	0.61	0.05	0.05	2.05	0.82	1.33	7%	93%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	2	2.09	0.04	0.07	0.30	0.03	0.04	1.47	0.59	0.96	8%	92%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	3	3.41	0.08	0.13	0.64	0.05	0.05	2.02	0.81	1.31	8%	92%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	4	2.28	0.04	0.07	0.32	0.01	0.05	1.62	0.65	1.02	5%	95%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	11	4.56	0.09	0.15	0.82	0.08	0.10	3.03	1.21	2.00	9%	91%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	12	4.14	0.08	0.12	0.53	0.07	0.08	3.05	1.22	1.98	7%	93%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	13	3.28	0.08	0.13	0.67	0.06	0.07	2.04	0.82	1.35	10%	90%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	14	3.78	0.07	0.12	0.57	0.06	0.07	2.51	1.01	1.64	8%	92%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	15	2.07	0.04	0.07	0.31	0.04	0.04	1.46	0.58	0.95	8%	92%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	16	3.57	0.06	0.09	0.59	0.06	0.06	2.51	1.01	1.63	8%	92%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	17	3.62	0.13	0.18	0.64	0.05	0.08	2.07	0.83	1.37	10%	90%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	18	2.12	0.19	0.23	0.42	0.03	0.04	1.16	0.46	0.77	9%	91%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	19	3.33	0.08	0.13	0.54	0.06	0.07	2.22	0.89	1.46	9%	91%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	UPSLOPE WEST	13.87									3%	97%	FOREST	SANDY CLAY LOAM	108	73	250	1.3	60	45
	UPSLOPE WETLAND 2 AG	15.57									6%	94%	AGRICULTURE	SANDY CLAY LOAM	108	73	250	1.3	60	45
	UPSLOPE WETLAND 2 FOREST	84.22									10%	90%	FOREST	SANDY CLAY LOAM	108	73	250	1.3	60	45
	WETLAND 2 REVEGETATION	11.10									0	100%	FOREST	LOAMY SAND/SAND	168	73	360	0.5	100	50
	WETLAND 2 BUFFER	12.48									0	100%	FOREST	CLAYEY SAND	107	75	250	1.3	60	45
	WETLAND 2 ADDITIONAL ROAD	0.49									100%	0%	ROAD	LOAMY SAND/SAND	168	73	360	0.5	100	50
	Total	**179.2**																		
WETLAND 1	27	7.19	0.13	0.23	0.30	0.12	0.72		1.47	5.19	16%	84%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	28a	1.52	0.02	0.04	0.00	0.10			0.00	1.36	7%	93%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	WETLAND 1 REVEGETATION	3.24									0	100%	FOREST	LOAMY SAND/SAND	168	73	360	0.5	100	50
	WETLAND 1 BUFFER	0.40									0	100%	FOREST	CLAYEY SAND	107	75	250	1.3	60	45
	ADDITIONAL WETLAND 1 BUFFER	7.73									0	100%	FOREST	CLAYEY SAND	107	75	250	1.3	60	45
	WETLAND 1 NATURAL REVEG	1.32									0	100%	FOREST	LOAMY SAND/SAND	168	73	360	0.5	100	50
	Total	**21.4**																		
MYALL CREEK	20	1.72	0.04	0.07	0.44	0.03	0.05	0.95	0.38	0.65	12%	88%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	21	1.97	0.06	0.10	0.43	0.03	0.04	1.16	0.46	0.77	10%	90%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	22	2.40	0.04	0.06	0.26	0.04	0.04	1.87	0.75	1.20	7%	93%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	23	2.56	0.05	0.09	0.35	0.04	0.05	1.83	0.73	1.19	8%	92%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	24	1.90	0.06	0.10	0.44	0.03	0.05	1.04	0.42	0.71	12%	88%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	25	1.38	0.04	0.06	0.24	0.03	0.03	0.89	0.36	0.59	10%	90%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	26	2.22	0.11	0.16	0.47	0.03	0.06	1.24	0.50	0.84	11%	89%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	28b	2.23	0.04	0.06	0.19	0.00			0.06	1.92	0%	100%		LOAMY SAND/SAND	168	73	360	0.5	100	50
	MYALL UPSLOPE	14.29									10%	90%	FOREST	SANDY CLAY LOAM	108	73	250	1.3	60	45
	MYALL FOREST	1.70									0%	100%	FOREST	LOAMY SAND	139	69	360	0.5	100	50
	MYALL REVEGETATION	0.19									0%	100%	FOREST	LOAMY SAND/SAND	168	73	360	0.5	100	50
	MYALL NATURAL REVEGETATION	2.77									0%	100%	FOREST	LOAMY SAND/SAND	168	73	360	0.5	100	50
	MYALL FLOODWAY FOREST	0.66									0%	100%	FOREST	LOAMY SAND/SAND	168	73	360	0.5	100	50
	MYALL FLOODWAY	0.68									0%	100%	URBAN	LOAMY SAND/SAND	168	73	360	0.5	100	50
	MYALL WETLAND	0.447											WETLAND							
	Total	**37.1**																		
	Total Catchment Area	**290**	**ha**																	

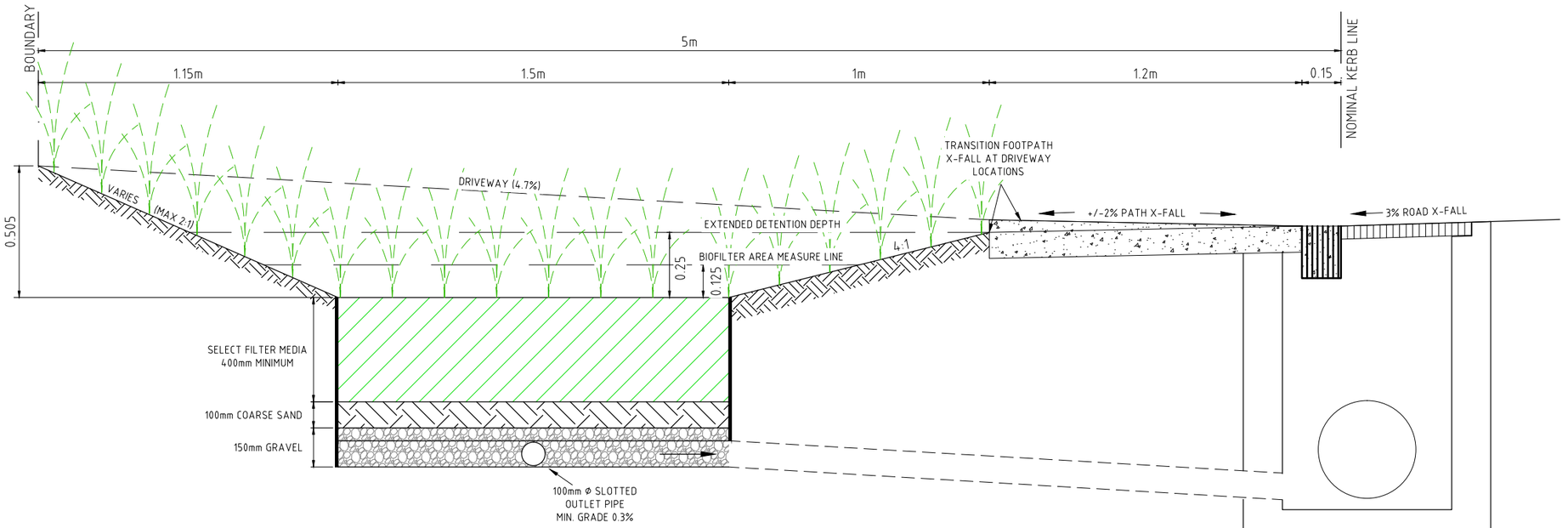
13 Attachment 3E – Conceptual Layout; Proposed Water Quality Treatment Train



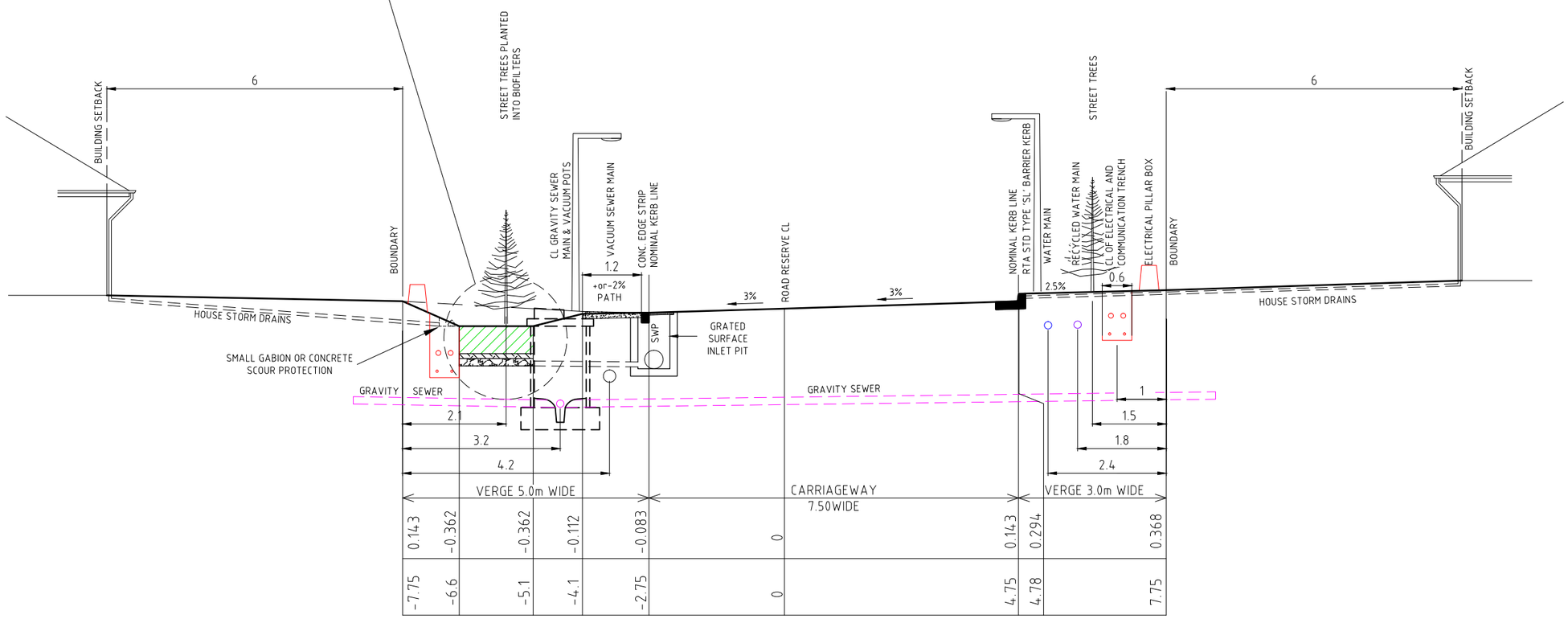
martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MLK	**Conceptual Model – Proposed Treatment Train**	**Attachment E**
Approved:	DM		
Date:	27.11.2012		
Scale:	NA		Job No: P0902346

14 Attachment 3F - Proposed Bioswale Design



TYPICAL 5.0m WIDE FOOTWAY PROFILE
WITH BIO-FILTER DETAIL



T.S. 1 TYPICAL SECTION
ROAD 15.5m WIDE
SCALE 1:50

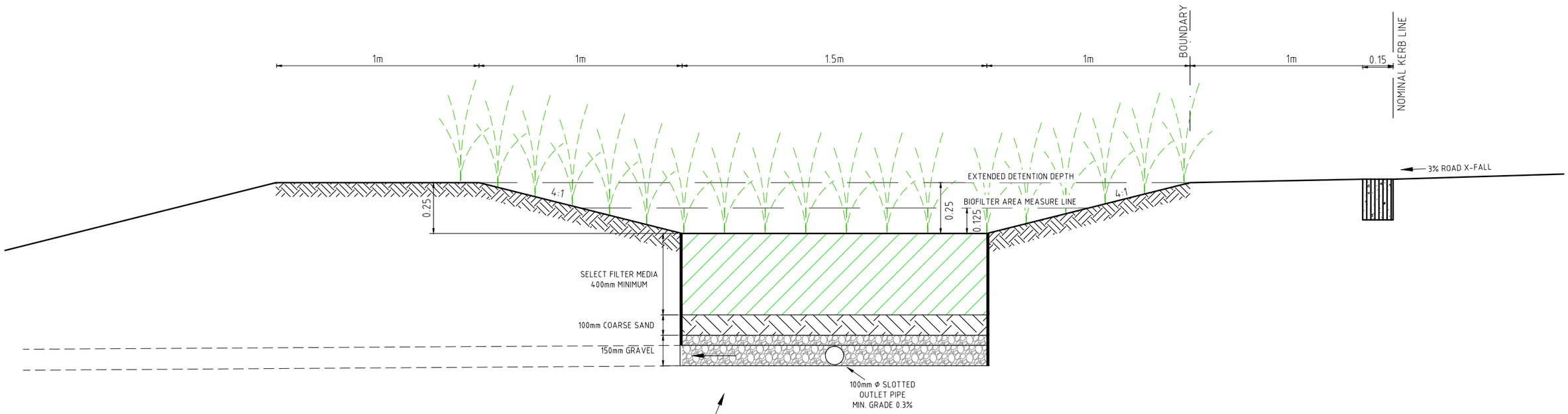
REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
B	Additional Details Added	AV	AV			
A	Original Issue	VL	DWK			

* Denote the original signature and date when revision was issued.

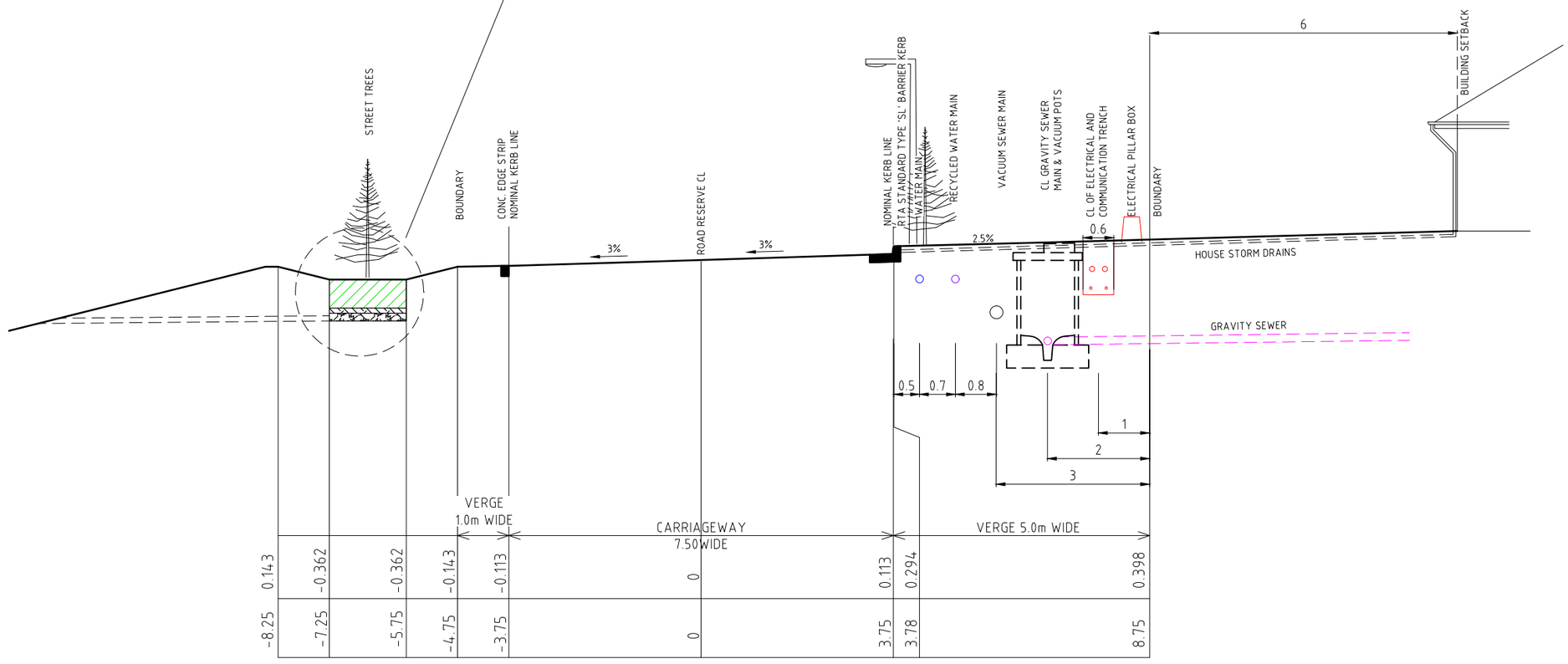
TATTERSALL LANDER Pty Ltd
DEVELOPMENT CONSULTANTS

SCALE :
SHEET No. :####
JOB No. : ####
FILE : ####
DATE : Plotted 16:54 31/08/12
SHEET SIZE A1

COMPUTER FILE : S:\projects\Myall Quays\dwg\STG9\Insertion of Biofilters into Riverside Lot Layout.dwg



TYPICAL 5.0m WIDE FOOTWAY PROFILE
WITH BIO-FILTER DETAIL



T.S. 2 TYPICAL SECTION
RING ROAD 12.5m WIDE
SCALE 1:50

REV	DETAILS OF AMENDMENT	DESIGNED	DRAWN	CHECKED	APPROVED	DATE
B	Additional Details Added	AV	AV			
A	Original Issue	VL	DWK			
*	Denote the original signature and date when revision was issued.					

TATTERSALL LANDER Pty Ltd
DEVELOPMENT CONSULTANTS

SCALE :
SHEET No. :####
JOB No. : ####
FILE : ####
DATE : Plotted 16:55 31/08/12
SHEET SIZE A1

COMPUTER FILE : S:\projects\Myall Quays\dwg\ST69\Insertion of Biofilters into Riverside Lot Layout.dwg

15 Attachment 3G – Pre and Post Development Recharge Rates; MUSIC Modelling

INFILTRATION RATES EXISTING - WATER BALANCE BY CATCHMENT AREA

			ML/yr					
RECEIVING NODE	CATCHMENT ID	TOTAL AREA (HA)	RAINFALL	ET	BASEFLOW (SOURCE NODES) / INFILTRATION LOSS (TREATMENT NODES)	STORM FLOW	INFILTRATION RATE (mm/yr)
J-LAKE	JLAKE FOREST	0.2	2.7	1.7	0.9	0.1	450.0
	JLAKE S/SC	6.97	95.8	57.6	30.9	7.3	443.3
	JLAKE CS	3.66	50.3	32.6	11	6.7	300.5
	JLAKE CS/SC	0.27	3.7	1.8	0.5	1.4	185.2
MYALL CREEK	MYALL FOREST	2.32	31.9	19.4	11.7	0.8	504.3
	MYALL LS/S	3.83	52.6	31.5	20.7	0.4	540.5
	MYALL LS	9.73	133.7	81.2	49.1	3.4	504.6
	UPSLOPE MYALL	9.14	121.9	71.7	25.6	24.6	280.1
	ADDITIONAL MYALL LS/S	7.47	102.6	61.3	40.4	0.8	540.8
WETLAND 1	WETLAND 1 FOREST LS/S	2.3	31.6	18.9	12.4	0.3	539.1
	WETLAND 1 FOREST CS	1.04	14.3	9.3	3.1	1.9	298.1
	WETLAND 1 LS/S	7.28	100	59.8	39.4	0.8	541.2
	WETLAND 1 CS	2.03	27.9	18.1	6.1	3.7	300.5
	UPSLOPE WETLAND 1	4.8	66	38.8	13.8	13.3	287.5
	WETLAND 1 BUFFER	0.4	5.5	3.6	1.2	0.7	300.0
	ADDITIONAL WETLAND 1 BUFFER	7.73	106.2	68.9	23.2	14.1	300.1
	ADDITIONAL WETLAND 1 LS/S	0.69	9.5	5.7	3.7	0.1	536.2
	ADDITIONAL WETLAND 1 CS	0.15	27.9	18.1	6.1	3.7	4066.7
WETLAND 2	UPSLOPE WETLAND 2 AGRICULTURAL	27.38	213.9	130.7	46.8	36.4	170.9
	UPSLOPE WETLAND 2 FOREST	86.28	1185.5	697.4	248.5	239.6	288.0
	WETLAND 2 SC/C	6.22	85.5	55.7	3.5	23.6	56.3
	WETLAND 2 SC	27.03	371.4	250.8	55	65.5	203.5
	WETLAND 2 S/SC	1.02	14	8.9	4.8	0.3	470.6
	WETLAND 2 CS/SC	11.58	159.1	105.8	35.2	18.1	304.0
	WETLAND 2 CS	15.96	219.3	142.3	47.9	29.1	300.1
	WETLAND 2 LS	7.09	97.4	59.1	35.8	2.5	504.9
	WETLAND 2 BUFFER	4.12	56.6	36.7	12.4	7.5	301.0
WETLAND 3	WETLAND 3 FOREST 1	0.8	11	7.2	0.5	3.4	62.5
	WETLAND 3 FOREST 2	0.77	10.6	7.1	1.6	34	207.8
	WETLAND 3 FOREST 3	0.96	13.2	8.4	4.5	0.3	468.8
	WETLAND 3 SC/C	1.07	14.7	9.6	0.6	5.1	56.1
	WETLAND 3 SC	0.28	3.8	2.6	0.6	0.7	214.3
	WETLAND 3 S/SC	1.88	25.8	16.4	8.9	0.6	473.4
	WETLAND 3 CS/SC	1.03	14.2	9.4	3.1	1.6	301.0
	WETLAND 3 CS	15.15	208.2	135.1	45.4	27.7	299.7
	WETLAND 3 LS	1.65	22.7	13.8	8.3	0.6	503.0
	WETLAND 3 BUFFER	10.01	137.5	89.2	30	18.3	299.7

Infiltration = 180 mm/hr for sandy loams and sands

INFILTRATION RATES PROPOSED - WATER BALANCE BY CATCHMENT AREA

			ML/yr					
RECEIVING NODE	CATCHMENT ID	RAINFALL/INFLOW	ET	BASEFLOW (SOURCE NODES) / INFILTRATION LOSS (TREATMENT NODES)	STORM FLOW	AREA (HA)	%Impervious	*INFILTRATION RATE (mm/yr)
JLAKE	**JLAKE FLOODWAY**	49.3	29.5	19.4	0.4	3.59	18%	540.4
	10 Residential	19	10.5	6.8	1.7			
	10 Bioswale	27.3	1.8	3.6	21.9			
	10					3.97	40%	262.0
	10a Residential	21.7	12.2	7.9	1.6			
	10a bioswale	36.6	1.5	6.7	28.4			
	10a					4.61	49%	316.7
Wetland 3	5 Residential	15	7.8	5	2.2			
	5 Bioswale	22.5	2.3	2.5	17.7			
	5					3.76	36%	199.5
	6 Residential	23.1	12	7.7	3.4			
	6 Bioswale	31.3	2.3	4.2	24.8			
	6					3.93	47%	302.8
	7 residential	20.7	11.5	7.5	1.7			
	7 Bioswale	29.3	3.1	2.3	23.9			
	7					3.67	46%	267.0
	8 residential	23.4	12.5	8.1	2.8			
	8 Bioswale	35	5.8	0.2	29.1			
	8					4.57	46%	181.6
	9 residential	21.3	12.1	7.9	1.4			
	9 Bioswale	36.7	3.3	3.7	29.8			
	9					4.98	45%	232.9
	WETLAND 3 AGRICULTURE	34.9	22.6	7.6	4.7	2.54	0%	299.2
	WETLAND 3 REVEGETATION	80.8	52.4	17.6	10.8	5.88	0%	299.3
	WETLAND 3 BUFFER	22.8	14.8	5	3	1.66	0%	301.2
	WETLAND 3 FLOODWAYS	123.1	71.7	47	4.4	8.96	3%	524.6
WETLAND 2	1 Residential	18.2	10.2	6.7	1.3			
	1 Bioswale	26.3	2	3.4	20.9			
	1					3.2	48%	315.6
	2 Residential	13.2	7.3	4.8	1.1			
	2 Bioswale	17.4	1.2	2.4	13.8			
	2					2.09	46%	344.5
	3 Residential	18	10	6.5	1.5			
	3 Bioswale	26.6	2.1	3.3	21.2			
	3					3.41	45%	287.4
	4 Residential	14	8	5.2	0.8			
	4 Bioswale	18.6	1.2	2.5	14.9			
	4					2.28	45%	337.7
	11 Residential	27.5	15.1	9.8	2.6			
	11 Bioswale	38.5	2.5	5.5	30.5			
	11					4.56	48%	335.5
	12 Residential	27.2	15.3	10	1.9			
	12 Bioswale	34.7	2	4.9	27.8			
	12					4.14	46%	359.9
	13 Residential	18.5	10.1	6.6	1.8			
	13 Bioswale	27.5	2	3.7	21.8			
	13					3.28	49%	314.0
	14 Residential	22.5	12.5	8.2	1.8			
	14 Bioswale	30.4	1.9	4.3	24.2			
	14					3.78	45%	330.7
	15 Residential	13.1	7.3	4.7	1.1			
	15 Bioswale	17.3	1.1	2.5	13.7			
	15					2.07	47%	347.8
	16 Residential	22.4	12.5	8.1	1.8			
	16 Bioswale	30.6	1.5	5	24.1			
	16					3.57	48%	366.9
	17 Residential	18.8	10.3	6.7	1.8			
	17 Bioswale	27.4	3.3	2	22.1			
	17					3.62	44%	240.3
	18 Residential	10.6	5.8	3.8	1			
	18 Bioswale	16	4.6	0.2	11.2			
	18					2.12	45%	188.7
	19 Residential	20.1	11.1	7.2	1.8			
	19 Bioswale	27.5	2.1	3.4	22			
	19					3.33	47%	318.3
	UPSLOPE WEST	190.6	119.6	43.1	27.9	13.87	3%	310.7
	UPSLOPE WETLAND 2 AG	213.9	130.7	46.8	36.4	15.57	6%	300.6
	UPSLOPE WETLAND 2 FOREST	1017.7	598.7	213.4	205.6	74.07	10%	288.1
	UPSLOPE WETLAND 2 REVEGETATION	167.8	108.2	39.1	20.5	12.21	0%	320.2
	WETLAND 2 REVEGETATION	152.5	91.2	60	1.3	11.1	0%	540.5
	WETLAND 2 BUFFER	171.5	111.3	37.4	22.8	12.48	0%	299.7
WETLAND 1	27 Residential	68.3	34.8	22.3	11.2			
	27 Bioswale	56.7	3.5	6.7	46.5			
	27					7.19	36%	403.3
	WETLAND 1 REVEGETATION	44.5	26.6	17.5	0.4	3.24	0%	540.1
	WETLAND 1 BUFFER	5.5	3.6	1.2	0.7	0.4	0%	300.0
	ADDITIONAL WETLAND 1 BUFFER	106.2	68.9	23.2	14.1	7.73	0%	300.1
	WETLAND 1 NATURAL REVEG	18.1	10.8	7.1	0.2	1.32	0%	537.9
	Residential 28A	18.7	11.2	7.4	0.2			
	28A Bioswale	1.2	0.5	0	0.7			
	28A					1.52	6%	486.8
MYALL CREEK	20 Residential	8.9	4.8	3.1	1			
	20 Bioswale	14.6	1.2	2	11.4			
	20					1.72	53%	296.5
	21 Residential	10.6	5.8	3.7	1.1			
	21 Bioswale	16.2	1.5	1.9	12.8			
	21					1.97	49%	284.3
	22 Residential	16.5	9.3	6	1.2			
	22 Bioswale	20.4	1	3.3	16.1			
	22					2.4	45%	387.5
	23 Residential	16.4	9.1	5.9	1.4			
	23 Bioswale	21.3	1.4	2.8	17.1			
	23					2.56	46%	339.8
	24 Residential	9.8	5.2	3.4	1.2			
	24 Bioswale	15.5	1.5	1.8	12.2			
	24					1.9	49%	273.7
	25 Residential	8.1	4.4	2.9	0.8			
	25 Bioswale	11.4	1	1.3	9.1			
	25					1.38	47%	304.3
	26 Residential	11.5	6.2	4	1.3			
	26 Bioswale	17.3	2.8	1	13.5			
	26					2.2	48%	227.3
	28b Residential	26	15.5	10.2	0.2			
	28B Bioswale	10.4	0.2	0.6	9.6			
	28B Bioswale roof	0.8	0	0.2	0.6			
	28B Bioswale road	2.2	0.8	0.1	1.3			
	28b					2.23	11%	497.8
	MYALL UPSLOPE	196.3	115.5	41.2	39.6	14.29	10%	288.3
	MYALL FOREST	23.4	14.2	8.6	0.6	1.7	0%	505.9
	MYALL REVEGETATION	2.6	1.6	1	0	0.19	0%	526.3
	MYALL NATURAL REVEGETATION	38.1	22.7	15	0.3	2.77	0%	541.5
	MYALL FLOODWAY FOREST	9.1	5.4	3.6	0.1	0.66	0%	545.5
	MYALL FLOODWAY	9.8	5.8	3.8	0.1	0.68	0%	558.8
	MYALL WETLAND	181.7	6.9	0	174.8			

* Net infiltration rate = (source node baseflow + treatment node infiltration) / area

16 Attachment 3H – Site Testing Plan

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MLK	**Site Testing Plan**	**Attachment H**
Approved:	DM		
Date:	29.11.2012		
Scale:	NA		Job No: P0902346

17 Attachment 3I – Borelogs

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP 1**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.586

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.5	0.5			**TOPSOIL:** SAND, fine to medium grained, dark brown with approximately 30% low plasticity fines, with 300mm of rootlets.	M			TOPSOIL
				D	2.0			CI	**Sandy CLAY:** medium plasticity, dark brown-orange, sand fine to medium grained.				
						1.0		SP	**SAND:** fine to medium grained, pale grey-white.		VD		
				D	1.5								
						1.5			Becoming pale grey-brown.	W			
				D	1.0								
			04-04-07 8:54am		0.5	2.0			Test pit TP 1 terminated at 1.9m				
						2.5							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description based on unified classification system

moisture

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

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TESTPIT 20248AA LOGS.GPJ COFFEY.GDT 23.10.07

Form GEO 5.2 Issue 3 Rev.2

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP 2**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.433

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N	▼ 04-04-07 9:13am	D	2.0	0.5			**TOPSOIL:** Silty Clayey SAND, fine to medium grained, dark brown with approximately 30% of low plasticity fines, with approximately 300mm of rootlets.	M			TOPSOIL
				D	1.5	1.0		CI	**Sandy CLAY:** medium plasticity, dark brown-orange, with some sand lenses.	M/W	St	× × ×	
				D	1.0	1.5		SP	**SAND:** fine to medium grained, brown-dark grey.	W			Rapid inflow of groundwater and pit collapsing below 1.7m depth.
				D	0.5	2.0			Test pit TP 2 terminated at 1.9m				
					0.0	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TESTPIT 20248AA LOGS.GPJ COFFEY.GDT 23.10.07

Form GEO 5.2 Issue 3 Rev.2

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP 3**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.571

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.5	0.5			**TOPSOIL:** Silty Clayey SAND, fine to coarse grained, pale brown-brown, low plasticity fines with some rootlets to 300mm.	M			TOPSOIL
				D	2.0			SC	**Clayey SAND:** fine to medium grained, orange-brown / pale brown, low plasticity fines.		VD		
						1.0		SP	**SAND:** fine to coarse grained to fine to medium grained, pale grey-white.	M/W			
				D	1.5				Becoming pale brown-white.				
			04-04 07		1.0	1.5			Becoming white.				Rapid inflow of groundwater and pit collapsing below 1.7m depth.
					0.5	2.0			Test pit TP 3 terminated at 1.8m				
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP 4**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.260

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N			2.0	0.0			**TOPSOIL:** Silty CLAY, medium plasticity, dark grey-black, small percentage of sand <10% with some rootlets.	M			TOPSOIL
				D		0.5		CH	**CLAY:** medium to high plasticity, dark grey.	M>Wp	St	×	
				D	1.5	1.0						×	
			▼ 05-04-07 12:12pm		1.0	1.5						×	
					0.5	2.0						×	Rapid inflow of groundwater at 2.0m depth.
				D				SP	**SAND:** fine to coarse grained, pale grey.	W			
					0.0	2.5			Test pit TP 4 terminated at 2.1m				

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP 5**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.765

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N	04-04-07 8:35am	D	2.5	0.5			**TOPSOIL:** SAND, fine to medium grained, dark brown, with low plasticity fines, approximately 30% fines with some rootlets to approximately 150mm.	M			TOPSOIL
				D	2.0	1.0		CI	**Sandy CLAY:** medium plasticity, orange-brown, sand fine to medium grained.		VSt		
				D	1.5	1.5		SP	**SAND:** fine to medium grained, pale grey-white. Becoming pale grey-brown.		VD		
				D	1.0					W			Rapid groundwater inflow below 1.7m depth.
					0.5	2.0			Test pit TP 5 terminated at 1.9m				
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP 6**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.846

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N			2.5	0.5			**TOPSOIL:** Silty SAND, fine to medium grained, dark grey mottled white, with some rootlets and roots to 150mm.	D			TOPSOIL
				D	2.0	1.0		SM	**Silty SAND:** fine to medium grianed, brown / red cemented sand nodules.	M	VD		INDURATED SAND?
				D	1.5	1.5		SP	**SAND:** fine to medium grained, pale brown-white with some cemented sand nodules.				
			▼ 05-04-07 12:33pm		1.0	2.0			Becoming pale grey-white.	W			Water visible. Pit collapsing due to groundwater.
									Lenses of cemented sand nodules dark brown-red present.				
					0.5	2.5			Test pit TP 6 terminated at 2.1m				

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. TP 7

Sheet 1 of 1

Project No: GEOTSGTE20248AA

Client: TATTERSALL SURVEYORS PTY LTD

Date started: 13.4.2007

Principal:

Date completed: 13.4.2007

Project: RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS

Logged by: JJT

Test pit location: REFER TO FIGURE 1

Checked by:

equipment type and model:

Pit Orientation:

Easting: m

R.L. Surface: 2.388

excavation dimensions: m long m wide

Northing: m

datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
HA		N		D	2.0	0.5		CH	**Sandy CLAY:** high plasticity, dark brown, sand fine to medium grained.	M			
			▼	D	1.5	1.0		SC	**Clayey SAND:** fine to medium grained, grey.	W	VD		
					1.0	1.5			Hole terminated at 1.0m, hole collapsing because of groundwater. Test pit TP 7 terminated at 1m				
					0.5	2.0							
					0.0	2.5							

Sketch

method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 — no resistance ranging to refusal

water

▼ water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description based on unified classification system

moisture

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

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP 8**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **13.4.2007**

Principal:

Date completed: **13.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **JJT**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: | Pit Orientation: | Easting: m | R.L. Surface: 3.184

excavation dimensions: m long m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
HA		N	Not Measured	D	3.0	0.5		SP	Clayey SAND: fine to medium grained, black.	M	D		
					2.5	1.0			Hole terminated at 0.6m, sand too dry to retrieve. Test pit TP 8 terminated at 0.6m				
					2.0	1.5							
					1.5	2.0							
					1.0	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP 9**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.735

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.5	0.5			TOPSOIL: Silty Clayey SAND, fine to medium grained, dark grey, low plasticity fines, with some rootlets and thick roots to 100mm.	M			TOPSOIL
				D									
					2.0			SC	Clayey SAND: fine to medium grained, dark brown-black, low plasticity fines with some black cemented sand nodules up to approximately 0.13m diameter.		D/VD		
				D		1.0							
			04-04-07 10:41am		1.5			SP	SAND: medium to coarse grained, pale grey-white.				
					1.0	1.5			Becoming pale grey-brown.	W			Groundwater inflow below 1.8m depth.
				D		2.0							
					0.5				Test pit TP 9 terminated at 2m				
						2.5							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4 no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Engineering Log - Excavation

Excavation No. **TP10**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.585

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N	None Observed		2.5	0.5			TOPSOIL: Clayey SAND, fine to medium grained, brown, low plasticity fines, with some rootlets and roots (10-30mm thick) to approximately 450mm.	M			TOPSOIL
				D	2.0			SC	Clayey SAND: fine to medium grained, pale brown, with some cemented sand nodules, low plasticity fines.		MD		
						1.0		SP	SAND: fine to medium grained, pale grey-white.		D		
				D	1.5						VD		
					1.0	1.5							
				D					One big, 0.7mm dia., cemented sand nodule.	W			No obvious groundwater level or inflow but pit collapsing.
					0.5	2.0			Test pit TP10 terminated at 1.9m				
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP11**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.732

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N			2.5	0.5			**TOPSOIL:** Silty SAND, fine to medium grained, grey-brown, low plasticity fines? with some rootlets.	M			TOPSOIL
								SC	**Clayey SAND:** fine to medium grained, pale grey-brown, low plasticity fines.		VD		
				D	2.0	1.0		SC	**Clayey SAND:** fine to medium grained, orange-brown, dark brown-black, low plasticity fines, with cemented sand nodules up to approximately 0.13mm dia.				
				D	1.5	1.5		SP	**SAND:** fine to coarse grained, pale grey-brown. Colour change.	W			
			04-04-07 11:15am	D	1.0	2.0			Test pit TP11 terminated at 1.9m				
					0.5	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP12**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 3.126

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			3.0				**TOPSOIL:** Silty Clayey SAND, fine to medium grained, dark grey, low plasticity fines, with some rootlets to approximately 350mm.	M			TOPSOIL
						0.5		SC	**Clayey SAND / Sandy CLAY:** fine to medium grained, dark grey-brown, medium plasticity fines.		St	x x	
				D	2.5			CL	**Sandy CLAY:** low to medium plasticity, orange-brown, sand fine to medium grained.				
						1.0		SP	**SAND:** fine to coarse grained, pale grey-white.		VD		
				D	2.0								
						1.5			Becoming pale grey-brown.				
				D	1.5								
			04-04-07 11:30am		1.0				Test pit TP12 terminated at 2m				
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP13**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.825

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.5	0.5			**TOPSOIL:** Silty SAND, fine to medium grained, dark grey-black with some rootlets and roots (10-30mm thick).	D/M			TOPSOIL
				D	2.0	1.0		SM	**Silty SAND:** dark brown-dark red, fine to medium grained, with cemented sand nodules to 0.16mm dia.	M	VD		Bucket scraping on hard layer.
			04-04-07 11:51am	D	1.5	1.5			Becoming brown-pale brown cemented nodules of sand still present.				
				D	1.0	2.0			Becoming dark brown-brown weakly cemented nodules present.	W			
					0.5	2.5			Test pit TP13 terminated at 2m				

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP14**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.760

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N			2.5	0.5			**TOPSOIL:** Silty CLAY, medium plasticity fines, brown with some rootlets approximately 400mm.				TOPSOIL
				D	2.0	1.0		CH	**CLAY:** high plasticity, brown-dark brown.		VSt	×	
				D	1.5	1.5			Becoming dark grey-black with some mottled orange.			×	
				D	1.0	2.0			Test pit TP14 terminated at 1.8m			×	
					0.5	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP15**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.355

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.0	0.5			TOPSOIL: Silty (Clayey) SAND, fine to medium grained, dark grey-black, with some roots 10mm and rootlets to approximately 400mm.	M			TOPSOIL
				D				SP	SAND: fine to coarse grained, pale grey-brown, small percent of fines <20%.	M/W	D/VD		
					1.5	1.0			Becoming pale grey mottled black and white.				
				D									
					1.0	1.5							Pit collapsing no groundwater observed.
				D									
					0.5	2.0			Pit collapsing. Test pit TP15 terminated at 1.7m				
					0.0	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP16**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.683

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.5				**TOPSOIL:** Silty SAND, fine to medium grained, dark grey-black mottled white, with some rootlets.	D			TOPSOIL
						0.5		SP	**SAND:** fine to medium grained, pale grey-brown.	M	D		
				D	2.0								
						1.0					VD		
				D	1.5					M/W			
			04-04-07 12:54pm			1.5							
				D	1.0			SP	**SAND:** fine to medium grained, dark grey-black, cemented sand nodules, coffee rock.	W			INDURATED SAND
						2.0			Pit collapsing. Test pit TP16 terminated at 1.8m				
					0.5								
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP17**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.635

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information						material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.5 / 0.5			**TOPSOIL:** Silty Clayey SAND, fine to medium grained, dark grey-black mottled white, low plasticity fines, with some rootlets.	D			TOPSOIL
				D	2.0 / 1.0		SC	**Silty Clayey SAND:** fine to medium grained, dark brown / red, low to medium plasticity fines, with cemented nodules of SAND.	M	VD		
							SC	**Clayey SAND:** fine to medium grained, brown-pale brown, low plasticity fines, with weakly cemented nodules of sand.				
				D	1.5 / 1.0		SP	**SAND:** fine to coarse grained, pale grey-pale brown.				
			05-04-07 10:53am					Becoming grey-brown.	W			Rapid inflow of groundwater below 1.7m depth.
				D	2.0 / 0.5			Pit collapsing. Test pit TP17 terminated at 2m				
					2.5							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4 no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Engineering Log - Excavation

Excavation No. **TP18**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.302

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N			2.0	0.5			**TOPSOIL:** Sandy CLAY, low to medium plasticity, dark brown-black, sand fine to medium grained, with some rootlets to 100mm.	M			TOPSOIL
				D				CI	**CLAY:** medium plasticity, dark grey mottled orange, with minor sand component approximately 10%.		VSt		
					1.5	1.0		SC	**Clayey SAND:** fine to medium grained, grey, low plasticity fines.		D		
				D				SP	**SAND:** fine to coarse grained, pale grey-white. Becoming grey / brown.		VD		
			05-04-07 10:35am		1.0	1.5							
				D	0.5				Sand becoming indurated and dark brown / red.	W			
					0.0	2.0			Pit collapsing due to inflow of groundwater, collapsing from sides. Test pit TP18 terminated at 1.9m				
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP19**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.261

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N			2.0	0.0			**TOPSOIL:** Clayey SAND, fine to medium grained, dark brown-black, low plasticity fines with some rootlets.	D			TOPSOIL
				D		0.5		CH	**Sandy CLAY:** medium to high plasticity, dark brown-black, sand fine to coarse grained.				
					1.5	1.0							
				D					Becoming dark grey-grey.				
			04-04-07 2:31pm		1.0			SP	**SAND:** fine to coarse grained, pale grey-white.	W	VD		
				D	0.5	1.5			Becoming pale brown / grey.				
									Pit collapsing due to groundwater. Test pit TP19 terminated at 1.8m				
					0.0	2.0							
						2.5							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4 no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Engineering Log - Excavation

Excavation No. **TP20**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.255

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information						material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.0 / 0.5			**TOPSOIL:** Silty Clayey SAND, fine to medium grained, dark grey-black mottled white, with some rootlets.	D			TOPSOIL
							CL	**Sandy CLAY:** low plasticity, dark brown-red, sand fine to medium grained, trace of rootlets and cemented sand nodules.	M			
				D	1.5 / 1.0		CL	**Sandy CLAY:** low to medium plasticity, pale grey-pale brown mottled orange, sand fine to medium grained.	M/W			
			04-04-07 2:15pm	D	1.0 / 1.5			Becoming pale brown / grey.				
				D	0.5 / 2.0			Pit collapsing due to groundwater. Test pit TP20 terminated at 1.7m				
					0.0 / 2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP21**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.675

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.5				**TOPSOIL:** Silty Clayey SAND, fine to medium grained, dark grey, low plasticity fines with some rootlets and some thick roots to 300mm.	M			TOPSOIL
						0.5		SC	**Clayey SAND:** fine to medium grained, orange-pale brown, low plasticity fines with some cemented red sand nodules.		VD		
				D									
					2.0			SP	**SAND:** fine to medium grained, pale grey-white.				
						1.0							
				D	1.5								
						1.5			Becoming pale brown-pale grey.				
			04-04-07		1.0					W			Rapid groundwater inflow below 1.7m depth.
						2.0							
				D	0.5				Test pit TP21 terminated at 2m				
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP22**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.332

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.0	0.5			**TOPSOIL:** Sandy CLAY, low to medium plasticity, dark brown-black, sand fine to medium grained, with some rootlets.	D			TOPSOIL
				D				CI	**CLAY:** medium plasticity, dark brown-black, with some sand component approximately 30%.	M			
					1.5	1.0		SM	**Silty SAND:** fine to medium grained, brown-pale brown, with some cemented sand nodules.		D		
				D							VD		
					1.0	1.5		SP	**SAND:** fine to medium grained, pale grey-white. Becoming pale grey / brown.	M/W			
				D	0.5								
			04-04-07 2:50pm			2.0			Pit collapsing due to groundwtaer inflow. Test pit TP22 terminated at 1.9m				
					0.0	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP23**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.090

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N	None Observed		2.0				**TOPSOIL:** Silty Clayey SAND, fine to medium grained, dark grey-black, low plasticity fines, with some rootlets to 300mm.	D			TOPSOIL
						0.5		SC	**Clayey SAND:** fine to medium grained, dark grey-black, low to medium plasticity fines.				
					1.5			CL	**Sandy CLAY:** low to medium plasticity, pale brown / orange, sand fine to medium grained.	M			
				D				SC	**Clayey SAND:** fine to medium grained, pale grey / pale brown, low plasticity fines.		VD		
								SP	**SAND:** fine to coarse grained, pale grey-white.				
						1.0							
				D	1.0								
						1.5							
					0.5				Becoming grey / brown.	W			No visible water, but pit collapsing below 1.7m depth.
				D		2.0							
					0.0				Test pit TP23 terminated at 2m				
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP24**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.177

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N			2.0	0.0			**TOPSOIL:** Sandy CLAY, low to medium plasticity, sand fine to medium grained, with some rootlets to 100mm.	M		x x x	TOPSOIL
				D		0.5		CL	**Sandy CLAY:** low to medium plasticity, orange, sand fine to coarse grained.				
					1.5			SP	**SAND:** fine to medium grained, pale grey-white mottled orange.		D		
				D		1.0					VD		
			05-04-07 11:44am		1.0	1.5							
				D	0.5	2.0			Lenses of colour change to pale grey / brown, with some clay lenses.	W			
					0.0	2.5			Pit collapsing from groundwater table. Test pit TP24 terminated at 2m				

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP25**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.611

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information						material substance							
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.5 / 0.5			**TOPSOIL:** Silty SAND, fine to medium grained, dark grey mottled white with some rootlets and roots (10mm) to 150mm.	D			TOPSOIL
				D	2.0 / 1.0			**Silty SAND:** fine to medium grained, dark grey-black, cemented nodules of SAND.	M	D / VD		INDURATED SAND
			05-04-07 11:08am	D	1.5 / 1.5			100mm band of pale grey-pale brown and then becoming grey-brown weakly cemented sand nodules.	W			
			▼	D	1.0 / 2.0			Becoming dark brown / red weakly sand nodules.				Rapid inflow of groundwater below 1.9m depth.
					0.5 / 2.5			Test pit TP25 terminated at 2m				

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP26**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 1.709

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N			1.5	0.0			**TOPSOIL:** Silty Sandy CLAY, medium plasticity, dark grey-black, sand fine to medium grained, with some rootlets to 100mm.	M			TOPSOIL
				D	1.0	0.5		SP	**SAND:** fine to coarse grained, pale grey-white.		D		
				D	0.5	1.0			Becoming pale brown / grey.				
				D	0.0	1.5			Pit collapsing due to groundwater. Test pit TP26 terminated at 1.5m				
					-0.5	2.0							
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP27**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 1.536

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information						material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N			1.0 / 0.5			**TOPSOIL:** Silty (Clayey) SAND, fine to medium grained, dark grey-black, with some rootlets to 200mm.	D			TOPSOIL
				D			SM	**Silty SAND:** fine to medium grained, dark brown, with some cemented sand nodules.	M	VD		
			04-04-07 3:46pm		0.5 / 1.0		SP	**SAND:** fine to coarse grained, brown / grey, with small percent of fines approximately 20-30% possibly clay lenses or nodules.				
				D								
					0.0 / 1.5			Becoming pale grey-white.	M/W			
				D				Becoming pale grey / brown.				
					-0.5 / 2.0			Pit collapsing due to groundwater inflow. Test pit TP27 terminated at 1.8m				
					2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP28**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **4.4.2007**

Principal:

Date completed: **4.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.012

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information						material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			1.5 / 0.5			TOPSOIL: Silty SAND, fine to medium grained, dark grey-black, with some rootlets.	D			TOPSOIL
				D			SM	**Silty SAND:** fine to medium grained, dark brown-black / red, cemented sand nodules.	M	D		
				D	1.0 / 1.0							
			04-04-07 3:31pm				SP	**SAND:** fine to coarse grained, pale brown / grey.	W			
				D	0.5 / 1.5			Becoming brown / grey mottled orange.				
					0.0 / 2.0			Test pit TP28 terminated at 1.8m				
					2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP29**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.170

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information						material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.0			TOPSOIL: Silty SAND, fine to medium grained, dark brown-black, with some rootlets.	D			TOPSOIL
				D	0.5 / 1.5			Silty SAND: fine to medium grianed, pale grey / pale brown.		D		
							SC	Clayey SAND: fine to medium grained, pale brown, low plasticity fines.	M			
				D	1.0							
							SP	SAND: fine to medium grained, pale grey-white.	W			
				D	1.5 / 0.5							
			05-04-07 3:12pm		0.0			Pit collapsing. Test pit TP29 terminated at 1.7m				
					2.0 / 2.5							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4 no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP30**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 1.159

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N	05-04-07 ▼		1.0	0.5			TOPSOIL: Silty Clayey SAND, fine to medium grained, dark grey-black mottled white, low plasticity fines, some rootlets 300mm and roots to 300mm.	D			TOPSOIL
				D	0.5			SP	SAND: fine to coarse grained, pale grey-white.	W	MD		Some inflow of groundwater to pit at 0.3m, 8:05am, pit slowly collapsing from sides, organic odour.
											D		
				D		1.0			Becoming pale brown-grey.				
					0.0								
				D		1.5			Becoming dark brown-red, with some cemented sand nodules.				
					-0.5								
									Pit collapsing. Test pit TP30 terminated at 1.7m				
					-1.0	2.0							
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP31**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 0.732

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			0.5	0.5		SC	**TOPSOIL:** Silty Clayey SAND, fine to medium grained, dark grey-black mottled white, low to medium plasticity fines, with layer of mulch and rootlets to 100mm.	D / M	MD		TOPSOIL (swampy area) organic odour.
				D					**Clayey SAND:** fine to medium grained, pale grey / pale brown, low plasticity fines.		D		
					0.0				Becoming grey / brown.	W			Very slow inflow of groundwater.
			05-04-07 8:29am	D		1.0							
					-0.5			SP	**SAND:** fine to medium grained, dark brown-red, indurated cemented sand nodules.				Rapid inflow of groundwater.
				D	-1.0	1.5			**Silty Gravelly SAND:** fine to coarse grained, dark grey-black, gravel fine to medium grained, rounded-subrounded.				
									Pit collapsing due to inflow of groundwater. Test pit TP31 terminated at 1.8m				
					-1.5	2.0							
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP32**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 0.994

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N							TOPSOIL: Silty Clayey SAND, fine to medium grained, dark grey-black mottled white, low plasticity fines, with some rootlets and roots (10mm).	D			TOPSOIL (swampy area)
					0.5	0.5		SC	**Clayey SAND:** fine to coarse grained, pale grey-pale brown, low plasticity fines maybe low percentage of fines approximately 30-40%.	M	D		Some inflow of water.
			05-04-07 8:47am ▼	D									
					0.0	1.0			Becoming grey-brown, some presence of cemented sand nodules.	W			Moderate inflow of groundwater 8:47am.
				D									
					-0.5	1.5							
				D					Becoming grey mottled brown / orange and presence of subrounded to rounded gravel (fine to medium grained) less than 10mm size.				
					-1.0	2.0			Pit continually collapsed due to water table. Test pit TP32 terminated at 1.7m				
					-1.5	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TESTPIT 20248AA LOGS.GPJ COFFEY.GDT 23.10.07

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coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP33**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 0.923

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
BH		N							**TOPSOIL:** Silty Clayey SAND, fine to medium grained, dark grey-black mottled white, low plasticity fines, with some rootlets to 250mm.	D/M			TOPSOIL (swampy area)
					0.5	0.5		SC	**Clayey SAND:** fine to coarse grained, pale grey-pale brown.	M	D		
			05-04-07 8:56am	D									
					0.0	1.0			Becoming grey / brown.	W			Very slow inflow of groundwater 8:56am, organic odour.
				D									
					-0.5	1.5							
				D	-1.0	2.0		SP	**SAND:** fine to medium grained, dark brown-black, some cemented nodules of sand.				
									Pit collapsing due to water table. Test pit TP33 terminated at 2m				
					-1.5	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP34**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.4.2007**

Principal:

Date completed: **5.4.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **CW**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 0.893

excavation dimensions: 1.5m long 0.4m wide | Northing: m | datum: AHD

excavation information						material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			0.5 / 0.5			**TOPSOIL:** Silty Clayey SAND, fine to medium grained, dark grey-black mottled white, low to medium plasticity fines.	M			TOPSOIL
							SC	**Clayey SAND:** fine to coarse grained, pale grey-white, low plasticity fines. Becoming pale grey-pale brown.		D		
			05-04-07 9:13am ▼	D	0.0 / 1.0		SP	**SAND:** with some clayey lenses, fine to medium grained, low plasticity fines.	M/W			Very slow inflow of water, 9:13am.
				D	-0.5 / 1.5		SC	**Clayey SAND:** fine to coarse grained, grey / brown, low to medium plasticity fines. Pit slowly collapsing due to water table.	W	MD L MD		
					-1.0 / 2.0		SM	**Silty SAND:** fine to medium grained, dark brown / red.				
					-1.5 / 2.5			Pit collapsing due to groundwater. Test pit TP34 terminated at 2m				

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	BH35
Sheet	1 of 1
Project No:	GEOTSGTE20248AA
Client:	TATTERSALL SURVEYORS PTY LTD
Date started:	11.4.2007
Principal:	
Date completed:	11.4.2007
Project:	RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS
Logged by:	JJT
Borehole Location:	REFER TO FIGURE 1
Checked by:	

drill model and mounting: MD20 | Easting: | slope: -90° | R.L. Surface: 1.006

hole diameter: 100 mm | Northing | bearing: | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
HF		C	▼	SPT 2,2,3 N*=5	0	1		SP	**SAND:** fine to medium grained, grey.	M	MD		
										W			
					-1	2					D		
				SPT 2,3,11 N*=14	-2	3							
				SPT 6,4,12 N*=16	-3	4							
									Borehole BH35 terminated at 4m				
					-4	5							
					-5	6							
					-6	7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration 1 2 3 4 — no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description based on unified classification system

moisture

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

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No. **BH36**
Sheet 1 of 1
Project No: **GEOTSGTE20248AA**

Client: *TATTERSALL SURVEYORS PTY LTD*
Date started: *11.4.2007*
Principal:
Date completed: *11.4.2007*
Project: *RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS*
Logged by: *JJT*
Borehole Location: *REFER TO FIGURE 1*
Checked by:

drill model and mounting: MD20 | Easting: | slope: -90° | R.L. Surface: 2.361
hole diameter: 100 mm | Northing | bearing: | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
HF		C	▼		2			SC	**Clayey SAND:** fine to medium grained, black, clay low plasticity.	M			
				SPT 4,4,5 N*=9		1		SP	**SAND:** fine grained, white.	W	D		
					1			SP	**SAND:** fine to medium grained, black (coffee rock).				
						2		SP	**SAND:** fine grained, white. Becoming grey.				
				SPT 2,9,11 N*=20	0								
						3					VD		
				SPT 6,13,24 N*=37	-1								
						4		SP	**SAND:** fine to medium grained, black (coffee rock). Becoming softer.				
					-2								
				SPT 6,9,23 N*=32	-3	5							
						6							
					-4								
				SPT 8,16,14 N*=30		7							
					-5				Borehole BH36 terminated at 7m				
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix e.g.	ADT

support
M mud N nil
C casing

penetration
1 2 3 4 — no resistance ranging to refusal

water
▼ 10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

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

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No. **BH37**
Sheet 1 of 1
Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**
Date started: **11.4.2007**
Principal:
Date completed: **11.4.2007**
Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**
Logged by: **JJT**
Borehole Location: **REFER TO FIGURE 1**
Checked by:

drill model and mounting: MD20 | Easting: | slope: -90° | R.L. Surface: Not Measured
hole diameter: 100 mm | Northing | bearing: | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
HF		C						SC	**Clayey SAND:** fine to medium grained, black, clay low plasticity.	M			
								SP	**SAND:** fine to medium grained, white.		D		
			▼	SPT 4,6,10 N*=16		1				W			
									Becoming dark brown, with some organic material.				
				SPT 1,7,8 N*=15		2							
						3							
				SPT 6,18,R N*=R		4		SP	**SAND:** fine to medium grained, black (coffee rock).		VD		INDURATED SAND
						5			Becoming brown.				
				SPT 5,7,R N*=R		6							
				SPT 6,7,R N*=R		7							
									Borehole BH37 terminated at 7m				
						8							

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method
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
B blank bit
V V bit
T TC bit
*bit shown by suffix
e.g. ADT

support
M mud N nil
C casing

penetration
1 2 3 4 no resistance ranging to refusal

water
▼ 10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
V vane shear (kPa)
P pressuremeter
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No.	BH38
Sheet	1 of 1
Project No:	GEOTSGTE20248AA
Client:	TATTERSALL SURVEYORS PTY LTD
Date started:	11.4.2007
Principal:	
Date completed:	11.4.2007
Project:	RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS
Logged by:	JJT
Borehole Location:	REFER TO FIGURE 1
Checked by:	

drill model and mounting:	MD20	Easting:	slope: -90°	R.L. Surface:	2.303
hole diameter:	100 mm	Northing	bearing:	datum:	AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
HF		C							TOPSOIL: Clayey SAND, fine grained, dark grey, clay low plasticity.	M			TOPSOIL
					2			CL	**Sandy CLAY:** medium to high plasticity, grey, sand fine grained.	>Wp			
				SPT 2,2,3 N*=5		1							
			▼		1			CL	**Sandy CLAY:** low to medium plasticity, dark brown, sand fine grained.				
						2				W			
				SPT 4,5,5 N*=10	0			SW	**SAND:** fine to medium grained, grey.		D		
						3							
					-1				Becoming black.				
				SPT 12,18,23 N*=41		4							
					-2								
						5							
				SPT 4,8,11 N*=19	-3								
						6					MD		
					-4								
				SPT 4,8,8 N*=16		7							
					-5				Borehole BH38 terminated at 7m				
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration 1 2 3 4 — no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown
► water inflow
◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description based on unified classification system

moisture

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

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP39**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: *TATTERSALL SURVEYORS PTY LTD*

Date started: **1.6.2007**

Principal:

Date completed: **1.6.2007**

Project: *RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS*

Logged by: **RJP**

Test pit location: *REFER TO FIGURE 1*

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.77

excavation dimensions: 2m long 0.45m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N							**TOPSOIL:** Sandy Silty CLAY, medium plasticity, dark grey, sand fine to medium grained.	M			TOPSOIL Root affected.
					2.5	0.5		CH	**CLAY:** high plasticity, grey-brown and orange mottled, some sand.	>Wp	St		
				D								x	
					2.0	1.0		CH	**CLAY:** high plasticity, grey-grey-brown, some orange mottled with a trace of sand fine to medium grained.			x	
				D									
					1.5	1.5		SP	**SAND:** fine to medium grained, white / light grey-brown.	W			Pit collapsing below 1.4m, organic odour.
				D									
					1.0	2.0			Moderate groundwater inflow below 1.4m. Test pit TP39 terminated at 1.7m				
					0.5	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **TP40**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **1.6.2007**

Principal:

Date completed: **1.6.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **RJP**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.59

excavation dimensions: 2m long 0.45m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			2.5	0.5			**TOPSOIL:** Silty Sandy CLAY, medium plasticity, dark grey, sand fine to medium grained.	>Wp			TOPSOIL Root affected.
				D	2.0			CI	**Sandy CLAY:** medium plasticity, grey-brown and orange mottled, sand fine to medium grained.		St	X	
						1.0			Becoming grey-brown and sand content increasing to Sandy CLAY / Clayey SAND.				
				D	1.5			SP	**SAND:** fine to medium grained, grey-brown with some clay.	W		X	
			▶	D	1.0	1.5		SP	**SAND:** fine to medium grained, light grey-brown.				Rapid groundwater inflow below 1.4m. Organic odour.
					0.5	2.0			Pit collapsing below 1.1m. Test pit TP40 terminated at 1.7m				
						2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP41**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **1.6.2007**

Principal:

Date completed: **1.6.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **RJP**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 3.63

excavation dimensions: 2m long 0.45m wide | Northing: m | datum: AHD

excavation information						material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N			3.5 / 0.0			**TOPSOIL:** Sandy CLAY, medium plasticity, grey-brown, sand fine to medium grained.	M			TOPSOIL Root affected.
				D	3.0 / 0.5		CI	**Sandy CLAY:** medium plasticity, light grey-brown and orange mottled, sand fine to medium grained.	>Wp	St	X	
								Becoming light grey-light grey-brown and orange mottled.			X	
				D	2.5 / 1.0			Sand content increasing light grey-brown and orange mottled.				
				D	2.0 / 1.5		SP	**SAND:** fine to medium grained, light grey-brown some orange mottled, cemented.	M			
			▶	D	1.5 / 2.0		SP	**SAND:** fine to medium grained, white-light grey-brown.	W			Slow groundwater inflow below 2.2m. Organic odour.
					2.5			Test pit TP41 terminated at 2.5m				

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP42**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **1.6.2007**

Principal:

Date completed: **1.6.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **RJP**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 2.82

excavation dimensions: 2m long 0.45m wide | Northing: m | datum: AHD

excavation information							material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
BH		N							**TOPSOIL:** Silty Sandy CLAY, low to medium plasticity, sand fine to medium grained, dark grey-brown.	M			TOPSOIL Root affected.
					2.5	0.5		CI	**Sandy CLAY:** medium plasticity, grey-brown and orange mottled, sand fine to medium grained.	>Wp	St	x	
				D									
					2.0	1.0		CI	**Sandy CLAY:** medium plasticity, grey-grey-brown some orange mottled, sand fine to medium grained, sand content increasing.			x	
			►	D				SP	**SAND:** fine to medium grained, white.	W			Very slow water inflow below 1.1m.
					1.5	1.5			Becoming grey-grey-brown, with a trace to some clay.				
				D									
					1.0	2.0			Test pit TP42 terminated at 1.7m				
					0.5	2.5							

Sketch

TESTPIT 20248AA LOGS.GPJ COFFEY.GDT 23.10.07

Form GEO 5.2 issue 3 Rev.2

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP43**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **1.6.2007**

Principal:

Date completed: **1.6.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **RJP**

Test pit location: **REFER TO FIGURE 1**

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 4.75

excavation dimensions: 2m long 0.45m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
BH		N			4.5	0.5		SP	**SAND:** fine to medium grained, grey-brown.	M			AEOLIAN Root affected to 0.15m.
				D					Becoming light grey-brown.				
					4.0	1.0		SP	**SAND:** fine to medium grained, grey-brown and orange mottled, trace to some clay.				
				D									
					3.5	1.5		SP	**SAND:** fine to medium grained, light grey-brown, some weakly cemented nodules, grey-brown.				
			►	D	3.0					W			Very slow water inflow below 1.7m.
						2.0			Test pit TP43 terminated at 1.85m				
					2.5	2.5							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4 no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP44**

Sheet 1 of 1

Project No: **GEOTSGTE20248AA**

Client: ***TATTERSALL SURVEYORS PTY LTD***

Date started: ***1.6.2007***

Principal:

Date completed: ***1.6.2007***

Project: ***RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS***

Logged by: ***RJP***

Test pit location: ***REFER TO FIGURE 1***

Checked by:

equipment type and model: 4WD Backhoe | Pit Orientation: | Easting: m | R.L. Surface: 4.46

excavation dimensions: 2m long 0.45m wide | Northing: m | datum: AHD

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
BH		N	None Observed	D	4.0	0.5		SP	**SAND:** fine to medium grained, dark grey-brown.	M			AEOLIAN Root affected to 0.3m.
									Becoming light grey-brown.				
				D	3.5	1.0		SP	**SAND:** fine to medium grained, dark brown, some silt / Silty SAND.				INDURATED SAND
				D	3.0	1.5			Becoming cleaner and less cemented, brown.				
				D									
					2.5	2.0			Test pit TP44 terminated at 1.8m				
					2.0	2.5							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration 1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	BH45
Sheet	1 of 2
Project No:	GEOTSGTE20248AA
Client:	TATTERSALL SURVEYORS PTY LTD
Date started:	5.6.2007
Principal:	
Date completed:	5.6.2007
Project:	RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS
Logged by:	RJP
Borehole Location:	REFER TO FIGURE 1
Checked by:	

drill model and mounting: | Easting: | slope: -90° | R.L. Surface: 3.20

hole diameter: mm | Northing | bearing: | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
HF		C			3			SP	**SAND:** fine to medium grained, grey-brown.	M	D		AEOLIAN SAND
						1							
				SPT 2,5,7 N*=12	2				Becoming light grey-brown.				
					1	2							
			▼	SPT 5,6,8 N*=14						W			
					0	3			Becoming dark grey-brown.				
						4							
				SPT 3,15,21 N*=36	-1			SP	**SAND:** fine to coarse grained, dark brown, trace of gravel fine grained and silt.		VD		
					-2	5							
				SPT 9,21,20 N*=41					With a trace fine grained gravel.				20 blows for 100mm penetration.
					-3	6							
				SPT 8,18,21 N*=39	-4	7			Becoming fine to medium grained, light brown and brown.				21 blows for 100mm penetration.
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration 1 2 3 4 — no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description based on unified classification system

moisture

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

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No. **BH45**

Sheet 2 of 2

Project No: **GEOTSGTE20248AA**

Client: **TATTERSALL SURVEYORS PTY LTD**

Date started: **5.6.2007**

Principal:

Date completed: **5.6.2007**

Project: **RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**

Logged by: **RJP**

Borehole Location: **REFER TO FIGURE 1**

Checked by:

drill model and mounting: | Easting: | slope: -90° | R.L. Surface: 3.20

hole diameter: mm | Northing | bearing: | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
HF		C			-5	9		SP	SAND: fine to coarse grained, dark brown, trace of gravel fine grained and silt. *(continued)*	W	D		
				SPT 5,13,17 N*=30									
					-6	10							
				SPT 1,6,15 N*=21	-7								
			▼ Collapsed back to 2.3m		-8	11			Borehole BH45 terminated at 10.45m				
					-9	12							
					-10	13							
					-11	14							
					-12	15							
						16							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix e.g.	ADT

support

M mud N nil

C casing

penetration 1 2 3 4 — no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown

► water inflow

◄ water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description based on unified classification system

moisture

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

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	**BH46**
Sheet	1 of 1
Project No:	**GEOTSGTE20248AA**
Client:	**TATTERSALL SURVEYORS PTY LTD**
Date started:	**6.6.2007**
Principal:	
Date completed:	**6.6.2007**
Project:	**RIVERSIDE ESTATE PROJECT APPLICATION, TEA GARDENS**
Logged by:	**RJP**
Borehole Location:	**REFER TO FIGURE 1**
Checked by:	

drill model and mounting: | Easting: | slope: -90° | R.L. Surface: 1.07

hole diameter: mm | Northing | bearing: | datum: AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
HF		C							TOPSOIL: Sandy CLAY / Clayey SAND, low plasticity, dark grey, sand fine to medium grained, some silt.	M			TOPSOIL
			▼			1		SP	**SAND:** fine to medium grained, grey-brown.	W	MD		
				SPT 3,2,2 N*=4	0				Becoming light grey-brown.				
					-1	2							
				SPT 7,12,14 N*=26				SP	**SAND:** fine to medium grained, dark brown, trace silt.		VD		
					-2	3							
				SPT 5,16,23 N*=39	-3	4		SP	**SAND:** fine to medium grained, some clay, brown and dark brown, trace fine grained gravel.				
					-4	5							
				SPT 2,9,18 N*=27				SP	**SAND:** fine to medium grained, light brown.				
					-5	6							
				SPT 3,10,18 N*=28	-6	7			Becoming fine to coarse grained, trace fine grained gravel, light grey-brown.				
						8			Borehole BH46 terminated at 7.45m				

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	dialube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

▼ 10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

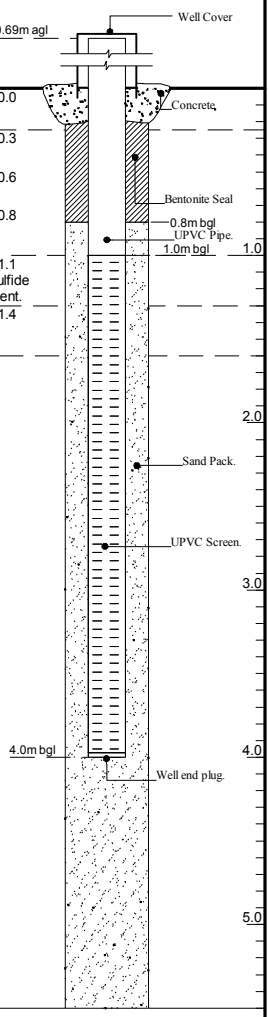
D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

CLIENT	Crighton Properties Pty Ltd	**COMMENCED**	25.09.12	**COMPLETED**	25.09.12	**REF**	**BH201**
PROJECT	Hydrogeological Investigation	**LOGGED**	NF	**CHECKED**	GT/DM	**Sheet**	1 of 1
SITE	MRD, Tea Gardens, NSW	**GEOLOGY**	Marine Sands	**VEGETATION**	Sedges and Grasses	**PROJECT NO.**	P0902346
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	100mmØ X 5.5m depth	**NORTHING**	NA	**ASPECT**	-	**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
V	Nil	N	M	0.25			OL	ORGANIC SILT - Dark brown to black, with some organic matter present, and minor fine grained sand.	VS-S		D	0.0	2346/201/ 0.0
								SANDY CLAY - Medium plasticity, grey brown to grey, with some fine to medium grained sand and minor organic matter present (rootlets). Sand content decreasing with depth, becoming high plasticity >0.7m.	St		D	0.3	2346/201/ 0.3
V	Nil	N	M				CL		VSt		D	0.6	2346/201/ 0.6
				1.0					St		D	0.8	2346/201/ 0.8
V	Nil	N	M				SP	Sand content increasing >0.9m.			D	1.1	2346/201/ 1.1 Hydrogen sulfide odour present.
				1.3				SAND - Medium grained sand, brown to dark brown.					
V	Nil	N	D				CL	SANDY CLAY - Low to medium plasticity, brown to dark brown, with some medium grained sand.	F-St		D	1.4	2346/201/ 1.4
				1.6									
				2.0									
				3.0									
V	Nil	N	M				SC	ORGANIC CLAYEY SAND - Medium grained sand, black to dark grey, with some organic matter present, grading to organic sand >1.9m.					
				4.0									
				5.0									
				5.5									
								Borehole terminated at 5.5m in organic clayey sand.					
				6.0									
				7.0									
				8.0									
				9.0									



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
PT Push tube
A Auger
TC Tungsten Carbide Bit
V V-Bit

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)
E Environmental sample
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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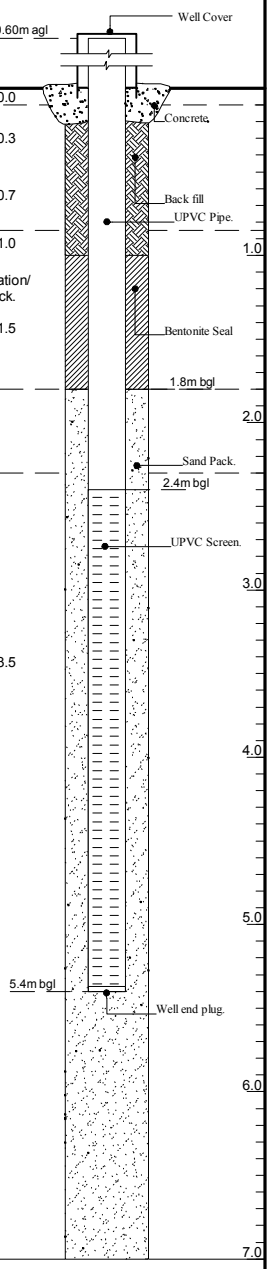
Engineering Log - Borehole

CLIENT	Crighton Properties Pty Ltd	**COMMENCED**	25.09.12	**COMPLETED**	25.09.12	**REF**	**BH202**
PROJECT	Hydrogeological Investigation	**LOGGED**	NF	**CHECKED**	GT/DM	**Sheet**	1 of 1
SITE	MRD, Tea Gardens, NSW	**GEOLOGY**	Marine Sands	**VEGETATION**	Grasses and Ferns	**PROJECT NO.**	P0902346
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	100mmØ X 7.0m depth	**NORTHING**	NA	**ASPECT**	-	**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)	SAMPLING & TESTING
V	Nil	N	D	0.1			SP	LOAMY SAND - Medium grained, dark grey, with some organic matter present.			D	0.0	2346/202/ 0.0
V	Nil	N	D				SP	SAND - Medium grained, pale grey to grey, with some organic matter present.		L	D	0.3	2346/202/ 0.3
			M	0.85						MD-D	D	0.7	2346/202/ 0.7
V	Nil	N	M	1.0			SP	SAND - Medium grained, pale grey, poorly graded, very minor shell fragments present.			D	1.0	2346/202/ 1.0 Hard panatration/ coffee rock.
				1.8							D	1.5	2346/202/ 1.5
V	Nil	N	M	2.0			SP	SAND - Medium grained, dark brown to dark orange brown, cemented occasional roots and rootles present.					
				2.3									
		Y	W								D	3.5	2346/202/ 3.5
V	Nil	Y	W	5.0			SC	SAND - Medium grained, pale brown to grey brown, with some shell fragments present.					
				7.0				Borehole terminated at 7.0m in sand.					
				9.0									

WATER WELL DETAILS



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
PT Push tube
A Auger
TC Tungsten Carbide Bit
V V-Bit

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)
E Environmental sample
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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Hornsby, NSW 2077 Australia
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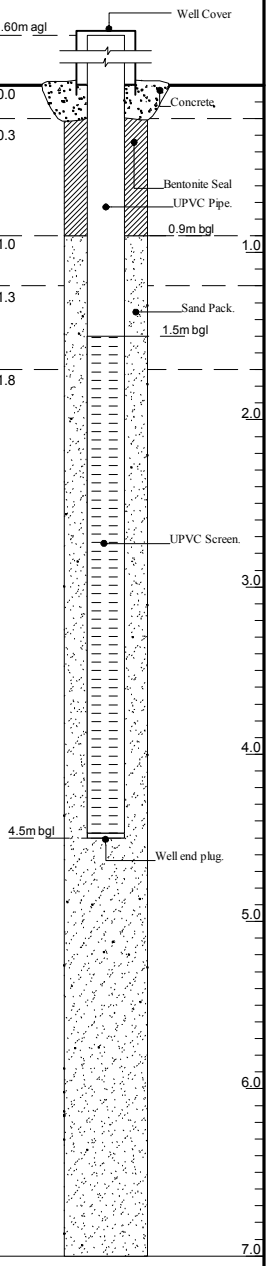
Engineering Log - Borehole

CLIENT	Crighton Properties Pty Ltd	**COMMENCED**	25.09.12	**COMPLETED**	25.09.12	**REF**	**BH203**
PROJECT	Hydrogeological Investigation	**LOGGED**	NF	**CHECKED**	GT/DM	**Sheet**	1 of 1
SITE	MRD, Tea Gardens, NSW	**GEOLOGY**	Marine Sands	**VEGETATION**	Grasses and Ferns	**PROJECT NO.**	P0902346
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	100mmØ X 7.0m depth	**NORTHING**	NA	**ASPECT**	-	**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)	SAMPLING & TESTING
V	Nil	N	D	0.2			SP	LOAMY SAND - Medium brown to dark grey, organic matter and rootlets present, grasses at surface.		VL-L	D	0.0	2346/203/ 0.0
V	Nil	N	M	0.9			SC	CLAYEY SAND - Medium grained, dark brown, grading to low plasticity sandy clay >0.70m.		L-MD	D	0.3	2346/203/ 0.3
V	Nil	N	M	1.0			CL	SANDY CLAY - Low ot medium plasticity, grey brown to dark yellow brown, with some fine to medium grained sand present.			D	1.0	2346/203/ 1.0
V	Nil	Y	W	1.2			SP	SAND - Medium grained, dark grey, mottled orange brown and yellow brown, with some shell fragments and minor fines.			D	1.3	2346/203/ 1.3
		Y	W	1.7							D	1.8	2346/203/ 1.8
				2.0									
				2.25									
V	Nil	Y	W	3.0			SP	SAND - Medium grained, grey to dark grey, with some shell fragments present.					
				4.0									
				5.0									
				6.0									
				7.0									
				8.0				Borehole terminated at 7.0m in sand.					
				9.0									

WATER WELL DETAILS



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
PT Push tube
A Auger
TC Tungsten Carbide Bit
V V-Bit

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)
E Environmental sample
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	**Crighton Properties Pty Ltd**	**COMMENCED**	25.09.12	**COMPLETED**	25.09.12	**REF**	**BH204**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	NF	**CHECKED**	GT/DM	**Sheet**	**1 of 1**
SITE	**MRD, Tea Gardens, NSW**	**GEOLOGY**	Marine Sands	**VEGETATION**	Grasses and Ferns	**PROJECT NO.**	P0902346
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	100mmØ X 1.0m depth	**NORTHING**	NA	**ASPECT**	-	**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
V	Nil	N	M	0.3			SP	ORGANIC LOAMY SAND - Medium grained, dark brown, black, with some organic matter and fines present.			D	0.1	2346/204/ 0.1
V	Nil	N	M	0.5			SP	LOAMY SAND - Medium grained, dark brown, with minor fines present.			D	0.4	2346/204/ 0.4
V	Nil	N Y	M W	0.65			SP	ORGANIC LOAMY SAND - Medium grained, dark brown to black, roots and rootles present.			D	0.6	2346/204/ 0.6
V	Nil	N	M	0.8 1.0			SC	CLAYEY SAND - Medium grained, pale brown, with minor shell fragments present.			D	0.9	2346/204/ 0.9
				1.5 2.0 2.25				Borehole terminated at 1.0m in clayey sand.					

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
PT Push tube
A Auger
TC Tungsten Carbide Bit
V V-Bit

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)
E Environmental sample

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	Crighton Properties Pty Ltd	**COMMENCED**	25.09.12	**COMPLETED**	25.09.12	**REF**	**BH205**
PROJECT	Hydrogeological Investigation	**LOGGED**	NF	**CHECKED**	GT/DM	**Sheet**	1 of 1
SITE	MRD, Tea Gardens, NSW	**GEOLOGY**	Marine Sands	**VEGETATION**	Grasses and Ferns	**PROJECT NO.**	P0902346
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	100mmØ X 1.0m depth	**NORTHING**	NA	**ASPECT**	-	**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
V	Nil	N	M	0.2			SP	ORGANIC LOAMY SAND - Medium grained, dark grey, with some organic matter present.			D	0.0	2346/205/ 0.0
V	Nil	N	M	0.5			SP	SAND - Medium grained, pale grey.			D	0.3	2346/205/ 0.3 0.5
V	Nil	N Y	M W	0.7			SP	SAND - Medium grained, dark brown, grading to orange brown with depth, with some minor shell fragments and fines present.			D	0.7	2346/205/ 0.7
				1.0									1.0
								Borehole terminated at 1.0m in sand.					
				1.5									1.5
				2.0									2.0
				2.25									2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
PT Push tube
A Auger
TC Tungsten Carbide Bit
V V-Bit

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)
E Environmental sample

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	**Crighton Properties Pty Ltd**	**COMMENCED**	25.09.12	**COMPLETED**	25.09.12	**REF**	**BH206**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	NF	**CHECKED**	GT/DM	**Sheet**	**1 of 1**
SITE	**MRD, Tea Gardens, NSW**	**GEOLOGY**	Marine Sands	**VEGETATION**	Grasses	**PROJECT NO.**	P0902346
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	100mmØ X 1.0m depth	**NORTHING**	NA	**ASPECT**	-	**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
V	Nil	N	M	0.25			SP	ORGANIC LOAMY SAND - Medium grained, dark brown, with some fines and organic present.			D	0.1	2346/206/ 0.1
V	Nil	N	M	0.5			SP	ORGANIC LOAMY SAND - Medium grained, dark brown to black, with some organics.			D	0.3	2346/206/ 0.3 0.5
V	Nil	N Y	M W	0.7 0.8			SP	SAND - Medium grained, dark grey, with minor organics.			D	0.7	2346/206/ 0.7
V	Nil	Y	W	1.0			SP	LOAMY SAND - Medium grained, black, parcially cemented.					Hard panatration/ coffee rock. 1.0
				1.5				Borehole terminated at 1.0m in sand.					1.5
				2.0									2.0
				2.25									2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
PT Push tube
A Auger
TC Tungsten Carbide Bit
V V-Bit

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)
E Environmental sample

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	**Crighton Properties Pty Ltd**	**COMMENCED**	25.09.12	**COMPLETED**	25.09.12	**REF**	**BH207**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	NF	**CHECKED**	GT/DM	**Sheet**	**1** of **1**
SITE	**MRD, Tea Gardens, NSW**	**GEOLOGY**	Marine Sands	**VEGETATION**	Grasses	**PROJECT NO.**	P0902346
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	100mmØ X 0.7m depth	**NORTHING**	NA	**ASPECT**	-	**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	
V	Nil	N	D	0.2			SP	ORGANIC LOAMY SAND - Medium grained, dark grey, with some organic matter present.			D	0.0	2346/207/ 0.0	0.0
V	Nil	N	D	0.5			SP	SAND - Medium grained, pale grey.			D	0.3	2346/207/ 0.3	0.5
		N	D	0.6										
		Y	W	0.7										
				1.0				Borehole terminated at 1.0m in sand.						1.0
				1.5										1.5
				2.0										2.0
				2.25										2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
PT Push tube
A Auger
TC Tungsten Carbide Bit
V V-Bit

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)
E Environmental sample
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	**Crighton Properties Pty Ltd**	**COMMENCED**	25.09.12	**COMPLETED**	25.09.12	**REF**	**BH208**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	NF	**CHECKED**	GT/DM	**Sheet**	**1** of **1**
SITE	**MRD, Tea Gardens, NSW**	**GEOLOGY**	Marine Sands	**VEGETATION**	Grasses	**PROJECT NO.**	P0902346
EQUIPMENT	Hydraulic Auger	**EASTING**	NA	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	100mmØ X 1.0m depth	**NORTHING**	NA	**ASPECT**	-	**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
V	Nil	N	D	0.2			SP	ORGANIC LOAMY SAND - Medium grained, dark grey, with some organic matter present.			D	0.0	2346/208/ 0.0
V	Nil	N	M	0.5			SP	SAND - Medium grained, pale grey.			D	0.4	2346/208/ 0.4
		N	M	0.7									
		Y	W										
				1.0				Borehole terminated at 1.0m in sand.					
				1.5									
				2.0									
				2.25									

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
PT Push tube
A Auger
TC Tungsten Carbide Bit
V V-Bit

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)
E Environmental sample

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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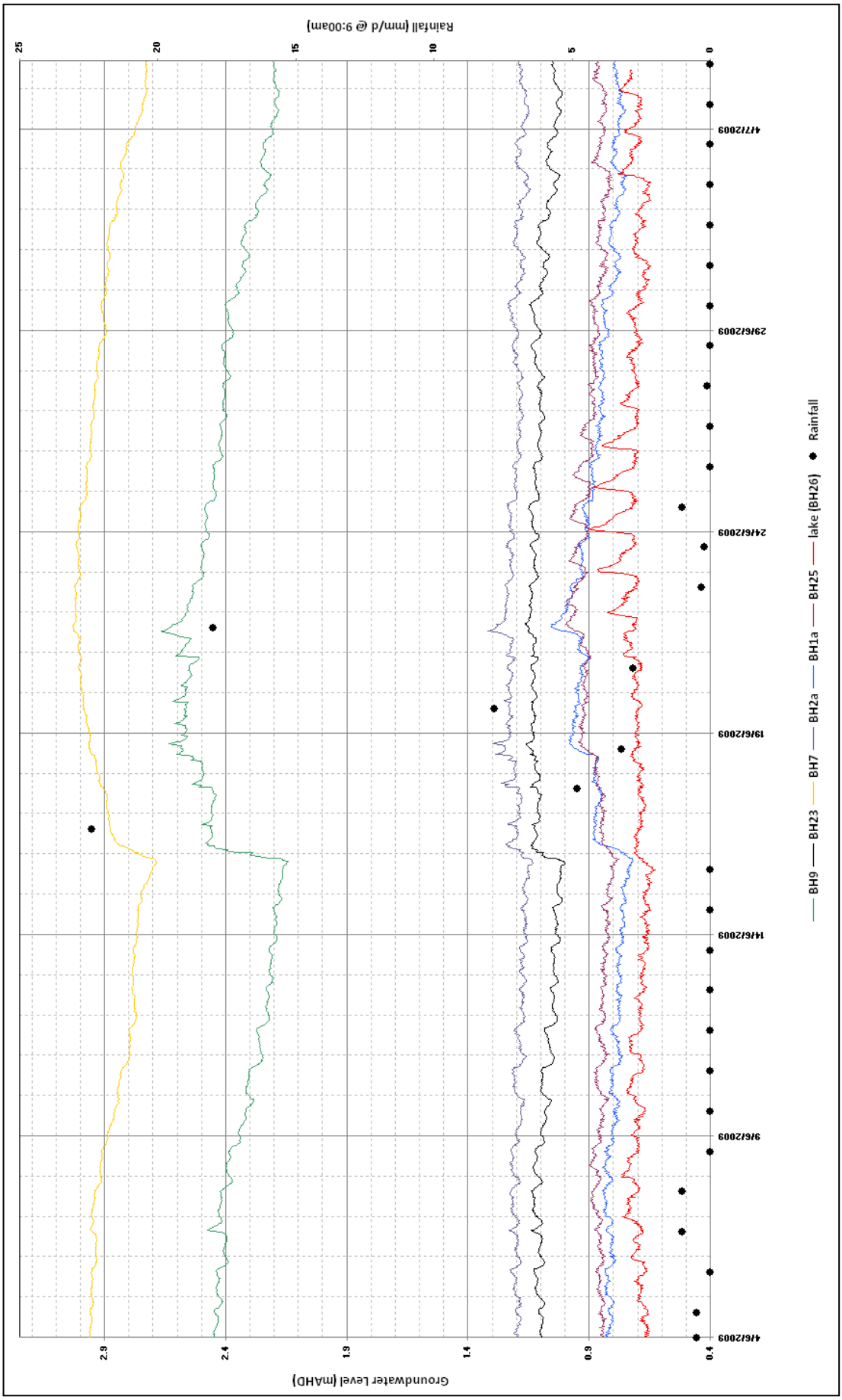
Engineering Log - Borehole

18 Attachment 4A – Groundwater Assessment Figures

Note:
Image shows location of all installed GMBs to date (with a postfix of R). GMBs 1, 2, 2A and 26ILAKE are no longer available. GMB 201, 202 & 203 installed September 2012. GMB 110 forms part of groundwater model but not included in reporting.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GMH	**SITE GROUNDWATER MONITORING BORES (GMBS) AND EXISTING SITE CONTOURS**	**Figure 3**
Approved:	DMM		
Date:	26.11.2012		
Scale:	NA		Job No: P0902346



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**RIVERSIDE GROUNDWATER LEVEL OBSERVATIONS: BORES 1A, 2A, 7, 9, 23, 25 AND 26 (Lake) PERIOD: 04/06/09 – 06/07/09**	**Figure 4**
Approved:	DMM		
Date:	22.11.2012		
Scale:	NA		Job No: P0902346

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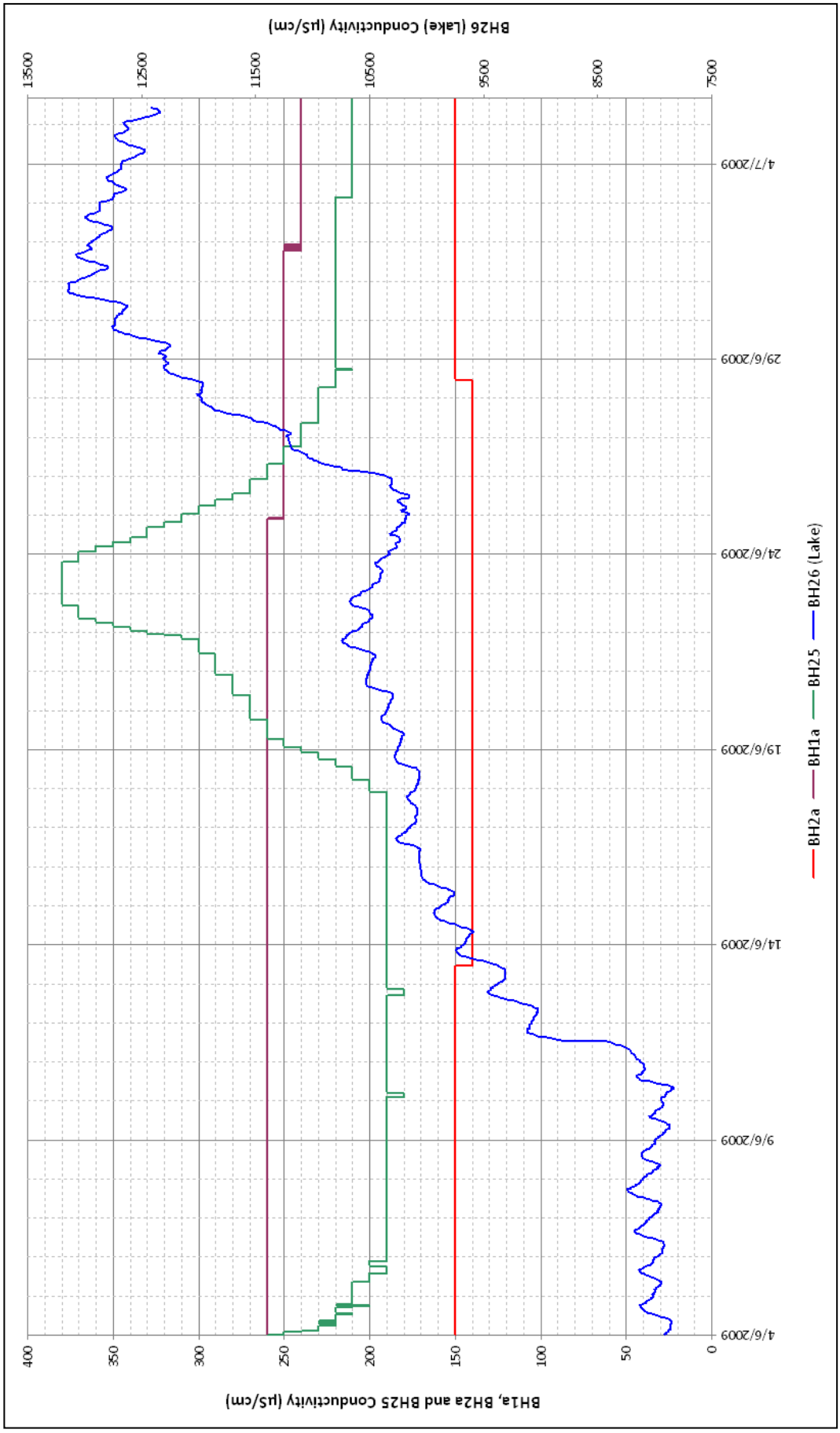
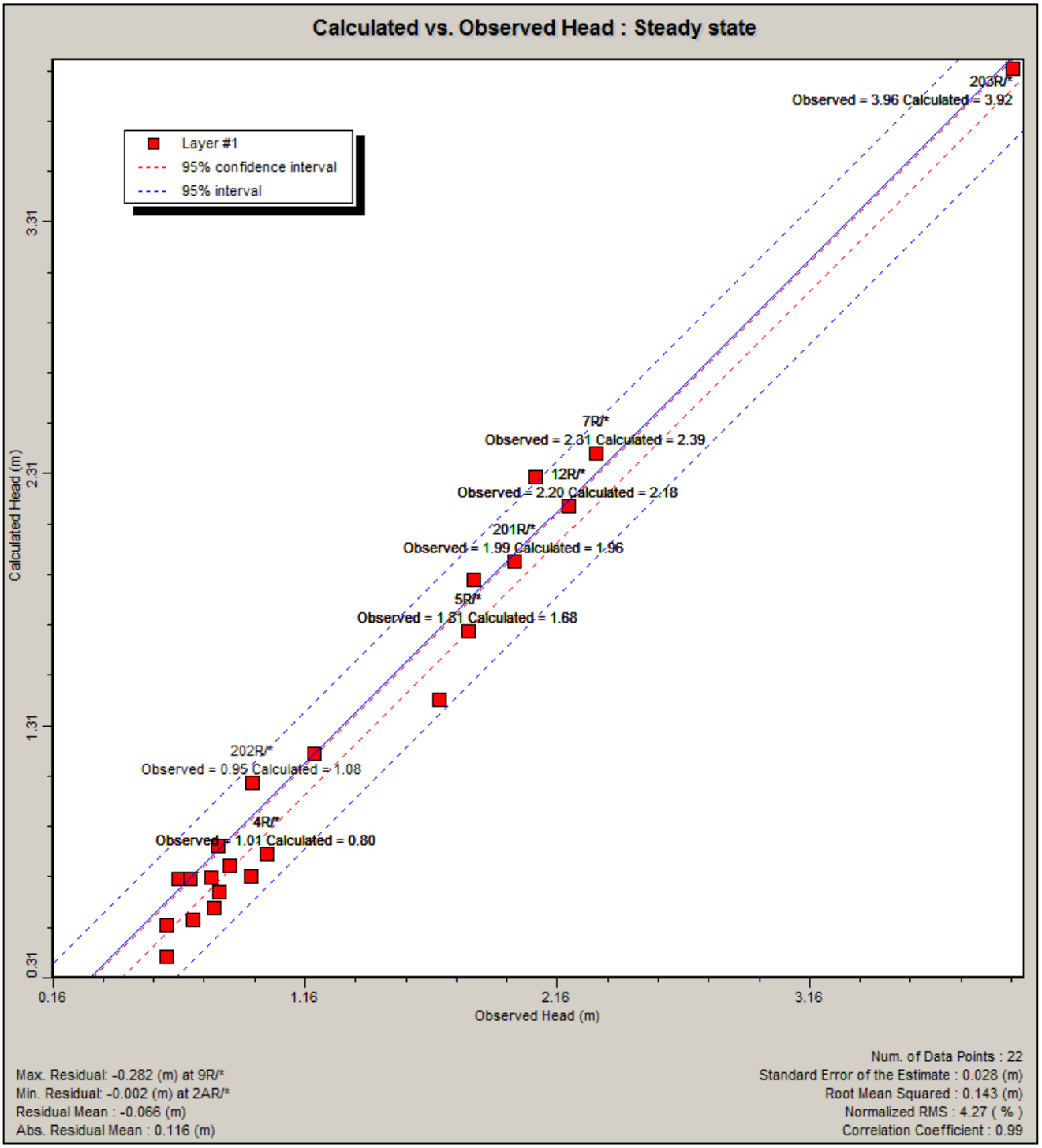


martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**RIVERSIDE GROUNDWATER EC (µS/CM) OBSERVATIONS: BORES 1A, 2A, 25 AND 26 (Lake) PERIOD: 04/06/09 – 06/07/09**	**Figure 5**
Approved:	DMM		
Date:	22.11.2012		
Scale:	NA		Job No: P0902346



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GMH	**M0 CALIBRATION**	**Figure 6**
Approved:	DMM		
Date:	26.11.2012		
Scale:	NA		Job No: P0902346