Bevian Road Concept Application

Water Management Report

Final: November 2007

Patterson Britton
& Partners Pty Ltd
consulting engineers

Marsim (trading as Nature Coast Developments P/L)

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1 EXECUTIVE SUMMARY

Marsim (trading as Nature Coast Developments P/L) propose the 807 lot residential and 20 lot community Bevian Road Residential Development at Rosedale.

The Rosedale site consists of approximately 188 ha of cleared rural land at the southern end of the Batemans Bay urban area. It was delineated as an urban expansion zone in the Eurobodalla Rural Local Environmental Plan (1987).

This report addresses the water management issues relating to the Concept Plan Application to the Minister for Planning. The application seeks approval of two specific plans, being the Concept Approval Plans. These plans are:

- A plan of the Net Developable Area – known as The Constraints Map (refer **Figure 1**); and
- A 807 lot residential and 20 lot community subdivision generally in accordance with the layout proposal in the Concept Plan (refer **Figure 2**).

The Director General of NSW Planning has provided the issues to be addressed in the application in the Director General's requirements (refer **Appendix A**). These issues are listed in Table 1 along with a summary of the compliance measures and the location of further detailed discussion in this report.

Table 1-1 – Director General's Requirements

Issue	Location in This Report
5. Riparian Management	
***5.2** Outline management measures to maintain/improve the stability, water quality, habitat and natural function of the wetland.* *A core riparian zone extending at least 40 m from the high water mark plus a further 10 metre buffer is required.*	The stability of the Bevian Wetland and Salt Water Creek is mainly influenced by the flow rate of frequent storms as well as the highly destructive flow rates of severe storms (up to 100yr ARI storm). These flow rates would be controlled to existing rates and are described in **Section 8**. Similarly, the proposed runoff water quality controls reduce runoff pollutant loads significantly below existing levels as described in **Section 10**. The natural function of the wetland and creek would be preserved by mimicking as close as possible the existing runoff hydrology. This is discussed in **Section 10.**
6. Water Cycle Management	
***6.1** Address NSW Coastal Policy, Wetlands Management Policy, Estuary Management*	Water management aspects of these policies are addressed in **Section 5**. The policies are

Issue	**Location in This Report**
Policy, State Rivers Policy and Estuary Policy.	discussed in more detail in **Section 5.2.**
***6.2** Address potential impacts on the water quality of surface and groundwater, on all water courses, and on groundwater dependent ecosystems. Consideration must also be given to the protection of the Bateman's Marine Park.*	The best practice water sensitive urban design approach would maintain the existing runoff volumes and the balance between surface and subsurface flows (groundwater). The runoff water quality would be significantly better than existing and any infiltration would not adversely impact on groundwater quality. The improvement in runoff water quality would contribute to a long positive impact on the Bateman's Marine Park. This is discussed in detail in **Section 10**.
***6.3** Address and outline measures for an Integrated Water Cycle Management Plan (including stormwater concept) based upon Water Sensitive Urban Design principles. This should include measures to ensure no net increase in nutrient/pollutant loads entering the watercourses including both construction and post construction operational management measures.*	A Water Sensitive Urban Design Strategy is presented in **Section 7**. Rainwater harvesting is considered as part of an Integrated Water Cycle Management Plan to reduce potable water use and is discussed in **Section 7.** Control of runoff water quantity to match existing flow rates and volumes is discussed in **Section 8**. The runoff control measures would ensure no net increase in nutrient/pollutant loads for the development (**Section 10**). Implementation of soil and water management plans in accordance with best practice state government guidelines, Managing Urban Stormwater, would ensure no net increase in runoff nutrient/pollutant loads during construction (refer **Section 11**). Other construction measures would be incorporated into an Environmental Management Plan for construction activities (refer **Section 11**).
***8.** Hazard Management and Mitigation*	
***8.4** Demonstrate the use of best management sediment and erosion techniques particularly to the area immediately surrounding the SEPP 14 Bevian Wetland*	The water quality controls proposed during construction would be designed in accordance with the best practice management guidelines as detailed in **Section 11**. Other measures to be instigated would include an Environmental Management Plan and a Site Emergency Plan to ensure best management practices during the construction phase (refer **Section 11**).
***8.5** Undertake a Flood Study having regard to the requirements of the NSW Floodplain Management Manual. Address potential impacts of flooding on the development, the impact of development on flood behaviour*	The flood study is reported in Flood Impact Assessment Report Issue 1, *PBP July 2007* and it addresses all these issues.

Issue	Location in This Report
(including cumulative impacts), and the impact of flooding on the safety of people over a full range of possible floods up to the probable maximum flood (PMF) and mitigation measures.	
8.6 *Address sea level rise and coastal inundation restricting where necessary development in low lying areas.*	Sea level rise and coastal inundation are addressed in the above Flood Impact Assessment Report *(PBP, July 2007)*.

A best practice water sensitive urban design strategy has been formulated in concert with the ecological and landscape design experts to provide an integrated water management strategy which significantly improves the runoff management and adds value in terms of ecological outcome and visual amenity of the area. The integrated water management strategy proposed for the development which is based on a water sensitive urban design approach would include:

- rainwater tanks to reuse runoff which reduces the runoff volume and pollutant loads and slows down the flow;
- bio-retention raingardens on selected lots to infiltrate, treat and slowdown runoff from paved areas on the lots;
- bio-retention swales along the roads to treat and slow down runoff from lots and roads, and to promote subsurface flows;
- gross pollutant traps to remove sediment, debris, organic matter and litter;
- rehabilitate wide riparian corridors and wetland buffers with native vegetation to stabilise banks and provide significantly improved habitat value;
- upgrade farm dams to improve runoff quality and provide more diverse aquatic habitat; and
- provide storage and promote infiltration in bioretention systems of runoff to balance the surface/subsurface flows and slow down flows to mimic closely existing conditions.

The strategy would significantly improve the stability, natural function and water quality of Salt Water Creek and Bevian Wetland. This would contribute to the long term improvement in these receiving waters as well as the Bateman Marine Park. This meets the Director General's (DG) requirements in Issues 5.2 and 6.1.

The water sensitive urban design strategy would ensure an integrated water cycle approach with rainwater harvesting and water saving devices leading to greater than a 40% reduction in potable water use compared to a traditional household. This meets the DG and BASIX requirements in Issue 6.3.

The proposed development would maintain the existing balance of surface and subsurface groundwater) flows to protect groundwater quality and the function of Bevian Wetland. This approach along with rehabilitation of riparian and endangered flora would enhance receiving waters including Bateman Marine Park. This meets the requirements on BASIX and the DG requirements in Issues 6.1 and 6.2.

The development proposed in the Concept Approval Plans would significantly reduce runoff pollutant loads below existing levels thereby ensuring no net increase in nutrient/pollutant loads entering watercourses. Best management practice soil and water management practices in accord with the Managing Urban Stormwater guidelines would ensure no net increase in runoff pollutant loads during construction. The proposed treatment measures comprise approximately 6.4% of the total area to be developed, with rainwater tanks offering significant further benefits. These meet the DG requirements in Issues 6.1, 6.3, and 6.4.

The proposed water management strategy conforms to government policy including the NSW Coastal Policy, Wetland Management Policy, Estuary Management Policy and State Rivers and Estuary Policy. This meets the DG requirements in Issue 6.1.

The proposed development has been designed to have habitable flood levels a minimum of 0.5m above the 100 year ARI flood level with safe access during extreme floods. This incorporates allowances for possible future sea level rise. This management of the flood hazard is discussed in detail in the report entitled *Flood Impact Assessment*, Patterson Britton and Partners. July 2007. This meets the DG requirements in Issues 8.5 and 8.6.

The Concept Approval Plans (The Constraints Map and The Concept Plan; **Figures 1 and 2**) incorporate the above water management features and controls such that they adequately address the water related Director General Requirements. As such, it is concluded that the Concept Approval Plans are satisfactory.

2 INTRODUCTION

Patterson Britton & Partners (*PBP*) have been engaged by Marsim (trading as Nature Coast Developments Pty. Ltd.) to address the water management issues for a concept plan application to the Minister for Planning, for the Bevian Road Residential Development at Rosedale, Batemans Bay. The application seeks approval of two specific plans, being the Concept Approval Plans. These plans are:

- a plan of the Net Developable Area known as The Constraints Map (refer **Figure 1**); and
- a 807 lot residential and 20 lot community subdivision generally in accordance with the layout proposed in the Concept Plan (refer **Figure 2**).

The Eurobodalla Rural Local Environmental Plan (*1987*) delineated Rosedale as an urban expansion zone. Development Control Plan (*DCP*) No. 160 titled "Rosedale Urban Expansion Area" was adopted by Eurobodalla Council in 1989.

The Director General of NSW Planning has provided the issues to be addressed in the application in the Director General's Requirements (refer to **Appendix A**).

This report addresses the proposed water management strategies and demonstrates how the development and water management strategies would conform to the Director General's requirements for the project.

3 EXISTING SITE CONDITIONS

3.1 TOPOGRAPHY

The Rosedale site consists of approximately 188 ha of cleared land located at the southern end of the Batemans Bay urban area.

The northern half of the site drains to the east into Salt Water Creek which discharges to the ocean across a sandy beach. This portion of the site consists of a number of valleys with relatively steep slopes. The creeklines have only isolated riparian vegetation and have numerous online farm dams. The headwaters of the catchment are only just outside the boundary of the site.

The southern half of the site drains to Bevian Swamp, which is a SEPP 14 Wetland. This portion of the site is undulating without any creeklines. The valleys consist of broad grass swales with the runoff travelling generally as sheetflow across the ground surface.

An aerial photograph of the site and the site boundary is presented in **Figure 3**.

3.2 LANDUSE & SITE HISTORY

The site is adjacent to State Forest on its western and northern boundaries with the villages of Rosedale and Guerilla Bay to the east of the site. The site is generally cleared of trees and currently used for rural activities, such as the grazing of cattle, and contains a number of farm dams mainly in the northern area.

3.3 GEOTECHNICAL CONDITIONS

A geotechnical investigation carried out by Douglas Partners found the site to be predominantly silty and sandy clays with low susceptibility to shrink swell movements and low dispersion potential. The potential for Acid Sulfate Soil presence is also considered low, but warranting further site specific investigation. The key geotechnical risk for the development is slope instability, which presents generally a very low to moderate risk.

3.4 RIPARIAN CORRIDORS

The NSW Rivers and Foreshores Improvement Act (RFI), 1948 is administered by Department of Environment and Climate Change (DECC), formerly DNR, DIPNR and DLWC. This Act requires an approval of works within 40m of the top of bank either side of a “river” including a wetland.

The watercourses on the northern half of the site have been classified as category 3 rivers by DECC and the wetland on the southern boundary of the site is also considered a river under the RFI Act. Over three site inspections with DECC personnel (Bob Britten), appropriate corridor and buffer widths and locations were agreed.

Development proposed in these corridors would consist of drainage outlets, limited road crossings, dam conversions to wetlands and creekline rehabilitation including low key pedestrian paths. These works would be designed and constructed according to DECC guideline documents.

4 PROPOSED DEVELOPMENT

The proposed development consists of largely residential areas supported by small scale commercial development.

The proposed development layout is presented in **Figure 4**.

The residential lot yield would be 807 with larger lots over the steeper northern half of the site and smaller lots over the more undulating southern half of the site.

The layout was influenced significantly by the need to achieve a water sensitive urban design. This design works to manage water at its source while improving the visual and passive recreational amenity of the development with emphasis on vegetative and landscape features to control water.

The roads have been located to minimise the impact on the riparian zones and important terrestrial vegetation. The layout was considered after all the constraints were identified on The Constraints Map. Topography especially in the sleeper sections was an important design consideration along with runoff water management in terms of road alignments, locations and widths. Where possible, each road would have a vegetated swale to treat road runoff at the source prior to further treatment in more areal measures.

The proposed development has responded positively to the challenge of the site constraints providing a development which is sustainable in terms of water management.

5 WATER MANAGEMENT REQUIREMENTS

5.1 DIRECTOR-GENERAL'S REQUIREMENTS

Key issues noted in the Director-General's Environmental Assessment Requirements that are relevant to water management are listed in **Table 5-1**. A summary of the manner in which the issue is addressed in the Concept Plans is provided in **Table 5-1** along with the section of this report in which there is a detailed assessment of the issue.

Table 5-1 – Director-General's Requirements

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***8.6** Address sea level rise and coastal inundation restricting where necessary development in low lying areas.*	Sea level rise and coastal inundation are addressed in the above Flood Impact Assessment Report *(PBP, July 2007).*

5.2 GOVERNMENT POLICY DOCUMENTS

Flood control and impacts are detailed in a separate *Flood Impact Assessment* report. The other impacts on government policy are discussed in the following sections.

5.2.1 NSW Coastal Policy (1997)

The overriding vision of the 1997 Coastal Policy is the ecological sustainability of the NSW Coast. In order to give expression to this vision, nine goals have been adopted in the policy which represent a commitment to:

- Protecting, rehabilitating and improving the natural environment of the coastal zone;
- Recognising and accommodating the natural processes of the coastal zone;
- Protecting and enhancing the aesthetic qualities of the coastal zone;
- Protecting and conserving the cultural heritage of the coastal zone;
- Providing for ecologically sustainable development and use of resources;
- Providing for ecologically sustainable human settlement in the coastal zone;
- Providing for appropriate public access and use;
- Providing information to enable effective management of the coastal zone;
- Providing for integrated planning and management of the coastal zone.

The water management elements of the proposed development conforms to the NSW Coastal Policy by:-

- Protecting the Bevian Wetland and riparian corridors on the site;
- Rehabilitating and enhancing the endangered flora areas and riparian corridors;
- Improving the runoff water quality from the site to Bevian Wetland and Salt Water Creek;
- Maintaining peak flow rates from the site at existing rates and mimicking existing hydrology to maintain the stability of these receiving waters;
- Controlling public access to sensitive areas.

This is all occurring within an integrated planning and management approach of the coastal zone by the local and state governments with respect to this development.

5.2.2 Wetlands Management Policy

The Wetlands Management Policy has the following goals to:-

1. Encourage the management of the wetlands of the State so as to halt and where possible, reverse:
    - Loss of wetland vegetation;
    - Declining water quality;
    - Declining natural productivity;
    - Loss of biological diversity; and
    - Declining natural flood mitigation.

2. Encourage projects and activities which will restore the quality of the State's wetlands, such as:
    - Rehabilitating wetlands;
    - Re-establishing areas of buffer vegetation around wetlands; and
    - Ensuring adequate water to restore wetland habitats.

Adoption of the NSW Wetlands Management Policy means that the Government, in its decision-making, will give explicit consideration to the biophysical requirements of wetlands with the goal of ensuring their sustainable management.

The Government has adopted a common goal to guide decision-making for wetlands:

"The ecologically sustainable use, management, and conservation of wetlands in NSW for the benefit of present and future generations."

The Government has adopted the following principles in order to achieve this goal:

- Water regimes needed to maintain or restore the physical, chemical and biological processes of wetlands will have formal recognition in water allocation and management plans;
- Land use and management practices that maintain or rehabilitate wetland habitats and processes will be encouraged;
- New developments will require allowance for suitable water distribution to and from wetlands;
- Water entering natural wetlands will be of sufficient quality so as not to degrade the wetlands;
- The construction of purpose-built wetlands on the site of viable natural ones will be discouraged;
- Natural wetlands should not be destroyed, but when social or economic imperatives require it, the rehabilitation or construction of a wetland should be required;
- Degraded wetlands and their habitats and processes will be actively rehabilitated as far as is practical;
- Wetlands of regional or national significance will be conserved; and
- The adoption of a stewardship ethos and co-operative action between land and water owners and managers, government authorities, non-government agencies and the general community is necessary for effective wetland management.

The water related elements of the proposed development on the southern portion of the site draining to the Bevian Wetland conform to the Wetlands Management Policy by:-

- Improving runoff water quality discharged to the wetland;
- Mimic the existing runoff hydrology and volume to the wetland, i.e. maintain the existing water regime;

- Providing a buffer to the wetland;
- Allows water distribution similar to existing conditions;
- No purpose built wetlands in the Bevian Wetland catchment; and
- Stewardship ethos and co-operative action is ensured with use of community title with residents who will have funds and responsibility for effective wetland and riparian zone management.

5.2.3 Estuary Management Policy

The general goal of the Government's Estuary Management Policy is to achieve an integrated, balanced, responsible and ecologically sustainable use of the State's estuaries, which form a key component of coastal catchments. Specific objectives of the policy for the government are:

- Protection of estuarine habitats and ecosystems in the long-term, including maintenance in each estuary of the necessary hydraulic regime;
- Preparation and implementation of a balanced long-term management plan for the sustainable use of each estuary and its catchment, in which all values and uses are considered.

The water related elements of the proposed development conform to the Estuary Management Plan by:-

- Rehabilitating and enhancing riparian corridors;
- Stabilising creeklines and maintaining existing flow characteristics to ensure long term stability;
- Improving water quality of runoff from the site discharging to the estuary and thereby contributing to the long term improvement in estuary water quality; and
- Maintaining the existing hydraulic regime.

5.2.4 State Rivers and Estuary Policy

It is the policy of the NSW Government to encourage the sustainable management of the natural resources of the State's rivers, estuaries and wetlands and on the adjacent riverine plains, so as to reduce, and where possible halt:

- Declining water quality;
- Loss of riparian vegetation;
- Damage to river banks and channels;
- Declining natural productivity;
- Loss of biological diversity;
- Declining natural flood mitigation; and
- To encourage projects and activities which will restore the quality of the river and estuarine systems.

The objectives of the State Rivers and Estuaries Policy are to manage the rivers and estuaries of NSW in ways which:

- Slow, halt or reverse the overall rate of degradation in their systems;
- Ensure the long-term sustainability of their essential biophysical functions; and
- Maintain the beneficial use of these resources.

The policy notes that these objectives would be achieved through application of the following management principles:

- Those uses of rivers and estuaries which are non-degrading should be encouraged;
- Non-sustainable resource uses which are not essential should be progressively phased out;
- Environmentally degrading processes and practices should be replaced with more efficient and less degrading alternatives;
- Environmentally degraded areas should be rehabilitated and their biophysical functions restored;
- Remnant areas of significant environmental values should be accorded special protection;
- An ethos for the sustainable management of river and estuarine resources should be encouraged in all agencies and individuals who own, manage or use these resources, and its practical application enabled.

The water related elements of the proposed development would conform to the State Rivers and Estuaries Policy by:-

- Rehabilitating, stabilising and enhancing the riparian corridors on the site;
- Protecting areas of significant environmental values;
- Improving runoff water quality into the rivers and estuaries;
- Mimicking existing hydraulic regime to enhance stability and sustainability; and
- Providing a buffer to Bevian Wetland.

6 WATER SENSITIVE URBAN DESIGN STRATEGY

The water sensitive urban design strategy for Rosedale has been formulated in recognition of the sensitive nature of Salt Water Creek and Bevian Wetland. A water sensitive urban design (WSUD) approach has been adopted to closely mimic the existing hydrology of the receiving waters.

The proposed development includes a range of best practice measures to meet the following Water Sensitive Urban Design (WSUD) objectives:

- Reduction in potable water consumption;
- Utilisation of available rainwater;
- Minimisation of impacts on downstream receiving waters;
- Safe conveyance of stormwater; and
- Integration of water management measures with landscape design into the proposed development.

The elements of the WSUD approach focus on a treatment train, which starts at each lot and extends to the receiving water. These elements include (refer **Figure 5**):

- rainwater tanks to reuse runoff which reduces the runoff volume and pollutant loads and slows down the flow;
- bio-retention rain gardens on selected lots to infiltrate, treat and slowdown runoff from paved areas on the lots;
- bio-retention swales along the roads to treat and slow down runoff from lots and roads, and to promote subsurface flows;
- gross pollutant traps to remove sediment, debris, organic matter and litter;
- rehabilitate wide riparian corridors and wetland buffers with native vegetation to stabilise banks and provide significantly improved habitat value;
- upgrade farm dams to improve runoff quality and provide more diverse aquatic habitat; and
- provide storage and promote infiltration of runoff in bioretention systems to balance the surface/subsurface flows and slow down flows to mimic closely existing conditions.

Hydrological and water quality simulations over a number of years have verified that the balance between surface and subsurface flows would closely mimic existing conditions for flows into the Bevian Wetland and Salt Water Creek. The runoff water quality to Salt Water Creek and Bevian Wetland could have pollutant loads up to 25% lower than for existing conditions thereby contributing significantly to the long term improvement in receiving water quality. This conforms with the Director General’s requirements for Issues 5.2, 6.2 and 6.3.

7 POTABLE WATER DEMAND MANAGEMENT

One component of the water sensitive urban design approach is the reduction in potable water usage. The State Government BASIX requirement is for a 40% reduction in potable water use compared with traditional households. This can be achieved through the provision of water efficient fixtures, the employment of rainwater capture and re-use devices and general conservation practises. Examples of these measures include:

- Landscaping with plant species that require minimal water and irrigating with appropriate systems to minimise water loss and evaporation;
- Using water-efficient taps, shower roses or flow restricting devices (*3-A rated minimum*);
- Providing water efficient dishwashers and toilets *(3-A rated minimum and dual flush toilet)*; and
- Water harvesting using rainwater tanks and re-use of stormwater for toilet flushing, washing machine use and irrigation.

According to the BASIX requirements, residential developments must be designed and built to use less drinking-quality water and produce less greenhouse gas emissions than average NSW homes of the same type. The target reductions are 40% for both water and greenhouse gas emissions. These targets represent significant yet readily achievable savings in water use and greenhouse gas emissions by proposed developments.

It is proposed to use up to 8kL of rainwater storage in two 4kL slimline tanks on each residential lot in subcatchments C,D & E and 4kL tanks in subcatchments A and B (refer **Figure 6**) to provide a substitute water stream for non-potable uses and thus reduce the demand on potable water. A summary of the proposed rainwater tank design is as follows:

- A rainwater tank volume designed to collect roof runoff and store it for external uses (*e.g. irrigation and car washing*) and internal use (*e.g. toilet flushing and laundry use*) purposes will be installed on each dwelling;
- The tank is to incorporate a first flush device, inspection/cleanout hatch and cleanout valve;
- The tank is to incorporate an outlet tap for connection to an irrigation system driven by the tank head (*where applicable*);
- All tank overflow would be directed to the formal piped stormwater drainage systems (*i.e. overflow to the street or water quality treatment measure where applicable*) to prevent nuisance flooding;
- Half of the volume of the rainwater tank would be effective in the long term as on-site detention;
- All rainwater tanks would be installed and maintained so as to prevent cross connection with the potable water supply;

- A "*topping up"* device (*from the potable water supply*) would be provided to supplement roof runoff from the rainwater tanks;
- A *"backflow prevention device"* would be installed on the potable water supply;
- All rainwater services would be clearly labelled "*Non Potable Water*" with appropriate hazard identification; and
- Pipe work used for rainwater services would be coloured purple in accordance with AS1345. All valves and apertures would be clearly and permanently labelled with safety signs to comply with AS 1319.

Potable water use reduction in this development is quantified in **Section 8.3**. This strategy meets the Director General's requirements for Issue 6.3.

8 WATER QUANTITY MANAGEMENT

Water quantity management in a development relates to three main issues:

- Flooding – runoff in severe storms needs to be managed to minimise the risk of flood damages and to risk personal safety;
- Hydrology – runoff hydrology needs to maintain the existing balance of surface/shallow subsurface (groundwater) flows; and
- Potable water – reduce use of this scarce resource.

Each of these issues is discussed in the following sections.

8.1 FLOODING

The flood hazard in the creeklines and Bevian Wetland would be managed by having dwelling habitable floor levels a minimum of 0.5 m above the 100 year ARI flood level.

Full discussion of flooding can be found in the flood management report entitled *Flood Impact Assessment Report*, Issue 1, PBP, July 2007.

Pedestrian safety would be ensured by design of an adequate minor/major stormwater system where the overland flow component would be controlled to a product of flow velocity and depth in the streets of less than $0.6m^2/s$.

The development would provide safe access to higher ground in the event of an extreme flood (PMF) as required by the NSW government Floodplain Management Policy. This approach conforms to the Director General's requirements in Issues 8.5 and 8.6.

8.2 STORMWATER RUNOFF AND GROUNDWATER

The water sensitive urban design approach was adopted so as to mimic the existing hydrology. This is the balance between surface and subsurface infiltration (groundwater) such that both the surface runoff peak flow rates and volumes closely match the existing conditions. This also leads to no significant adverse impacts on shallow subsurface throughflows or groundwater. This is discussed in detail in **Sections 10.7** and **10.8**.

The matching of the existing hydrology would allow the Bevian Wetland to dry in extended periods of no rainfall and would ensure no change in the bank stability for the riparian corridors and Salt Water Creek. In fact, with the rehabilitation of the riparian corridors on the site, there would be improved conditions for Salt Water Creek. The past clearing of vegetation on the site creeks and destabilisation of the creek banks by grazing animals would have increased the sediment supply to Salt Water Creek thereby contributing to destabilising the creek. The proposed rehabilitation of the riparian corridors therefore would enhance the stability of Salt Water Creek.

The proposed works to control the hydrology of this site are:-

- 50m wide buffer around the edge of Bevian Wetland and a minimum 20m wide vegetative riparian setback on each side of the creek banks;
- rehabilitation of the EEC adjacent to the wetland and the riparian vegetation along the creeklines; and
- proposed water management measures in the development, including:-
    - rainwater tanks on all lots to remove part of the increased runoff;
    - bio-retention rain gardens on selected lots to promote infiltration into special drainage media and native soils;
    - bio-retention swales on roads to slow down flows and promote infiltration to special drainage media and native soil; and
    - ponds, swales and bio-retention basins to slow down flows and promote infiltration to special drainage media and native soil.

The above measures would control the 'flashy' hydrological behaviour of the urban development and produce outflow with a similar behaviour to the existing site catchment.

The water management measures proposed as part of the development have been formulated so as to restore the predevelopment balance of surface runoff and shallow subsurface throughflow (groundwater) resulting from infiltration of rainfall and runoff. The shallow throughflow provides valuable soil moisture as well as a slow flow path into the wetland and creeks.

For Bevian Wetland and the riparian corridors, the proposed water management measures importantly increase losses of water prior to reaching the wetland/creeks compared with direct runoff from the development to the wetland/creeks. Infiltration over the development is proposed initially in specialised media which will hold water longer providing more opportunity for infiltration into the native soils. Therefore, in the important low flow/rainfall events, the runoff reaching the wetland/creeks would be similar to existing conditions with the wetland/creeks able to dry during long periods of little or no rainfall. This would also ensure there were no significant changes to shallow throughflow or groundwater conditions.

The proposed measures were modelled using the MUSIC (*Model for Urban Stormwater Improvement Conceptualisation*) software. This allowed concurrent assessment of the hydrological impacts and water quality impacts. Full details of the runoff characteristics for the development are presented in **Section 10**.

The proposed water management strategy represents industry best practice and in terms of runoff quality and volume control, it exceeds current best practice. It exceeds the requirements of the Director General's Issue 6.3 and meets the requirements of Issues 5.2, 6.1, 6.2 and 8.4.

8.3 POTABLE WATER USE

Stormwater runoff collected from residential roofs would be reused for internal (*toilet flushing and washing machine use*) and external (*irrigation and car washing*) domestic use. In addition, the water conservation measures such as water efficient taps and flow regulators in the kitchen, bathroom and shower and dual flush toilets would be incorporated into the dwellings. No account has been made for water efficient dishwashers or washing machines as these items could be readily changed by residents.

The reduction in potable water use for the proposed development compared to a traditional house has been assessed using the daily water balance component model. This model and the quantification of the potable water use reductions is discussed in detail in **Section 10**.

The values adopted for water reuse demand were compiled from a water use study from NSW Planning guidelines. The study also took into consideration the use of water saving devices required to adhere to BASIX requirements. The water use and adopted values used in the model are listed in **Table 8-1**.

If rainwater harvesting could satisfy all the demand for toilet flushing, washing machines, irrigation and car washing, the reduction in potable water use would be approximately 80%. However, rainfall is variable in time and quantity and as such it can only provide for part of the demand. The water balance model simulations estimated an effective reduction in potable water use of 45% compared to a traditional dwelling.

This provides an integrated water cycle management plan which uses rainwater harvesting to reduce potable water consumption. This is in accord with the Director General's requirement Issue 6.3.

Table 8-1 – NSW Planning Average Water Use Rates (Single Dwelling)

Internal	End Use	Traditional House Usage (L/person/day)	Proportion of total water use	Best Practise Feature	Reduction - where possible	Reduction (L/person/day)	Reduction as a percentage of total Traditional House use	Score	Adopted Reduction for Water Balance Modelling	BASIX Potable Water Usage (L/person/day)	Adopted Rainwater Demand for Water Balance Modelling (L/person/day)
a	Kitchen Sink	11.8	4.6%	Flow Regulator	50%	5.9	2%	**2**	**0%**	5.9	-
b	Bathroom Basin	6.9	2.7%	Flow Regulator	50%	3.4	1%	**1**	**0%**	3.5	-
c	Laundry Trough	7.9	3.1%	N/A	0%	0.0	0%	**0**	**0%**	7.9	-
d	Bath	8.8	3.4%	N/A	0%	0.0	0%	**0**	**0%**	8.8	-
e	Shower	55.9	21.8%	AAA-rated Showerhead	55%	30.7	12%	**12**	**55%**	25.2	-
f	Toilet	44.2	17.2%	6/3 L Dual Flush	67%	29.6	12%	**12**	**67%**	-	14.6
g	Washing Clothes	40.2	15.6%	AAA rating best practice front loading washing machine	63%	25.4	10%	**10**	**63%**	-	40.2
h	Washing Dishes	1.9	0.7%	Current AAA-rated dishwasher	64%	1.2	0%	**0**	**0%**	1.9	-
	TOTAL INDOOR	177.5	69.0%							53.2	54.8
External											
j	Garden Irrigation	72.5	28.2%	Controlled Irrigation System with Moisture Sensor	50%	36.2	14%	**14**	**50%**	-	72.5
k	Car Washing	2.3	0.9%	Bucket Washing	44%	1.0	0%	**0**	**0%**	-	2.3
l	Swimming Pool	4.8	1.9%	Pool Cover	50%	2.4	1%	**1**	**0%**	4.8	
	TOTAL OUTDOOR	79.6	31.0%							4.8	74.8
	GRAND TOTAL	257.1								58.0	129.6

9 WATER QUALITY MONITORING STRATEGY

Baseline water quality monitoring was carried out on the site in 2006 for the parameters in **Table 9-1**. The results were presented in the report titled *Rosedale, Batemans Bay, Baseline Water Quality Monitoring*, by Patterson Britton & Partners, 2006 (refer **Appendix B**).

Table 9-1 – Water Quality Monitoring Parameters

Variable	Units	Surface Water	Bed Sediment
Biological Oxygen Demand (*BOD*)	mg O^2/L	ü	
Moisture	%		ü
Suspended Solids	mg/L	ü	
Dissolved Metals*	mg/L	ü	
Heavy Metals*	mg/kg		ü
Hardness	mg/L	ü	
Salinity	%	ü	
Total Nitrogen	mg/L	ü	
Ammonia	mg/L	ü	
Total Kjeldahl Nitrogen	mg/L	ü	
Nitrates	mg/L	ü	
Nitrites	mg/L	ü	
Total Phosphorous	mg/L	ü	
Ortho Phosphorous	mg/L	ü	
Polycyclic Aromatic Hydrocarbons (PAH's)	m g/L or mg/kg	ü	ü
Phenolic Compounds	m g/L or mg/kg	ü	ü
OC/OP Pesticides	mg/L or mg/kg	ü	ü
Oil and grease	mg/L	ü	
Algal ID	cells/mL	ü	
Faecal Coliform Count	cfu/100ml	ü	
Chlorophyll-a	mg/m^3	ü	

The baseline monitoring analysis revealed that water bodies within and around the site contained elevated levels of ammonia and total nitrogen, well above ANZECC (*2000*) guidelines for a freshwater lowland river system in south-eastern New South Wales. Similarly there were elevated levels of chlorophyll-a in and around the site, highlighting the potential for algal blooms to occur.

Analysis of the bed sediment samples taken revealed that only one site recorded a marginally elevated level of copper.

Comparison of the collected TSS, TN and TP data with widely accepted published values applicable to a range of differing land use settings in Australia has indicated that the site runoff closely approximates runoff quality from an agricultural landscape. A comparison of typical runoff water quality for rural and agricultural landuses is presented in **Table 9-14**. Adoption, therefore, of a rural (*less intensive than agricultural*) land use category as a target for runoff water quality for the proposed development would result in a significant improvement in receiving water quality.

It is recommended that water quality monitoring is undertaken throughout all phases of the project (*i.e. pre-construction, during construction and post-construction*). Further monitoring would be undertaken at the same locations, along the major natural drainage paths and also at the primary discharge points for the same parameters as listed in **Table 9.1**.

During construction water quality monitoring would be undertaken to assess, and mitigate as required, the impacts of construction on the quality of water being discharged from the site controls proposed in the construction phase for soil and water management are discussed in **Section 10**.

Post-construction water quality monitoring would assess the improvements that the development has had on overall water quality when compared to results obtained during the pre-construction monitoring phase.

The measurement of the existing runoff water quality assists to formulate a strategy to meet the Director General's requirement (Issue 6.1, 6.3, 6.4) for no net increase in the nutrient/pollutant load in runoff. The proposed monitoring would test to ensure this objective was achieved.

10 WATER QUALITY MANAGEMENT

10.1 INTRODUCTION

A water sensitive urban design approach has been adopted for the development with incorporation of industry best practices to reduce runoff volume, flows and pollutant loads. The principles for application of these best management practices include:

- At-source runoff control, such as rainwater reuse and bio-retention systems; and
- Integration of water quality control measures with the urban design and ecological features.

This section primarily deals with the permanent water quality management. During the construction phase, sediment and erosion control facilities will be designed and installed in accordance with the Council's specifications and the requirements of the best management guideline publication "Managing Urban Stormwater – Soils and Construction" (Landcom, 2004). The proposed controls during the construction phase are discussed in **Section 11**.

10.2 WATER QUALITY TREATMENT TARGETS

The NSW Department of Environment and Climate Change (*DECC*) recommends reduction targets in annual runoff pollutant loads for developments of:

- 80% for total suspended solids (TSS);
- 45% for total phosphorous (TP); and
- 45% for total nitrogen (TN).

However, due to the sensitive nature of downstream ecosystems, stricter criteria have been adopted for the Rosedale development.

The guiding principle adopted for this development was to contribute to the long term improvement in receiving water quality.

The water quality monitoring carried out and summarised in **Section 9** indicates that the existing site has runoff quality approximating agricultural landuses. Therefore, by adopting the existing conditions as equivalent to a lower runoff pollutant landuse of "rural" will mean that achievement of these conditions in the post development phase would result in a significant improvement in water quality discharged to the receiving waters of Salt Water Creek and Bevian Wetland. Hence, the water quality target for the development was to achieve runoff pollutant loads less than those under rural conditions.

10.3 MUSIC MODEL SET-UP

A long-term model was established to assess the potential water quality impact of the proposed development. The model was used to estimate the annual pollutant load that would be generated under existing and developed conditions to assess the effectiveness of the proposed "*treatment train*" and therefore ensure compliance with the proposed objectives. The software package developed by the Cooperative Research Centres for Catchment Hydrology (*CRCCH*) termed "MUSIC" (*Model for Urban Stormwater Improvement Conceptualisation*) was selected.

MUSIC is a continual-run conceptual water quality assessment model developed by the Cooperative Research Centre for Catchment Hydrology. MUSIC can be used to estimate the long-term annual average stormwater volume generated by a catchment as well as the expected pollutant loads. MUSIC is able to conceptually simulate the performance of a group of stormwater treatment measures (*treatment train*) to assess whether a proposed water quality strategy is able to meet specified water quality objectives.

MUSIC was chosen for this investigation because it has the following attributes:

- it can account for the temporal variation in storm rainfall throughout the year;
- modelling steps can be as low as 6 minutes to allow accurate modelling of treatment devices;
- it can model a range of treatment devices;
- it can be used to estimate pollutant loads at any location within the catchment; and
- is based on logical and accepted algorithms.

The model's algorithms are based on the known performance characteristics of common stormwater quality improvement measures. These data, derived from research undertaken by CRCCH and other organisations, represent the most reliable information currently available in the water management industry.

10.3.1 Subcatchment Characteristics

The current development consists of approximately 188 ha of generally undulating cleared rural land. The northern catchment contains several farm dams and drains to Salt Water Creek, while the southern catchment lies adjacent to the Bevian Wetland, to the south. The soil of the proposed site is generally silty and sandy clay.

The proposed layout of the development comprises largely residential housing with access from main streets, public roads and laneways.

The southern catchment of the development would consist of residential lots with rainwater capture, excess lot runoff and road runoff would drain through bioretention swales along the roads towards two bio-retention basins, which would act both as a treatment system and an infiltration area, prior to discharging flows into the Bevian Wetland.

The northern catchment would also consist of residential housing, however, with a more rural characteristic and larger lots. As a result, the northern catchment would have a lower impervious percentage than the southern catchment. Bioretention rain gardens and rainwater capture would be incorporated on lots with bioretention swales along the roads and a number of existing farm dams would be rehabilitated as part of the riparian corridors.

The proposed layout of the water sensitive urban design features within the layout are presented schematically on **Figure 5**. The southern catchment consists of catchments A and B, while the northern catchment is defined by catchments C, D and E. A breakdown of the subcatchments characteristics can be found in **Table 10-1** and **Figure 6**.

Table 10-1 – Adopted Catchment Areas and Impervious Percentage

	Area (ha)	Impervious Percentage
Catchment A	28.9	65%
Catchment B	37.7	65%
Catchment C	18.0	65%
Catchment D	63.3	50%
Catchment E	32.7	50%

10.3.2 Rainfall

In order to develop a model that could comprehensively assess the performance of water quality treatment devices such as bioretention systems, the use of 6 minute interval pluviograph data was considered necessary.

The nearest pluviometer (*i.e. 6 minute interval data instrument*) station to the site is located at Moruya (*Moruya Airport – 69148*). Rain gauges, which capture only daily rainfall data are present at Moruya Heads Pilot Station (*069018*) and Batemans Bay (*Catalina Country Club – 069134*). The long term average annual rainfall for the Moruya Heads Pilot Station (*069018*) as provided by the Bureau of Meteorology is 957 mm based on over 132 years of data. However, the development is located closer to Batemans Bay, where long term average annual rainfall for the Batemans Bay (*Catalina Country Club – 069134*) rain station as provided by the Bureau of Meteorology is 884 mm based on over 22 years of data.

With the collected information and the location of the site situated between the two rain stations, it was concluded that Rosedale would have an annual average rainfall of approximately 900 mm. Hence, for this study, a one year rainfall period from Moruya Airport (*69148*) in 2001 was used. It was not possible to use more than one year of rainfall for this study due to insufficient rainfall (well below average), for all other years on record. The annual rainfall at Moruya Heads Pilot Station for 2001 was 901mm.

10.3.3 Evapotranspiration

Monthly areal potential evapotranspiration values were obtained for the site from 'Climate Atlas of Australia, Evapotranspiration' (*Bureau of Meteorology, 2001*) and are shown in **Table 10-2**.

Table 10-2 - Monthly Area Potential Evapotranspiration

Month	Areal Potential Evapotranspiration (mm)
January	165.8
February	122.1
March	110.1
April	75.9
May	48.1
June	38.1
July	40.0
August	53.9
September	77.1
October	119.0
November	140.1
December	146.0
Total	1,136.2

These values were adopted for the MUSIC modelling

10.3.4 Model Calibration and Soil Parameters

Calibration of the runoff-rainfall parameters within the MUSIC model was completed to achieve an appropriate runoff co-efficient for the site. The MUSIC default and adopted rainfall run-off parameters along with the resulting run-off co-efficient are presented in **Table 10-3**. The Soil Storage Capacity and Field Capacity were changed to achieve a suitable volumetric runoff co-efficient for the existing site of 0.31. This is in the range of expected values based on available data for gauged catchments.

Tests to determine infiltration rates of site soils were carried out by Douglas Partners (refer **Appendix C**). Double Ring Infiltrometer Tests and Falling Head Percolation Tests were used to determine the rates of surface and subsoil infiltration. The tests indicated low infiltration capacity for the alluvial deposits along the gullies (0.2 to 1.4 m/day) with higher rates on the slopes composed of residual soils (2.2 to 4.2 m/day). These rates were used to estimate the infiltration from water quality treatment measures.

Table 10-3 – Adopted rainfall run-off parameters

	Default Parameters	Adopted Parameters
Impervious Area Properties		
Rainfall Threshold (mm/day)	1	1
Pervious Area Properties		
Soil Storage Capacity (mm)	120	90
Initial Storage (% of capacity)	30	30
Field Capacity (mm)	80	50
Infiltration Capacity Coefficient (a)	200	200
Infiltration Capacity Exponent (b)	1	1
Groundwater Properties		
Initial Depth (mm)	10	10
Daily Recharge Rate (%)	25	25
Daily Baseflow Rate (%)	5	5
Daily Deep Seepage Rate (%)	0	0
Runoff Co-efficient		
100% Pervious	0.25	0.31
65% Impervious	0.67	0.69

These values were adopted for the MUSIC modelling.

10.3.5 Pollutant Concentrations

Each catchment was divided into roads, roofs and general urban areas to allow runoff from each area to be directed to specified treatment measures, for instance runoff from roads has been directed to bio-retention swales. Road reserves and roof areas were estimated or measured from the proposed layout and general urban areas were designated as the remaining area. The expected pollutant load from the catchment was determined by applying the pollutant concentrations or Event Mean Concentrations (EMCs).

The adopted EMCs for total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN) are given in **Table 10-4** and are sourced from the findings of a comprehensive review of stormwater quality in urban catchments undertaken by Duncan (1999) and adopted by the Department of Environment and Conservation (DEC) in March 2004. Analysis by Duncan (1999) found event mean concentrations of TSS, TP and TN to be approximately log-normally distributed for a range of different urban land-uses.

As discussed in **Section 9**, the existing runoff quality from the site equates to an agricultural landuse. The target water quality adopted for the development is a rural landuse. Based on the values in **Table 10.4**, achievement of this water quality target would improve the existing conditions substantially provided the runoff volume from the development was reduced.

Table 10-4 – Runoff Pollutant Event Mean Concentrations (EMC)

Land Use	TSS	TP	TN
	mg/L	*mg/L*	*mg/L*
Roads	270	0.5	2.2
Roofs	20	0.13	2.0
General Urban	140	0.25	2.0
Rural	90	0.22	2.0
Agricultural	140	0.6	3

These values were adopted for the MUSIC modelling.

10.4 TREATMENT TRAIN & PROPOSED MEASURES

In order to achieve the objectives stated earlier, controls such as rainwater tanks and bio-retention systems are to be coupled with more common end of line control measures such as gross pollutant traps and ponds. Bio-retention systems are to be incorporated at the source of the runoff within the development in such a manner as to enhance the aesthetics of the development and blend with the natural environs.

The elements of the proposed water quality management strategy include:

- implement rainwater re-use tanks to reduce runoff volume;
- incorporate bio-retention systems and or rain gardens on selected lots and in road reserves to remove fine sediment, nutrients, and oils and greases;
- upgrade farm dams to improve runoff quality and provide more diverse aquatic habitat (in northern catchment);
- provide storage and promote infiltration of runoff to balance the surface/subsurface flows and slow down flows to mimic closely existing conditions;
- rehabilitate wide riparian corridors and wetland buffers with native vegetation to stabilise banks and provide significantly improved habitat value; and
- install gross pollutant traps prior to discharge to bio-retention systems to capture litter, debris, coarse sediment, oils and greases.

Generally, the stormwater treatment flow path for runoff would consist of the following:

- runoff from roof areas would be collected and retained in rainwater re-use tanks with an overflow by-pass to on lot bioretention raingardens (if available) and then into the minor drainage system or formalised drainage channels (*as appropriate*);

- runoff from many roads and lots would be directed into bio-retention swales where it would be filtered and treated biologically;
- stormwater collected from impervious areas, such as roads, paths and driveways would be piped towards gross pollutant traps (*GPT's*) to remove coarse sediment, litter, debris, oils and greases; and
- stormwater discharging to open corridors would be treated in rehabitated ponds (farm dams - northern catchment) or bio-retention basins (Bevian Wetland catchment) before discharge to natural watercourses.

The proposed treatment measures comprise approximately 6.4% of the total area to be developed, with rainwater tanks offering significant further benefits.

The various components of this treatment train are described in more detail in the following sections.

10.4.1 Rainwater Tanks

In addition to the water re-use benefits evident with installation of a rainwater tank, there are also water quality benefits. Rainwater tanks contribute to the retention of rainwater thus resulting in a reduction of the quantity of runoff from the development which in turn reduces the annual pollutant loads.

Rainwater storage of 8 kL were modelled for each lot in the northern catchment (subcatchments C,D & E) and 4kL storage for each lot in the southern catchment (subcatchments A&B) with the proposed reuse of rainwater for internal and external uses, e.g. toilet flushing, laundry use, irrigation and car washing. For the small storms, the rainwater tanks have the potential to trap a significant portion of the runoff to either remove it or considerably slow down the runoff.

10.4.2 Bio-retention Systems

Bio-retention systems promote the filtration of stormwater through a prescribed filter medium. The type of filter medium determines the effectiveness of the pollutant removal, with material of lower hydraulic conductivity providing the most efficient pollutant removal.

Bio-retention systems can also be referred to as rain gardens, where they are created on lots, or in pockets of available parkland or road reserve. Alternatively, long linear bio-retention systems can be created in the form of swales, e.g. alongside roadways.

Bio-retention systems can be incorporated into road reserves where they can aesthetically enhance the visual impact of the development or easily be located adjacent to or within vegetated areas of development. The systems would be planted with native grasses and fringe vegetation on a layer of coarse sand and soil. A special drainage media is incorporated in a trench connected to the surface to firstly encourage infiltration into this trench, then secondly along this trench and then with extended detention in the trench and on the surface, into the native soil.

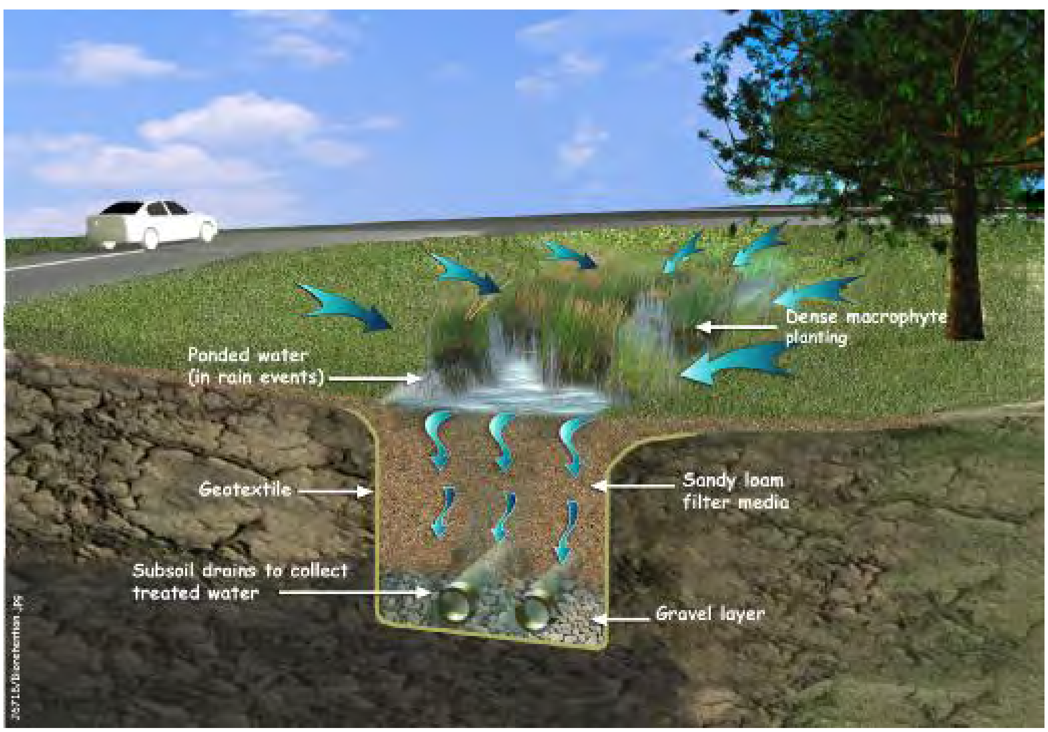
A typical section of a bio-retention system is shown in **Diagram 10-1** and a photo is shown in **Diagram 10-2**. The actual shape and physical characteristics of each system is required to be individually designed as part of the detailed design stage of the development.

The purpose of a bio-retention system is to provide a filtering effect to remove pollutants typically found in urban runoff (*i.e. TN, TP and TSS*). Further treatment would be achieved by biological action due to microbial growth on the filter medium. Flows would be exposed to sunlight and with turbulence introducing oxygen to the flows. These systems can be located in the streetscape and/or in open space areas.

The swales for the Rosedale development would typically be 4m wide with a base width and filter width of 1 m. An extended detention depth of up to 300 mm would be provided above the filter media. The filter media, consisting of sandy loam, would be a minimum of 600mm deep, followed by a coarse sand transition layer, and a subsoil drainage line in a fine gravel surround. The swales would be located along the roads and at the rear of properties adjacent to the Bevian Wetland. These would treat road runoff as well as excess runoff from lots not captured by rainwater tanks or the on lot raingardens. On steeper roads, the swales would have shorter lengths separated by rock drop structures to prevent scour. The retail area in the southern area of the development would incorporate gross pollutant traps in the drainage inlet pits as well as being ringed by bioretention swales to remove gross pollutants, oils and grease and nutrients from runoff. In addition, the retail area would have rainwater tanks as a further control of runoff.

The raingardens would be located on lots in subcatchments C3, D4, D12, E1, E2 and E5. Their plan area would vary but they would treat, slowdown and infiltrate runoff from paved areas on the lot as well as overflow from the rainwater tank.

Diagram 10-1 – Bio-retention Swale Schematic



Two large bioretention basins have been located upstream of Bevian Wetland to assist in the water quality treatment and promote infiltration into the subsoils. This will mimic the existing balance of surface and shallow subsoil flows into the Bevian Wetland from the development over the southern catchment. An infiltration value of 50mm/hr was adopted for the bio-retention systems, a value based on testing presented in **Appendix C**. The surface areas of the basins would be 2250m² and 6300m². These basins would temporarily pond water during rainfall up to a maximum depth of 0.3m for a duration up to approximately 16 to 24 hours. The basins would have a matrix of bioretention trenches across the base of the basins to aid the infiltration. The basins would be vegetated to form a natural landscape.

Diagram 10-2 – Example Bio-retention Swale, Warriewood, NSW

10.4.3 Gross Pollutant Traps

A Gross Pollutant Trap (*GPT*) captures litter, coarse sediment, some nutrients, oils and greases. While the pollutant capture efficiency of various traps may vary, the paper "Removal of Suspended Solids and Associated Pollutants by a Gross Pollutant Trap" (*Cooperative Research Centre for Catchment Hydrology, 1999*) suggests the following efficiencies:

- gross pollutants — majority (~*100%*)
- sediments — up to 70%
- total phosphorous — up to 30%
- total nitrogen — up to 13%

The GPTs would be placed at the end of main stormwater lines or other critical locations and sized accordingly.

Gross Pollutant Traps (GPTs) would be used primarily to reduce litter, debris, oil and grease, total suspended solids and phosphorus loads from the developed areas.

10.4.4 Ponds

The existing farm dams in the northern catchment only would be rehabilitated to function as water quality control ponds. The parameters used in modelling the farm dams can be seen in **Table 10-5**. The ponds were modelled with an extended detention depth of 0.5 metres and detention time of 72 hours.

Table 10-5 – Farm Dam Parameters

Parameters	Adopted Values
Low Flow By-Pass	0 m^3/s
High Flow By-Pass	100 m^3/s
Extended Detention Depth	0.5 m
Seepage Loss	2 mm/hr

A conservative infiltration rate of 0.04m/day (2mm/hr) was adopted, based on the testing in **Appendix C**.

10.4.5 Vegetated Swales

Vegetated swales would be provided as required in open space areas and corridors to enhance the level of runoff treatment. The vegetated swales for the Rosedale development would typically have a base width of 2 metres at a depth of 0.5 metres. The surface of the swale would have a width of 10 metres with 0.3 metres of vegetation height. The swales would have similar filtration characteristics of the ponds, thus the filtration value of 2mm/hr was adopted.

10.4.6 Summary of Treatment Measures

The proposed treatment measures incorporated into each sub catchment are presented in **Table 10-6.**

Table 10-6 – Runoff Water Quality Control Measures

Catchment	Rainwater Tanks (m^3)	Bioretention Swales (m length)	Bioretention Basin Raingarden (m^2 surface area)	GPT (no.)	Pond (m^2 surface area)
A	652	3,168	2,250	3	0
B	780	3,025	6,300	2	0
C	816	1,923	460	3	954
D	1,616	4,364	448	9	15,390

E	1,080	2,700	1,202	4	2,385

10.5 RUNOFF WATER QUALITY

The water sensitive urban design approach incorporated into the Concept Plans would significantly reduce pollutant loads in runoff compared to existing conditions.

The comparison of annual pollutant loads for ‘rural’ and ‘proposed development’ are presented in **Table 10.7**. The results illustrate that the proposed treatment measures are capable of reducing the levels of suspended solids, total phosphorus and total nitrogen to below those of rural conditions which would be significantly better than for existing conditions. Flows would be unaffected, with post developed treatment measures producing a similar runoff co-efficient (runoff volume) as for the existing site. Hence, the measures would ensure no net increase in nutrient/pollutant loads or surface runoff volume post construction, as specified in the Director-General’s requirements (Issue 6.3).

Table 10-7 – Results of MUSIC model

Bevian Wetland (subcatchments A & B)	**Rural**	**Proposed Development**
Flow (ML/yr)	247	206
Cv	0.31	0.26
Total Suspended Solids (kg/yr)	9670	4690
Total Phosphorus (kg/yr)	27.9	21.3
Total Nitrogen (kg/yr)	312	247

Salt Water Creek (subcatchment C)	**Rural**	**Proposed Development**
Flow (ML/yr)	51.7	48.5
Cv	0.27	0.25
Total Suspended Solids (kg/yr)	1980	1030
Total Phosphorus (kg/yr)	5.98	5.21
Total Nitrogen (kg/yr)	66.4	65.4

Tributary 1 (subcatchment E)	Rural	Proposed Treated
Flow (ML/yr)	211	202
Cv	0.37	0.35
Total Suspended Solids (kg/yr)	8130	7150
Total Phosphorus (kg/yr)	24.2	22.7
Total Nitrogen (kg/yr)	269	262

Tributary 2 (subcatchment D)	Rural	Proposed Treated
Flow	84.9	84.1
Cv	0.13	0.12
Suspended Solids	2510	1640
Total Phosphorus	10.1	8.73
Total Nitrogen	114	113

The results indicate that the proposed treatment of runoff would control runoff rates, volumes and pollutant loads such that there would be a significant contribution to the long term improvement in the receiving water quality of Salt Water Creek and Bevian Wetland.

The extent of the improvement can be determined by comparison to the agricultural landuse equivalent for the existing conditions. When the runoff pollutant loads are compared for the proposed development to these existing conditions, the extent of the improvement in the annual runoff pollutant load would be:

- Suspended solids 56% improvement
- Total phosphorus 60% improvement
- Total nitrogen 31% improvement

This demonstrates that the proposed water sensitive urban design measures readily achieve the Director General's requirements in Issues 5.2, 6.1, 6.2 and 6.3.

10.6 RUNOFF WATER QUALITY – SENSITIVITY ANALYSIS

A longer duration rainfall record (three years) was adopted to undertake a sensitivity analysis to verify the system would still provide runoff water quality improvements in more variable rainfall conditions.

Rainfall data from the North Araluen (*069102*) rainfall station between 1977 and 1979 was adopted for the sensitivity modelling. These years were selected because the average annual rainfall for the period approximated the annual average rainfall of 900 mm used in the water quality analysis but provide dry and wet years. The annual rainfall depths were 648 mm in 1977, 1686 mm in 1978 and 618 mm in 1979. The average annual rainfall across the 3 years was 993 mm.

The sensitivity analysis was undertaken for the southern subcatchments that flow into the Bevian Wetland. The same existing and proposed MUSIC models used in the water quality assessment were used for this analysis.

The results from the MUSIC model showed that with the increased and more variable rainfall data, the proposed treatment measures still met the water quality and quantity objectives. Results from the model are shown in **Table 10-8**.

Table 10-8 – Sensitivity Analysis MUSIC Results

Bevian Wetland	Rural	Proposed Treated
Flow (ML/yr)	396	344
Cv	0.45	0.39
Total Suspended Solids (kg/yr)	25000	11100
Total Phosphorus (kg/yr)	64.9	43.8
Total Nitrogen (kg/yr)	639	492

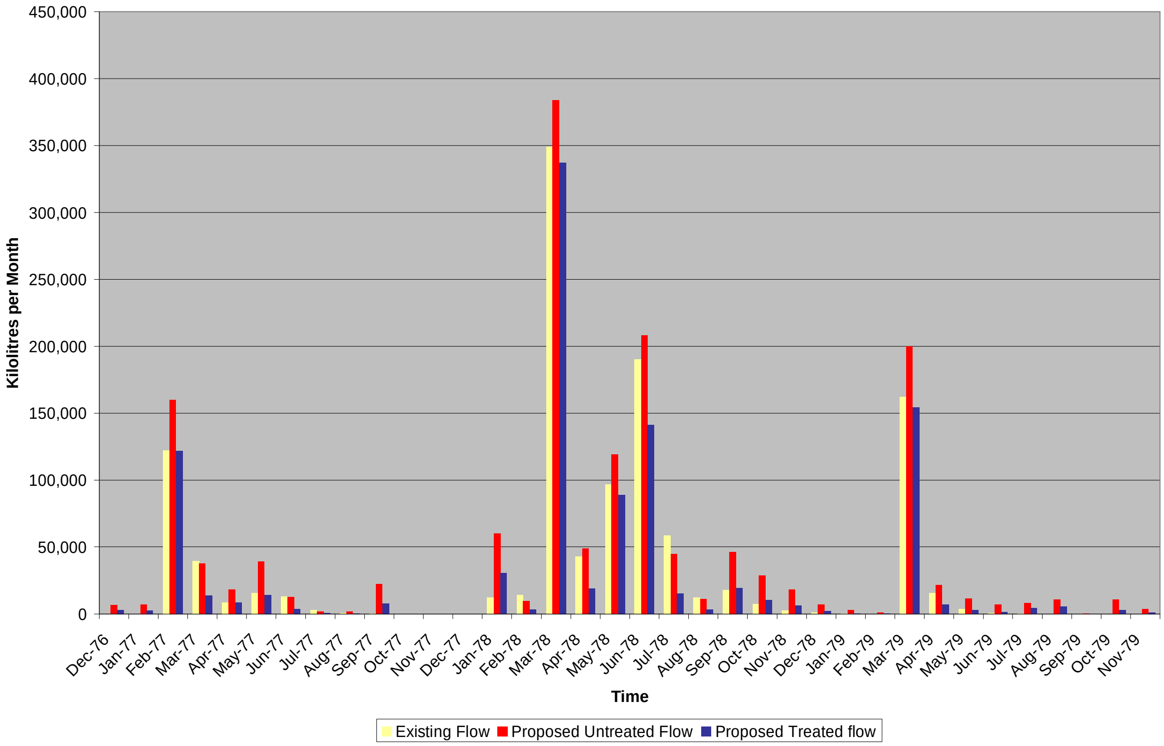
10.7 BEVIAN WETLAND HYDROLOGY

The Director General’s requirements in Issues 5.2 and 6.2 require maintenance of the natural function of the Bevian Wetland and groundwater dependent ecosystems. The water sensitive urban design features in the development have been designed to mimic the existing hydrology to maintain existing surface runoff volumes and the balance between surface and shallow throughflow (groundwater) flows.

This has been achieved by a combination of rainwater retention (rainwater reuse) and infiltration in bioretention systems. This balance can be demonstrated by comparison of runoff volumes over the highly variable three year rainfall period described in **Section 10.6**.

Comparative flows across the 3 year rainfall period shown in **Diagram 10-3** indicate that the treated flows from the proposed development would mimic the existing flows into the wetland. As such, the wetland would experience the same wetting and drying episodes post development as occurs at present.

Diagram 10-3 – Monthly Time Series Comparison of Flows into Bevian Wetland



This balance of surface and subsurface flows from the development to match existing conditions meets the Director General's requirements in Issues 5.2 and 6.2.

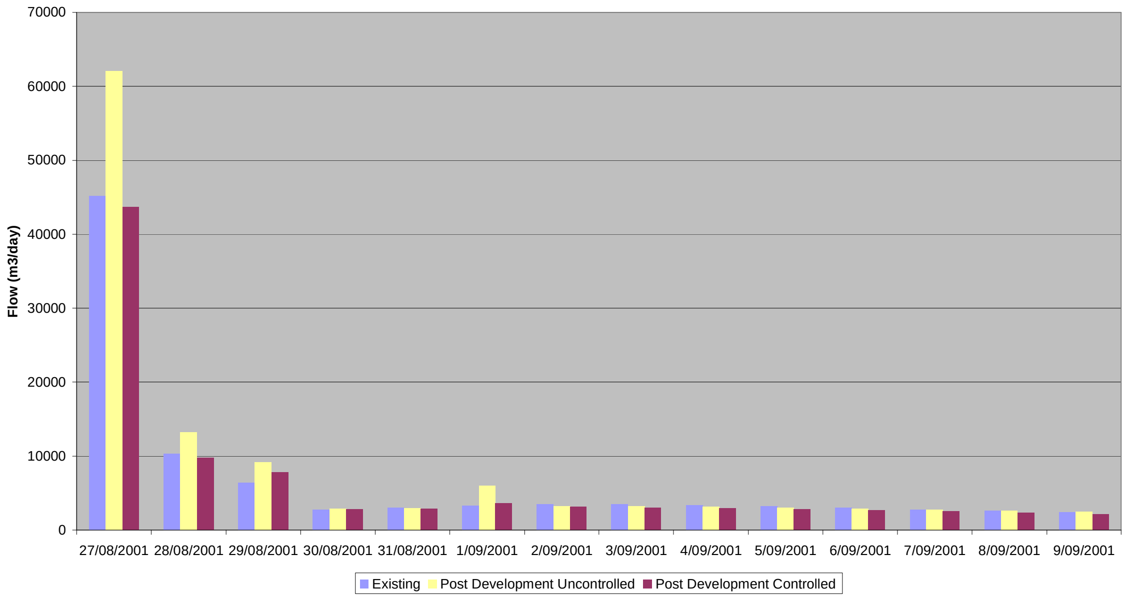
10.8 SALT WATER CREEK HYDROLOGY

The proposed development runoff entering Salt Water Creek would be derived from the Salt Water Creek, Tributary 1 and 2 subcatchments as described in **Table 10-7**.

The proposed water sensitive urban design features in the development would maintain the runoff volume as for existing conditions. This is demonstrated by the runoff coefficients (Cv) in **Table 10-7** which are essentially the same for existing and developed conditions. This can be further demonstrated by comparison of the daily runoff volumes for a two week period for existing and developed scenarios (refer **Diagram 10-4**). The runoff volume over this two week period for the developed scenario closely mimics the existing runoff volumes.

The control of the runoff behaviour in the development would ensure that the stability and natural hydrological function of Salt Water Creek was not adversely affected. This meets the Director General's requirements for Issues 5.2 and 6.2.

Diagram 10-4 – Daily Time Series Comparison of Flows into Salt Water Creek



10.9 BATEMAN MARINE PARK

Runoff from the site flows to the Salt Water Creek and Bevian Wetland catchments which eventually discharge to the ocean. It has been established that the runoff flows would mimic closely the existing hydrology and the runoff water quality would be improved significantly compared to the existing conditions. This would ensure that the proposed development would not adversely impact on the Bateman Marine Park but would contribute to the long term improvement in the local and regional receiving water quality.

This meets the Director General's requirements for Issue 6.2.

10.10 STREAM EROSION INDEX

Simulations were undertaken to determine the Stream Erosion Index of the proposed development. The purpose in determining the Stream Erosion Index for the development is to assess the impact on the watercourses downstream of the proposed site in terms of the erosive potential caused by runoff from the site.

The stream erosion index is defined as the post-development duration of flows greater than the stream-forming flow divided by pre-development duration of flows greater than the stream-forming flow. An index of 1 indicates zero variation from the prior conditions. An index of 3.5 to 5 is considered to represent a permissible increase in flows. For the purposes of this study, the stream forming flow will be defined as half of the 2 year average recurrence interval (ARI) flow of the catchment under existing conditions.

Pre-development flows and post development flows obtained from MUSIC models were used to determine the stream erosion index.

The stream forming flow values were obtained by running a RAFTS hydrological model of the existing development conditions under a 2 year ARI storm event. The model used for the flood investigation was employed for this analysis (***refer to the report on Flood Impact Assessment for further details***).

The peak flows under the 2 year ARI event were determined at three locations representing the primary points of discharge from the development to streams(*at Salt Water Creek, Tributary 1 and Tributary 2*). The stream forming flows were determined by halving the peak 2yr ARI flows at Salt Water Creek and Tributary 1, however as this flow was not exceeded for Tributary 2, 15% of the peak flow was adopted to assess the stream erosion index for Tributary 2. This yielded stream forming flow values of 6.26 m^3/s, 1.65 m^3/s, 4.22 m^3/s and 4.54 m^3/s respectively.

The flows at the three locations for existing and post developed scenarios were exported from the MUSIC models previously used for the water quality analysis at a six minute time-step (*using the Moruya Airport (69148) data for the year of 2001*). The exported flow data was compared against the stream forming flow to distinguish how frequently the flows in both scenarios would exceed the stream forming flow.

The stream forming flow exceedance rates and corresponding Stream Erosion Index values are shown in **Table 10-9**. The results show that the proposed development will not significantly increase erosion at the locations of discharge from the site to streams, as the indices are close to or less than one.

Table 10-9 – Results of Erosion Index Simulation

Location	Stream Forming Flow (m^3/s)	Site Condition	Exceedance % at stream forming flow	Stream Erosion Index
Salt Water Creek	1.65	Existing	2.28×10^{-5}	1.5
		Proposed development	3.42×10^{-5}	
Tributary 1	4.22	Existing	9.13×10^{-5}	1
		Proposed development	9.13×10^{-5}	
Tributary 2	4.54	Existing	1.14×10^{-5}	0
		Proposed development	0×10^{-5}	

10.11 WATER MANAGEMENT TARGET

In the Planning Assessment Report from the Department of Infrastructure, Planning and Natural Resources (DIPNR), for the previous application, it notes in Section 5.2.5 that the Department of Land and Water Conservation (DLWC) requires the benchmark for both runoff water quality and peak discharge to be a naturally forested catchment not the existing conditions.

The selection of an appropriate benchmark is a subjective decision as there is no legislative requirement specifically relating to runoff water management. However the guiding legislative principle of both the Environmental Planning and Assessment Act (EPA) and the Protection of the Environment Operations Act (PEOA) is that the development is not to have a significant adverse impact on the environment.

General best management practice in water management has interpreted this to require matching the existing conditions.

The authority responsible for PEOA is the Department of Environment and Climate Change (DECC). This authority has issued various guidelines on how to undertake an assessment of runoff water quality and peak flow impacts. Generally, its requirement is to achieve a minimum reduction in annual runoff pollutant load from the development of 80% for suspended sediment and 45% for nutrients. This equates to what is reasonably feasible given the technology available rather than setting a benchmark for landuse.

The Director General's requirements specify a water management target of no net increase in nutrient pollutant loads. This equates to matching existing conditions.

It is considered that as specified in the legislation, and in the Director General's requirements, the appropriate target for water management for the proposed development should be to match existing conditions. In order to demonstrate industry best practice, the water management target adopted for this project was to reduce the runoff pollutant load below existing conditions and to contribute to the long term improvement in receiving water quality. This has been achieved as demonstrated in **Section 10.5**.

10.12 ENTRY ROAD BESIDE BEVIAN WETLAND

The existing entry road to the site from the south is a dirt track which would be discharging significant sediment and nutrients into the Bevian Wetland because of the unstable nature of this dirt track. The proposed entry road would mitigate any adverse impacts on Bevian Wetland from runoff by:

- Minimising the width of hard surfaces for the road;
- One way cross fall to direct all runoff to a bioretention swale along the edge of the road closest to the wetland;
- Treatment of runoff in a bioretention swale;
- Diffuse discharge along the whole length of the road (no concentrated discharges from a pipe) via a porous rock gabion;
- In large storms, diffuse flow (not concentrated) overtopping the length of the swale and gabion.

More detailed information is provided in the Services and Infrastructure Report prepared for this Concept Application.

The road surface would be stabilised, runoff treated and no concentrated flows would be discharged to the wetland. This would greatly improve the existing conditions and runoff quality from the road into the wetland.

11 CONSTRUCTION AND OTHER WORKS

11.1 PHASING OF CONSTRUCTION AND OTHER WORKS

Detailed Soil and Water Management Plans (SWMPs) would be completed to accompany further applications for construction and other works. These SWMPs would be formulated in accordance with the best practice state government guideline “Managing Urban Stormwater-Soils and Construction” (*Landcom, 2004*) and Council guidelines. The SWMPs will also meet any DECC license requirements.

The soil and water management plans would provide a control strategy for each subcatchment to ensure appropriate runoff water quality. These controls would consist of filter fences, hay bales, run off diversion mounds, sediment ponds and vegetative filters. The ponds would be designed to trap all runoff for storms up to the design event. This design event would be selected to match the sensitive environments of the Bevian Wetland and Salt Water Creek. Runoff would not be released from the sediment basins until the quality was acceptable. Disturbed areas would be stabilised with native grasses to minimise the sediment load in the runoff.

The subdivision construction would be staged to limit the extent of disturbed areas at any one time. This would enable more stringent management of activities and runoff quality. The works would typically proceed in an upstream direction so that areas were progressively stabilised, rehabilitated and operating in the proposed water sensitive urban design strategy.

11.2 CONTINGENCY MEASURES

An outline of the proposed contingency measures to be employed during works is presented below. Contingency measures will be investigated in more detail closer to the construction phase of the project.

11.2.1 Flooding

Flooding on the site would be limited to the riparian corridors and the Bevian Wetland. No works are proposed in the Bevian Wetland. The rehabilitation of the riparian corridors would be undertaken in short lengths to minimise the risk to erosion and damage by flood flows.

Runoff from the subdivision works would be controlled in accord with the soil and water management plans. These plans would incorporate measures to divert runoff around the disturbed areas of the works and scour protection measures to accommodate severe storm related runoff.

Phasing of construction works and other soil and water management measures would assist to minimise the exposure to risks associated with flooding during the construction phases.

11.2.2 Environmental

There would be stringent management of the construction works to minimise the potential for environmental incidents. Environmental management plans would provide strict guidance to the contractor with regular review by the superintendent and Council.

Environmental incidents would be reported immediately to the Site Supervisor who would be in contact with either the Environmental Manager or Project Director. All incidents would be investigated and the appropriate course of action taken to address any issues.

Serious environmental incidents would be reported to DECC in accordance with the *Protection of the Environmental Operations Act* 1997, Duty to Notify.

11.2.2.1 Spills

The environmental management plans would require adequate management and storage of hazardous construction materials in secure and bunded areas. The operational procedures, would along with these physical controls, minimise the potential for any spillages.

Spill kits would be provided at each worksite. In the event of a spill the first priority of personnel would be to contain the spill. In the event that the spill is unable to be contained at the source, the spill would be contained at the nearest point. The fail safe measure would be containment of the spill within the sediment pond.

Once contained, the Environmental Operations Manager would be notified that an incident has occurred and is then responsible for the cleanup and reporting this incident to the appropriate authorities should it be necessary to do so.

11.2.2.2 Turbid Water

All staff and contractors would be trained to recognise the occurrence of turbid water discharge and/or unauthorised discharge. The soil and water management plans would provide stringent controls and operating procedures. There would be a target suspended sediment concentration above which it would not be allowed to discharge water from the sediment ponds. Dosing with alum would be possible to reduce the turbidity in stored runoff prior to release. In the event of an overflow of turbid water, the Environmental Operations Manager would be contacted immediately and the situation managed as an emergency in accordance with the Site Emergency Plan.

11.2.2.3 Corrective Action

Subsequent to the successful containment or management of a risk event, corrective actions would be formulated regarding the incident and is likely to involve the following:

- Reviewing the possible causes of the incident;
- Implementing/modifying controls as required;
- Notifying procedures as required; and
- Conducting additional training to the relevant personnel as required.

12 CONCLUSION

A best practice water sensitive urban design strategy has been formulated in concert with the ecological and landscape design experts to provide an integrated water management strategy which significantly improves the runoff management and adds value in terms of ecological outcome and visual amenity of the area. The integrated water management strategy proposed for the development which is based on a water sensitive urban design approach would include:

- rainwater tanks to reuse runoff which reduces the runoff volume and pollutant loads and slows down the flow;
- bio-retention raingardens on selected lots to infiltrate, treat and slowdown runoff from paved areas on the lots;
- bio-retention swales along the roads to treat and slow down runoff from lots and roads, and to promote subsurface flows;
- gross pollutant traps to remove sediment, debris, organic matter and litter;
- rehabilitate wide riparian corridors and wetland buffers with native vegetation to stabilise banks and provide significantly improved habitat value;
- upgrade farm dams to improve runoff quality and provide more diverse aquatic habitat; and
- provide storage and promote infiltration in bioretention systems of runoff to balance the surface/subsurface flows and slow down flows to mimic closely existing conditions.

The strategy would significantly improve the stability, natural function and water quality of Salt Water Creek and Bevian Wetland. This would contribute to the long term improvement in these receiving waters as well as the Bateman Marine Park. This meets the Director General's (DG) requirements in Issues 5.2 and 6.1.

The water sensitive urban design strategy would ensure an integrated water cycle approach with rainwater harvesting and water saving devices leading to greater than a 40% reduction in potable water use compared to a traditional household. This meets the DG requirements in Issue 6.3.

The proposed development would maintain the existing balance of surface and subsurface groundwater) flows to protect groundwater quality and the function of Bevian Wetland. This approach along with rehabilitation of riparian and endangered flora would enhance receiving waters including Bateman Marine Park. This meets the DG requirements in Issues 6.1 and 6.2.

The development proposed in the Concept Approval Plans would significantly reduce runoff pollutant loads below existing levels thereby ensuring no net increase in nutrient/pollutant loads entering watercourses. Best management practice soil and water management practices in accord with the Managing Urban Stormwater guidelines would ensure no net increase in runoff pollutant loads during construction. The proposed treatment measures comprise approximately 6.4% of the total area to be developed, with rainwater tanks offering significant further benefits. These meet the DG requirements in Issues 6.1, 6.3, and 6.4.

The proposed water management strategy conforms to government policy including the NSW Coastal Policy, Wetland Management Policy, Estuary Management Policy and State Rivers and Estuary Policy. This meets the DG requirements in Issue 6.1.

The proposed development has been designed to have habitable flood levels a minimum of 0.5m above the 100 year ARI flood level with safe access during extreme floods. This incorporates allowances for possible future sea level rise. This management of the flood hazard is discussed in detail in the report entitled *Flood Impact Assessment*, Patterson Britton and Partners. July 2007. This meets the DG requirements in Issues 8.5 and 8.6.

The Concept Approval Plans (The Constraints Map and Plan of Subdivision; **Figures 1 and 2**) incorporate the above water management features and controls such that they adequately address the water related Director General Requirements. As such, it is concluded that the Concept Approval Plans are satisfactory.

13 REFERENCES

1. Co-operative Research Centre for Catchment Hydrology, 2005, *MUSIC User Guide*

2. Duncan, 1999, *Urban Stormwater Quality: A Statistical Overview*

3. Douglas Partners, 2002, *Report on Geotechnical Investigation, Rosedale Urban Release Area, Rosedale*

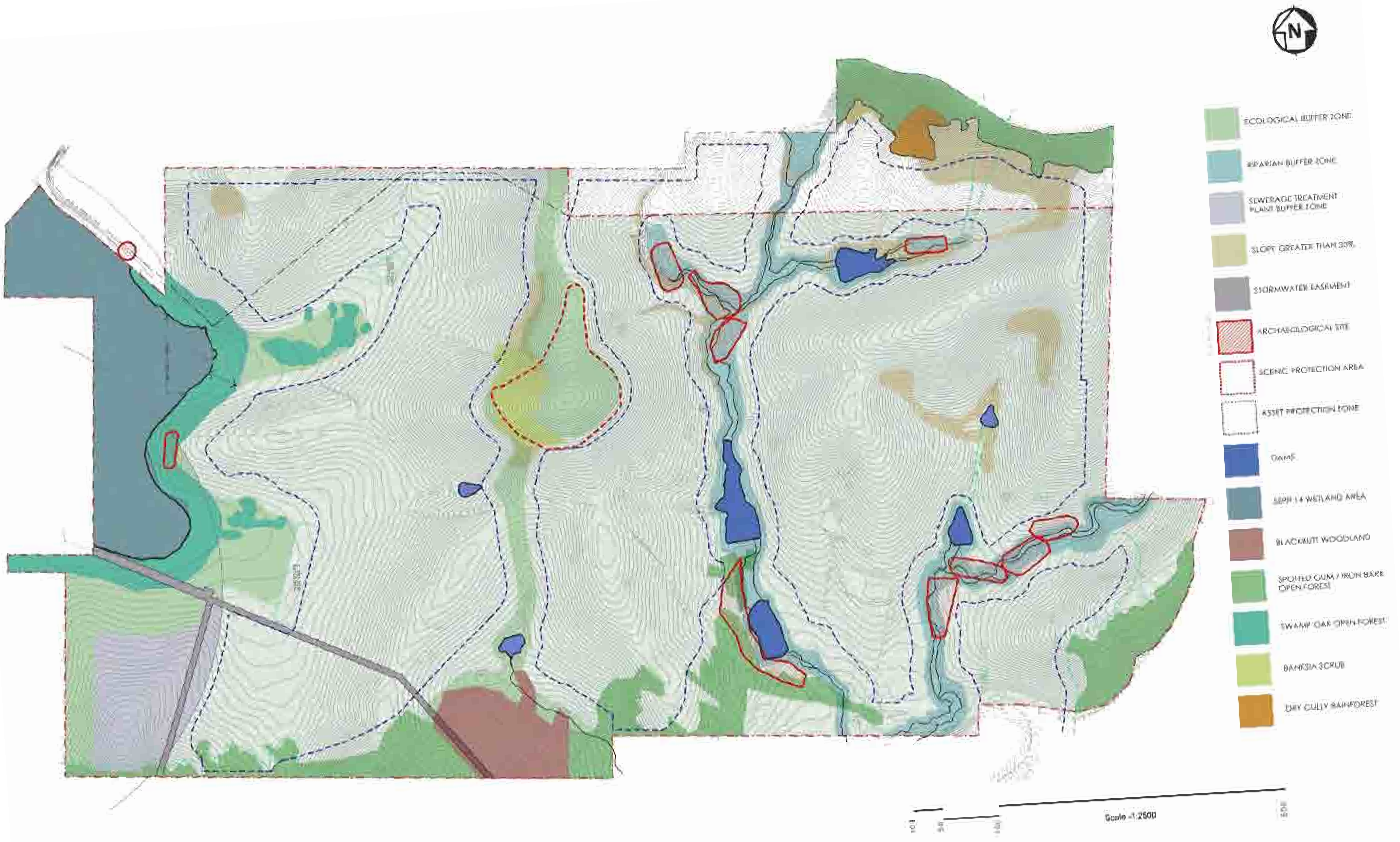
4. Landcom, 2004, *Managing Urban Stormwater – Soils and Construction.*

5. Walker, T.A., Allison, R.A., Wong, T.H.F., Wootton, R.M., February 1999, *Removal of Suspended Solids and Associated Pollutants by a CDS Gross Pollutant Trap*

6. Independent Review Panel, *South Coast Sensitive Urban Lands Review, Report to the Honourable Frank Sartor MP Minister for Planning*, October 2006

FIGURES

FIGURE 1



CONSTRAINTS MAP

Patterson Britton & Partners Pty Ltd

J4661_01/FIG1_ConstraintsMap_WMReport.jpg

FIGURE 2

CONCEPT PLAN

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& Partners Pty Ltd

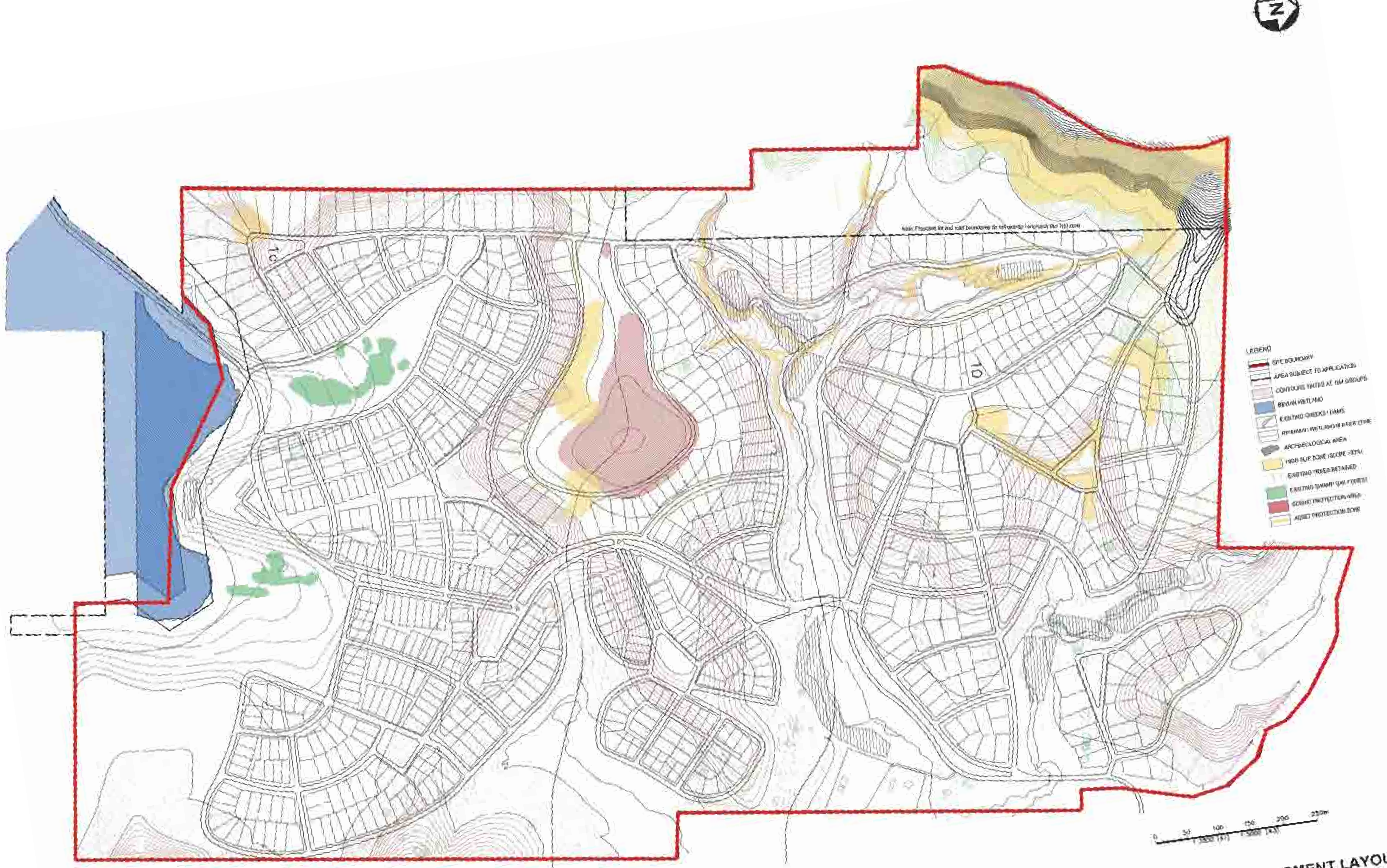
J4561_02/FIG2_ConceptPlan_WMReport.jpg

FIGURE 3

Patterson Britton
& Partners Pty Ltd

consulting engineers
4561-01 ROSEDALE

SITE PLAN
ROSEDALE URBAN EXPANSION AREA



PROPOSED DEVELOPMENT LAYOUT

Patterson Britton
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WATER SENSITIVE URBAN DESIGN

LEGEND

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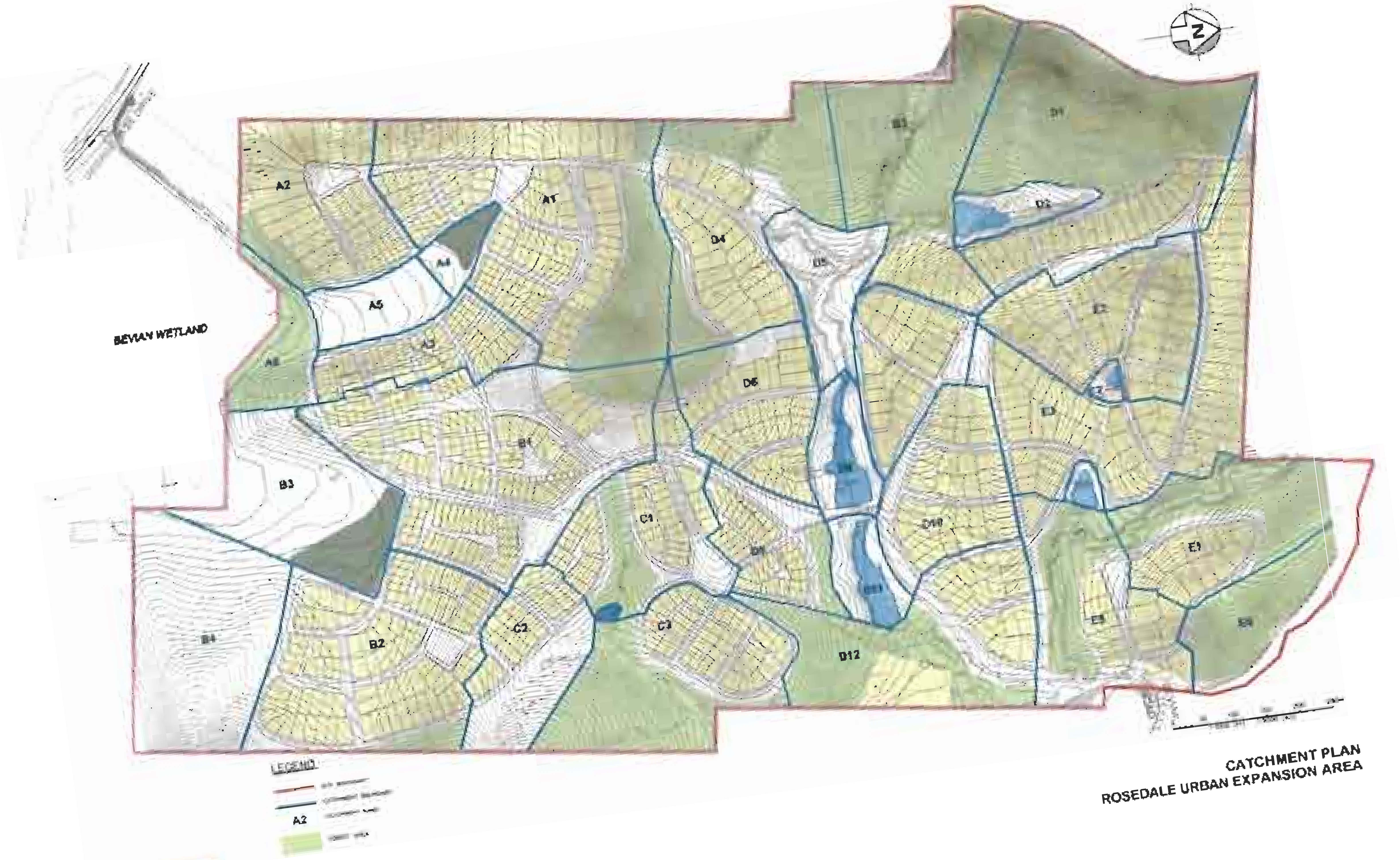
& Partners Pty Ltd



CATCHMENT PLAN
ROSEDALE URBAN EXPANSION AREA

Patterson Britton
& Partners Pty Ltd

APPENDIX A
DIRECTOR GENERAL'S REQUIREMENTS

NSW GOVERNMENT
Department of Planning

Contact: John Arnold
Phone: (02) 9228 6398
Fax: (02) 9228 6540
Email: john.a.arnold@planning.nsw.gov.au

Our ref: MP05_0199
Your ref:
File: 9041393-1

John Kass, Director
Kass-hermes
Urban Planning + Development
76 Drumalbyn Road, Bellevue Hill
NSW 2023

Dear Mr Kass

Subject: Director-General's Environmental Assessment Requirements for the Environmental Assessment of a Concept Plan for a Proposed Residential Subdivision at George Bass Drive, Rosedale (MP05_0199)

The Department has received your application for the above project (Application Number: 05_0199).

The Director General's Environmental Assessment Requirements (DGRs) for the environmental assessment of the project for a Concept Plan are attached to this correspondence at **Attachment 1**. These requirements have been prepared in consultation with the relevant government agencies including council, and have been based on the information that you have provided to date. Please note that the Director-General may alter these requirements at any time.

Attachment 2 lists the relevant plans and documents which are likely to be required upon submission of your proposal; however, this should be confirmed with the Department prior to lodgement.

It should be noted that the DGRs have been prepared based on the information provided to date. Under section 75F(3) of the Act, the Director-General may alter or supplement these requirements if necessary and in light of any additional information that may be provided prior to the proponent seeking approval for the project.

It would be appreciated if you would contact the Department at least two weeks before you propose to submit the Environmental Assessment for the project to determine:

- the fees applicable to the application;
- consultation and public exhibition arrangements that will apply; and
- number and format (hard-copy or CD-ROM) of the Environmental Assessment that will be required.

A list of some relevant technical and policy guidelines which may assist in the preparation of this Environmental Assessment are attached at **Attachment 3**.

Prior to exhibiting the Environmental Assessment, the Department will review the document to determine if it adequately addresses the DGRs. The Department may consult with other relevant government agencies in making this decision. If the Director-General considers that the Environmental Assessment does not adequately address the DGRs, the Director-General may require the proponent to revise the Environmental Assessment to address the matters notified to the proponent.

Following this review period the Environmental Assessment will be made publicly available for a minimum period of 30 days.

If your proposal includes any actions that could have a significant impact on matters of National Environmental Significance, it will require an additional approval under the Commonwealth Environment Protection Biodiversity Conservation Act 1999 (EPBC Act). This approval would be in addition to any approvals required under NSW legislation. If you have any questions about the application of the EPBC Act to your proposal, you should contact the Commonwealth Department of Environment and Heritage in Canberra (6274 1111 or http://www.deh.gov.au).

If you have any queries regarding these requirements, please contact John Arnold on 9228 6398 or email john.a.arnold@planning.nsw.gov.au.

Yours sincerely

18.12.06

Chris Wilson
Executive Director
as delegate for the Director General

Attachment 1
Director-General's Environmental Assessment Requirements

Section 75F of the *Environmental Planning and Assessment Act 1979*

Application number	05_0199
Project	**A Concept Plan Application for Proposed Residential Subdivision at George Bass Drive, Rosedale**
Location	**Lots 11, 29, 32, 72, 102, 118, 119 and 213 in DP755902; Lot 2 DP627034 and Lot 2 DP623340**
Proponent	Marsim
Date issued	December 2006
Expiry date	2 years from date of issue
General requirements	The Environmental Assessment (EA) for the **Concept Plan** must include: • An executive summary; • A outline of the scope of the project including: (i) Any development options; (ii) Justification for the project taking into consideration any environmental impacts of the project, the suitability of the site and whether the project is in the public interest; (iii) Outline of the staged implementation of the project, if applicable; • A thorough site analysis and description of existing environment; • Consideration of any relevant statutory and non-statutory requirements, in particular relevant provisions of Environmental Planning Instruments, draft South Coast Regional Strategy and Development Control Plans as well as impacts, if any, on matters of national environmental significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*; • Where relevant, demonstrate compliance with BCA and relevant Australian Standards for proposed building; traffic, road and parking; utilities; noise and flooding; • An environmental risk analysis of the project including consideration of the issues raised during consultation; • An assessment of the potential impacts of the project and a draft Statement of Commitments, outlining environmental management, mitigation and monitoring measures to be implemented to minimise any potential impacts of the project; • The plans and documents outlined in **Attachment 2**; • A signed statement from the author of the Environmental Assessment certifying that the information contained in the report is neither false nor misleading; • A Quantity Surveyor's certificate of cost to verify the capital investment value of the project; and • An assessment of the key issues specified below and a table outlining how these key issues have been addressed.
Key issues	The Environmental Assessment for the Concept Plan must address the following key issues: **1. Conceptual Layout** 1.1. Address the requirements of the *Eurobodalla Rural Local Environmental Plan 1987 (as amended)* and Eurobodalla Council's *DCP No. 160 - Rosedale* and *DCP No. 157 - Rural Subdivision.* Demonstrate consistency with all relevant zone objectives and standards. 1.2. Identify the extent of potential development footprints, building envelopes

	and built form controls, and any significant vegetation to be removed. 1.3. Address safety, provision of public reserves, potential perimeter road layouts, pedestrian and bicycle movement to, within and through the site. 1.4. Demonstrate a clear delineation between public and private spaces. 1.5. Identify the indicative staging of the development and the future management of the land (torrens, strata and/or community title). **2. Visual Impact, Amenity and Scale** 2.1. Demonstrate suitability of the proposal with the surrounding area in relation to potential character, bulk, scale and visual amenity of development resulting from the development having regard to the *Coastal Design Guidelines of NSW (2003), NSW Coastal Policy (1997), State Environmental Planning Policy No. 71 – Coastal Considerations* (specifically Clauses 2 and 8) and the *Eurobodalla Urban Settlement Strategy*. 2.2. In accordance with the recommendations of the *Independent Review Panel for Sensitive Lands* demonstrate how the development will ensure the visual separation between Barlings Beach and Rosedale, and along George Bass Drive between Tomakin and Rosedale North. **3. Social and Community** 3.1. Demonstrate that the development achieves a range of housing types to meet anticipated demographic needs. 3.2. Address the social and economic context of the development in terms of infrastructure requirements, access, public transport, community services and facilities, including medical and educational needs. **4. Environmental Protection** 4.1. Address measures for the conservation of animals and plants and their habitats within the meaning of the *Threatened Species Conservation Act 1995* having regard to the *Draft Guidelines for Threatened Species Assessment (DEC & DPI July 2005)*. Address the measures for the conservation of aquatic species within the meaning of the *Fisheries Management Act 1994*. 4.2. Outline the measures for the conservation of existing wildlife corridor values and/or connective importance of vegetation on the subject land, including areas identified as being of high and/or very high ecological status. 4.3. Demonstrate how the proposal will allow for the future transition of areas of high environmental conservation value to the new Environmental Conservation Zone 2 areas under the LEP template, particularly in relation to riparian corridors, wetlands, and areas containing Endangered Ecological Communities (EEC's) **5. Riparian Management** 5.1. In accordance with the objectives of the *draft Eurobodalla Riparian Corridor Study (RCOS)* address riparian zone buffering to the wetland and drainage lines demonstrating how they will be protected and how the downstream environment will not be adversely affected by the proposed development. 5.2. Outline management measures to maintain/improve the stability, water quality, habitat and natural function of the wetland. A core riparian zone extending at least 40 metres from the high water mark plus a further 10 metre buffer is required. 5.3. A 10 metre riparian buffer zone extending from the 'top of the bank' is required to all drainage lines within the development area. **6. Water Cycle Management** 6.1. Address *NSW Coastal Policy, Wetlands Management Policy, Estuary Management Policy, State Rivers Policy* and *Estuary Policy*.

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	6.2. Address potential impacts on the water quality of surface and groundwater, on all water courses, and on ground water dependent ecosystems. Consideration must also be given to the protection of the Bateman's Marine Park. 6.3. Address and outline measures for an Integrated Water Cycle Management Plan (including stormwater concept) based upon Water Sensitive Urban Design principles. This should include measures to ensure no net increase in nutrient/pollutant loads entering the watercourses including both construction and post construction operational management measures. **7. Traffic and Access** 7.1. Prepare a Traffic Impact Study (TIS) in accordance with the *RTA Guide to Traffic Generation Developments*. 7.2. Identify the needs to upgrade roads/junctions and improvement works to ameliorate any traffic inefficiency and safety impacts associated with the development, particularly in relation to access points from George Bass Drive. This should include identification of pedestrian movements and appropriate treatments. 7.3. Consult with Eurobodalla Shire Council and the Department of Lands with regard to management and ownership of Crown roads. **8. Hazard Management and Mitigation** 8.1. Address the requirements of *Planning for Bush Fire Protection 2001* (RFS) in particular the provision of adequate access for fighting bushfire, adequate asset protection zones and water supply for bushfire suppression operations. 8.2. Prepare a plan of management for fuel management including the provision and maintenance of APZ's, natural area, buffer zones and revegetation. 8.3. Address *AS 3959: Building in Bush Fire Prone Areas*. 8.4. Demonstrate the use of best management sediment and erosion techniques particularly to the area immediately surrounding the SEPP 14 Bevian Wetland. 8.5. Undertake a Flood Study having regard to the requirements of the *NSW Floodplain Management Manual*. Address potential impacts of flooding on the development, the impact of development on flood behaviour (including cumulative impacts), and the impact of flooding on the safety of people over a full range of possible floods up to the probable maximum flood (PMF) and mitigation measures. 8.6. Address sea level rise and coastal inundation restricting where necessary development in low lying areas. **9. Infrastructure Provision** 9.1. Address existing capacity and requirements of the development for sewerage, water and electricity in consultation with relevant agencies. 9.2. Identify staging, if any, of infrastructure works. 9.3. Address provision of public services and infrastructure having regard to the Council's Section 94 Contribution Plans. 9.4. Prepare an Odour Management Study to address potential odour issues in conflict with provision of the *POEO Act*. (note: the cost of odour management studies and cost of design and construction of any odour control works at the STP are to be fully funded by the applicant). 9.5. An appropriate buffer distance should be identified in accordance with the *Assessment and Management of Odour from Stationary Sources in NSW (Technical Framework and Supporting Technical Notes (DEC November 2006))*.

	10. Heritage 10.1. Address the *draft Guidelines for Aboriginal Cultural Heritage Impact Assessment can Community Consultation (DEC, July 2005).* 10.2. Identify whether the site has significance in relation to Aboriginal cultural heritage and identify appropriate measures to preserve any significance. 10.3. Identify any other items of heritage significance and provide measures for conservation of such items. **11. Noise** 11.1. Address potential road traffic impacts on future residents and identify appropriate mitigation measures. 11.2. Address potential impacts of demolition, construction and operational noise. **12. Soil and Contamination** 12.1. Identify the presence and extent of acid sulfate soils on the site and outline appropriate mitigation measures. Identify areas of contamination on site and appropriate mitigation measures. The level of assessment shall be consistent with the *Acid Sulfate Soil Manual* by ASSMAC.
Consultation	You should undertake an appropriate and justified level of consultation with the following agencies during the preparation of the environmental assessment: (a) *Agencies or other authorities:* • Eurobodalla Shire Council; • NSW Department of Planning – South Coast Regional Office;; • NSW Department of Environment and Conservation; • NSW Department of Natural Resources; • NSW Department of Primary Industries; • NSW Department of Education and Training; • NSW Department of Health • NSW Rural Fire Service; • NSW State Emergency Services; and • relevant Aboriginal Land Council contact. (b) *Public:* Document all community consultation undertaken to date or discuss the proposed strategy for undertaking community consultation. This should include any contingencies for addressing any issues arising from the community consultation and an effective communications strategy. The consultation process and the issues raised should be described in the Environmental Assessment.
Deemed refusal period	60 days
Electronic Documents	Electronic documents presented to the NSW Department of Planning for publication via the Internet must satisfy the criteria:- • Adobe Acrobat PDF files and Microsoft Word documents must be no bigger that 1.5 Mb. Large files of more than 1.5 Mb will need to be broken down and supplied as different files. • File names will need to be logical so that the Department can publish them in the correct order. Avoid sending documents that are broken down in more than 10 files. • Image files should not be bigger than 2Mb. The file names will need to be clear and logical so the Department can publish them in the correct order. • Graphic images will need to be provided as [.gif] files. • Photographic images should be provided as [.jpg] files.

	• Large maps will need to be presented as individual files and will need to be calibrated to be no more than 2Mb each. • Images inserted into the document will need to be calibrated to produce files smaller than 1.5Mb. Large images will need to be presented as individual files and will need to be calibrated to be no more than 2Mb each. The file names will need to be clear and logical so the Department can publish them in the correct order. Alternatively, these electronic documents may be placed on your own web site with a link to the Department of Planning's website.

Attachment 2
Plans and Documents to accompany the Application

Plans of the development	The following plans, architectural drawings and diagrams of your proposal as well as the relevant documents will be required to be submitted for the <u>Concept Plan</u> : 1. The **existing site survey plan** is to be drawn to 1:500 scale (or other appropriate scale) and show: • the location of the land, the measurements of the boundaries of the land, the size of the land and north point; • the existing levels of the land in relation to buildings and roads; • location and height of existing structures on the site; and • location and height of adjacent buildings and private open space. 2. An **aerial photograph** outlining the subject site and surrounding area (at an appropriate scale). 3. A **Site Analysis Plan** must be provided which identifies existing natural elements of the site (including all hazards and constraints), existing vegetation, property dimensions, footpath crossing levels and alignments, existing pedestrian and vehicular access points and other facilities, slope and topography, natural features such as watercourses, rock outcrops, utility services, boundaries, orientation, view corridors and all structures on neighbouring properties where relevant to the application (including windows, driveways etc. 4. A **locality/context plan** drawn to 1:500 scale (or other appropriate scale) should be submitted indicating: • significant local features such as parks, community facilities and open space, water courses and heritage items; • the location and uses of existing buildings, shopping and employment areas; and • traffic and road patterns, pedestrian routes and public transport nodes. • The existing site plan and locality plan should be supported by a written explanation of the local and site constraints and opportunities revealed through the above documentation. 5. The **Environmental Assessment** in accordance with the Director-General's Environmental Assessment Requirements as outlined in Attachment 1. 6. **Conceptual layout plans** to illustrate the following:- • Conceptual layout of the proposed development including staging; • North point; • Name of the road fronting the site and other surrounding major roads; • Title showing the description of the land with lot and DP numbers etc; • Vegetation retention; • Access points and road layout; • Any easements, covenants or other restrictions either existing or proposed on the site; • Type of subdivision proposed (Torrens, strata and/or community title). 7. **Other Plans** including (where relevant): **Infrastructure Concept Plans** – conceptual drawings indicating proposed infrastructure including roads, drainage, water, sewerage and earthworks **Stormwater Concept Plan** - illustrating the plan for stormwater management of the site and must Include details of any drainage lines and major overland flow paths through the site, stormwater treatment measures and any discharge points to existing drainage systems.

	Flood Evacuation Plan – plan showing the proposed access from the site during extreme flood events. **Erosion and Sediment Control Plan** – plan or drawing that shows the nature and location of all erosion and sedimentation control measures to be utilised on the site; **Landscape Concept Plan** – plan or drawing that shows the basic detail of planting design and plat species to be used, listing botanical and common names, mature height and spread, number of plants to be utilised and surface treatments (i.e. pavers, lawn etc);
Specialist advice	Specialist advice, where required to support your Environmental Assessment, must be prepared by suitably qualified and practising consultants.
Documents to be submitted	• 15 hard copies of the Environmental Assessment; • 15 sets of architectural and landscape plans to scale, including set one (1) set at A3 size (to scale); and • 4 copy of the Environmental Assessment and plans on CD-ROM (PDF format), not exceeding 5Mb in size.

Attachment 3
Technical and Policy Guidelines

The majority of these documents can be found on the relevant Departmental Websites, on the NSW Government's on-line bookshop at http://www.bookshop.nsw.gov.au or on the Commonwealth Government's publications website at http://www.publications.gov.au.

Aspect	Policy /Methodology
Biodiversity	
Flora and Fauna	Draft Guidelines for Threatened Species Assessment (DEC, 2004)
Bushfire	
	Planning for Bushfire Protection 2001 (NSW Rural Fire Service)
	Australian Standard 3959 – Building in Bushfire Prone Areas
Coastal Planning & Water Bodies	
	NSW Coastal Policy 1997 - A sustainable Future for the New South Wales Coast (Department of Urban Affairs & Planning, 1997)
	Coastal Design Guidelines for NSW, Coastal Council, March 2003
	NSW Wetlands Management Policy (DLWC, March 1996)
	NSW State Rivers and Estuaries Policy (DLWC, 1992)
	NSW Estuary Management Manual (DLWC, 1992)
	Constructed Wetlands Manual (DLWC, 1998)
Heritage	
	Draft guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation (DEC, July 2005)
	NPWS Aboriginal Cultural Heritage Standards and Guidelines Kit – Working Draft (NPWS, September 1997)
	Aboriginal cultural heritage: standards and guidelines (DEC 2005)
	Protecting Aboriginal Objects and Places - Interim Guidelines for Community Consultation (DEC 2005)
Soils & Contamination	
	Contaminated Land: Planning Guidelines for Contaminated Land, Department of Urban Affairs and Planning and the NSW EPA, October 1995.
	Managing Land Contamination: Planning Guidelines – SEPP 55 – Remediation of Land (NSW EPA, 1998)
	Contaminated Sites – Guidelines for Consultants Reporting on Contaminated Sites (NSW EPA, 1997)
	Contaminated Sites – Guidelines on Significant Risk of Harm and Duty to Report (NSW EPA, 1999)
Traffic, Transport & Pedestrian & Cyclist Facilities	
	Guide to Traffic Generating Developments (RTA, 1993)
	RTA Road Design Guide (RTA, 1996)
	Planning Guidelines for Walking and Cycling (DIPNR & RTA, December 2004)
	Guide to Traffic Engineering and Guide to Geometric Design of Rural Roads (Ausroads, 2003)

Aspect	Policy /Methodology
Water	
Water Quality	Australian & New Zealand Guidelines for Fresh & Marine Water Quality (Australian & New Zealand Environment & Conservation Council (ANZECC), October 2000)
	National Water Quality Management System - Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC 2000)
	Integrated Water Cycle Management Guidelines for NSW Local Utilities, Oct 2004
	Water Quality and River flow Objectives (DEC, 2000)
	State Water Management Outcomes Plan Order 2002
	NSW Guidelines for Urban & Residential Use of Reclaimed Water (NSW Water Recycling Coordination Committee, 1993)
Wastewater	National Water Quality Management Strategy: Guidelines for Sewerage Systems – Effluent Management (ARMCANZ/ANZECC 1997)
	National Water Quality Management Strategy: Guidelines for Sewerage Systems – Use of Reclaimed Water (ARMCANZ/ANZECC 2000)
	Environmental Guidelines for the Utilisation of Treated Effluent by Irrigation (NSW DEC 2004)
	Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households (1998)
Flooding & the Floodplain	NSW Government Floodplain Development Manual - the Management of Flood Liable Land (DIPNR, 2005)
Groundwater	NSW Groundwater Policy Framework Document – General (DLWC, 1997)
	NSW State Groundwater Quality Protection Policy (DLWC, 1998)
	NSW State Groundwater Dependent Ecosystems Policy (DLWC, 2002)
Stormwater	Managing Urban Stormwater :Soils and Construction (NSW Landcom, 2004)
	Managing Urban Stormwater: Source Control (DEC, 1998)
	Managing Urban Stormwater: Treatment Techniques (DEC, 1998)
	Better Drainage: Guidelines for the Multiple Use of Drainage System (PlanningNSW, 1993)
Noise and Vibration	
	NSW Industrial Noise Policy (NSW EPA, 1999)
	NSW Environmental Criteria for Road Traffic Noise (NSW EPA, 1999)
	Environmental Noise Control Manual (NSW EPA, 1994)

APPENDIX B
BASELINE WATER QUALITY MONITORING

Bevian Road Concept Application

Baseline Water Quality Monitoring

Bevian Road,
Rosedale,
Batemans Bay

Issued: July 2007

Patterson Britton
& Partners Pty Ltd
consulting engineers

Marsim (Trading as Nature Coast Developments P/L)

Issue	Description of Amendment	Prepared by (date)	Verified by (date)	Approved by (date)
1	First Issue – Draft	AMZ	OJR	
2	Second Issue - Final	FC	MST	MST

Issue No.2

Note:

This document is preliminary unless it is approved by a principal of Patterson Britton & Partners.

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1 INTRODUCTION

1.1 BACKGROUND

Patterson Britton & Partners (*PBP*) have been engaged by Marsim (trading as Nature Coast Developments P/L) to assess the pre-development (*i.e. "baseline"*) surface water quality for the Bevian Road residential development site at Rosedale, south of Batemans Bay on the NSW south coast. The Eurobodalla Rural Local Environmental Plan (*1987*) delineated Rosedale as an urban expansion zone. Development Control Plan (*DCP*) No. 160 titled "Rosedale Urban Expansion Area" was adopted by Eurobodalla Council in 1989.

The information contained in this report will assist in development of a suitable, targeted strategy for the continued monitoring of surface water quality both during and post development. It will allow for the appropriate development and placement of water quality management systems designed to achieve specific water quality management targets for any proposed development of the Rosedale urban expansion site.

1.2 THIS REPORT

The information presented in this report has been developed to establish existing baseline water quality conditions of watercourses within the Rosedale site and the receiving waters (*Salt Water Creek and Bevian Wetland*). This baseline surface water quality data provides a snapshot of the water quality in the watercourses within and around the site.

1.3 SITE AND CATCHMENT DESCRIPTION

The Rosedale site consists of approximately 188 ha of cleared land located at the southern end of the Batemans Bay urban area.

The site is adjacent to State Forest on its western and northern boundaries with the villages of Rosedale and Guerilla Bay to the east of the site. The site is currently used for rural activities, such as the grazing of cattle, and contains a number of farm dams mainly in the northern area.

The northern half of the site drains to the east into Salt Water Creek. This portion of the site consists of a number of valleys with relatively steep slopes. The creeklines have only isolated riparian vegetation and have three main online farm dams. The headwaters of the catchment are only just outside the boundary of the site.

The southern half of the site drains to Bevian Wetland, which is a SEPP 14 Wetland. This portion of the site is undulating without any creeklines. The valleys consist of broad grass swales with the runoff travelling generally as sheetflow across the ground surface.

2 WATER QUALITY MONITORING STRATEGY

2.1 OBJECTIVES

The main objectives of the water quality monitoring are to assess the:

- surface water quality at relevant locations within the site under present conditions; and
- ecological health of the receiving waters (i.e.: Salt Water Creek and Bevian Wetland) under existing conditions.

This will allow an assessment of:

- the effectiveness of proposed water quality measures (*i.e. bio-retention systems, ponds, gross pollutant traps, constructed wetlands, etc…*) on surface and receiving water quality; and
- The monitoring of actual impacts (*if any*) on surface and receiving water quality both during and post construction on surface water quality.

2.2 GUIDING DOCUMENTS

The monitoring strategy, procedures and analysis have been developed with reference to the following:

- ANZECC (*2000*) "*Australian and New Zealand Guidelines for Fresh and Marine Water Quality*";
- AS/NZ 5667.1: 1998 "*Water Quality Sampling* **-** *Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples*"; and
- AS/NZ 5667.6: 1998 "*Water Quality Sampling* **-** *Guidance on sampling of rivers and streams*".

2.3 TYPES OF MONITORING

The surface water monitoring component of the strategy included the assessment of key physio-chemical water quality indicators.

Bed sediment samples were collected at a number of locations from within the site and analysed for organochlorine pesticides, metals and oils/greases.

Groundwater conditions were not assessed within the scope of this report.

Samples were tested for the parameters as detailed in **Table 2.1**.

Table 2.1 - Surface Water Testing Parameters

Variable	Units	Surface Water	Bed Sediment
Biological Oxygen Demand (*BOD*)	mg O^2/L	ü	
Moisture	%		ü
Suspended Solids	mg/L	ü	
Dissolved Metals*	mg/L	ü	
Heavy Metals*	mg/kg		ü
Hardness	mg/L	ü	
Salinity	%	ü	
Total Nitrogen	mg/L	ü	
Ammonia	mg/L	ü	
Total Kjeldahl Nitrogen	mg/L	ü	
Nitrates	mg/L	ü	
Nitrites	mg/L	ü	
Total Phosphorous	mg/L	ü	
Ortho Phosphorous	mg/L	ü	
Polycyclic Aromatic Hydrocarbons (PAH's)	m g/L or mg/kg	ü	ü
Phenolic Compounds	m g/L or mg/kg	ü	ü
OC/OP Pesticides	mg/L or mg/kg	ü	ü
Oil and grease	mg/L	ü	
Algal ID	cells/mL	ü	
Faecal Coliform Count	cfu/100ml	ü	
Chlorophyll-a	**mg/m^3**	ü	

* Metal tested: As, Cd, Cr, Cu, Pb, Hg, Ni, and Zn.

2.4 SURFACE WATER QUALITY SAMPLING LOCATIONS

The Rosedale site has a number of valleys, some with relatively steep slopes. Flow from these areas feed into a number of small to medium farm dams spread across the site. This includes three larger online farms dams located in the northern portion of the site leading to Salt Water Creek. Two smaller farm dams in southern half of the site overflow to Bevian Wetland. Samples were attempted to be taken from each of the dams within the Rosedale site, as well as the junctions of any tributaries at the eastern border of the Rosedale site to gain an overall picture of current surface water quality within the site. Additionally, two samples were taken from within Bevian Wetland. Due to dry weather conditions prior to the sampling date, the sampling sites in Salt Water Creek and tributaries east of the site (*sample Site 5 and Site 7, refer* ***Section 2.4.5 and 2.4.7***) were dry. Ten surface water quality samples were taken at different locations across the site. Sample locations are indicated in **Figure 1** and are summarised below. Notation in brackets represents the sample identification tag (*refer* ***Appendix A***).

2.4.1 Site 1 (*W16730/001*)

The sample was taken near the overflow of the relatively large online farm dam towards the north-eastern corner of the Rosedale site. The sample site is characterised by a large amount of reeds, lilies and wildlife (*birds*), as shown in **Plate 1**. Sediment was sampled from the edge of the dam.

Plate 1 – Online Farm Dam 1

2.4.2 Site 2 (*W16730/002*)

The sample was taken near the overflow of the largest of the online farm dams, located towards the middle of the Rosedale site (*refer **Figure 1***). Clusters of reeds can be seen around the edge of the dam (*refer **Plate 2***) and cattle were observed to be grazing in the paddock adjacent the dam. Sediment was sampled from the edge of the dam.

Plate 2 – Online Farm Dam 2

2.4.3 Site 3 (*W16730/003*)

The sample from Site 3 was taken near the overflow of the large online farm dam located approximately 100m east of Site 2. Similar to Site 2, clusters of reeds were observed around the edge of the dam. Sediment was sampled from the edge of the dam.

Plate 3 – Online Farm Dam 3

2.4.4 Site 4 (*W16730/004*)

The sample from Site 4 was taken from a small creek adjacent the eastern boundary of the Rosedale site (*refer **Figure 1***).

Plate 4 – Tributary Adjacent Boundary

2.4.5 Site 5 (*Dry*)

The specified sample location at Site 5 at the confluence of two tributaries did not contain any flow or standing water on the date of sampling. No surface water or bed sediment samples were obtained.

Plate 5 – Tributary Confluence East of Site

2.4.6 Site 6 (*W16730/005*)

Surface water and bed sediment samples were taken from small pools of water within the creek adjacent the eastern boundary of the Rosedale site.

Plate 6 – Creek Adjacent Eastern Boundary

2.4.7 Site 7 (*Dry*)

The specified sample location at Site 7 at the confluence of two main creeks east of the Rosedale site did not contain any flow or standing water on the date of sampling. No surface water or bed sediment samples were taken.

Plate 7 – Main Creek Confluence East of Site

2.4.8 Site 8 (*W16730/006*)

Water quality sample was taken adjacent the main tree observed in **Plate 8**, below (*approximately, 2.5m from shore*).

Plate 8 – Bevian Wetland (*Wetland 1*)

2.4.9 Site 9 (*W16730/007*)

Water quality sample was obtained in shallow water from wetland at the location observed in **Plate 9**, below.

Plate 9 – Bevian Wetland (*Wetland 2*)

2.4.10 Site 10 (*Dry*)

The identified possible sample location at Site 10 was at a small farm dam immediately north of the wetland. The dam contained many reeds and there was evidence of cattle presence nearby. No surface water was visible in the dam. No surface water or bed sediment samples were taken.

Plate 10 – Small Farm Dam 1

2.4.11 Site 11 (*W16730/008*)

The sample location at Site 11 was a small farm dam positioned towards the middle of the site, adjacent the road bisecting the Rosedale site. The contained reeds around the edge and cattle were seen nearby. A surface water sample was obtained from water on the inside of the reeds.

Plate 11 – Small Farm Dam 2

2.4.12 Site 12 (*W16730/009*)

Site 12 was a small farm dam located in the eastern half of the Rosedale site. Again, reeds were observed around the edge of the dam and a surface water sample was obtained from the clearer water on the inside of the reeds (*approximately 3m from the edge of the dam*).

Plate 12 – Small Farm Dam 3

2.4.13 Site 13 (*W16730/010*)

Site 13 was a small to medium sized farm dam located in the north of the Rosedale site. Reeds were observed around the edge of the dam and a surface water sample was obtained from approximately 2.5m from the edge of the dam. Overflow from this dam is directed towards sample Site 5 (*refer **Section 2.4.5***).

Plate 13 – Small/Medium Farm Dam 4

2.5 BED SEDIMENT SAMPLING STATIONS

Samples of bed sediment were collected and analysed from Site 1, Site 2, Site 3 and Site 6 (*refer water quality sampling stations, above*). A summary of selected results are presented in **Section** Error! Reference source not found.. Complete results are included in **Appendix A**.

2.6 WEATHER CONDITIONS

Surface water quality and bed sediment sampling was undertaken on site between 10:00am and 4:00pm on Wednesday 15th March 2006. Weather observations were made on site during sampling and data obtained from the Bureau of Meteorology (*BOM*) for the Batemans Bay (*Catalina Country Club*) station (*Stn No. 069134*). Data from the BoM state that no rain fell in the three weeks prior to 15th March 2006 and that 3.4mm of rain fell on the date of sampling. On-site observations suggest that this rainfall was prior to sampling being undertaken, which commenced at approximately at 10:00am. The weather on the date of sampling was observed to be generally overcast with light breezes ranging from SSW to NNE.

2.7 QUALITY ASSURANCE / MEASUREMENT ACCURACY

All samples were tested by a NATA certified laboratory. Copies of all original data testing certificates are provided along with information detailing the laboratories' quality assurance results (*refer **Appendix A***).

2.8 WATER QUALITY COMPARISON DATA

The results of the baseline surface water quality are compared with the ANZECC (*2000*) trigger values for freshwater lowland rivers in south eastern Australia. These values can be found in **Table 2.2**.

Trigger values from the ANZECC Guidelines for Fresh and Marine Water Quality (*2000*) have been used as measures for appropriate water quality within the pond and wetland systems. These trigger values indicate the concentrations which, if exceeded, may present a *potential* environmental problem. Comparison of the collected baseline data with ANZECC values provides a useful positioning exercise, indicating the current health and quality of the surface and receiving water in and around the site.

Additionally, sampled values for Total Suspended Solids (*TSS*), Total Nitrogen (*TN*) and Total Phosphorous (*TP*) have been compared with data published by the Cooperative Research Centre for Catchment Hydrology (*CRCCH, Fletcher et al, 2004. The CRCCH is now formally part of the eWater Cooperative Research Centre*). Typical values and ranges (*i.e.: characteristic upper and lower limits*) for pollutants presented in this publication represent a comprehensive review of published pollutant concentrations during both wet and dry weather events both in Australia and overseas, with a weighted preference given to local (*i.e.: Australian and NSW*) data. Comparison with the CRCCH published data will assist in the development of appropriate water quality targets for the proposed development and aid the accurate design of suitable surface water quality management strategies and structures for the site.

Typical values and ranges for a variety of land uses from the CRCCH published data is provided for comparison and discussion in **Table 3.1**, **Table 3.2** and **Table 3.3**.

Table 2.2 - Example ANZECC 2000 Trigger Values (*for Lowland Rivers*)

Parameter	Units	ANZECC[1]
Suspended Solids	mg/L	50
BOD_5	mg O^2/L	15
Total Nitrogen	mg/L	0.50
Ammonia – N	mg/L	0.02
Total Kjeldahl Nitrogen	mg/L	-
Nitrate	mg/L	NO_x (i.e. $NO_3 + NO_2$) < 0.04
Nitrite	mg/L	
Total Phosphorous	mg/L	0.05
Faecal Coliforms	cfu/ 100 ml	150 PC
Grease and Oil (Hexane)	mg/L	-
Chlorophyll-a	mg/L	3
Turbidity	NTU	50

Dissolved Metals:

Arsenic	mg/L	13
Cadmium	mg/L	0.2
Copper	mg/L	1.4
Chromium	mg/L	1
Nickel	mg/L	11
Lead	mg/L	3.4
Zinc	mg/L	8
Mercury	mg/L	0.6

1. Derived from ANZECC, 2000 for freshwater ecosystems (trigger values for lowland rivers – south eastern Australia).

3 MONITORING RESULTS

3.1 SURFACE WATER QUALITY MONITORING RESULTS

The surface water quality test results are summarised in **Table 3.4**. Further details, including a breakdown of phenolic compounds**,** OC/OP's, oil/grease and specific algal ID information are provided in **Appendix A**.

3.1.1 Nitrogen (*TN*)

Levels of nitrogen, particularly in the forms of Ammonia and Total Nitrogen, were elevated above the ANZECC (*2000*) trigger values for all locations within the Rosedale site. Most sampling sites were either in dams or relatively stationary ponds of water (*at time of sampling*). Hence the elevated ammonia and total nitrogen levels may be accounted for by a combination of anaerobic decay of organic matter and the presence of mammal and avian faecal matter.

Table 3.1 - Total Nitrogen Comparison with CRCCH Data

TN (*mg/L*)	**Land Use**				***Rosedale Average***
	Forest	**Rural**	**Agricultural**	**General Urban**	
Lower Limit	0.08	0.4	0.4	0.4	-
Typical Value	0.3	0.9	1.1	1.3	***1.75***
Upper Limit	1	2	3	4	-

A comparison of the tested levels of total nitrogen with the CRCCH published typical values shows they are currently elevated above the typical value for land use classed as General Urban. They are, however, well within the defined range for agricultural land use.

3.1.2 Phosphorous (*TP*)

Levels of total phosphorous were found to be within ANZECC (*2000*) guidelines for most samples however those taken in Bevian Wetland (*Sites 8 and 9*) were up to nine times greater than the ANZECC trigger value for freshwater ecosystems. This may be due to a number of reasons, including an accumulation of phosphorous in run-off from the site, the release of phosphorous from sediment in the active wetland system and/or a source of phosphorous external to (*upstream of*) the Rosedale site.

Table 3.2 - Total Phosphorous Comparison with CRCCH Data

TP (*mg/L*)	Land Use				*Rosedale Average*
	Forest	Rural	Agricultural	General Urban	
Lower Limit	0.01	0.02	0.03	0.04	-
Typical Value	0.03	0.06	0.09	0.14	***0.089***
Upper Limit	0.09	0.2	0.3	0.5	-

Comparison with the CRCCH published data shows the Rosedale average concentration of TP to be approximate to the typical value corresponding to agricultural land use.

3.1.3 Suspended Solids (*TSS*)

Levels of suspended solids in the water samples collected were less than the relevant ANZECC (*2000*) trigger value at all locations except Site 6 (*adjacent the eastern boundary*). Site 6 recorded levels of TSS were only marginally elevated above the trigger value. This may in part be due to the very low water levels within the pools from which the samples were taken.

Table 3.3 - Total Suspended Solids Comparison with CRCCH Data

TSS (*mg/L*)	Land Use				*Rosedale Average*
	Forest	Rural	Agricultural	General Urban	
Lower Limit	2	5	8	5	-
Typical Value	6	14	20	16	***27.2***
Upper Limit	20	40	50	50	-

The Rosedale average for the concentration of total suspended solids within the samples is elevated above the CRCCH typical value for all land uses but remains, however, closest to that corresponding to agricultural land use.

3.1.4 Faecal Coliforms

Faecal coliforms, which are used as an indicator of the potential for other pathogens, were generally compliant to ANZECC (*2000*) trigger values across all sites. Only Site 6 recorded a significantly elevated reading of 8000 cfu/100mL and Site 9 recording a borderline reading of 150 cfu/100mL. The increased presence of coliforms at Site 6 may be caused by increased animal activity near to the sampling site.

3.1.5 Chlorophyll-a/Algal ID

Chlorophyll-a is used as an indicator of algal activity in aquatic ecosystems and may be used to identify the potential for algal blooms. Levels of chlorophyll-a were reasonably higher than ANZECC (*2000*) trigger values at all sites sampled. This is most likely related to the high levels of TN and ammonia also found at all sites. A complete breakdown of algal species identified at each sampling site is presented in **Appendix A**.

Table 3.4 - Rosedale Baseline Surface Water Quality Sampling Summary

Component	Unit	Detection Limit	ANZECC[1]	Site 1	Site 2	Site 3	Site 4	Site 6*	Site 8	Site 9	Site 11	Site 12	Site 13
				(W16730/001)	*(W16730/002)*	*(W16730/003)*	*(W16730/004)*	*(W16730/005)*	*(W16730/006)*	*(W16730/007)*	*(W16730/008)*	*(W16730/009)*	*(W16730/010)*
BOD_5	mg O^2/L	2	15	2	4	3	3	6	**20**	3	4	3	6
Suspended Solids	mg/L	1	50	11	3	14	8	**72**	41	29	21	27	46
Hardness	mg/L	0.1	-	19	62	55	64	2153	135	136	22	22	32
Total Nitrogen	mg/L	0.05	0.50	**0.95**	**0.84**	**0.81**	**0.88**	**2.3**	**5.1**	**2.8**	**0.98**	**1.3**	**1.5**
TKN	mg/L	0.02	-	0.95	0.84	0.81	0.88	2.3	5.1	2.8	0.98	1.3	1.5
Ammonia	mg/L	0.02	0.02	**0.17**	**0.12**	**0.10**	**0.12**	**0.61**	**0.77**	**0.54**	**0.13**	**0.19**	**0.04**
Nitrites (NO_2)	mg/L	0.002	NO_x (*i.e.:* $NO_2 + NO_3$) < 0.04	0.008	0.004	0.004	0.004	0.015	0.013	0.021	0.008	0.009	0.006
Nitrates (NO_3)	mg/L	0.04		<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Total Phosphorous	mg/L	0.005	0.05	0.025	0.018	0.022	0.020	<0.005	**0.45**	**0.20**	0.009	0.010	0.043
Ortho-Phosphorous	mg/L	0.004	-	<0.004	<0.004	<0.004	<0.004	<0.004	0.089	0.042	<0.004	<0.004	<0.004
PAH's	mg/L	0.001	-	***Refer Appendix A***									
Faecal Coliforms	cfu/100ml	1	150 PC	50	30	40	8	**8000**	130	**150**	40	54	68
Chlorophyll-a	mg/L	0.1	3	**22**	**4.4**	**9.0**	**9.0**	**4.6**	**530**	**40**	**25**	**42**	**110**
Dissolved Metals:													
Arsenic**	mg/L	15	13	<15	<15	<15	<15	**830**	<15	<15	<15	<15	<15
Cadmium	mg/L	0.05	0.2	**0.42**	<0.05	**0.84**	0.07	*<1*	**0.25**	<0.05	<0.05	<0.05	<0.05
Copper	mg/L	1	1.4	**54**	<1	**95**	**21**	**120**	**19**	**18**	<1	<1	<1
Chromium**	mg/L	2	1	<2	<2	<2	<2	*<5*	<2	**3**	<2	<2	<2
Nickel	mg/L	5	11	<5	<5	<5	<5	**40**	<5	<5	<5	<5	<5
Lead	mg/L	0.2	3.4	**4.0**	<0.2	**98**	1.9	*<15*	2.2	**8.2**	<0.2	<0.2	<0.2
Zinc	mg/L	5	8	<5	<5	<5	<5	**270**	<5	<5	<5	<5	<5
Mercury	mg/L	0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

1. Derived from ANZECC, 2000 for freshwater aquatic ecosystems (trigger values for lowland river – south eastern Australia). Dissolved metal trigger values provide a level of protection for 95% of species.
2. Figures in normal case satisfy ANZEC 2000 guidelines
3. Figures in **Bold and Shaded** do not achieve ANZEC 2000 guidelines

* The sample collected at Site 6 was unable to be re-tested at a higher detection limit for Cadmium, Chromium and Lead.
** Indeterminate results. Detection limits are above ANZECC 2000 guidelines due to testing methods used. The minor difference between detection limit and ANZECC trigger value in each case is not considered significant.

3.1.6 Dissolved Metals

Water samples taken were analysed for the dissolved metals arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc. The results in **Table 3.4** were compared to the *ANZECC (2000)* trigger values for protection of 95% of species in fresh water, with the following observations:

- Elevated levels of arsenic, copper, nickel and zinc were found at Site 6 (*creek adjacent eastern boundary*). The elevated recorded levels may be due to point source pollution of the small pools from which the samples were taken (*It is noted that Site 12, which drains to Site 6, recorded levels below detection limits for all heavy metals*). All other sites were at or below ANZECC (*2000*) trigger values for these metals.
- Elevated levels of cadmium, copper, and lead were recorded at Site 1 and Site 3, at the outlet to two of the large farm dams. The combination of these three elements in elevated concentrations at these locations is thought to be a result of the local geology and the possible presence of iron oxides within the clayey soils. Increased levels of cadmium may also result from the use phosphatic fertilizers.
- Marginally elevated levels of certain dissolved metals were also found within the wetland (*Bevian Wetland*). Samples obtained from Site 8 recorded slightly elevated of copper and cadmium while Site 9 recorded concentrations above ANZECC (*2000*) trigger values for copper, chromium and lead. Site 4 recorded a slightly elevated level of copper. Again, the increased concentrations of dissolved metals at these locations are expected to result from the surrounding geology.
- Levels of mercury were below ANZECC (*2000*) trigger values for all sites.

3.1.7 Summary

The concentrations of pollutants in the sampled surface water within the site and the samples obtained from receiving waters adjacent the site were generally found to be at or below ANZECC (*2000*) for most parameters, with the exceptions of total nitrogen, ammonia and chlorophyll-a. This is thought to be due to the anaerobic decay of organic matter at or near the sampling locations and the uptake of available nutrients by algae (*in the case of chlorophyll-a*).

Some sites recorded concentrations of certain dissolved metals (*mainly cadmium, copper and lead*) above ANZECC (*2000*) trigger values. This is expected to have resulted from the surrounding geology.

In addition, comparison with the published CRCCH data for TSS, TP, TN suggests that, for modelling purposes, the Rosedale site is equivalent to an agricultural landscape.

Resultant to comparison with CRCCH data, it is recommended that any water quality targets that are to be achieved by future development of the Rosedale Urban Expansion Site be compared with a rural landscape, which would result in a significant improvement in receiving water quality downstream of the site.

3.2 BED SEDIMENT QUALITY MONITORING RESULTS

Bed sediment samples were collected from Site 1, Site 2, Site 3 and Site 6 (*also refer **Figure 1***).

A summary of selected results from the bed sediment quality analysis are presented in **Table 3.5**. Further details are provided in **Appendix A**.

Table 3.5 - Rosedale Bed Sediment Sampling Summary

Component	Unit	Detection Limit	ANZECC[1]	Site 1 (*W16917/ 001*)	Site 2 (*W16917/ 002*)	Site 3 (*W16917/ 003*)	Site 6 (*W16917/ 004*)
Moisture	%	1%	-	57%	88%	48%	42%
Total PAH's	mg/kg	0.5	4.00	***Refer Appendix A***			
Metals:							
Arsenic	mg/kg	2	20	13	1.3	11	5.6
Copper	mg/kg	5	65	63	**65**	42	34
Chromium	mg/kg	2	80	57	22	9.5	10
Lead	mg/kg	10	50	35	11	11	15
Zinc	mg/kg	10	200	90	50	38	34
Mercury	mg/kg	0.10	0.15	<0.10	<0.10	<0.10	<0.10

1. Derived from ANZECC (*2000*) low range trigger values from the Interim Sediment Quality Guidelines (*ISQG*).

Assessment of the presence of metals within the bed sediment of dams in the Rosedale urban expansion zone showed only a minor accumulation of copper at or above ANZECC (*2000*) trigger levels at sediment sampling site 2.

All other metals detected in the bed sediments locations were below the low-range trigger values (*interim sediment quality guideline values*) as presented in ANZECC (*2000*).

4 CONCLUSIONS

Baseline water quality monitoring was undertaken to assess the quality of surface waters within and around the Rosedale Urban Expansion Site prior to development.

Baseline water quality monitoring was undertaken at ten locations around the site and sediment sampling and analysis was undertaken at four locations. It was noticeable that the creeks immediately downstream of the site only flow in wet weather and do not have standing water in dry weather. No water or sediment samples were obtained from these sites.

Analysis of the samples has revealed that water bodies within and around the site contain elevated levels of ammonia and total nitrogen, well above ANZECC (*2000*) guidelines for freshwater lowland river system in south-eastern New South Wales. Similarly there are elevated levels of chlorophyll-a in and around the site, highlighting the potential for algal blooms to occur. Analysis of the bed sediment samples taken revealed that only one site recorded a marginally elevated level of copper.

Comparison of the collected TSS, TN and TP data with widely accepted published values applicable to a range of differing land use settings in Australia has indicated that the Rosedale Urban Expansion Site closely approximates an agricultural landscape. Adoption, therefore, of a rural land use category as a target for runoff water quality for the proposed development would result in a significant improvement in receiving water quality.

Water quality and bed sediment sampling results presented in this report can provide baseline data with which to compare the results of similar monitoring schemes undertaken during and post development of the site. This will allow an assessment of the impact, if any, of development of the Rosedale Urban Expansion Site on the quality of water and health of receiving waters.

5 REFERENCES

1. Australian and New Zealand Environment and Conservation Council (*ANZECC*), *Australian and New Zealand Guidelines for Fresh and Marine Water Quality,* 2000.

2. Ecowise Environmental, *Ulladulla Sampling Site Descriptions (Batemans Bay),* March 2006.

3. Ecowise Environmental, *Replacement Analytical Report: Report Number W06/1247-1,* (*Surface Water Quality Analysis*), April 2006.

4. Ecowise Environmental, *Analytical Report: Report Number W06/1269,* (*Bed Sediment Analysis*), April 2006.

5. Ecowise Environmental, *Analytical Report: Report Number W06/1247-1,* (*Algal ID Analysis*), April 2006.

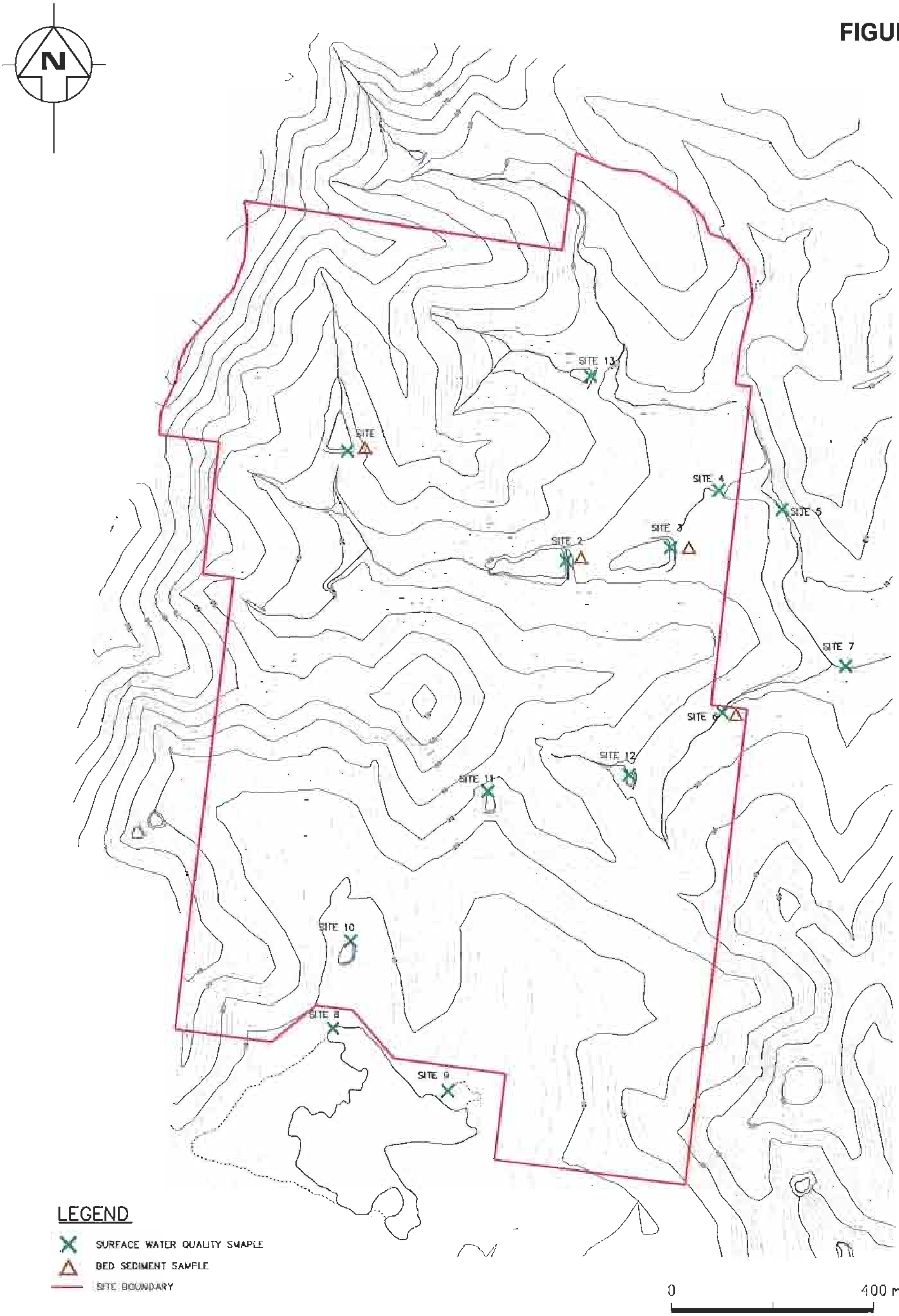
6. Ecowise Environmental, *Replacement Analytical Report: Report Number W06/2178-1,* (*Surface Water Dissolved Metals Re-Test Analysis*), May 2006.

7. Fletcher et al; CRCCH, *Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures – A Review and Gap Analysis: Technical Report 04/08,* December 2004.

8. Patterson Britton and Partners, *Rosedale, Batemans Bay Proposed Residential Development Water Management Strategy,* Issue No. 3, November 2002.

FIGURES

FIGURE 1



Patterson Britton
& Partners Pty Ltd

consulting engineers
4561-01 *ROSEDALE URBAN EXPANSION ZONE*

ROSEDALE, BATESMAN BAY
BASELINE WATER QUALITY AND
BED SEDIMENT SAMPLING STATIONS

APPENDIX A – ECOWISE ENVIRONMENTAL REPORT, APRIL 2006

Ecowise Environmental

Patterson Britton + Partners
Ulladulla Sampling Site Descriptions (Batemans Bay)
15/3/06 – Date of Sampling

Weather – Overcast with rain previous evening

Site 1 – Dam 3.00pm
GPS 247301E, 6033135N
The start of the 3 dams, tree on the top side of dam, reeds and some lily's, a lot of birds, Sample point 2.5m in and 400mm deep near the exit (overflow).

Site 2 – Dam 1.00pm
GPS 247722E, 6032882N
Just up from Site 3 sample taken near the exit (overflow) point of the dam. Big dam with reeds around sides, some cattle in the paddock, sample taken 2.5m in and 300-400mm deep, sediment taken from edge.

Site 3 – Dam 1.30pm
GPS 247934E, 6032912N
Big Dam, reeds around sampling point near overflow exit, sampled 2.5m in and 400mm deep, sediment sampled from round the edge. Just down from Site 2. Overflow from Site 2 would flow into Site 3.

Site 4 – Creek 2.30pm
GPS 248039E, 6033078N
Sample taken on the boundary line, just off road in a small creek/dam.

Site 5 – Creek 2.00pm - DRY
GPS 248142E, 6033034N
Sample point about 100 to 150 m downsteam from Site 4. Where the two creeks join and then about 25m on. In a small rainforest like environment. Sample point was dry.

Site 6 – Creek 2.30pm
GPS 247955E, 6032568N
50 to 100m down from Site 12 (Dam) near two trees marked with an X, 1 to 2 pools of water, very low on boundary. Very hard to get the sample due to low water levels. 2 sediment samples.

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Site 7 – Creek 12.40pm - DRY
GPS 248139E, 6032671N
From boundary 200m down from where both creeks join there is a steel pipe/bridge. No sample taken as it was dry. Big Black snake observed – no further sampling pursued.

Site 8 – Wetlands 10.00am
GPS 247340E, 6032019N
On the first bend of Bevian River, 10 – 15m to shore line sample taken 2m to 2.5m from shore line and 300mm deep of tree in photo.

Site 9 – Wetlands 4.00pm
GPS 247562E, 6031894N
About 500m to 1 km in a straight line across from Site No 8, sample taken 2.5m in but near the surface as wetland was quite shallow.

Site 10 – Dam (New) 10.30pm - DRY
GPS 247298E, 6032062N
On the same bend as Site 9 but 50m inland. Photo 3 sample point. Photo 4 taken from Bevian road. Some reeds, cow prints and faeces on side of road but dam was dry.

Site 11 - Dam (New) 11.00pm - DRY
GPS 247578E, 6032439N
About 1km up the road from Site 8, 50m inland. Sample taken from inside of the reeds. Photo 5 sample point, Photo 6 taken from the road

Site 12 - Dam (New) 11.30pm
GPS 247856E, 6032470N
100m up from Site 11 is a gate, about 1km through the paddocks. Tree on the upper side of the dam, reeds around the edge. Sample taken in the dam on the inside of the reeds about 3m in and 400 mm deep.

Site 13 – Dam (new) 3.30pm
GPS 247780E, 6033272N
Sample taken in a dam, Sample point 2.5m in and 400mm near overflow point (on far side of the reeds). Overflow runs into Site 5.

Ecowise Environmental

Replacement Analytical Report

Patterson Britton & Partners Pty Ltd		Contact Name:	**Oliver Roborgh**
PO Box 515			
North Sydney		Report Number:	**W06/1247-1**
NSW, 2059			
		Sample(s) Collected:	**17/03/2006**
Phone:	**02 9957 1619**	Client Reference:	**Rosedale**
Fax:	**02 9957 1291**	Batch Number:	**W16730**

Notes:

OCP, OPP, PAH and Speciated Phenols analysed by Ecowise Report No.923727, NATA Accreditation No.1205

Symbols Used:
< = less than.
> = greater than.
MPN = Most Probable Number.
cfu = Colony Forming Units.
MF = Membrane Filtration Method
(app) = Approximate
(est) = Estimated
The NATA accreditation of Enviro-Managers Pty Ltd does not cover analyses performed by external laboratories.
The results stated in this report relate only to the sample(s) as collected by Enviro-Managers Pty Ltd (Refer procedures in SAM 1, 2, 5, 6, 7, 9 and 10 in LPM)
Samples analysed as received.

Results Approved By:

Valerie Smith
Laboratory Director

Tony de Souza
Microbiologist

NATA Accredited Laboratory
Number. 3628 (Chemical Testing)
Number. 3629 (Biological Testing)

NATA
WORLD RECOGNISED
ACCREDITATION

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Replacement Analytical Report — *Report No: W06/1247-1*

Results:

Client Id		Site 1	Site 2	Site 3	Site 4	Site 6
Laboratory Id		W16730/001	W16730/002	W16730/003	W16730/004	W16730/005
Ammonia (NH3 as N) *Method: WCM084*	*Units: mg/L*	0.17	0.12	0.10	0.12	0.61
Arsenic (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.015	<0.015	<0.015	<0.015	0.83
BOD5 *Method: APHA 5210 B*	*Units: mg O2/L* <2	2	4	3	3	6
Cadmium (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.001	<0.001	<0.001	<0.001	<0.001
Chlorophyll "a" *Method: APHA 10200 H*	*Units: ug/L*	22	4.4	9.0	9.0	4.6
Chromium (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.005	<0.005	<0.005	<0.005	<0.005
Copper (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.010	<0.010	<0.010	<0.010	0.12
Hardness (as CaCO3) *Method: APHA 2340 B*	*Units: mg/L*	19	62	55	64	2153
Lead (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.015	<0.015	<0.015	<0.015	<0.015
Mercury (VGA) *Method: APHA 3112 B*	*Units: mg/L*	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.005	<0.005	<0.005	<0.005	0.04
Nitrate (NO3 as N) *Method: WCM085*	*Units: mg/L*	<0.04	<0.04	<0.04	<0.04	<0.04
Nitrite (NO2 as N) *Method: WCM085*	*Units: mg/L*	0.008	0.004	0.004	0.004	0.015
Orthophosphate as P *Method: WCM089*	*Units: mg/L*	<0.004	<0.004	<0.004	<0.004	<0.004
Thermotolerant (Faecal) coliforms MF *Method: WMM 009 (~AS 4276.7 -1995)*	*Units: /100mL* C1	50	30	40	8	8000
Total Kjeldahl Nitrogen (TKN) *Method: WCM083*	*Units: mg/L*	0.95	0.84	0.81	0.88	2.3
Total Nitrogen (TN) *Method: WCM083*	*Units: mg/L*	0.95	0.84	0.81	0.88	2.3
Total Phosphorus (TP) *Method: WCM090*	*Units: mg/L*	0.025	0.018	0.022	0.020	<0.005

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Replacement Analytical Report — *Report No: W06/1247-1*

Results:						
Client Id		Site 1	Site 2	Site 3	Site 4	Site 6
Laboratory Id		W16730/001	W16730/002	W16730/003	W16730/004	W16730/005
Total Suspended Solids (TSS) *Method: APHA 2540 D*	*Units: mg/L*	11	3	14	8	72
Zinc (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.005	<0.005	<0.005	<0.005	0.27
OCP *Method:*	*Units: mg/L*					
Aldrin		<0.001	<0.001	<0.001	<0.001	<0.001
alpha-BHC		<0.001	<0.001	<0.001	<0.001	<0.001
alpha-Endosulphan		<0.001	<0.001	<0.001	<0.001	<0.001
beta-BHC		<0.001	<0.001	<0.001	<0.001	<0.001
beta-Endosulphan		<0.001	<0.001	<0.001	<0.001	<0.001
Chlordane		<0.001	<0.001	<0.001	<0.001	<0.001
delta-BHC		<0.001	<0.001	<0.001	<0.001	<0.001
Dieldrin		<0.001	<0.001	<0.001	<0.001	<0.001
Endosulphan Sulphate		<0.001	<0.001	<0.001	<0.001	<0.001
Endrin		<0.001	<0.001	<0.001	<0.001	<0.001
Endrin Aldehyde		<0.001	<0.001	<0.001	<0.001	<0.001
gamma-BHC (Lindane)		<0.001	<0.001	<0.001	<0.001	<0.001
Heptachlor		<0.001	<0.001	<0.001	<0.001	<0.001
Heptachlor Epoxide		<0.001	<0.001	<0.001	<0.001	<0.001
Hexachlorobenzene		<0.001	<0.001	<0.001	<0.001	<0.001
Methoxychlor		<0.001	<0.001	<0.001	<0.001	<0.001
o,p'-DDD		<0.001	<0.001	<0.001	<0.001	<0.001
o,p'-DDE		<0.001	<0.001	<0.001	<0.001	<0.001
o,p'-DDT		<0.001	<0.001	<0.001	<0.001	<0.001
OPP *Method:*	*Units: mg/L*					
Chlorpyrifos		<0.001	<0.001	<0.001	<0.001	<0.001
Diazinon		<0.001	<0.001	<0.001	<0.001	<0.001
Dichlorvos		<0.001	<0.001	<0.001	<0.001	<0.001
Ethion		<0.001	<0.001	<0.001	<0.001	<0.001
Fenthion		<0.001	<0.001	<0.001	<0.001	<0.001
Malathion		<0.001	<0.001	<0.001	<0.001	<0.001

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Replacement Analytical Report | **Report No: W06/1247-1**

Results:						
Client Id		Site 1	Site 2	Site 3	Site 4	Site 6
Laboratory Id		W16730/001	W16730/002	W16730/003	W16730/004	W16730/005
Mevinphos (Phosdrin)		<0.001	<0.001	<0.001	<0.001	<0.001
Parathion		<0.001	<0.001	<0.001	<0.001	<0.001
Ronnel		<0.001	<0.001	<0.001	<0.001	<0.001
PAH						
Method:	*Units: mg/L*					
Acenaphthene		<0.001	<0.001	<0.001	<0.001	<0.001
Acenaphthylene		<0.001	<0.001	<0.001	<0.001	<0.001
Anthracene		<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(a)anthracene		<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(a)pyrene		<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(b)&(k)fluoranthene		<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(b)fluoranthene		<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(g,h,i)perylene		<0.001	<0.001	<0.001	<0.001	<0.001
Chrysene		<0.001	<0.001	<0.001	<0.001	<0.001
Dibenzo(a,h)anthracene		<0.001	<0.001	<0.001	<0.001	<0.001
Fluoranthene		<0.001	<0.001	<0.001	<0.001	<0.001
Fluorene		<0.001	<0.001	<0.001	<0.001	<0.001
Indeno(1,2,3-c,d)pyrene		<0.001	<0.001	<0.001	<0.001	<0.001
Naphthalene		<0.001	<0.001	<0.001	<0.001	<0.001
Phenanthrene		<0.001	<0.001	<0.001	<0.001	<0.001
Pyrene		<0.001	<0.001	<0.001	<0.001	<0.001
Speciated Phenols						
Method:	*Units: mg/L*					
2,3,4,6-Tetrachlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
2,4 Dimethyl Phenol		<0.001	<0.001	<0.001	<0.001	<0.001
2,4,5-Trichlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
2,4,6-Trichlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
2,4-Dichlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
2-Chlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
2-Nitrophenol		<0.001	<0.001	<0.001	<0.001	<0.001
4-chloro-3-methylphenol		<0.001	<0.001	<0.001	<0.001	<0.001
4-Nitrophenol		<0.001	<0.001	<0.001	<0.001	<0.001
Cresol (total)		<0.003	<0.003	<0.003	<0.003	<0.003

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SYDNEY 02 4721 3477

Results:

Client Id		**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 6**
Laboratory Id		**W16730/001**	**W16730/002**	**W16730/003**	**W16730/004**	**W16730/005**
Pentachlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
Phenols		<0.002	<0.002	<0.002	<0.002	<0.002

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Enviro-Managers Pty Ltd trading as Ecowise Environmental ABN 18 072 428 810 www.ecowise.com.au (Subsidiary of ActewAGL)

Replacement Analytical Report | **Report No: W06/1247-1**

Results:						
Client Id		**Site 8**	**Site 9**	**Site 11**	**Site 12**	**Site 13**
Laboratory Id		**W16730/006**	**W16730/007**	**W16730/008**	**W16730/009**	**W16730/010**
Ammonia (NH_3 as N) *Method: WCM084*	*Units: mg/L*	0.77	0.54	0.13	0.19	0.04
Arsenic (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.015	<0.015	<0.015	<0.015	<0.015
BOD5 *Method: APHA 5210 B*	*Units: mg O2/L*	20	3	4	3	6
Cadmium (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.001	<0.001	<0.001	<0.001	<0.001
Chlorophyll "a" *Method: APHA 10200 H*	*Units: ug/L*	530	40	25	42	110
Chromium (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.005	<0.005	<0.005	<0.005	<0.005
Copper (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.010	<0.010	<0.010	<0.010	<0.010
Hardness (as $CaCO_3$) *Method: APHA 2340 B*	*Units: mg/L*	135	136	22	22	32
Lead (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.015	<0.015	<0.015	<0.015	<0.015
Mercury (VGA) *Method: APHA 3112 B*	*Units: mg/L*	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel (ICP) *Method: APHA 3120 B*	*Units: mg/L*	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrate (NO_3 as N) *Method: WCM085*	*Units: mg/L*	<0.04	<0.04	<0.04	<0.04	<0.04
Nitrite (NO_2 as N) *Method: WCM085*	*Units: mg/L*	0.013	0.021	0.008	0.009	0.006
Orthophosphate as P *Method: WCM089*	*Units: mg/L*	0.089	0.042	<0.004	<0.004	<0.004
Thermotolerant (Faecal) coliforms MF *Method: WMM 009 (~AS 4276.7 -1995)*	*Units: /100mL*	130	150	40	54	68
Total Kjeldahl Nitrogen (TKN) *Method: WCM083*	*Units: mg/L*	5.1	2.8	0.98	1.3	1.5
Total Nitrogen (TN) *Method: WCM083*	*Units: mg/L*	5.1	2.8	0.98	1.3	1.5
Total Phosphorus (TP) *Method: WCM090*	*Units: mg/L*	0.45	0.20	0.009	0.010	0.043

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Ecowise Environmental

Replacement Analytical Report	*Report No: W06/1247-1*

Results:						
Client Id		**Site 8**	**Site 9**	**Site 11**	**Site 12**	**Site 13**
Laboratory Id		**W16730/006**	**W16730/007**	**W16730/008**	**W16730/009**	**W16730/010**
Total Suspended Solids (TSS)						
Method: APHA 2540 D	*Units: mg/L*	41	29	21	27	46
Zinc (ICP)						
Method: APHA 3120 B	*Units: mg/L*	<0.005	<0.005	<0.005	<0.005	<0.005
OCP						
Method:	*Units: mg/L*					
Aldrin		<0.001	<0.001	<0.001	<0.001	<0.001
alpha-BHC		<0.001	<0.001	<0.001	<0.001	<0.001
alpha-Endosulphan		<0.001	<0.001	<0.001	<0.001	<0.001
beta-BHC		<0.001	<0.001	<0.001	<0.001	<0.001
beta-Endosulphan		<0.001	<0.001	<0.001	<0.001	<0.001
Chlordane		<0.001	<0.001	<0.001	<0.001	<0.001
delta-BHC		<0.001	<0.001	<0.001	<0.001	<0.001
Dieldrin		<0.001	<0.001	<0.001	<0.001	<0.001
Endosulphan Sulphate		<0.001	<0.001	<0.001	<0.001	<0.001
Endrin		<0.001	<0.001	<0.001	<0.001	<0.001
Endrin Aldehyde		<0.001	<0.001	<0.001	<0.001	<0.001
gamma-BHC (Lindane)		<0.001	<0.001	<0.001	<0.001	<0.001
Heptachlor		<0.001	<0.001	<0.001	<0.001	<0.001
Heptachlor Epoxide		<0.001	<0.001	<0.001	<0.001	<0.001
Hexachlorobenzene		<0.001	<0.001	<0.001	<0.001	<0.001
Methoxychlor		<0.001	<0.001	<0.001	<0.001	<0.001
o,p'-DDD		<0.001	<0.001	<0.001	<0.001	<0.001
o,p'-DDE		<0.001	<0.001	<0.001	<0.001	<0.001
o,p'-DDT		<0.001	<0.001	<0.001	<0.001	<0.001
OPP						
Method:	*Units: mg/L*					
Chlorpyrifos		<0.001	<0.001	<0.001	<0.001	<0.001
Diazinon		<0.001	<0.001	<0.001	<0.001	<0.001
Dichlorvos		<0.001	<0.001	<0.001	<0.001	<0.001
Ethion		<0.001	<0.001	<0.001	<0.001	<0.001
Fenthion		<0.001	<0.001	<0.001	<0.001	<0.001
Malathion		<0.001	<0.001	<0.001	<0.001	<0.001

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Ecowise Environmental

Replacement Analytical Report	*Report No: W06/1247-1*

Results:

Client Id		Site 8	Site 9	Site 11	Site 12	Site 13
Laboratory Id		W16730/006	W16730/007	W16730/008	W16730/009	W16730/010
Mevinphos (Phosdrin)		<0.001	<0.001	<0.001	<0.001	<0.001
Parathion		<0.001	<0.001	<0.001	<0.001	<0.001
Ronnel		<0.001	<0.001	<0.001	<0.001	<0.001
PAH						
Method:	*Units: mg/L*					
Acenaphthene		<0.001	<0.001	<0.001	<0.001	<0.001
Acenaphthylene		<0.001	<0.001	<0.001	<0.001	<0.001
Anthracene		<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(a)anthracene		<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(a)pyrene		<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(b)&(k)fluoranthene		<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(b)fluoranthene		<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(g,h,i)perylene		<0.001	<0.001	<0.001	<0.001	<0.001
Chrysene		<0.001	<0.001	<0.001	<0.001	<0.001
Dibenzo(a,h)anthracene		<0.001	<0.001	<0.001	<0.001	<0.001
Fluoranthene		<0.001	<0.001	<0.001	<0.001	<0.001
Fluorene		<0.001	<0.001	<0.001	<0.001	<0.001
Indeno(1,2,3-c,d)pyrene		<0.001	<0.001	<0.001	<0.001	<0.001
Naphthalene		<0.001	<0.001	<0.001	<0.001	<0.001
Phenanthrene		<0.001	<0.001	<0.001	<0.001	<0.001
Pyrene		<0.001	<0.001	<0.001	<0.001	<0.001
Speciated Phenols						
Method:	*Units: mg/L*					
2,3,4,6-Tetrachlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
2,4 Dimethyl Phenol		<0.001	<0.001	<0.001	<0.001	<0.001
2,4,5-Trichlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
2,4,6-Trichlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
2,4-Dichlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
2-Chlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
2-Nitrophenol		<0.001	<0.001	<0.001	<0.001	<0.001
4-chloro-3-methylphenol		<0.001	<0.001	<0.001	<0.001	<0.001
4-Nitrophenol		<0.001	<0.001	<0.001	<0.001	<0.001
Cresol (total)		<0.003	<0.003	<0.003	<0.003	<0.003

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Replacement Analytical Report — *Report No: W06/1247-1*

Results:

Client Id		Site 8	Site 9	Site 11	Site 12	Site 13
Laboratory Id		W16730/006	W16730/007	W16730/008	W16730/009	W16730/010
Pentachlorophenol		<0.001	<0.001	<0.001	<0.001	<0.001
Phenols		<0.002	<0.002	<0.002	<0.002	<0.002

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Replacement Analytical Report **_Report No: W06/1247-1_**

Results:						
Client Id		**Site 1 QA**	**Site 3 QA**			
Laboratory Id		**W16730/011**	**W16730/012**			
Ammonia (NH3 as N) *Method: WCM084*	*Units: mg/L*	-	-			
Arsenic (ICP) *Method: APHA 3120 B*	*Units: mg/L*	-	-			
BOD5 *Method: APHA 5210 B*	*Units: mg O2/L*	-	-			
Cadmium (ICP) *Method: APHA 3120 B*	*Units: mg/L*	-	-			
Chlorophyll "a" *Method: APHA 10200 H*	*Units: ug/L*	-	-			
Chromium (ICP) *Method: APHA 3120 B*	*Units: mg/L*	-	-			
Copper (ICP) *Method: APHA 3120 B*	*Units: mg/L*	-	-			
Hardness (as CaCO3) *Method: APHA 2340 B*	*Units: mg/L*	-	-			
Lead (ICP) *Method: APHA 3120 B*	*Units: mg/L*	-	-			
Mercury (VGA) *Method: APHA 3112 B*	*Units: mg/L*	-	-			
Nickel (ICP) *Method: APHA 3120 B*	*Units: mg/L*	-	-			
Nitrate (NO3 as N) *Method: WCM085*	*Units: mg/L*	-	-			
Nitrite (NO2 as N) *Method: WCM085*	*Units: mg/L*	-	-			
Orthophosphate as P *Method: WCM089*	*Units: mg/L*	-	-			
Thermotolerant (Faecal) coliforms MF *Method: WMM 009 (~AS 4276.7 -1995)*	*Units: /100mL*	-	-			
Total Kjeldahl Nitrogen (TKN) *Method: WCM083*	*Units: mg/L*	-	-			
Total Nitrogen (TN) *Method: WCM083*	*Units: mg/L*	-	-			
Total Phosphorus (TP) *Method: WCM090*	*Units: mg/L*	-	-			

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Replacement Analytical Report — *Report No: W06/1247-1*

Results:

Client Id		**Site 1 QA**	**Site 3 QA**			
Laboratory Id		**W16730/011**	**W16730/012**			
Total Suspended Solids (TSS)						
Method: APHA 2540 D	*Units: mg/L*	-	-			
Zinc (ICP)						
Method: APHA 3120 B	*Units: mg/L*	-	-			
OCP						
Method:	*Units: mg/L*					
Aldrin		<0.001	<0.001			
alpha-BHC		<0.001	<0.001			
alpha-Endosulphan		<0.001	<0.001			
beta-BHC		<0.001	<0.001			
beta-Endosulphan		<0.001	<0.001			
Chlordane		<0.001	<0.001			
delta-BHC		<0.001	<0.001			
Dieldrin		<0.001	<0.001			
Endosulphan Sulphate		<0.001	<0.001			
Endrin		<0.001	<0.001			
Endrin Aldehyde		<0.001	<0.001			
gamma-BHC (Lindane)		<0.001	<0.001			
Heptachlor		<0.001	<0.001			
Heptachlor Epoxide		<0.001	<0.001			
Hexachlorobenzene		<0.001	<0.001			
Methoxychlor		<0.001	<0.001			
o,p'-DDD		<0.001	<0.001			
o,p'-DDE		<0.001	<0.001			
o,p'-DDT		<0.001	<0.001			
OPP						
Method:	*Units: mg/L*					
Chlorpyrifos		<0.001	<0.001			
Diazinon		<0.001	<0.001			
Dichlorvos		<0.001	<0.001			
Ethion		<0.001	<0.001			
Fenthion		<0.001	<0.001			
Malathion		<0.001	<0.001			

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Ecowise Environmental

Replacement Analytical Report	*Report No: W06/1247-1*

Results:						
Client Id		**Site 1 QA**	**Site 3 QA**			
Laboratory Id		**W16730/011**	**W16730/012**			
Mevinphos (Phosdrin)		<0.001	<0.001			
Parathion		<0.001	<0.001			
Ronnel		<0.001	<0.001			
PAH						
Method:	*Units: mg/L*					
Acenaphthene		<0.001	<0.001			
Acenaphthylene		<0.001	<0.001			
Anthracene		<0.001	<0.001			
Benzo(a)anthracene		<0.001	<0.001			
Benzo(a)pyrene		<0.001	<0.001			
Benzo(b)&(k)fluoranthene		<0.001	<0.001			
Benzo(b)fluoranthene		<0.001	<0.001			
Benzo(g,h,i)perylene		<0.001	<0.001			
Chrysene		<0.001	<0.001			
Dibenzo(a,h)anthracene		<0.001	<0.001			
Fluoranthene		<0.001	<0.001			
Fluorene		<0.001	<0.001			
Indeno(1,2,3-c,d)pyrene		<0.001	<0.001			
Naphthalene		<0.001	<0.001			
Phenanthrene		<0.001	<0.001			
Pyrene		<0.001	<0.001			
Speciated Phenols						
Method:	*Units: mg/L*					
2,3,4,6-Tetrachlorophenol		<0.001	<0.001			
2,4 Dimethyl Phenol		<0.001	<0.001			
2,4,5-Trichlorophenol		<0.001	<0.001			
2,4,6-Trichlorophenol		<0.001	<0.001			
2,4-Dichlorophenol		<0.001	<0.001			
2-Chlorophenol		<0.001	<0.001			
2-Nitrophenol		<0.001	<0.001			
4-chloro-3-methylphenol		<0.001	<0.001			
4-Nitrophenol		<0.001	<0.001			
Cresol (total)		<0.003	<0.003			

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Ecowise Environmental

Replacement Analytical Report	*Report No: W06/1247-1*

Results:

Client Id		**Site 1 QA**	**Site 3 QA**			
Laboratory Id		**W16730/011**	**W16730/012**			
Pentachlorophenol		<0.001	<0.001			
Phenols		<0.002	<0.002			

Method(s):

APHA 10200 H	Chlorophyll "a"
APHA 2340 B	Hardness (as CaCO3)
APHA 2540 D	Total Suspended Solids (TSS)
APHA 3112 B	Mercury (VGA)
APHA 3120 B	Arsenic (ICP)
APHA 3120 B	Cadmium (ICP)
APHA 3120 B	Chromium (ICP)
APHA 3120 B	Copper (ICP)
APHA 3120 B	Lead (ICP)
APHA 3120 B	Nickel (ICP)
APHA 3120 B	Zinc (ICP)
APHA 5210 B	BOD5
WCM083	Total Kjeldahl Nitrogen (TKN)
WCM083	Total Nitrogen (TN)
WCM084	Ammonia (NH3 as N)
WCM085	Nitrate (NO3 as N)
WCM085	Nitrite (NO2 as N)
WCM089	Orthophosphate as P
WCM090	Total Phosphorus (TP)
WMM 009 (~AS 4276.7 -1995)	Thermotolerant (Faecal) coliforms MF

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Analytical Report

Patterson Britton & Partners Pty Ltd		Contact Name:	**Oliver Roborgh**
PO Box 515			
North Sydney		Report Number:	**W06/1269**
NSW, 2059			
		Sample(s) Collected:	**17/03/2006**
Phone:	**02 9957 1619**	Client Reference:	**Sediment**
Fax:	**02 9957 1291**	Batch Number:	**W16917**

Notes:

OCP, OPP, PAH and Speciated Phenols analysed by Ecowise, Report No.927602, NATA Accreditation No.1205

Sample for metals dried overnight then digested in Aqua Regia for one hour.
The NATA accreditation of Enviro-Managers Pty Ltd does not cover analyses performed by external laboratories.
The results stated in this report relate only to the sample(s) as submitted by the client.

Results Approved By:

Valerie Smith
Laboratory Director

NATA Accredited Laboratory
Number. 3628 (Chemical Testing)
Number. 3629 (Biological Testing)

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Ecowise Environmental

Analytical Report	*Report No: W06/1269*

Results:

Client Id		Site 1	Site 2	Site 3	Site 6	
Laboratory Id		W16917/001	W16917/002	W16917/003	W16917/004	
Arsenic (ICP) *Method: APHA 3120 B*	*Units: mg/kg*	13	1.3	11	5.6	
Cadmium (ICP) *Method: APHA 3120 B*	*Units: mg/kg*	4.4	2.1	1.2	1.6	
Chromium (ICP) *Method: APHA 3120 B*	*Units: mg/kg*	57	22	9.5	10	
Copper (ICP) *Method: APHA 3120 B*	*Units: mg/kg*	63	65	42	34	
Lead (ICP) *Method: APHA 3120 B*	*Units: mg/kg*	35	11	11	15	
Mercury (VGA) *Method: APHA 3120 B*	*Units: mg/kg*	<0.10*	<0.10*	<0.10*	<0.10*	
Moisture (%) *Method: APHA 3120 B*	*Units: %*	57	88	48	42	
Nickel (ICP) *Method: APHA 3120 B*	*Units: mg/kg*	27	17	3.6	7.4	
Zinc (ICP) *Method: APHA 3120 B*	*Units: mg/kg*	90	50	38	34	
OCP *Method:*	*Units: mg/kg*					
Aldrin		<0.10	<0.30	<0.05	<0.10	
alpha-BHC		<0.10	<0.30	<0.05	<0.10	
alpha-Endosulphan		<0.10	<0.30	<0.05	<0.10	
beta-BHC		<0.10	<0.30	<0.05	<0.10	
beta-Endosulphan		<0.10	<0.30	<0.05	<0.10	
Chlordane		<0.20	<0.50	<0.05	<0.20	
DDD		<0.10	<0.30	<0.05	<0.10	
DDE		<0.10	<0.30	<0.05	<0.10	
DDT		<0.10	<0.30	<0.05	<0.10	
delta-BHC		<0.10	<0.30	<0.05	<0.10	
Dieldrin		<0.10	<0.30	<0.05	<0.10	
Endosulphan Sulphate		<0.10	<0.30	<0.05	<0.10	
Endrin		<0.10	<0.30	<0.05	<0.10	
Endrin Aldehyde		<0.10	<0.30	<0.05	<0.10	

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Analytical Report	*Report No: W06/1269*

Results:

Client Id		Site 1	Site 2	Site 3	Site 6	
Laboratory Id		W16917/001	W16917/002	W16917/003	W16917/004	
HCB		<0.10	<0.30	<0.05	<0.10	
Heptachlor		<0.10	<0.30	<0.05	<0.10	
Heptachlor Epoxide		<0.10	<0.30	<0.05	<0.10	
Lindane		<0.10	<0.30	<0.05	<0.10	
Methoxychlor		<0.10	<0.30	<0.05	<0.10	
OPP						
Method:	*Units: mg/kg*					
Chlorpyrifos		<0.2	<0.5	<0.1	<0.2	
Diazinon		<0.2	<0.5	<0.1	<0.2	
Dichlorvos		<0.2	<0.5	<0.1	<0.2	
Ethion		<0.2	<0.5	<0.1	<0.2	
Fenitrothion		<0.2	<0.5	<0.1	<0.2	
Malthion		<0.2	<0.5	<0.1	<0.2	
Mevinphos		<0.2	<0.5	<0.1	<0.2	
Parathion		<0.2	<0.5	<0.1	<0.2	
Ronnel		<0.2	<0.5	<0.1	<0.2	
Stirofos		<0.2	<0.5	<0.1	<0.2	
PAH						
Method:	*Units: mg/kg*					
Acenaphthene		<0.2	<0.5	<0.1	<0.2	
Acenaphthylene		<0.2	<0.5	<0.1	<0.2	
Anthracene		<0.2	<0.5	<0.1	<0.2	
Benzo(a)anthracene		<0.2	<0.5	<0.1	<0.2	
Benzo(a)pyrene		<0.2	<0.5	<0.1	<0.2	
Benzo(b)fluoranthene		<0.2	<0.5	<0.1	<0.2	
Benzo(g,h,i)perylene		<0.2	<0.5	<0.1	<0.2	
Benzo(k)fluoranthene		<0.2	<0.5	<0.1	<0.2	
Chrysene		<0.2	<0.5	<0.1	<0.2	
Dibenzo(a,h)anthracene		<0.2	<0.5	<0.1	<0.2	
Fluoranthene		<0.2	<0.5	<0.1	<0.2	
Fluorene		<0.2	<0.5	<0.1	<0.2	
Indeno(1,2,3-c,d)pyrene		<0.2	<0.5	<0.1	<0.2	
Naphthalene		<0.2	<0.5	<0.1	<0.2	

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Ecowise Environmental

Analytical Report	*Report No: W06/1269*

Results:

Client Id		Site 1	Site 2	Site 3	Site 6	
Laboratory Id		W16917/001	W16917/002	W16917/003	W16917/004	
Phenanthrene		<0.2	<0.5	<0.1	<0.2	
Pyrene		<0.2	<0.5	<0.1	<0.2	
Speciated Phenols						
Method:	*Units:*					
2,3,4,6 Tetrachlorophenol		<0.2	<0.5	<0.1	<0.2	
2,4 Dichlorophenol		<0.2	<0.5	<0.1	<0.2	
2,4 Dimethyl Phenol		<0.2	<0.5	<0.1	<0.2	
2,4,6-Trichlorophenol		<0.2	<0.5	<0.1	<0.2	
2-Chlorophenol		<0.2	<0.5	<0.1	<0.2	
2-Nitrophenol		<0.2	<0.5	<0.1	<0.2	
4-chloro-3-methylphenol		<0.2	<0.5	<0.1	<0.2	
4-Nitrophenol		<0.2	<0.5	<0.1	<0.2	
Cresol (total)		<0.2	19	0.8	4.2	
Pentachlorophenol		<0.2	<0.5	<0.1	<0.2	
Phenol		<0.2	1.5	<0.5	<0.2	

Method(s):

APHA 3120 B	Arsenic (ICP)
APHA 3120 B	Cadmium (ICP)
APHA 3120 B	Chromium (ICP)
APHA 3120 B	Copper (ICP)
APHA 3120 B	Lead (ICP)
APHA 3120 B	Mercury (VGA)
APHA 3120 B	Moisture (%)
APHA 3120 B	Nickel (ICP)
APHA 3120 B	Zinc (ICP)

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Analytical Report

Patterson Britton & Partners Pty Ltd
PO Box 515
North Sydney
NSW, 2059

Phone: **02 9957 1619**
Fax: **02 9957 1291**

Contact Name: **Oliver Roborgh**

Report Number: **W06/0963**

Sample(s) Received: **17/03/2006**
Client Reference: **Rosedale**
Batch Number: **W16729**

Notes:

Algae count by Sedgewick Rafter cell (method EM MM037)
 * potentially toxic
The results stated in this report relate only to the sample(s) as submitted by the client.
Samples analysed as received.

Results Approved By:

Suzanne Merritt
Biotechnologist

NATA Accredited Laboratory
Number. 3628 (Chemical Testing)
Number. 3629 (Biological Testing)

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Results:

Client Id		Site #1 Dam	Site # 2 Dam	Site # 3 Dam	Site # 4 Creek	Site # 6 Creek
Laboratory Id		W16729/001	W16729/002	W16729/003	W16729/004	W16729/005
* Microcystis aeruginosa *Method:*	*Units: cells/mL*	-	-	-	-	-
Amphora *Method:*	*Units: cells/mL*	-	-	-	-	-
Anabaena (Other sp) *Method:*	*Units: cells/mL*	Rare	-	-	-	-
Ankistrodesmus *Method:*	*Units: cells/mL*	Occasional	Rare	Occasional	Occasional	Rare
Aphanacapsa *Method:*	*Units: -*	Common	-	-	Rare	-
Aulocoseira *Method:*	*Units: cells/mL*	-	-	-	-	-
Chodatella *Method:*	*Units: -*	Rare	-	-	-	-
Chroococcus *Method:*	*Units: cells/mL*	-	-	-	-	-
Closterium *Method:*	*Units: cells/mL*	-	Rare	Rare	-	-
Cosmarium *Method:*	*Units: cells/mL*	-	-	-	-	-
Crucigenia *Method:*	*Units: cells/mL*	Rare	Rare	Rare	-	-
Cryptomonas *Method:*	*Units: cells/mL*	Occasional	Rare	Rare	Occasional	-
Cyclotella *Method:*	*Units: cells/mL*	-	-	Rare	-	-
Cymbella *Method:*	*Units: cells/mL*	Rare	-	-	-	-
Desmidium *Method:*	*Units: cells/mL*	Occasional	-	-	-	-
Dinobryon *Method:*	*Units: cells/mL*	-	Rare	Rare	Rare	-
Euglena *Method:*	*Units: cells/mL*	Occasional	-	Occasional	Occasional	-
Fragilaria *Method:*	*Units: cells/mL*	-	-	Rare	-	-

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Results:

Client Id		Site #1 Dam	Site # 2 Dam	Site # 3 Dam	Site # 4 Creek	Site # 6 Creek
Laboratory Id		W16729/001	W16729/002	W16729/003	W16729/004	W16729/005
Kirchneriella *Method:*	*Units: cells/mL*	Rare	-	-	-	-
Leptolyngbya *Method:*	*Units: cells/mL*	Occasional	-	-	-	-
Mallomonas *Method:*	*Units: cells/mL*	-	-	Rare	-	-
Merismopedia *Method:*	*Units: cells/mL*	-	-	-	-	-
Merotrichia *Method:*	*Units: cells/mL*	-	-	Rare	Rare	-
Microcystis Sp (other) *Method:*	*Units: -*	-	-	-	-	-
Mougeotia *Method:*	*Units: cells/mL*	-	Rare	-	-	-
Navicula *Method:*	*Units: cells/mL*	-	-	-	-	-
Nephrocytium *Method:*	*Units: cells/mL*	-	-	-	-	-
Nitzschia *Method:*	*Units: cells/mL*	Rare	-	Rare	Rare	Rare
Oocystis *Method:*	*Units: -*	Rare	-	-	-	-
Oscillatoria *Method:*	*Units: cells/mL*	Dominant	-	-	-	-
Pandorina *Method:*	*Units: cells/mL*	-	-	-	-	-
Penium *Method:*	*Units: cells/mL*	-	Rare	-	-	-
Peridinium *Method:*	*Units: cells/mL*	Rare	Occasional	Common	-	-
Phacus *Method:*	*Units: cells/mL*	-	-	-	Rare	-
Phormidium *Method:*	*Units: cells/mL*	Occasional	-	-	-	-
Pseudanabaena *Method:*	*Units: cells/mL*	Rare	Rare	Rare	-	-

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Ecowise Environmental

Analytical Report	Report No: W06/0963

Results:

Client Id		Site #1 Dam	Site # 2 Dam	Site # 3 Dam	Site # 4 Creek	Site # 6 Creek
Laboratory Id		W16729/001	W16729/002	W16729/003	W16729/004	W16729/005
Rhodomonas						
Method:	*Units: cells/mL*	-	-	-	-	-
Scenedesmus						
Method:	*Units: cells/mL*	Occasional	Rare	Occasional	-	-
Staurastrum						
Method:	*Units: cells/mL*	-	Rare	-	-	-
Staurodesmus						
Method:	*Units: cells/mL*	Rare	-	-	-	-
Stauroneis						
Method:	*Units: -*	-	-	-	-	-
Synedra						
Method:	*Units: cells/mL*	Occasional	-	Rare	-	Rare
Teilingia						
Method:	*Units: cells/mL*	Rare	-	-	-	-
Trachelomonas						
Method:	*Units: cells/mL*	Occasional	Rare	Rare	Occasional	-

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Analytical Report	*Report No: W06/0963*

Results:						
Client Id		Site # 8 Wetlands	Site # 9 Wetlands	Site # 11 Dam	Site # 12 Dam	Site # 13 Dam
Laboratory Id		W16729/006	W16729/007	W16729/008	W16729/009	W16729/010
*** Microcystis aeruginosa** *Method:*	*Units: cells/mL*	Occasional	Occasional	-	-	-
Amphora *Method:*	*Units: cells/mL*	-	-	-	-	Rare
Anabaena (Other sp) *Method:*	*Units: cells/mL*	-	Rare	-	-	-
Ankistrodesmus *Method:*	*Units: cells/mL*	Occasional	Rare	Rare	Rare	Occasional
Aphanacapsa *Method:*	*Units: -*	-	Rare	-	-	-
Aulocoseira *Method:*	*Units: cells/mL*	Rare	Rare	Rare	-	-
Chodatella *Method:*	*Units: -*	-	Rare	-	-	Rare
Chroococcus *Method:*	*Units: cells/mL*	-	-	Rare	-	Occasional
Closterium *Method:*	*Units: cells/mL*	Rare	-	Rare	Rare	Occasional
Cosmarium *Method:*	*Units: cells/mL*	-	-	Rare	Rare	Rare
Crucigenia *Method:*	*Units: cells/mL*	-	-	-	-	Rare
Cryptomonas *Method:*	*Units: cells/mL*	-	Common	Occasional	Rare	Rare
Cyclotella *Method:*	*Units: cells/mL*	-	-	-	-	-
Cymbella *Method:*	*Units: cells/mL*	-	-	-	-	-
Desmidium *Method:*	*Units: cells/mL*	-	-	-	-	-
Dinobryon *Method:*	*Units: cells/mL*	-	-	-	-	Occasional
Euglena *Method:*	*Units: cells/mL*	Common	Rare	Rare	Occasional	Rare
Fragilaria *Method:*	*Units: cells/mL*	Rare	-	-	-	-

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Results:

Client Id		Site # 8 Wetlands	Site # 9 Wetlands	Site # 11 Dam	Site # 12 Dam	Site # 13 Dam
Laboratory Id		W16729/006	W16729/007	W16729/008	W16729/009	W16729/010
Kirchneriella *Method:*	*Units: cells/mL*	-	-	-	-	Rare
Leptolyngbya *Method:*	*Units: cells/mL*	-	Occasional	-	-	-
Mallomonas *Method:*	*Units: cells/mL*	-	-	-	-	-
Merismopedia *Method:*	*Units: cells/mL*	-	-	-	-	Rare
Merotrichia *Method:*	*Units: cells/mL*	-	-	-	Occasional	-
Microcystis Sp (other) *Method:*	*Units: -*	-	Rare	-	-	-
Mougeotia *Method:*	*Units: cells/mL*	-	-	Occasional	Occasional	Occasional
Navicula *Method:*	*Units: cells/mL*	Rare	Rare	-	Rare	-
Nephrocytium *Method:*	*Units: cells/mL*	-	-	-	-	Rare
Nitzschia *Method:*	*Units: cells/mL*	Rare	-	Rare	Occasional	Occasional
Oocystis *Method:*	*Units: -*	-	-	-	-	-
Oscillatoria *Method:*	*Units: cells/mL*	-	Rare	-	-	Rare
Pandorina *Method:*	*Units: cells/mL*	Rare	-	-	-	-
Penium *Method:*	*Units: cells/mL*	-	-	-	Rare	Rare
Peridinium *Method:*	*Units: cells/mL*	Dominant	-	Occasional	Common	Occasional
Phacus *Method:*	*Units: cells/mL*	-	Rare	-	Rare	Rare
Phormidium *Method:*	*Units: cells/mL*	Rare	Occasional	-	-	-
Pseudanabaena *Method:*	*Units: cells/mL*	-	Occasional	-	Rare	-

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SYDNEY 02 4721 3477

Ecowise Environmental

Analytical Report	*Report No: W06/0963*

Results:

Client Id		Site # 8 Wetlands	Site # 9 Wetlands	Site # 11 Dam	Site # 12 Dam	Site # 13 Dam
Laboratory Id		W16729/006	W16729/007	W16729/008	W16729/009	W16729/010
Rhodomonas *Method:*	*Units: cells/mL*	Dominant	Occasional	-	-	Common
Scenedesmus *Method:*	*Units: cells/mL*	-	Rare	-	-	Rare
Staurastrum *Method:*	*Units: cells/mL*	-	Rare	-	Occasional	-
Staurodesmus *Method:*	*Units: cells/mL*	-	-	-	-	-
Stauroneis *Method:*	*Units: -*	-	-	Rare	-	-
Synedra *Method:*	*Units: cells/mL*	Rare	Rare	-	-	Rare
Teilingia *Method:*	*Units: cells/mL*	-	-	-	-	-
Trachelomonas *Method:*	*Units: cells/mL*	Occasional	Occasional	Occasional	Occasional	Occasional

Method(s):

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Ecowise Environmental

Replacement Analytical Report

Patterson Britton & Partners Pty Ltd		Contact Name:	**Oliver Roborgh**
PO Box 515			
North Sydney		Report Number:	**W06/2178-1**
NSW, 2059			
		Sample(s) Received:	**17/05/2006**
Phone:	**02 9957 1619**	Client Reference:	**Re-Test Low levels**
Fax:	**02 9957 1291**	Batch Number:	**W17940**

Notes:

These results form part of the original Batch analysed in March 2006. The original batch # was W16730.
Analysis conducted by Ecoswise Fyshwick Acc # 1531.

This report supersedes any reports previously issued relating to the sample(s) included.
The NATA accreditation of Enviro-Managers Pty Ltd does not cover analyses performed by external laboratories.
The results stated in this report relate only to the sample(s) as collected by Enviro-Managers Pty Ltd (Refer procedures in SAM 1, 2, 5, 6, 7, 9 and 10 in LPM)
Samples analysed as received.

Results Approved By:

Valerie Smith
Authorised Signatory

NATA Accredited Laboratory
Number. 3628 (Chemical Testing)
Number. 3629 (Biological Testing)

NATA
WORLD RECOGNISED
ACCREDITATION

This document is issued in accordance with NATA's accreditation requirements.

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Date Reported: Friday June 16, 2006

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Ecowise Environmental

Replacement Analytical Report ***Report No: W06/2178-1***

Results:						
Client Id		**Site 1 W16730/1**	**Site 2 W16730/002**	**Site 3 W16730/003**	**Site 4 W16730/4**	**Site 6 W17630/6**
Laboratory Id		**W17940/001**	**W17940/002**	**W17940/003**	**W17940/004**	**W17940/006**
Cadmium (low level) *Method:*	*Units: ug/L*	0.42	<0.05	0.84	0.07	0.25
Chromium (low levels) *Method:*	*Units: ug/L*	<2	<2	<2	<2	<2
Copper (low levels) *Method:*	*Units: ug/L*	54	<1	95	21	19
Lead (low levels) *Method:*	*Units: ug/L*	4.0	<0.2	98	1.9	2.2

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Ecowise Environmental

Replacement Analytical Report ***Report No: W06/2178-1***

Results:						
Client Id		**Site 7 W16730/7**	**Site 8 W17630/8**	**Site 9 W17630/9**	**Site 10 W16730/10**	
Laboratory Id		**W17940/007**	**W17940/008**	**W17940/009**	**W17940/010**	
Cadmium (low level)						
Method:	*Units: ug/L*	<0.05	<0.08	<0.05	<0.05	
Chromium (low levels)						
Method:	*Units: ug/L*	3	<2	<2	<2	
Copper (low levels)						
Method:	*Units: ug/L*	18	<1	<1	<1	
Lead (low levels)						
Method:	*Units: ug/L*	8.2	<0.2	<0.2	<0.02	

Method(s):

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APPENDIX C
INFILTRATION TESTS

Douglas Partners
Geotechnics · Environment · Groundwater

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MJJ:mj
Project 38045D
10 November 2006

Nature Coast Developments
57 Yugura Street
MALUA BAY NSW 2536

Attention: Mr Peter Best

Email: thebest@naturecoastproperty.com.au

Dear Sir

INFILTRATION/PERMEABILITY TESTING
PROPOSED RESIDENTIAL DEVELOPMENT
GEORGE BASS DRIVE, ROSEDALE

As requested, field testing has been undertaken at the above site to assist in design of stormwater management for the proposed development. The work was undertaken for Nature Coast Developments Pty Ltd, developers of the site.

The field testing comprised falling head percolation testing at two locations (FHNW and FHSE) and double ring infiltration testing at six locations (Locations 1 – 6). The test locations were selected by the client with the GPS coordinates provided to locate the test sites.

The results of the field testing is summarised in Table 1 below:

Table 1 – Results of Field Testing

Test Location	Infiltration Velocity from Double Ring Infiltration (m/day)	Permeability from Falling Head Percolation (m/day)	Test Location Coordinates	Soil Description
1	0.4		247402.62E 6032282.39N	Clay/Silty Clay
2	1.2		247300.02E 6032529.51N	Silty Clay
3	1.4		247699.54E 6032258.72N	Silty Clay
4	2.2		247599.40E 6032589.46N	Clayey Silt with some Gravel
5	0.05		247745.16E 6033532.76N	Clay
6	4.2		247480.51E 6033348.99N	Clayey Silt with some Gravel
FHNW		0.4	247392.27E 6032407.81N	Silty Clay
FHSE		0.2	247636.95E 6032190.62N	Clay

It is noted that the double ring infiltrometer test is usually used for determining infiltration velocity rates within coarse grained soils and that care should be taken in interpreting the above data.

We trust the above is in accordance with your present requirements. If you require any additional information or have any questions please contact the undersigned.

Yours faithfully
DOUGLAS PARTNERS PTY LTD

Reviewed by

Michael Jones
Associate

G W McIntosh
Managing Principal

Encl: Notes Relating to this Report
Site Location Sketch

Douglas Partners
Geotechnics · Environment · Groundwater

NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigations Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

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

Relative Density	SPT “N” Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

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

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

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

Drilling Methods.

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

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

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

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

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

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

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

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

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test 6.3.1.

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

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7

  as 4, 6, 7
  N = 13

- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm

  as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

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

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

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

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

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

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

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

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

Hand Penetrometers

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

Two relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

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

Bore Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than ‘straight line’ variations between the boreholes.

Ground Water

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

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

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

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

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

Site Anomalies

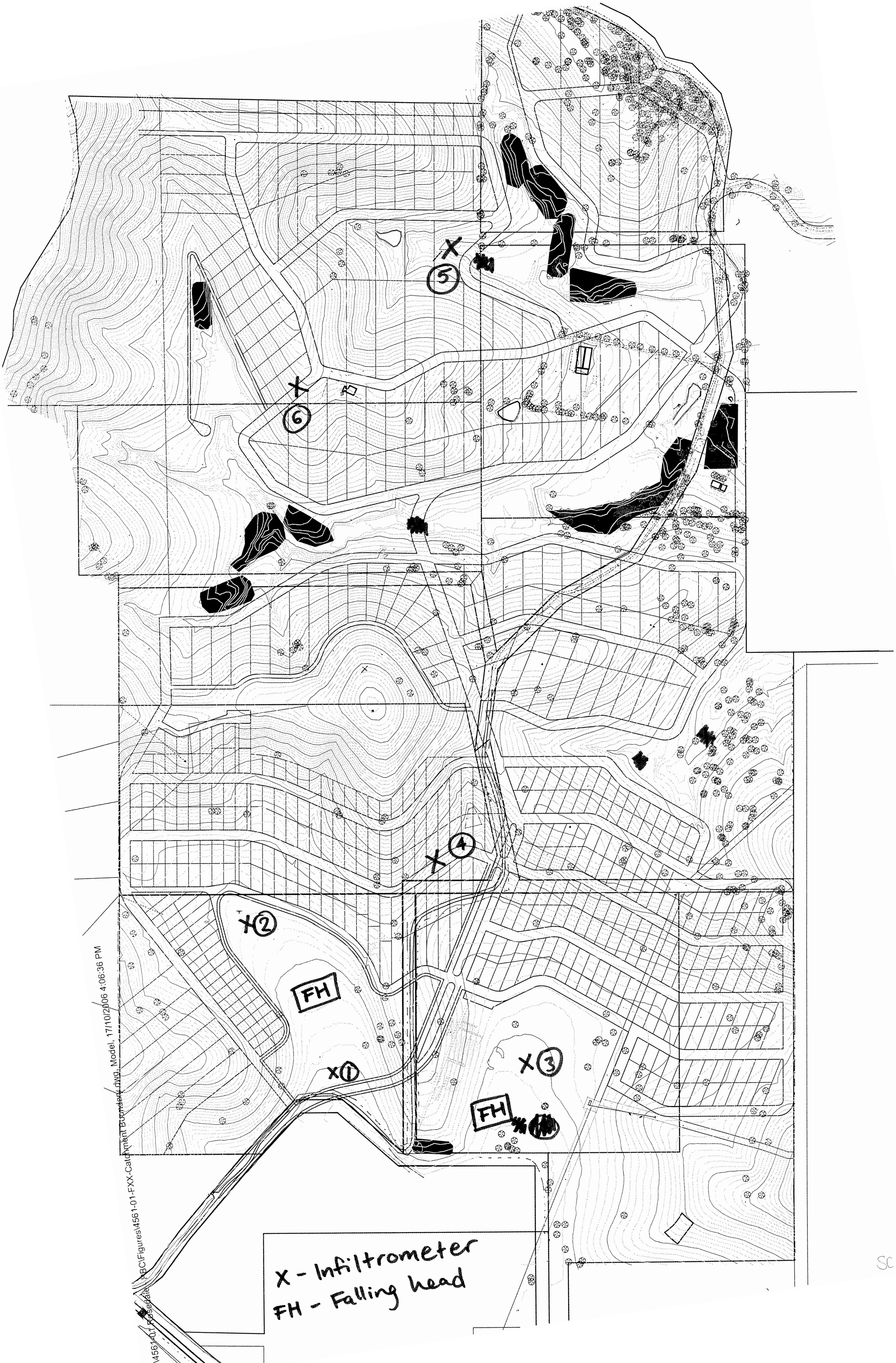
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some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

Reproduction of Information for Contractual Purposes

Attention is drawn to the document “Guidelines for the Provision of Geotechnical Information in Tender Documents”, published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

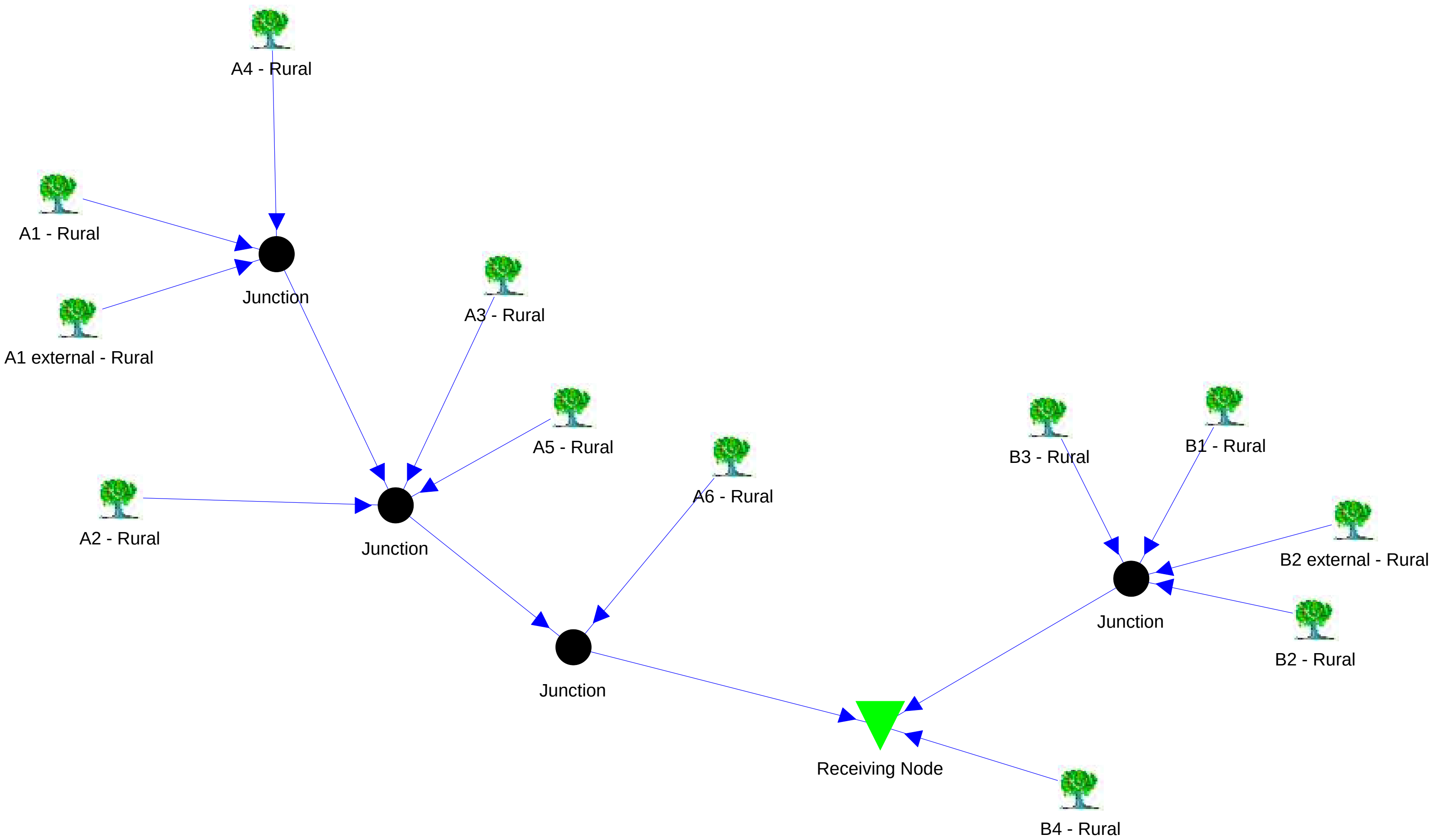
The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

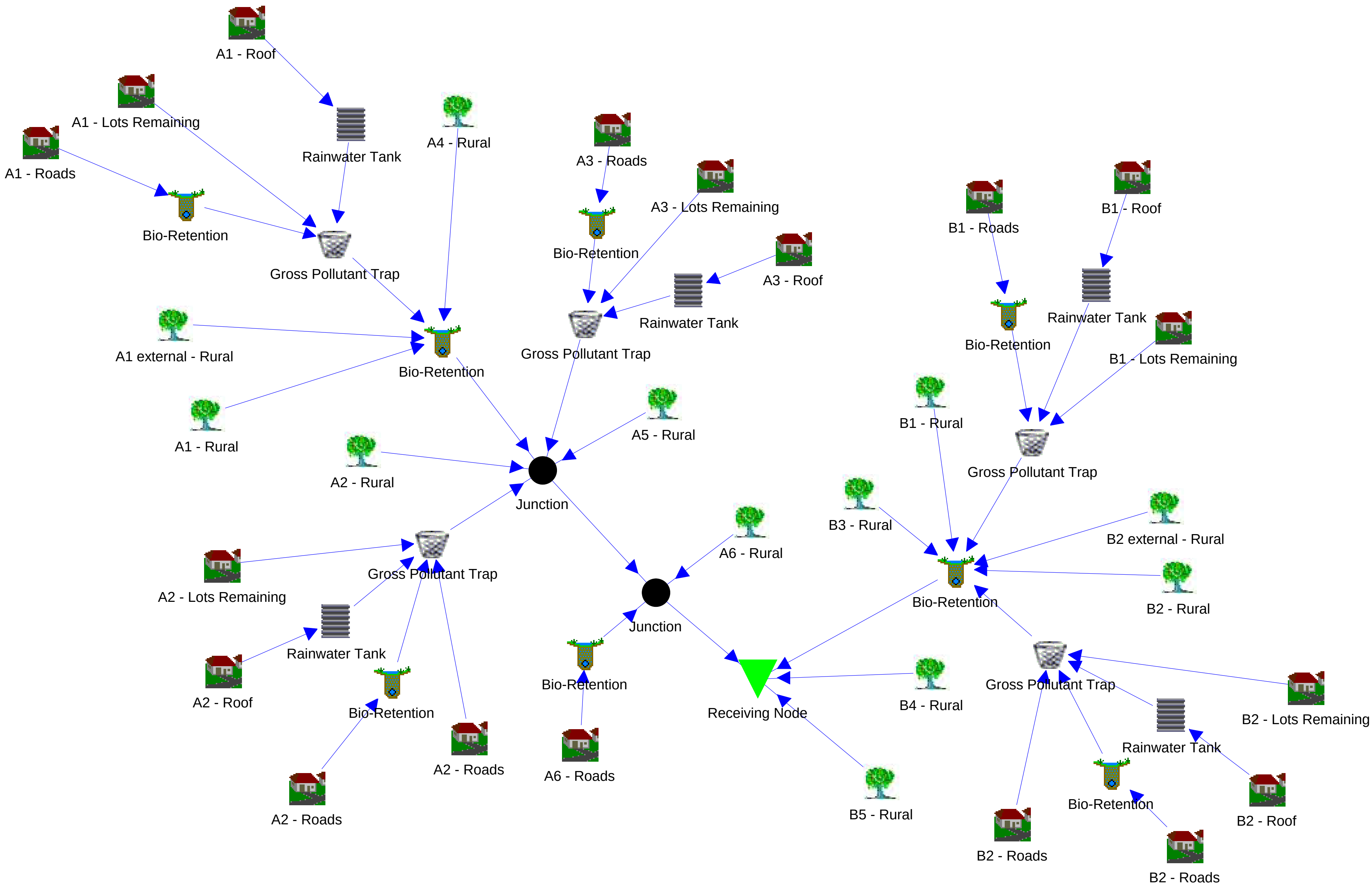


\4561-01 Rosedale \ BC\Figures\4561-01-FXX-Catchment Boundary.dwg, Model, 17/10/2006 4:06:36 PM

SCALE 1:

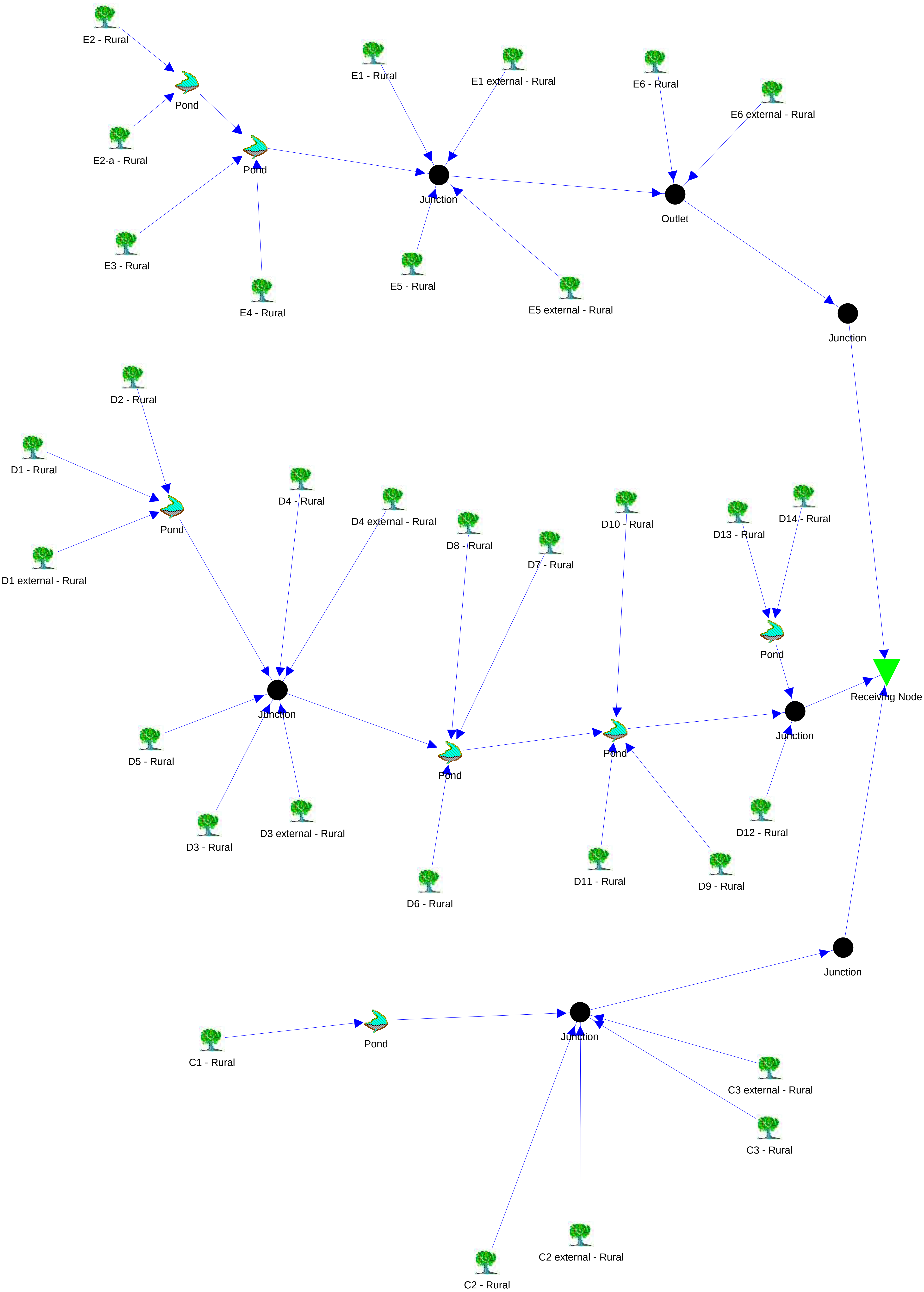
APPENDIX D
MUSIC MODEL RESULTS

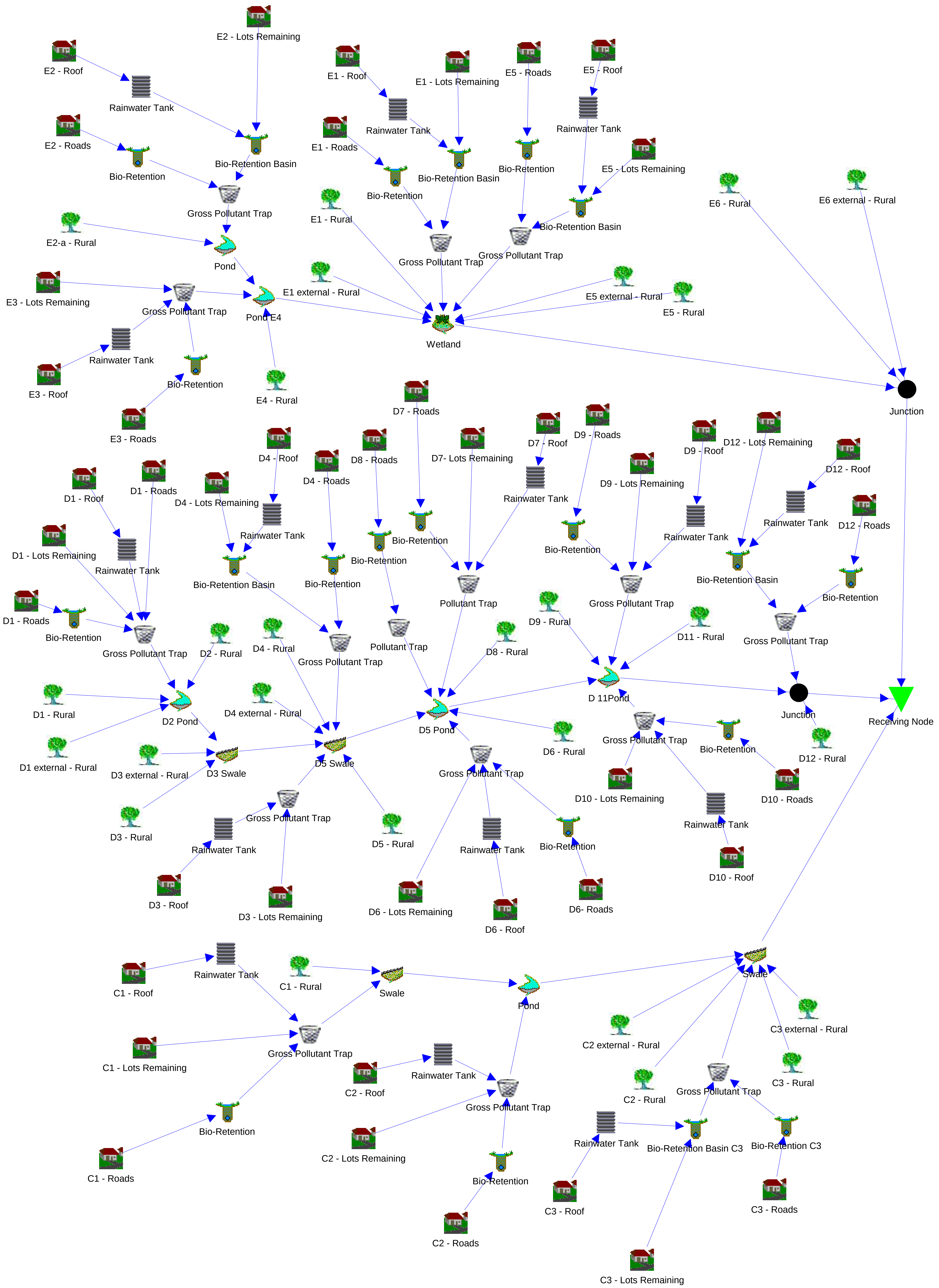

A4 - Rural
A1 - Rural
Junction
A1 external - Rural
A3 - Rural
A5 - Rural
A2 - Rural
Junction
A6 - Rural
Junction
B3 - Rural
B1 - Rural
B2 external - Rural
Junction
B2 - Rural
Receiving Node
B4 - Rural



MUSIC - Model for Urban Stormwater Improvement Conceptualisation - [pt4651-01jnh070524 south v1]

19/07/2007 9:49:57 AM


E2 - Rural
Pond
E2-a - Rural
Pond
E3 - Rural
E4 - Rural
E1 - Rural
E1 external - Rural
Junction
E5 - Rural
E5 external - Rural
E6 - Rural
E6 external - Rural
Outlet
Junction
D2 - Rural
D1 - Rural
Pond
D1 external - Rural
D4 - Rural
D4 external - Rural
D8 - Rural
D7 - Rural
D10 - Rural
D13 - Rural
D14 - Rural
Pond
Receiving Node
Junction
D5 - Rural
D3 - Rural
D3 external - Rural
Pond
D6 - Rural
Pond
D11 - Rural
D9 - Rural
Junction
D12 - Rural
Junction
C1 - Rural
Pond
Junction
C3 external - Rural
C3 - Rural
C2 external - Rural
C2 - Rural


E2 - Lots Remaining
E2 - Roof
Rainwater Tank
E2 - Roads
Bio-Retention Basin
Bio-Retention
Gross Pollutant Trap
E2-a - Rural
Pond
E3 - Lots Remaining
Gross Pollutant Trap
Pond E4
Rainwater Tank
Bio-Retention
E3 - Roof
E3 - Roads
E4 - Rural
E1 - Roof
E1 - Lots Remaining
E5 - Roads
E5 - Roof
Rainwater Tank
E1 - Roads
Rainwater Tank
Bio-Retention Basin
Bio-Retention
E5 - Lots Remaining
Bio-Retention
E1 - Rural
Bio-Retention Basin
Gross Pollutant Trap
Gross Pollutant Trap
E1 external - Rural
E5 external - Rural
E5 - Rural
Wetland
E6 - Rural
E6 external - Rural
Junction
D7 - Roads
D7 - Roof
D9 - Roads
D12 - Lots Remaining
D4 - Roof
D8 - Roads
D7- Lots Remaining
D9 - Roof
D12 - Roof
D1 - Roof
D1 - Roads
D4 - Roads
D9 - Lots Remaining
D4 - Lots Remaining
Rainwater Tank
Rainwater Tank
D12 - Roads
Rainwater Tank
D1 - Lots Remaining
Rainwater Tank
Bio-Retention
Rainwater Tank
Bio-Retention
Rainwater Tank
Bio-Retention
Bio-Retention Basin
Bio-Retention
Bio-Retention Basin
Bio-Retention
Pollutant Trap
Gross Pollutant Trap
D1 - Roads
Bio-Retention
D9 - Rural
D11 - Rural
Gross Pollutant Trap
Pollutant Trap
D8 - Rural
Gross Pollutant Trap
D2 - Rural
D4 - Rural
Gross Pollutant Trap
D 11Pond
Junction
Receiving Node
D1 - Rural
D2 Pond
D4 external - Rural
D5 Pond
D6 - Rural
Gross Pollutant Trap
Bio-Retention
D12 - Rural
D1 external - Rural
D3 external - Rural
D3 Swale
D5 Swale
Gross Pollutant Trap
D10 - Lots Remaining
D10 - Roads
D3 - Rural
Gross Pollutant Trap
Rainwater Tank
Rainwater Tank
D5 - Rural
Rainwater Tank
Bio-Retention
D10 - Roof
D3 - Roof
D3 - Lots Remaining
D6 - Lots Remaining
D6 - Roof
D6- Roads
Rainwater Tank
C1 - Rural
C1 - Roof
Swale
Pond
Swale
C1 - Lots Remaining
Gross Pollutant Trap
C2 external - Rural
C3 external - Rural
Rainwater Tank
C2 - Roof
Gross Pollutant Trap
C2 - Rural
C3 - Rural
Gross Pollutant Trap
Bio-Retention
Rainwater Tank
Bio-Retention Basin C3
Bio-Retention C3
C1 - Roads
C2 - Lots Remaining
Bio-Retention
C3 - Roof
C3 - Roads
C2 - Roads
C3 - Lots Remaining

Southern Catchment (Existing Parameters)

Source nodes

Location	A1 - Rural	A2 - Rural	A4 - Rural	A5 - Rural	A6 - Rural	B1 - Rural	B2 - Rural	B3 - Rural	B4 - Rural	A3 - Rural	A1 external - Rural	B2 external - Rural
ID	2	3	4	5	6	7	8	9	10	13	16	17
Node Type	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode
Total Area (ha)	14.265	6.186	0.95	2.071	2.1	13.185	10.032	6.225	8.225	3.314	12.72	9.235
Area Impervious (ha)	0	0	0	0	0	0	0	0	0	0	0	0
Area Pervious (ha)	14.265	6.186	0.95	2.071	2.1	13.185	10.032	6.225	8.225	3.314	12.72	9.235
Field Capacity (mm)	50	50	50	50	50	50	50	50	50	50	50	50
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	90	90	90	90	90	90	90	90	90	90	90	90
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	1.954	1.954	1.954	1.954	1.954	1.954	1.954	1.954	1.954	1.954	1.954	1.954
Stormflow Total Suspended Solids Standard Deviation (log mg/	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Stormflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Stormflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Stormflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146
Baseflow Total Suspended Solids Standard Deviation (log mg/L	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Baseflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Baseflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Baseflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	39.9	17.3	2.66	5.79	5.87	36.9	28	17.4	23	9.26	35.6	25.8
OUT - TSS Mean Annual Load (kg/yr)	1.56E+03	676	104	226	229	1.44E+03	1.10E+03	680	898	362	1.39E+03	1.01E+03
OUT - TP Mean Annual Load (kg/yr)	4.5	1.95	0.3	0.654	0.663	4.16	3.17	1.96	2.6	1.05	4.01	2.91
OUT - TN Mean Annual Load (kg/yr)	50.4	21.8	3.35	7.31	7.41	46.5	35.4	22	29	11.7	44.9	32.6
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0

Other nodes

Location	Receiving Node
ID	1
Node Type	ReceivingNode
IN - Mean Annual Flow (ML/yr)	247
IN - TSS Mean Annual Load (kg/yr)	9.67E+03
IN - TP Mean Annual Load (kg/yr)	27.9
IN - TN Mean Annual Load (kg/yr)	312
IN - Gross Pollutant Mean Annual Load (kg/yr)	0
OUT - Mean Annual Flow (ML/yr)	0
OUT - TSS Mean Annual Load (kg/yr)	0
OUT - TP Mean Annual Load (kg/yr)	0
OUT - TN Mean Annual Load (kg/yr)	0
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0

Southern Catchment (Proposed Parameters)

Source nodes								
Location	**A1 - Lots Remaining**	**A3 - Lots Remaining**	**A2 - Lots Remaining**	**B1 - Lots Remaining**	**B2 - Lots Remaining**	**A1 - Roof**	**A2 - Roof**	**A3 - Roof**
ID	2	3	4	5	6	7	8	9
Node Type	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**
Total Area (ha)	6.135	1.519	4.021	6.63	5.1	1.92	0.62	0.72
Area Impervious (ha)	2.795730263	0.571090702	2.242060219	3.021302632	2.256302632	1.92	0.62	0.72
Area Pervious (ha)	3.339269737	0.947909298	1.778939781	3.608697368	2.843697368	0	0	0
Field Capacity (mm)	50	50	50	50	50	50	50	50
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	90	90	90	90	90	90	90	90
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.146	2.146	2.146	2.146	2.146	1.301	1.301	1.301
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Stormflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.602	-0.602	-0.602	-0.602	-0.602	-0.886	-0.886	-0.886
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Stormflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Stormflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	1.204	1.204	1.204	1.204	1.204	0	0	0
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Baseflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-0.854	-0.854	-0.854	-0.854	-0.854	0	0	0
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Baseflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	0.114	0.114	0.114	0.114	0.114	0	0	0
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Baseflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	32.1	7.31	23.2	34.7	26.1	15.5	5.02	5.83
OUT - TSS Mean Annual Load (kg/yr)	3.72E+03	804	2.83E+03	4.03E+03	3.00E+03	311	100	117
OUT - TP Mean Annual Load (kg/yr)	7.35	1.63	5.43	7.94	5.95	2.02	0.653	0.758
OUT - TN Mean Annual Load (kg/yr)	59.9	13.4	44	64.7	48.6	31.1	10	11.7
OUT - Gross Pollutant Mean Annual Load (kg/yr)	841	186	617	909	681	395	128	148

Other nodes

Location	**Receiving Node**
ID	1
Node Type	**ReceivingNode**
IN - Mean Annual Flow (ML/yr)	206
IN - TSS Mean Annual Load (kg/yr)	4.69E+03
IN - TP Mean Annual Load (kg/yr)	21.3
IN - TN Mean Annual Load (kg/yr)	247
IN - Gross Pollutant Mean Annual Load (kg/yr)	41.1
OUT - Mean Annual Flow (ML/yr)	0
OUT - TSS Mean Annual Load (kg/yr)	0
OUT - TP Mean Annual Load (kg/yr)	0
OUT - TN Mean Annual Load (kg/yr)	0
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0

B1 - Roof	**B2 - Roof**	**A1 - Roads**	**A3 - Roads**	**A2 - Roads**	**B1 - Roads**	**B2 - Roads**	**A1 - Rural**	**A2 - Rural**	**A4 - Rural**	**A5 - Rural**	**A6 - Rural**
10	11	12	13	14	15	16	17	18	19	20	21
UrbanSourceNode	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**
1.98	1.92	3.167	1.075	0.837	3.772	1.522	3.043	0.506	0.674	2.355	1.635
1.98	1.92	2.521654298	0.860707237	0.670150658	3.020081579	1.218601316	0	0	0	0	0
0	0	0.645345702	0.214292763	0.166849342	0.751918421	0.303398684	3.043	0.506	0.674	2.355	1.635
50	50	50	50	50	50	50	50	50	50	50	50
200	200	200	200	200	200	200	200	200	200	200	200
1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
90	90	90	90	90	90	90	90	90	90	90	90
30	30	30	30	30	30	30	30	30	30	30	30
10	10	10	10	10	10	10	10	10	10	10	10
25	25	25	25	25	25	25	25	25	25	25	25
5	5	5	5	5	5	5	5	5	5	5	5
0	0	0	0	0	0	0	0	0	0	0	0
1.301	1.301	2.431	2.431	2.431	2.431	2.431	1.954	1.954	1.954	1.954	1.954
0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.2	0.2	0.2	0.2	0.2
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0
-0.886	-0.886	-0.301	-0.301	-0.301	-0.301	-0.301	-0.657	-0.657	-0.657	-0.657	-0.657
0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.22	0.22	0.22	0.22	0.22
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0
0.301	0.301	0.342	0.342	0.342	0.342	0.342	0.301	0.301	0.301	0.301	0.301
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.24	0.24	0.24	0.24	0.24
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1.146	1.146	1.146	1.146	1.146
0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	-1.222	-1.222	-1.222	-1.222	-1.222
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	-0.046	-0.046	-0.046	-0.046	-0.046
0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0
16	15.5	22.3	7.56	5.89	26.5	10.7	8.51	1.41	1.88	6.58	4.57
321	311	5.69E+03	1.93E+03	1.50E+03	6.78E+03	2.74E+03	332	55.3	73.6	257	179
2.08	2.02	11.7	3.98	3.1	14	5.64	0.96	0.16	0.213	0.743	0.516
32.1	31.1	47.6	16.1	12.6	56.6	22.9	10.7	1.79	2.38	8.31	5.77
408	395	586	199	155	698	282	0	0	0	0	0

B1 - Rural	**B2 - Rural**	**B3 - Rural**	**B4 - Rural**	**A6 - Roads**	**A2 - Roads**	**B2 - Roads**	**B5 - Rural**	**A1 external - Rural**	**B2 external - Rural**
22	23	24	25	26	43	44	49	50	51
ForestSourceNode	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**
0.803	0.434	1.594	8.225	0.465	0.202	1.056	4.621	12.72	9.235
0	0	0	0	0.372305921	0.16083807	0.845494737	0	0	0
0.803	0.434	1.594	8.225	0.092694079	0.04116193	0.210505263	4.621	12.72	9.235
50	50	50	50	50	50	50	50	50	50
200	200	200	200	200	200	200	200	200	200
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
90	90	90	90	90	90	90	90	90	90
30	30	30	30	30	30	30	30	30	30
10	10	10	10	10	10	10	10	10	10
25	25	25	25	25	25	25	25	25	25
5	5	5	5	5	5	5	5	5	5
0	0	0	0	0	0	0	0	0	0
1.954	1.954	1.954	1.954	2.431	2.431	2.431	1.954	1.954	1.954
0.2	0.2	0.2	0.2	0.32	0.32	0.32	0.2	0.2	0.2
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0
-0.657	-0.657	-0.657	-0.657	-0.301	-0.301	-0.301	-0.657	-0.657	-0.657
0.22	0.22	0.22	0.22	0.25	0.25	0.25	0.22	0.22	0.22
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0
0.301	0.301	0.301	0.301	0.342	0.342	0.342	0.301	0.301	0.301
0.24	0.24	0.24	0.24	0.19	0.19	0.19	0.24	0.24	0.24
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0
1.146	1.146	1.146	1.146	0	0	0	1.146	1.146	1.146
0.13	0.13	0.13	0.13	0.17	0.17	0.17	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0
-1.222	-1.222	-1.222	-1.222	0	0	0	-1.222	-1.222	-1.222
0.13	0.13	0.13	0.13	0.19	0.19	0.19	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0
-0.046	-0.046	-0.046	-0.046	0	0	0	-0.046	-0.046	-0.046
0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0
2.24	1.21	4.46	23	3.27	1.42	7.43	12.9	35.6	25.8
87.7	47.4	174	898	836	363	1.90E+03	505	1.39E+03	1.01E+03
0.253	0.137	0.503	2.6	1.72	0.748	3.91	1.46	4.01	2.91
2.83	1.53	5.63	29	6.98	3.03	15.9	16.3	44.9	32.6
0	0	0	0	86	37.4	195	0	0	0

Northern Catchment (Existing Parameters)

Source nodes

Location	D6 - Rural	D8 - Rural	D2 - Rural	D1 - Rural	D5 - Rural	D3 - Rural	D7 - Rural	D9 - Rural	D11 - Rural	D12 - Rural
ID	2	3	4	5	6	7	8	9	10	11
Node Type	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode
Total Area (ha)	5.022	1.988	1.411	12.445	3.124	8.096	3.895	3.409	1.682	9.69
Area Impervious (ha)	0	0	0	0	0	0	0	0	0	0
Area Pervious (ha)	5.022	1.988	1.411	12.445	3.124	8.096	3.895	3.409	1.682	9.69
Field Capacity (mm)	50	50	50	50	50	50	50	50	50	50
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	90	90	90	90	90	90	90	90	90	90
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	1.954	1.954	1.954	1.954	1.954	1.195	1.954	1.954	1.954	1.954
Stormflow Total Suspended Solids Standard Deviation (log mg/	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Stormflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Stormflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Stormflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146
Baseflow Total Suspended Solids Standard Deviation (log mg/L	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Baseflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Baseflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Baseflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	14	5.56	3.94	34.8	8.73	22.6	10.9	9.53	4.7	27.1
OUT - TSS Mean Annual Load (kg/yr)	549	217	154	1.36E+03	341	329	425	372	184	1.06E+03
OUT - TP Mean Annual Load (kg/yr)	1.59	0.627	0.445	3.93	0.986	2.56	1.23	1.08	0.531	3.06
OUT - TN Mean Annual Load (kg/yr)	17.7	7.02	4.98	43.9	11	28.6	13.7	12	5.94	34.2
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	0	0	0	0	0	0	0

Other nodes

Location	Receiving Node
ID	1
Node Type	ReceivingNode
IN - Mean Annual Flow (ML/yr)	347
IN - TSS Mean Annual Load (kg/yr)	1.26E+04
IN - TP Mean Annual Load (kg/yr)	40.2
IN - TN Mean Annual Load (kg/yr)	449
IN - Gross Pollutant Mean Annual Load (kg/yr)	0
OUT - Mean Annual Flow (ML/yr)	0
OUT - TSS Mean Annual Load (kg/yr)	0
OUT - TP Mean Annual Load (kg/yr)	0
OUT - TN Mean Annual Load (kg/yr)	0
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0

D4 - Rural	D10 - Rural	D13 - Rural	D14 - Rural	D1 external - Rural	D3 external - Rural	D4 external - Rural	E1 - Rural	E4 - Rural	E5 - Rural	E6 - Rural	E2 - Rural	E3 - Rural
13	15	19	21	22	23	24	25	28	29	30	32	33
ForestSourceNode	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**
8.93	1.846	1.643	0.074	1.697	4.366	5.439	6.083	0.367	6.51	3.636	6.243	9.527
0	0	0	0	0	0	0	0	0	0	0	0	0
8.93	1.846	1.643	0.074	1.697	4.366	5.439	6.083	0.367	6.51	3.636	6.243	9.527
50	50	50	50	50	50	50	50	50	50	50	50	50
200	200	200	200	200	200	200	200	200	200	200	200	200
1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1
90	90	90	90	90	90	90	90	90	90	90	90	90
30	30	30	30	30	30	30	30	30	30	30	30	30
10	10	10	10	10	10	10	10	10	10	10	10	10
25	25	25	25	25	25	25	25	25	25	25	25	25
5	5	5	5	5	5	5	5	5	5	5	5	5
0	0	0	0	0	0	0	0	0	0	0	0	0
1.954	1.195	1.954	1.954	1.954	1.195	1.954	1.954	1.954	1.954	1.954	1.954	1.954
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657
0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
25	5.16	4.59	0.207	4.74	12.2	15.2	17	1.03	18.2	10.2	17.4	26.6
975	75.1	179	8.08	185	178	594	664	40.1	711	397	682	1.04E+03
2.82	0.583	0.519	2.34E-02	0.536	1.38	1.72	1.92	0.116	2.05	1.15	1.97	3.01
31.5	6.52	5.8	0.261	5.99	15.4	19.2	21.5	1.3	23	12.8	22	33.6
0	0	0	0	0	0	0	0	0	0	0	0	0

E2-a - Rural	C1 - Rural	C2 - Rural	C3 - Rural	E6 external - Rural	E1 external - Rural	E5 external - Rural	C2 external - Rural	C3 external - Rural
36	37	38	40	43	44	45	46	47
ForestSourceNode	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**
0.105	6.057	4.317	7.653	24.379	22.278	3.915	0.665	2.817
0	0	0	0	0	0	0	0	0
0.105	6.057	4.317	7.653	24.379	22.278	3.915	0.665	2.817
50	50	50	50	50	50	50	50	50
200	200	200	200	200	200	200	200	200
1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1
90	90	90	90	90	90	90	90	90
30	30	30	30	30	30	30	30	30
10	10	10	10	10	10	10	10	10
25	25	25	25	25	25	25	25	25
5	5	5	5	5	5	5	5	5
0	0	0	0	0	0	0	0	0
1.954	1.954	1.954	1.954	1.954	1.954	1.954	1.954	1.954
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0
-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657
0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0
0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0
1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0
-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0
-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046
0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0
0.293	16.9	12.1	21.4	68.1	62.3	10.9	1.86	7.87
11.5	662	472	836	2.66E+03	2.43E+03	428	72.6	308
3.31E-02	1.91	1.36	2.42	7.69	7.03	1.24	0.21	0.889
0.371	21.4	15.2	27	86.1	78.6	13.8	2.35	9.94
0	0	0	0	0	0	0	0	0

Northern Catchment (Proposed Parameters)

Source nodes

Location	**D7- Lots Remaining**	**D6 - Lots Remaining**	**D6 - Roof**	**D7 - Roof**	**D7 - Roads**	**D6- Roads**	**D6 - Rural**	**D8 - Rural**	**D2 - Rural**
ID	2	3	4	5	6	7	8	9	10
Node Type	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**
Total Area (ha)	3.535	2.566	1.075	1.075	1.919	0.945	0.435	1.988	1.411
Area Impervious (ha)	0.686999342	0.453214123	1.075	1.075	1.5364625	0.756621711	0	0	0
Area Pervious (ha)	2.848000658	2.112785877	0	0	0.3825375	0.188378289	0.435	1.988	1.411
Field Capacity (mm)	50	50	50	50	50	50	50	50	50
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	90	90	90	90	90	90	90	90	90
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.146	2.146	1.301	1.301	2.431	2.431	1.954	1.954	1.954
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32	0.32	0.32	0.32	0.32	0.32	0.2	0.2	0.2
Stormflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.602	-0.602	-0.886	-0.886	-0.301	-0.301	-0.657	-0.657	-0.657
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25	0.25	0.25	0.25	0.22	0.22	0.22
Stormflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.301	0.301	0.301	0.301	0.342	0.342	0.301	0.301	0.301
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.24	0.24	0.24
Stormflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	1.204	1.204	0	0	0	0	1.146	1.146	1.146
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17	0.17	0.17	0.17	0.13	0.13	0.13
Baseflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-0.854	-0.854	0	0	0	0	-1.222	-1.222	-1.222
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.13	0.13	0.13
Baseflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	0.114	0.114	0	0	0	0	-0.046	-0.046	-0.046
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13
Baseflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	13.4	9.62	8.7	8.7	13.5	6.65	1.22	5.56	3.94
OUT - TSS Mean Annual Load (kg/yr)	1.22E+03	858	174	174	3.45E+03	1.70E+03	47.5	217	154
OUT - TP Mean Annual Load (kg/yr)	2.77	1.97	1.13	1.13	7.11	3.5	0.137	0.627	0.445
OUT - TN Mean Annual Load (kg/yr)	23.1	16.5	17.4	17.4	28.8	14.2	1.54	7.02	4.98
OUT - Gross Pollutant Mean Annual Load (kg/yr)	264	183	221	221	355	175	0	0	0

Other nodes

Location	**Receiving Node**
ID	1
Node Type	**ReceivingNode**
IN - Mean Annual Flow (ML/yr)	335
IN - TSS Mean Annual Load (kg/yr)	9.82E+03
IN - TP Mean Annual Load (kg/yr)	36.7
IN - TN Mean Annual Load (kg/yr)	440
IN - Gross Pollutant Mean Annual Load (kg/yr)	0
OUT - Mean Annual Flow (ML/yr)	0
OUT - TSS Mean Annual Load (kg/yr)	0
OUT - TP Mean Annual Load (kg/yr)	0
OUT - TN Mean Annual Load (kg/yr)	0
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0

D1 - Lots Remaining	D1 - Roof	D1 - Roads	D1 - Rural	D5 - Rural	D3 - Lots Remaining	D3 - Roof	D3 - Forest	D9 - Lots Remaining	D9 - Roof	D9 - Roads	D9 - Rural	D11 - Rural
11	12	13	14	15	16	17	18	19	20	21	22	23
UrbanSourceNode	**UrbanSourceNode**	**UrbanSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**ForestSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**ForestSourceNode**	**ForestSourceNode**
2.863	0.475	0.665	8.224	3.124	1.446	0.2	6.451	1.287	0.54	1.116	0.466	1.682
0.911513904	0.475	0.5324375	0	0	0.626917105	0.2	0	0.472464474	0.54	0.893534211	0	0
1.951486096	0	0.1325625	8.224	3.124	0.819082895	0	6.451	0.814535526	0	0.222465789	0.466	1.682
50	50	50	50	50	50	50	50	50	50	50	50	50
200	200	200	200	200	200	200	200	200	200	200	200	200
1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1
90	90	90	90	90	90	90	90	90	90	90	90	90
30	30	30	30	30	30	30	30	30	30	30	30	30
10	10	10	10	10	10	10	10	10	10	10	10	10
25	25	25	25	25	25	25	25	25	25	25	25	25
5	5	5	5	5	5	5	5	5	5	5	5	5
0	0	0	0	0	0	0	0	0	0	0	0	0
2.146	1.301	2.431	1.954	1.954	2.146	1.301	1.954	2.146	1.301	2.431	1.954	1.954
0.32	0.32	0.32	0.2	0.2	0.32	0.32	0.2	0.32	0.32	0.32	0.2	0.2
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-0.602	-0.886	-0.301	-0.657	-0.657	-0.602	-0.886	-0.657	-0.602	-0.886	-0.301	-0.657	-0.657
0.25	0.25	0.25	0.22	0.22	0.25	0.25	0.22	0.25	0.25	0.25	0.22	0.22
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
0.301	0.301	0.342	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.342	0.301	0.301
0.19	0.19	0.19	0.24	0.24	0.19	0.19	0.24	0.19	0.19	0.19	0.24	0.24
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
1.204	0	0	1.146	1.146	1.204	0	1.146	1.204	0	0	1.146	1.146
0.17	0.17	0.17	0.13	0.13	0.17	0.17	0.13	0.17	0.17	0.17	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-0.854	0	0	-1.222	-1.222	-0.854	0	-1.222	-0.854	0	0	-1.222	-1.222
0.19	0.19	0.19	0.13	0.13	0.19	0.19	0.13	0.19	0.19	0.19	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
0.114	0	0	-0.046	-0.046	0.114	0	-0.046	0.114	0	0	-0.046	-0.046
0.12	0.12	0.12	0.13	0.13	0.12	0.12	0.13	0.12	0.12	0.12	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
12.9	3.85	4.68	23	8.73	7.34	1.62	18	6.12	4.37	7.85	1.3	4.7
1.35E+03	76.9	1.20E+03	898	341	836	32.4	705	669	87.4	2.01E+03	50.9	184
2.81	0.5	2.46	2.6	0.986	1.66	0.211	2.04	1.36	0.568	4.13	0.147	0.531
23.2	7.69	9.98	29	11	13.6	3.24	22.8	11.2	8.74	16.8	1.64	5.94
314	97.8	123	0	0	190	41.2	0	155	111	207	0	0

D10 - Lots Remaining	**D10 - Roof**	**D10 - Roads**	**D12 - Lots Remaining**	**D12 - Roof**	**D12 - Roads**	**D12 - Rural**	**D1 - Roads**	**D4 - Lots Remaining**	**D4 - Roof**	**D4 - Roads**	**D4 - Rural**	**D8 - Roads**
24	25	26	27	28	29	30	52	53	54	55	59	60
UrbanSourceNode	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**ForestSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**ForestSourceNode**	**UrbanSourceNode**
1.285	0.4	0.777	1.983	0.5	1.11	4.649	0.218	3.48	0.65	0.998	3.802	0.106
0.209883333	0.4	0.622111184	0.420517763	0.5	0.888730263	0	0.174543421	1.123368421	0.65	0.799056579	0	0.084869737
1.075116667	0	0.154888816	1.562482237	0	0.221269737	4.649	0.043456579	2.356631579	0	0.198943421	3.802	0.021130263
50	50	50	50	50	50	50	50	50	50	50	50	50
200	200	200	200	200	200	200	200	200	200	200	200	200
1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1
90	90	90	90	90	90	90	90	90	90	90	90	90
30	30	30	30	30	30	30	30	30	30	30	30	30
10	10	10	10	10	10	10	10	10	10	10	10	10
25	25	25	25	25	25	25	25	25	25	25	25	25
5	5	5	5	5	5	5	5	5	5	5	5	5
0	0	0	0	0	0	0	0	0	0	0	0	0
2.146	1.301	2.431	2.146	1.301	2.431	1.954	2.431	2.146	1.301	2.431	1.954	2.431
0.32	0.32	0.32	0.32	0.32	0.32	0.2	0.32	0.32	0.32	0.32	0.2	0.32
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-0.602	-0.886	-0.301	-0.602	-0.886	-0.301	-0.657	-0.301	-0.602	-0.886	-0.301	-0.657	-0.301
0.25	0.25	0.25	0.25	0.25	0.25	0.22	0.25	0.25	0.25	0.25	0.22	0.25
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
0.301	0.301	0.342	0.301	0.301	0.342	0.301	0.342	0.301	0.301	0.342	0.301	0.342
0.19	0.19	0.19	0.19	0.19	0.19	0.24	0.19	0.19	0.19	0.19	0.24	0.19
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
1.204	0	0	1.204	0	0	1.146	0	1.204	0	0	1.146	0
0.17	0.17	0.17	0.17	0.17	0.17	0.13	0.17	0.17	0.17	0.17	0.13	0.17
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-0.854	0	0	-0.854	0	0	-1.222	0	-0.854	0	0	-1.222	0
0.19	0.19	0.19	0.19	0.19	0.19	0.13	0.19	0.19	0.19	0.19	0.13	0.19
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
0.114	0	0	0.114	0	0	-0.046	0	0.114	0	0	-0.046	0
0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.13	0.12
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
4.68	3.24	5.47	7.75	4.05	7.81	13	1.53	15.6	5.26	7.02	10.6	0.746
405	64.8	1.40E+03	721	81	2.00E+03	508	392	1.64E+03	105	1.79E+03	415	191
0.948	0.421	2.88	1.61	0.526	4.11	1.47	0.808	3.42	0.684	3.7	1.2	0.393
7.95	6.48	11.7	13.4	8.1	16.7	16.4	3.27	28.2	10.5	15	13.4	1.59
82.6	82.4	144	160	103	205	0	40.3	382	134	185	0	19.6

C1 - Lots Remaining	**C1 - Roof**	**C1 - Roads**	**C2 - Lots Remaining**	**C2 - Roof**	**C2 - Roads**	**C3 - Lots Remaining**	**C3 - Roof**	**C3 - Roads**	**C1 - Rural**	**C2 - Rural**	**C3 - Rural**	**D1 external - Rural**
70	71	72	85	86	87	88	89	90	92	93	94	95
UrbanSourceNode	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**
2.49	0.7	1.707	1.239	0.42	0.587	1.56	0.92	1.072	1.161	2.072	4.101	1.697
1.123667105	0.7	1.366723026	0.570103026	0.42	0.467385877	0.531221053	0.92	0.858305263	0	0	0	0
1.366332895	0	0.340276974	0.668896974	0	0.119614123	1.028778947	0	0.213694737	1.161	2.072	4.101	1.697
50	50	50	50	50	50	50	50	50	50	50	50	50
200	200	200	200	200	200	200	200	200	200	200	200	200
1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1
90	90	90	90	90	90	90	90	90	90	90	90	90
30	30	30	30	30	30	30	30	30	30	30	30	30
10	10	10	10	10	10	10	10	10	10	10	10	10
25	25	25	25	25	25	25	25	25	25	25	25	25
5	5	5	5	5	5	5	5	5	5	5	5	5
0	0	0	0	0	0	0	0	0	0	0	0	0
2.146	1.301	2.431	2.146	1.301	2.431	2.146	1.301	2.431	1.954	1.954	1.954	1.954
0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.2	0.2	0.2	0.2
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-0.602	-0.886	-0.301	-0.602	-0.886	-0.301	-0.602	-0.886	-0.301	-0.657	-0.657	-0.657	-0.657
0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.22	0.22	0.22	0.22
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
0.301	0.301	0.342	0.301	0.301	0.342	0.301	0.301	0.342	0.301	0.301	0.301	0.301
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.24	0.24	0.24	0.24
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
1.204	0	0	1.204	0	0	1.204	0	0	1.146	1.146	1.146	1.146
0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-0.854	0	0	-0.854	0	0	-0.854	0	0	-1.222	-1.222	-1.222	-1.222
0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
0.114	0	0	0.114	0	0	0.114	0	0	-0.046	-0.046	-0.046	-0.046
0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
12.9	5.67	12	6.48	3.4	4.13	7.17	7.45	7.54	3.25	5.79	11.5	4.74
1.49E+03	113	3.07E+03	752	68	1.06E+03	765	149	1.93E+03	127	226	448	185
2.94	0.737	6.32	1.48	0.442	2.17	1.58	0.968	3.97	0.366	0.654	1.29	0.536
24	11.3	25.6	12.1	6.8	8.81	13	14.9	16.1	4.1	7.31	14.5	5.99
337	144	316	170	86.5	109	178	189	198	0	0	0	0

D3 external - Rural	D4 external - Rural	C3 external - Rural	C2 external - Rural	E1 - Lots Remaining	E1 - Roof	E1 - Roads	E5 - Lots Remaining	E5 - Roof	E5 - Roads	E2 - Lots Remaining	E2 - Roof	E2 - Roads
96	97	98	99	100	101	102	103	104	105	118	119	120
ForestSourceNode	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**	**UrbanSourceNode**
4.366	5.439	2.817	0.665	1.502	0.325	0.564	2.549	0.375	1.429	4.214	1.15	0.879
0	0	0	0	0.424973772	0.325	0.449072632	0.653460746	0.375	1.144140132	1.266972368	1.15	0.699884474
4.366	5.439	2.817	0.665	1.077026228	0	0.114927368	1.895539254	0	0.284859868	2.947027632	0	0.179115526
50	50	50	50	50	50	50	50	50	50	50	50	50
200	200	200	200	200	200	200	200	200	200	200	200	200
1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1
90	90	90	90	90	90	90	90	90	90	90	90	90
30	30	30	30	30	30	30	30	30	30	30	30	30
10	10	10	10	10	10	10	10	10	10	10	10	10
25	25	25	25	25	25	25	25	25	25	25	25	25
5	5	5	5	5	5	5	5	5	5	5	5	5
0	0	0	0	0	0	0	0	0	0	0	0	0
1.954	1.954	1.954	1.954	2.146	1.301	2.431	2.146	1.301	2.431	2.146	1.301	2.431
0.2	0.2	0.2	0.2	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-0.657	-0.657	-0.657	-0.657	-0.602	-0.886	-0.301	-0.602	-0.886	-0.301	-0.602	-0.886	-0.301
0.22	0.22	0.22	0.22	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
0.301	0.301	0.301	0.301	0.301	0.301	0.342	0.301	0.301	0.342	0.301	0.301	0.342
0.24	0.24	0.24	0.24	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
1.146	1.146	1.146	1.146	1.204	0	0	1.204	0	0	1.204	0	0
0.13	0.13	0.13	0.13	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-1.222	-1.222	-1.222	-1.222	-0.854	0	0	-0.854	0	0	-0.854	0	0
0.13	0.13	0.13	0.13	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
-0.046	-0.046	-0.046	-0.046	0.114	0	0	0.114	0	0	0.114	0	0
0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0	0	0
12.2	15.2	7.87	1.86	6.43	2.63	3.97	10.6	3.04	10.1	18.5	9.31	6.18
477	594	308	72.6	649	52.6	1.01E+03	1.05E+03	60.7	2.57E+03	1.90E+03	186	1.58E+03
1.38	1.72	0.889	0.21	1.38	0.342	2.09	2.27	0.395	5.29	4.01	1.21	3.26
15.4	19.2	9.94	2.35	11.4	5.26	8.47	18.8	6.07	21.5	33.1	18.6	13.2
0	0	0	0	150	66.9	104	242	77.2	264	443	237	163

E3 - Lots Remaining	**E3 - Roof**	**E3 - Roads**	**E6 - Rural**	**E1 - Rural**	**E5 - Rural**	**E4 - Rural**	**E2-a - Rural**	**E6 external - Rural**	**E1 external - Rural**	**E5 external - Rural**
121	122	123	131	132	133	134	135	136	137	138
UrbanSourceNode	**UrbanSourceNode**	**UrbanSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**	**ForestSourceNode**
6.15	1.525	1.852	3.636	3.692	2.156	0.367	0.289	24.379	22.278	3.915
1.767315789	1.525	1.474614386	0	0	0	0	0	0	0	0
4.382684211	0	0.377385614	3.636	3.692	2.156	0.367	0.289	24.379	22.278	3.915
50	50	50	50	50	50	50	50	50	50	50
200	200	200	200	200	200	200	200	200	200	200
1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1
90	90	90	90	90	90	90	90	90	90	90
30	30	30	30	30	30	30	30	30	30	30
10	10	10	10	10	10	10	10	10	10	10
25	25	25	25	25	25	25	25	25	25	25
5	5	5	5	5	5	5	5	5	5	5
0	0	0	0	0	0	0	0	0	0	0
2.146	1.301	2.431	1.954	1.954	1.954	1.954	1.954	1.954	1.954	1.954
0.32	0.32	0.32	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0
-0.602	-0.886	-0.301	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657	-0.657
0.25	0.25	0.25	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0
0.301	0.301	0.342	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
0.19	0.19	0.19	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0
1.204	0	0	1.146	1.146	1.146	1.146	1.146	1.146	1.146	1.146
0.17	0.17	0.17	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0
-0.854	0	0	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222	-1.222
0.19	0.19	0.19	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0
0.114	0	0	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046	-0.046
0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	0	0	0	0	0	0	0	0	0
26.6	12.3	13	10.2	10.3	6.03	1.03	0.808	68.1	62.3	10.9
2.72E+03	247	3.33E+03	397	403	236	40.1	31.6	2.66E+03	2.43E+03	428
5.76	1.61	6.86	1.15	1.17	0.68	0.116	9.12E-02	7.69	7.03	1.24
47.6	24.7	27.8	12.8	13	7.61	1.3	1.02	86.1	78.6	13.8
631	314	343	0	0	0	0	0	0	0	0

Summary of Results

Northern Catchment

TOTAL area	179.15	Ha
Average annual rainfall	901	mm
Total flow	1614	ML

Rural

	Existing	untreated	Treated	Reduction
Flow (ML/yr)	347	684	335	3%
Total Suspended Solids (kg/yr)	12600	59900	9820	22%
Total Phosphorus (kg/yr)	40.2	142	36.7	9%
Total Nitrogen (kg/yr)	449	1110	440	2%
Gross Pollutants (kg/yr)	0	8960	0	0%
CV	0.21	0.42	0.21	

Agricultural

	Existing	untreated	treated	Reduction
Flow (ML/yr)	328	674	321	2%
Total Suspended Solids (kg/yr)	18300	66000	13600	26%
Total Phosphorus (kg/yr)	82.1	187	64.8	21%
Total Nitrogen (kg/yr)	573	1240	524	9%
Gross Pollutants (kg/yr)	0	8960	0	0%
CV	0.20	0.42	0.20	

Southern Catchment

TOTAL area	88.51	HA
Average annual rainfall	901	mm
Total flow	797	ML

Rural

	Existing	untreated	treated	Reduction
Flow (ML/yr)	247	395	206	17%
Total Suspended Solids (kg/yr)	9670	42300	4690	51%
Total Phosphorus (kg/yr)	27.9	95.1	21.3	24%
Total Nitrogen (kg/yr)	312	690	247	21%
Gross Pollutants (kg/yr)	0	6950	41.1	
CV	0.31	0.50	0.26	

Agricultural

	Existing	untreated	treated	Reduction
Flow (ML/yr)	247	395	206	17%
Total Suspended Solids (kg/yr)	14700	44900	5910	60%
Total Phosphorus (kg/yr)	63.9	114	30.5	52%
Total Nitrogen (kg/yr)	427	749	284	33%
Gross Pollutants (kg/yr)	0	6950	41.1	
CV	0.31	0.50	0.26	