Moonee Beach

Water Management Report

Subdivision DA

Issued: October 2007

Patterson Britton & Partners Pty Ltd
consulting engineers

Hillview Heights Pty. Ltd.

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1 INTRODUCTION

The development on the Mercer Land at Moonee Beach is known as the Moonee Waters development and will comprise a mix of residential uses*(refer* **Figure 1***)*. The site is located approximately 10km north of Coffs Harbour. The village of Moonee Moonee and Moonee Creek are located to the north, the Pacific Highway and coastal forest to the west, cleared agricultural land to the south and the Tasman Sea to the east. An existing dedicated road reservation connects the Pacific Highway on the southern edge of the site which provides access to development south of the subject site.

The Coffs Harbour LEP (*2000*) zones the site as:

- Residential 2E Tourist Zone in the higher lands above the flood liable/wetland areas; and
- Environmental Protection 7A Habitat Catchment Zone in low lying areas and SEPP 14 Wetlands.

Patterson Britton and Partners (PBP) have been engaged by Hillview Heights Pty Ltd to devise a water sensitive urban design strategy to accompany a Part 3A Major Project application. This report outlines the investigation of, and provides recommendations regarding, water management aspects (*flooding, water quality, water quantity and water cycle management*) for the development. It outlines how the development would successfully implement a water management strategy employing the latest principles of Water Sensitive Urban Design (*WSUD*) and Ecologically Sustainable Development (*ESD*) in order to create an environmentally friendly development.

This water sensitive urban design (WSUD) management strategy has been prepared in accordance with the various development control plans (*DCPs*) which are relevant to this development, the Building Sustainability Index requirements of the Department of Environment and Climate Change (*DECC*) and best management practice.

2 EXECUTIVE SUMMARY

2.1 WATER MANAGEMENT STRATEGY

The proposed Water Management Strategy has been designed to meet the following objectives implementing the principles of Water Sensitive Urban Design (*WSUD*) and Integrated Water Cycle Management:

- Minimise Potable Water Demand;
- Minimise Impacts on Water Quantity; and
- Minimise Impacts on Water Quality.

2.1.1 Minimising Potable Water Demand

It is expected that a 46% reduction in potable water demand can be achieved through implementation of the following measures:

- Rainwater re-use tanks (*8000 litres per lot*)
- Flow restrictors in the kitchen, laundry and bathroom;
- AAA rated dual flush toilets; and
- AAA rated shower heads and dishwasher.

This exceeds the 40% reduction required by BASIX.

2.1.2 Minimising Impacts on Water Quantity

2.1.2.1 Flooding

The topography of the site is such that the Moonee Waters development will not be affected by elevated ocean and flood levels within Moonee Creek even taking into account possible future sea level rises due to global warming.

2.1.2.2 Peak Flow Rates

The peak flow rates for runoff in regular storms would be detained to existing flow rates by the rainwater runoff tanks, raingardens and bioretention swales. This would alleviate adverse impacts on the stability of both Sugar Mill and Moonee Creeks.

2.1.2.3 Runoff Volume

The adherence to a best practice water sensitive urban design would allow runoff for regular storms to mimic the existing runoff behaviour. This would be achieved through incorporation of large rainwater tank storage volumes and considerable infiltration into special drainage media in the raingardens and bioretention swales. Also, the maximisation of pervious areas by minimising road carriageway and footpath widths further reduces runoff volumes.

The average annual runoff co-efficient for the existing site was determined to be 0.31. It has been shown that the runoff co-efficient for the developed site can be reduced to 0.20 through implementation of the following measures:

- Installation of rainwater re-use tanks and reuse;
- Installation of bio-retention swales and raingardens; and
- Maximisation of pervious area within the development.

2.1.3 Minimising Impacts on Water Quality

Runoff water quality is to be managed through a combination of treatment measures in a treatment train, with special emphasis on source control. The proposed stormwater treatment strategy will consist of rainwater reuse tanks, raingardens on lots, bioretention swales in the road reserve, gross pollutant traps and a bioretention swale around the whole perimeter of the development area. The swale area would occupy approximately 17% of the development area.

The implementation of the various treatment measures would reduce runoff pollutant loads below existing levels and contribute to the long term improvement in the water quality in Sugar Mill and Moonee Creeks.

2.2 STORMWATER DRAINAGE CONCEPT PLAN

The elements of the proposed Stormwater Drainage Concept Plan are presented in **Figure 1**

All flows generated as runoff are proposed to be directed to rainwater tanks, raingardens, gross pollutant traps, and bioretention swales. These will maximise the runoff treatment and minimise the runoff volumes. The runoff will mimic the existing hydrology/runoff behaviour.

A major/minor drainage philosophy has been adopted. All piped drainage infrastructure would be designed to convey the 5yr ARI flows generated on site. Flows in excess of the 5yr ARI (*up to the 100yr ARI*) event would be conveyed safely within the internal roadways and swales.

3 EXISTING SITE CONDITIONS

3.1 TOPOGRAPHY

The site has two distinct areas. The low lying areas cover approximately 60% of the total site. The higher ridgeline area at the western end of the site generally lies above RL 5.0m AHD and has an area of approximately 35 ha. The topography of the ridge areas, where the majority of the development is to occur, is moderately undulating with slopes grading from flat areas to 10% or more. The development layout has been designed to match the topography allowing development to occur without extensive earthworks. The ridge areas are separated from the lower reaches by a distinct embankment of up to 5m in height.

3.2 GEOTECHNICAL CONDITIONS

The geotechnical investigation undertaken by Coffey Geoscience revealed that the site comprises aeolian sands, clay soils and extremely weathered rock. Borehole and test pit results show that the majority of the developable area has clay soils covered by approximately 300mm of silty topsoil.

4 PROPOSED DEVELOPMENT

4.1 DESCRIPTION

Figure 1 shows the proposed layout for the Moonee Waters development.

The proposed development would be a mixture of residential lots incorporating considerable open space.

A diversity of lot types is proposed as detailed below:

	Street Frontage	**Number**	**%**
Apartments	-	-	-
Attached House	7.5m	69	18
Semi/Small Lot	10m	38	10
Small Lot	12m	114	30
Traditional Lot	15m	160	42
		381	**100**

4.2 WATER SENSITIVE URBAN DESIGN

The proposed development has been formulated based on best practice water sensitive urban design principles with emphasis on source control of water and overall integrated water cycle management. The water management system formulated in the creation of the development layout was to mimic the existing flow characteristics for the important frequent storms (small runoff events) by a combination of capturing (retention) flows, promoting infiltration into special drainage media, maintaining flows on the surface and generally slowing down the runoff. This drives maintenance of runoff volumes, reduction in runoff pollutant loads and infiltration to groundwater during these small storms. Rainwater harvesting of runoff from roofs assists to reduce potable water use but also assists significantly in mimicking the natural hydrology of the area.

5 PROPOSED WATER SENSITIVE URBAN DESIGN STRATEGY

5.1 STRATEGY OVERVIEW

This report has been prepared in accordance with the following Coffs Harbour City Council documents as well as with the reference documents listed in the Director General's requirements dated 20 October 2006:

- Subdivision DCP (*July 2003*);
- Moonee DCP (*September 2004*);
- Various Housing DCPs (*Low, medium and high density*); and
- Draft Estuary Management Plan for Moonee Creek.

In accordance with the abovementioned DCPs and the latest best management practise, the following water sensitive urban design objectives were identified for the Moonee Waters development:

- Conserve and utilise stormwater;
- Minimise increase in stormwater runoff due to the development;
- Promote long-term improvement of SEPP 14 wetland health;
- Treat runoff to ensure no adverse impact on downstream flora and fauna;
- Implement collection, conservation and re-use of stormwater; and
- Integrate water management with urban design.

These objectives represent the underlying principles of sustainable development and can be categorised into one of the three major principles identified for the site:

1. **Minimise Potable Water Demand**

   *Minimise the potable water demand of the development by implementing water saving measures and water re-use measures (refer **Section 7**).*

2. **Minimise Impacts on Water Quantity**

   *Minimise the volume of stormwater runoff from the developed site through minimising impervious areas and implementation of stormwater retention measures (refer **Section 8**).*

3. **Minimise Impacts on Water Quality**

   *Minimise impact on water quality (nutrients, sediment and gross pollutants) during and following construction activities, (refer **Section 9**).*

5.2 BASIX COMPLIANCE

The Building Sustainability Index (*BASIX*) assesses the potential performance of new homes against a range of sustainability indices, viz Landscape, Stormwater, Water, Thermal Comfort and Energy. BASIX aims to reduce the environmental impact on these features by new development by setting targets for these indices which all new developments must meet.

According to the BASIX requirements, residential developments must be designed and built to use 40% less drinking-quality water than average NSW homes of the same type. This target represents significant savings in water use.

The BASIX requirements relating to water quality (*not yet in place*) were defined by the Department of Environment and Climate Change which has specific goals regarding reducing the annual pollutant loads for developed conditions. These target reductions for the urban conditions are 80% for Total Suspended Solids (*TSS*) and 45% for Total Nitrogen (*TN*) and Total Phosphorous (*TP*).

This report outlines the measures that would be implemented to ensure compliance with the BASIX requirements where they relate to water management (*i.e. reduction in potable water usage and reduction in nutrient and sediment loading in stormwater runoff*).

6 WATER SENSITIVE URBAN DESIGN

In order for the Moonee Beach site to meet the required water management objectives, it was necessary to formulate an integrated suite of measures which, while being effective in water management, also contributed to the visual and recreational amenity of the development. This has been achieved through a treatment train series of landscaped water management features both on lot, along the roads and around the perimeter of the development. In this way, there will be a progressive treatment of runoff without reliance on one end of line feature. These features, through their landscape characters, would add value to the visual amenity of the development. The elements of the proposed WSUD strategy are outlined below and discussed in more detail in Sections 7 to 9.

Often WSUD is narrowly defined in relation to only stormwater management, however in order to achieve an environmentally sustainable development it should also encompass potable water usage. The Moonee Beach site is seen as an ideal location to apply these principles to achieve a development which will demonstrate an industry best practice commitment to sustainability.

6.1 WATER CYCLE MANAGEMENT STRATEGY

6.1.1 Overview

A design approach has been adopted in the concept plan with emphasis on source control. The objectives of the strategy are to:

- Maximise collection and re-use of stormwater for potable uses;
- Maximise runoff quantity and quality controls at the source; and
- Reduce annual pollutant load exported from the site.

In order to achieve these objectives, source controls such as rainwater tanks, and bioretention swales would be coupled with more common control measures such as gross pollutant traps. Bioretention swales would be incorporated into road reserves where they can aesthetically enhance the visual impact of the development and around the whole perimeter of the development.

The elements of the water management strategy include:

- **Source controls**
    - o minimise areas of impervious surfaces to minimise runoff volume;
    - o encourage infiltration to special drainage media to reduce the volume of runoff;
    - o implement rainwater re-use tanks and use water saving devices to reduce the domestic household demand for potable water;

- harvest rainwater to reduce the runoff volume and pollutant load in small storms;
- incorporate detention storage on lots to reduce peak flow rates to existing rates for small storms;
- pit inserts at all inlet pits (gross pollutant traps) to capture litter, debris, coarse sediment, oils and greases;
- incorporate raingardens and bioretention swales to remove fine sediment, nutrients, oils and greases; and

- **Downstream controls**
    - incorporate bioretention swales around the perimeter of the development to reduce flow rates and pollutant loads as well as promoting a diverse overflow rather than point discharges.

6.1.2 Water Sensitive Urban Design Treatment Train

Generally, the treatment train path for runoff would be:

- water saving devices and appliances would be incorporated into the dwellings along with reuse of roof runoff to reduce potable water use;
- runoff from roof areas would be collected and retained in two 4kL slim line rainwater re-use tanks to be used for toilet flushing, car washing and irrigation;
- overflow from the tanks and runoff from the lot would be detained in an onsite detention tank (if required to supplement the storage in the rainwater tank and raingarden);
- flow from the tank would be treated in an on lot raingarden (40m^2) where runoff would be filtered and treated biologically;
- stormwater entering the pipe drainage system would pass through a pit insert to remove remaining coarse sediment, litter, debris, oils and greases;
- flow from the lots and roads would be detained and treated in bioretention swales along the centreline of roads where runoff would be filtered and treated biologically;
- excess flows from the bioretention swales would flow to the pipe drainage system designed to cater for the 5 year ARI event;
- stormwater would flow to a perimeter bioretention swale which would further treat the stormwater and ensure un-concentrated discharge to the receiving environment; and
- the perimeter swales would act as the discharge mechanism for the site. Flows would overtop along the whole length of the swale with a distributed sheetflow to the receiving environment. This would replicate the existing conditions.

7 MINIMISING POTABLE WATER USE

The State Government BASIX requires a minimum 40% reduction in potable water use compared with traditional households. This can be achieved through the provision of water saving devices, conservation practises and rainwater harvesting and reuse such as:

- 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;
- Providing water efficient dishwashers and toilets (*dual flush*) etc; and
- Harvesting of roof runoff in rainwater tanks for reuse in toilets and irrigation.

7.1 WATER SAVING MEASURES

The main uses of potable water in a traditional household (*refer **Table 7.1***) are garden irrigation (*27%*), shower (25%), toilet (*16%*) and washing machine (*19%*).

Table 7.1 Typical Household Water Usage

Area/Use	***Traditional Household***		***With Water Saving Devices***	
	Usage l/person/day	**Percentage of Total Use (%)**	**Usage l/person/day**	**Percentage Reduction (%)**
Internal				
Kitchen	11.9	5.3	8.6	18%
Bathroom basin	5.9	2.6	4.2	18%
Laundry basin	4.9	2.2	3.5	18%
Shower	56.8	25.4	39.7	30%
Toilet	35.2	15.7	21.2	40%
Washing machine	42.5	19.0	42.5	-
Dishwasher	3.3	1.5	2.3	30%
Sub Total	*160.5*	*71.7*	*122.0*	*24%*
External				
Irrigation	59.3	26.6	59.3	-
car washing	3.7	1.7	3.7	-
Sub Total	*63.0*	*28.3*	*63.0*	**-**
TOTALS	**223.5**	**100**	**185.0**	**17%**

The reductions in potable water use due to water saving devices (*listed in **Table 7.1***) have been derived from the report, *Investigation of Options to Minimise Potable Water Demand and Reduce Wastewater Flows* (*URS 2003*).

It is recommend that the development incorporate flow restrictors in the kitchen, laundry and bathroom, AAA rated shower heads and taps, dual flush toilets, and AAA rated dishwashers. These alone would directly reduce total potable water usage by approximately 17%.

Water saving devices in combination with reuse of rainwater from rainwater tanks (*described further in **Section 7.2***) for toilet flushing, car washing and irrigation would be implemented to achieve the minimum 40% reduction required by BASIX.

7.2 RAINWATER RE-USE

7.2.1 Strategy

The re-use of rainwater from rainwater tanks has the potential to make considerable reductions in potable water usage in concert with water savings devices. With full substitution of potable water with recycled water for toilet flushing, car washing and irrigation, the reduction in potable water usage would be 63% *(with the 17% reduction due to water saving devices – see **Section 7.1***). However, full substitution could not be guaranteed due to the variability of rainfall.

It is proposed to re-use harvested rainwater for toilet flushing, car washing and garden irrigation with a mains water supply top-up system. In order to mimic the existing site hydrology (runoff characteristics) and reduce pollutant loads in runoff it was decided to adopt two 4kL slim line rainwater tanks for each lot. This would maximise the potable water reduction and the retention of runoff pollutant loads at the source.

7.2.2 Rainwater Tanks

Based on PBP experience and an initial site analysis, it was estimated that a provision of two 4000 litre slim line rainwater storage per dwelling would readily achieve the minimum 40% reduction requirement (*BASIX*).

The PBP daily water balance model has been utilised to estimate the potable water use reduction.

The water balance analysis was undertaken using recorded historical rainfall and evaporation data with the two 4000 litre rainwater tanks included in each household *(see* **Table 7.2** *and refer* **Appendix A***).*

Table 7.2 Water Balance Summary

All volumes in (m^3/yr), for annual average		No-controls	Proposed
Flow to Rainwater Tanks	(1)	-	57,703
Rainwater Tank water losses as overflow	(2)	-	34,864
Water available from Rainwater Tanks	3 = (1-2)	-	22,839
Rainwater Tank demand incl. car washing, irrigation, toilet flushing	(4)	-	21,659

Potable water demand as a substitute for Rainwater Tank	(5)		5,041
Potable Water demand general internal use	(6)		25,388
Total potable water use	7 = (5+6)	56 288	30,427
Total Water Use	9 = (3+7)		53,266
Potable Water Use Reduction (%)			**46%**

The water balance model predicted a total potable water use reduction from 56,288m^3/yr in the traditional household model to 30,427m^3/yr with the introduction of water saving devices and the rainwater reuse, representing a reduction in potable water usage of 46% which exceeds the BASIX requirement of 40%.

The rainwater system would employ a mains top-up scheme to ensure reliable water supply from the tank. When tank water levels are low, during period of little rainfall, the tank is topped up with mains water via a trickle system. This trickle system reduces the peak demands on the mains water distribution network.

An air gap between the rainwater tank and the top up system along with a one way valve would be installed to ensure no rainwater enters the mains water supply system. These devices are mandatory as required by the Department of Health. Tanks would be fitted with a first flush device which causes the initial volume of runoff (***containing the highest concentration of pollutants***) to bypass the tank.

8 MINIMISING IMPACTS ON WATER QUANTITY

There are three issues which require consideration in regard to the water quantity management of the Moonee Waters development:

- Flooding;
- Detention; and
- Runoff volume.

These are discussed in the following sections.

8.1 FLOODING

8.1.1 Moonee Creek

The site is located adjacent to the downstream sections of Sugar Mill Creek and Moonee Creek. The confluence of these creeks is located just downstream of the subject property at the ocean entrance to Moonee Creek. The flood level at this location would be driven by the elevated ocean levels in a severe storm. The conservatively estimated 100yr ARI elevated ocean level at a shoaled river entrance is predicted to be approximately RL 2.6m AHD.

Estimates of future sea level rise due to Greenhouse Effects are under regular review and generally consist of lower, medium and upper bound scenarios. The generally accepted prediction of sea level rise in the next 100 years ranges from 0.2m to 0.5m.

The estimated 100yr ARI level at the subject site in 100 years time is approximately RL 2.8m to RL 3.1m AHD. The proposed development would have a minimum ground level of RL 3.1m AHD and the habitable floor levels would be located at or above RL 3.6m AHD.

A flood map has been included as **Figure 2** plotting the approximate locations of these estimated levels in the vicinity of the development.

8.1.2 Overland Flow Hazard

The stormwater pipe drainage would have a 5yr ARI capacity as required by Council. Runoff beyond this capacity would flow overland along the roads. This is practice accepted by Council in all areas. The overland flows would be contained within the road carriageways (*and swales where present*) and therefore measures would be implemented to ensure safe flows for pedestrian movement in all storms up to the 100yr ARI event.

The maximum longitudinal road grade within the development would be 10% thus limiting the velocity of the overland flows. It would be ensured that the product of the depth and velocity of the overland flows (*standard measure used to estimate risk to pedestrians*) would not exceed $0.4m^2/s$ for pedestrians and $0.6m^2/s$ for vehicles. If necessary, this would be achieved through installation of larger pipes (*i.e. containing a greater proportion of the runoff flow beneath the surface*) and/or by flow diversion.

8.2 PEAK FLOW RATES

Because the Moonee Waters development discharges directly to Sugar Mill Creek, there is no potential for adverse impacts on downstream Council drainage systems. On this measure, no detention storage is required for the development. However, the use of rainwater re-use tanks and bioretention swales would reduce the peak flow rates from the site.

The stability of creeklines is significantly influenced by regular small runoff events up to bank full flows which typically coincide with a 1yr to 2yr ARI storm. This is why Council guidelines and the draft Estuary Management Plan for Moonee Creek require control of the peak flow rates to existing rates for frequent storms.

The peak flow rate of storms can be controlled with temporary storage and slow release. The rainwater tanks and on lot raingardens would provide this temporary detention storage. The swales in the roads and around the site perimeter would also provide detention storage.

Research has estimated that rainwater tanks provide effective detention storage equal to about 40% of the tank volume. This would equate to approximately 3.2m³ with an additional 1.2m³ in the raingarden. This, in addition to the road and perimeter swale, would provide sufficient detention storage to maintain existing peak flow rates from the site for regular storms and not adversely impact on the stability of the creek.

8.3 RUNOFF VOLUME

8.3.1 Objective

One of the major objectives of the water management strategy for the proposed development is to maximise the reduction in runoff volume from the site in frequent storms. This would be achieved by harvesting roof runoff and by infiltrating runoff into special drainage media incorporated in the proposed raingardens and bioretention swales.

8.3.2 Proposed Stormwater Retention Measures

8.3.2.1 Rainwater Re-use Tanks

Rainwater tanks retain a portion of the stormwater falling on the roof areas of the development and therefore contribute to reducing the total volume of stormwater runoff from the site. A large volume of rainwater storage has been stipulated for each lot to maximise the runoff volume reduction. The water balance model determined that 22.8ML of rainwater would be utilised from the rainwater tanks in a year. This represents a reduction in the runoff volume of nearly 54%.

The rainwater storage could be provided in two 4kL slim line tanks. These tanks can be readily installed alongside the side of a house.

8.3.2.2 Bio-Retention Swales/Raingardens

These devices would serve a threefold function of stormwater retention, stormwater detention and reduction of stormwater pollution levels.
A raingarden is a sunken landscaped garden with special subsurface drainage media (sandy loam/fine gravel) to promote infiltration of stored runoff. It would be typically located across each lot near the low point of the lot (either front or rear of the lot) with a width of about 4m. A bioretention swale is a similar feature in that it is landscaped and includes special subsurface drainage media. A swale is a shallow channel or depression which forms a drainage corridor in which the vegetation filters the runoff. Runoff infiltrating into the drainage media is also filtered and biological actions further breakdown nutrients.

Bio-retention swales would be located in the streetscape (***i.e.*** *in the central median of main internal roads)* and around the perimeter of the site

The swales along the roads would be 4m wide while the swale around the site perimeter would be 10m wide. The perimeter swale would have infiltration drains at the base at regular intervals to promote further infiltration. The proposed bio-retention swale configuration is shown on **Figure 1** and is typical of the wider perimeter swale. Each swale would consist of a low flow storage area underlain by topsoil, infiltration media and an underdrain system. To promote detention, the surface of the swales will be densely planted in accordance with the landscape architects specifications and bunds or check dams will be incorporated at regular intervals.

The extent and type of planting proposed within the swales would be designed to discourage mistreatment and misuse.

The drainage media in the raingardens and swales would have an infiltration rate of 100mm/h. A portion of the runoff will also infiltrate into the surrounding subsoils. Flows collected by the underdrain system will eventually discharge into the pipe drainage system. This underdrain system along with the highly permeable backfill and topsoil (*sandy loam*) utilised within the raingarden and swale would prevent the area from being saturated or becoming “boggy” during extended periods of wet weather.

8.3.2.3 Pervious Area

Runoff from the development has been further reduced by promoting pervious areas and minimising impervious areas. Impervious area has been minimised by adopting minimum pavement widths for roads, reducing the extent of concrete footpaths and maximising the use of vegetated swales.

9 MINIMISING IMPACT ON WATER QUALITY

9.1 OBJECTIVES

The DECC's specific goals regarding reduction of annual pollutant loads in runoff under developed conditions are listed below.

- total suspended sediments 80% of average annual load;
- total phosphorous 45% of average annual load; and
- total nitrogen 45% of average annual load.

These targets represent the BASIX requirements and have been adopted as the targets for Moonee Waters. Due to the sensitive nature of the receiving waters of this development (***SEPP 14 wetlands***), this development has made a commitment to implement a water quality management strategy which not only achieves, but greatly exceeds these requirements. The goal adopted for this development is to match existing conditions and where possible provide a reduction in the runoff pollutant load.

In order to achieve these objectives, a treatment train approach would be implemented into the development where the stormwater treatment flow path for runoff would be:

- runoff from roof areas would be collected and retained in two 4kL slim line rainwater re-use tanks to be used for toilet flushing, car washing and irrigation;
- overflow from the tanks and runoff from the lot would be detained in an onsite detention tank (if required to supplement the storage in the rainwater tank and raingarden);
- flow from the tank would be treated in an on lot raingarden (40m^2) where runoff would be filtered and treated biologically;
- flow from the lots and roads would be detained and treated in bioretention swales along the centreline of roads where runoff would be filtered and treated biologically;
- excess flows from the bioretention swales would flow to the pipe drainage system designed to cater for the 5 year ARI event;
- stormwater exiting the pipe drainage system would pass through a gross pollutant trap to remove remaining coarse sediment, litter, debris, oils and greases;
- stormwater would flow to a perimeter bioretention swale which would further treat the stormwater and ensure un-concentrated discharge to the receiving environment; and
- the perimeter swales would act as the discharge mechanism for the site. Flows would overtop along the whole length of the swale with a distributed sheetflow to the receiving environment. This would replicate the existing conditions.

These processes are described in more detail in **Section 9.2**.

9.2 PROPOSED MEASURES

9.2.1 Rainwater Tanks

In addition to the water re-use benefits evident with installation of a rainwater tank, there would also be water quality benefits. Rainwater tanks contribute to the retention of rainwater thus resulting in a reduction of the runoff co-efficient for the development which in turn reduces the annual pollutant loads. The installation of rainwater re-use tanks is described in more detail in **Section 7.2**.

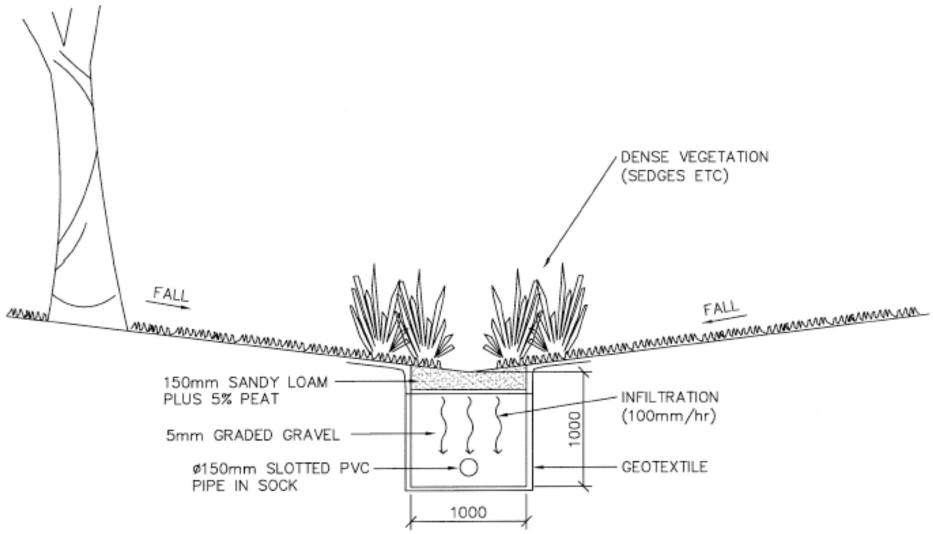
9.2.2 Bio-retention Systems

Bio-retention systems are systems that 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. Bioretention systems include raingardens and bioretention swales.

Bioretention swales would be incorporated into road reserves and around the site perimeter where they can aesthetically enhance the visual impact of the development. The swales would be planted with native grasses and fringe vegetation on a layer of coarse sand and soil. Below the swale would be a gravel filled trench approximately 1000mm deep and 1000mm wide wrapped in geo-textile with a perforated pipe at the base.

The swales and raingardens will facilitate seepage loss to groundwater. Based on the existing in situ soil conditions the raingardens and median swales have an assumed seepage loss of 1mm/hour as per MUSIC default for light clays. It is proposed to ameliorate the soil conditions adjacent to the perimeter swales to enable surface water to infiltrate into the surrounding soils at a rate of 15mm/hour as per the MUSIC default for sandy loam.

A typical bioretention swale is shown in the figure below.



TYPICAL CROSS SECTION
OF A BIORETENTION SWALE
NTS

The raingarden is a landscaped depressed area with special subsurface drainage media. It performs the same function as a swale but can be more effective due to its ability to detain larger volumes of runoff in the same area.

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 filtering through the gravel trench and biological action due to growth on the gravel. Low flows are maintained as much as possible on the surface which 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 Moonee Waters site is ideal for implementation of bioretention systems where flat grades enable water to temporarily pond thus increasing the nutrient uptake capacity.

9.2.3 Pit Inserts

A Pit Insert captures litter, coarse sediment, some nutrients, oils and greases. While the pollutant capture efficiency of various traps may vary, it is vital that the entire catchment is serviced by these gross pollutant traps (GPT) and therefore that they be placed in stormwater inlet pits.

Because the stormwater runoff would have received a considerable amount of treatment before it reaches the GPTs, we have conservatively modelled the following removal efficiencies in line with manufacturer's specifications:

- gross pollutants 80%
- sediments 50%
- total phosphorous 20%

- total nitrogen 6%

Refer to www.ecosol.com.au/solutions_source.asp

9.3 ANALYSIS OF STORMWATER QUALITY IMPROVEMENT MEASURES

9.3.1 Model for Urban Stormwater Improvement Conceptualisation (*MUSIC*)

The software package developed by the CRC for Catchment Hydrology termed "MUSIC" (*Model for Urban Stormwater Improvement Conceptualisation*) was used to assess the effectiveness of the proposed "*treatment train*" and therefore ensure compliance with the proposed objectives.

MUSIC is a continual-run conceptual water quality assessment model developed by the Cooperative Research Centre for Catchment Hydrology (*CRCCH*). 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 has been used to ensure compliance 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
- It 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.

9.3.2 Rainfall

In order to develop a model that could comprehensively assess the performance of water quality treatment devices such as swales and bioretention, the use of 6 minute pluviograph data is necessary. Long term annual rainfall measurements for the region, as measured by the Bureau of Meteorology station 059039 High Street Woolgoolga, estimate the mean rainfall at the site to be 1611mm/year.

This estimate was based on 40 complete years of record at this site, between 1963 and 2004 (*Bureau of Meteorology, 2004*). No pluviograph data to provide six minute rainfall records is available for this station.

Pluviograph data recorded at the Bureau of Meteorology station 059040 in Coffs Harbour was adopted for the analysis. During 1973 the yearly rainfall total was 1629mm this is considered to be representative of the mean annual rainfall experienced at the site.

9.3.3 Evaporation

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 9.3.3.**

Table 9.3.3 - Monthly Areal Potential Evapotranspiration

Month	Areal Potential Evapotranspiration (*mm*)
January	195
February	160
March	150
April	95
May	65
June	55
July	55
August	70
September	105
October	145
November	170
December	190

9.3.4 Catchment data

A catchment plan has been developed for the site, (refer **Figure 1)** that details the stormwater management strategy. The sub catchment areas, land use types and percentage impervious adopted are detailed in **Table 9.3.4**.

Table 9.3.4 – Catchment Parameters

Sub Catchment	Land use	Area (*Ha*)
Northern		
N1 - Urban	Urban	1.61
N2 - Urban	Urban	0.91
N3 - Urban	Urban	0.96
N4 - Urban	Urban	1.29
N5 - Urban	Urban	1.06
N6 - Urban	Urban	0.43
N7 - Urban	Urban	0.38
N8 - Urban	Urban	0.29
N9 - Urban	Urban	1.01
N10 - Urban	Urban	0.77
N11 - Urban	Urban	2.32
N12 - Urban	Urban	1.09
N13 - Urban	Urban	1.24
N14 - Urban	Urban	0.53
N15 - Urban	Urban	2.2
Link	Urban	0.91
Southern		
S1 - Urban	Urban	0.63
S2 - Urban	Urban	1.42
S3 - Urban	Urban	1.21
S4 - Urban	Urban	1.52
S5 - Urban	Urban	1.39
S6 - Urban	Urban	1.39
S7 - Urban	Urban	2.31
Link	Urban	0.88
TOTAL		**27.75**

9.3.5 Soil Data and Model Calibration

Soil properties for the site were adopted in light of the geotechnical investigation undertaken by Coffey Geosciences and calibrated to achieve a runoff coefficient (C_v) of 0.28 for the existing site

Impervious
- rain threshold 3mm/day

Pervious
- soil capacity 120mm
- Initial storage 30% of capacity
- field capacity 80mm
- coefficient '*a*' 200
- coefficient '*b*' 1.0

9.3.6 Pollutant Concentrations

The event mean pollutant concentrations (*EMC's*) that were used in the modelling of the development were derived from a literature review that the CRC (*Duncan et al.*) undertook for the DECC in March 2004.

The adopted pollutant concentrations are shown in **Table 9.3.6**.

Table 9.3.6 – Adopted Runoff Pollutant Concentrations

	Pollutant Concentration (mg/L)		
	Suspended Solids	**Total Phosphorous**	**Total Nitrogen**
Roof			
Landscape Buffer ("Forest/Natural")	20.0	0.13	2.0
Residential	140.0	0.25	2.0

9.3.7 Existing Conditions Simulation

A MUSIC model of the existing conditions was created incorporating the parameters discussed in the preceding sections (*i.e. rainfall, percentage imperviousness, evaporation, soil data and pollutant concentrations*). The model was used to simulate the pollutant export generated during a mean rainfall and evaporation year under existing conditions.

The estimated annual export of pollutants from the site for a mean rainfall year are shown in **Table 9.3.7**.

Table 9.3.7 – Annual Pollutant Export Loads – Existing Conditions

Node / Location	Pollutant Load (kg/yr)		
	Suspended Solids	**Total Phosphorus**	**Total Nitrogen**
Overall Site	3,330	12.9	85

9.3.8 Proposed Development (without treatment measures)

The model was revised to incorporate the proposed development but without treatment measures in order to quantify the likely increase in pollutant loads in the runoff.

The estimated annual export of pollutants from the development without treatment measures are presented in **Table 9.3.8.**

Table 9.3.8 – Annual Pollutant Export Loads – Developed (without treatment measures)

Node / Location	Pollutant Load (kg/yr)		
	Suspended Solids	**Total Phosphorus**	**Total Nitrogen**
Overall Site	22,600	42.9	473

9.3.9 Proposed Development (with treatment measures)

The model was revised to incorporate the proposed development with treatment measures to quantify their effectiveness. The proposed treatment measures comprised in total:

- 2,208m^3 rainwater tank storage;
- 11,040m^2 of raingarden;
- 1,350m of bioretention swale in the roads;
- Pit inserts in all inlet pits; and
- 5,100m of bioretention swale around the perimeter of the site.

The swale and raingarden area represents approximately 17% of the site area to be developed.

The estimated annual export of pollutants from the development is compared for scenarios with and without the treatment measures and for existing conditions in **Table 9.3.9**.

Table 9.3.9 – Annual Pollutant Export Loads – Developed State Treated

Node / Location	Pollutant Load (kg/yr)								
	Suspended Solids			Total Phosphorus			Total Nitrogen		
	Exist.	Dev	Dev-Treat	Exist.	Dev	Dev-Treat	Exist	Dev	Dev-Treat
Overall Site	3,330	22,600	214	12.9	42.9	3.4	84.9	473	76.2

The following reductions in pollutant export would be achieved from the development with the incorporation of the treatment measures:

- Suspended Solids 99%
- Total Phosphorus 92%
- Total Nitrogen 84%

It can be seen that the DECC requirements of 80% reduction in suspended solids, 45% reduction in total phosphorous and 45% reduction in total nitrogen have been significantly exceeded for water discharging to Moonee Creek.

The runoff pollutant load from the development would be less than for existing conditions on the site. This would contribute to the long term improvement in the water quality in Sugar Mill and Moonee Creeks.

9.4 CONSTRUCTION PHASE

Sediment and erosion control plans would be designed in accordance with the NSW Department of Housing "*Managing Urban Stormwater – Soils and Construction*" (*Blue Book*) and to the satisfaction of Council. Staging of the development would minimise impacts during construction.

A sediment and erosion control plan would be prepared prior to construction, outlining the strategies proposed to prevent excessive pollutant loads being exported from the site in runoff during and immediately following construction. It is recommended that the following measures be implemented:

- At the upstream end of works, clean water would be temporarily diverted around disturbed areas;
- A sediment fence would be erected at the downstream end of any disturbed areas;
- The area of soil disturbed at any one time would be minimised where possible;
- Sediment basins would be constructed as required; and
- Disturbed areas would be rehabilitated as soon as practical.

These controls would ensure that there are no significant adverse impacts on receiving water quality during construction.

10 DIRECTOR GENERAL'S REQUIREMENTS

10.1 INTRODUCTION

The Director General's Requirements were attached to the letter from the Department of Planning dated 20 October 2006. The key issues relating to water management issues were contained in issues 5 and 6. The issues and the manner in which the proposed development addresses these issues is described in the following sections with reference to the relevant sections in this report containing the detailed assessment.

Attachment 3 of the Director General's Requirements provides a list of relevant technical and policy guidelines. Where relevant, these guidelines have been invaluable reference documents in the preparation of this water management strategy.

10.2 ISSUE 5 – WATER CYCLE

10.2.1 Issue 5.1 – Runoff Quality Control

The inclusion of rainwater harvesting and reuse, raingardens, bioretention swales and gross pollutant traps in the development to represent a water sensitive urban design would result in average annual runoff pollutant loads being the same or less than for existing conditions. This would contribute to the long term improvement in receiving waters water quality. The receiving waters include Sugar Mill and Moonee Creeks, wetlands and the waters of the Solitary Islands Marine Park. The treatment of runoff at the source and in a treatment train would ensure no adverse impacts on groundwater quality.

The runoff water quality control is discussed in detail in **Section 9.**

10.2.2 Issue 5.2 – Estuary Management Plan

The Moonee Creek Estuary Management Plan (EMP) provides a "road map" for future sustainability of the estuary. It identified fourteen objectives for which the two highest ranked objectives were related to water quality and future development. These objectives were described as:

- Reduce the level of pollutant and sediment load entering Moonee Creek; and
- Future development to not place any additional stress on the estuary.

A total of forty two strategies were identified to meet these objectives of which twenty four were short listed as the preferred management options or strategies. These strategies were prioritised. The strategies related to water management (and their ranking) were:

- CD 3 – ranked ninth
  - Ø Provide policy document restricting allowable surface runoff rates and pollutant loads for rainfall events up to 2 yr ARI;

  - Ø Controls should relate to both the construction and post construction phases of development.

- CD 4 – ranked eleventh
  - Ø Onsite runoff management to prevent excess sediment, nutrients and volumetric runoff;
  - Ø Rainwater harvesting;
  - Ø Developments to be connected to reticulated sewerage system.

- CD 6 – ranked twelfth
  - Ø Implementation of water sensitive urban design and integrated water cycle management;
  - Ø Best practice stormwater management including rainwater harvesting.

The Moonee DCP 2004 requires incorporation of WSUD and adherence to the runoff treatment targets for water quality. For new developments, Council's policy requires implementation of best practice stormwater management practices and no net increase in the average annual load of pollutants in runoff. By conforming to Council's policies, the proposed development would conform with the draft EMP requirements.

The development conforms to draft EMP requirements by:

- Incorporation of a WSUD best practice stormwater management strategy;
- Incorporation of an integrated water cycle management approach with rainwater harvesting and reuse for toilet flushing and irrigation which would reduce potable water use;
- Harvesting runoff, promoting infiltration of runoff into subsoil drainage media (bioretention systems) and slowing down runoff through these systems will assist to mimic the existing runoff characteristics; and
- Runoff pollutant loads would be less than for the existing conditions thereby contributing to the long term improvement in water quality in Sugar Mill and Moonee Creeks.

10.2.3 Issue 5.3 – Water Cycle

The measures incorporated in the proposed development for Integrated Water Cycle Management include:

- Potable water saving devices and appliances in dwellings;
- Rainwater harvesting and reuse for toilet flushing, car washing and irrigation;
- Use of raingardens and bioretention swales which will reduce irrigation requirements;
- Encouragement of low water demand vegetation in landscaping;
- Treatment of runoff at the source and in a train to alleviate significant impacts on groundwater quality; and
- The stormwater management strategy is based on water sensitive urban design.

The measures are described in detail in **Sections 5 to 9**.

10.2.4 Issue 5.4 – Access

The development as proposed on the subject site at Moonee will provide a high degree of visual monitoring of the watercourses adjoining the development areas. Implementation of the Management Plan for the Conservation Area in perpetuity will also provide opportunities to identify areas where human encroachment is causing damage, and provide the resources to repair any such damage and to educate those responsible. Such measures are not currently part of management of the subject site, and could not conceivably occur without development as proposed on the site at Moonee.

The project will provide features which identify the physical edge of the Conservation Area, as well as signage to encourage proper respect for the conservation values of retained vegetation on the site. In addition, the proposal incorporates the construction of dedicated walkways and bicycle paths through the Conservation Area which are intended specifically to concentrate human activities and to both educate with respect to the environmental values of the Conservation Area and constrain human access to environmentally sound constructed pathways. Again, these features will not be provided unless the project is approved.

10.2.5 Issue 5.5 – Government Liaison Authority

The project team has liaised with the government authorities and their requirements have been addressed in the overall documentation in the application.

10.3 ISSUE 6 – HAZARDS

10.3.1 Issue 6.2 – Flooding

The estimated 100yr ARI flood level adjacent to the site has been estimated along with allowance for possible future sea level rise associated with Greenhouse Effects. The proposed ground levels in the development area would be at or above the predicted 100yr ARI flood level and habitable flow levels would be a minimum of 0.5m above this level.

This is discussed in detail in **Section 8.1.**

10.3.2 Issue 6.5 – Coastal Hazards

The proposed development would be located a considerable distance landward of the estimated 100yr coastal hazard line and hence would not be exposed to these risks. The development conforms to the Coastline Management Manual.

This issue is discussed in detail in a separate Patterson Britton report entitled *Moonee Water Coastline Hazard Definition (June 2007).*

11 CONCLUSIONS

11.1 WATER MANAGEMENT

This report has outlined how a successful water sensitive urban design strategy would be implemented for the Moonee Waters development. The specific conclusions that can be drawn regarding the three areas of water management are outlined below.

11.1.1 Potable Water Use

Installation of rainwater re-use tanks to deliver rainwater to households for certain uses (*toilet flushing, car washing and irrigation*) in conjunction with implementation of water saving measures (*flow restrictors, water efficient appliances, responsible landscaping etc*) would reduce the potable water demand by approximately 46%.

Given these figures, it can be concluded that the requirements of BASIX would be met.

11.1.2 Water Quantity

The proposed water management strategy would successfully reduce the volume of runoff for regular storms.

Peak flows from the development during frequent storms would be reduced due to the detention provided by the rainwater tanks, raingardens and bioretention swales. This detention storage would be at least 18,000m^3 being equivalent to 67m^3/lot.

The perimeter swale would provide a distributed sheetflow discharge from the site similar to existing conditions.

11.1.3 Water Quality

Installation of rainwater tanks and construction of raingardens and bioretention swales in the configuration proposed in conjunction with installation of gross pollutant traps would significantly reduce the pollutant export from the site. The level of treatment proposed would significantly exceed the pollutant removal objectives set by the DECC. The pollutant loads would be less than for existing conditions leading to a contribution to the long term improvement in the water quality in Sugar Mill and Moonee Creeks.

12 REFERENCES

Australian Rainfall and Runoff, a Guide to Flood Estimation, Institution of Engineers, 1987

Promote long-term improvement of SEPP 14 wetland health; *Development Control Plan, Subdivisions*, Coffs Harbour City Council, July 2003

Development Control Plan, Moonee, Coffs Harbour City Council, September 2004

Development Control Plans, Low, Medium and High Density Housing, Coffs Harbour City Council

Climate Atlas of Australia, Evapotranspiration, Bureau of Meteorology in conjunction with the Cooperative Research Centre for Catchment Hydrology, 2001

Urban Stormwater Quality **-** *A Statistical Overview*, Duncan, Hugh P, 1999

Managing Urban Stormwater **-** *Treatment Techniques,* Environment Protection Authority, 1996

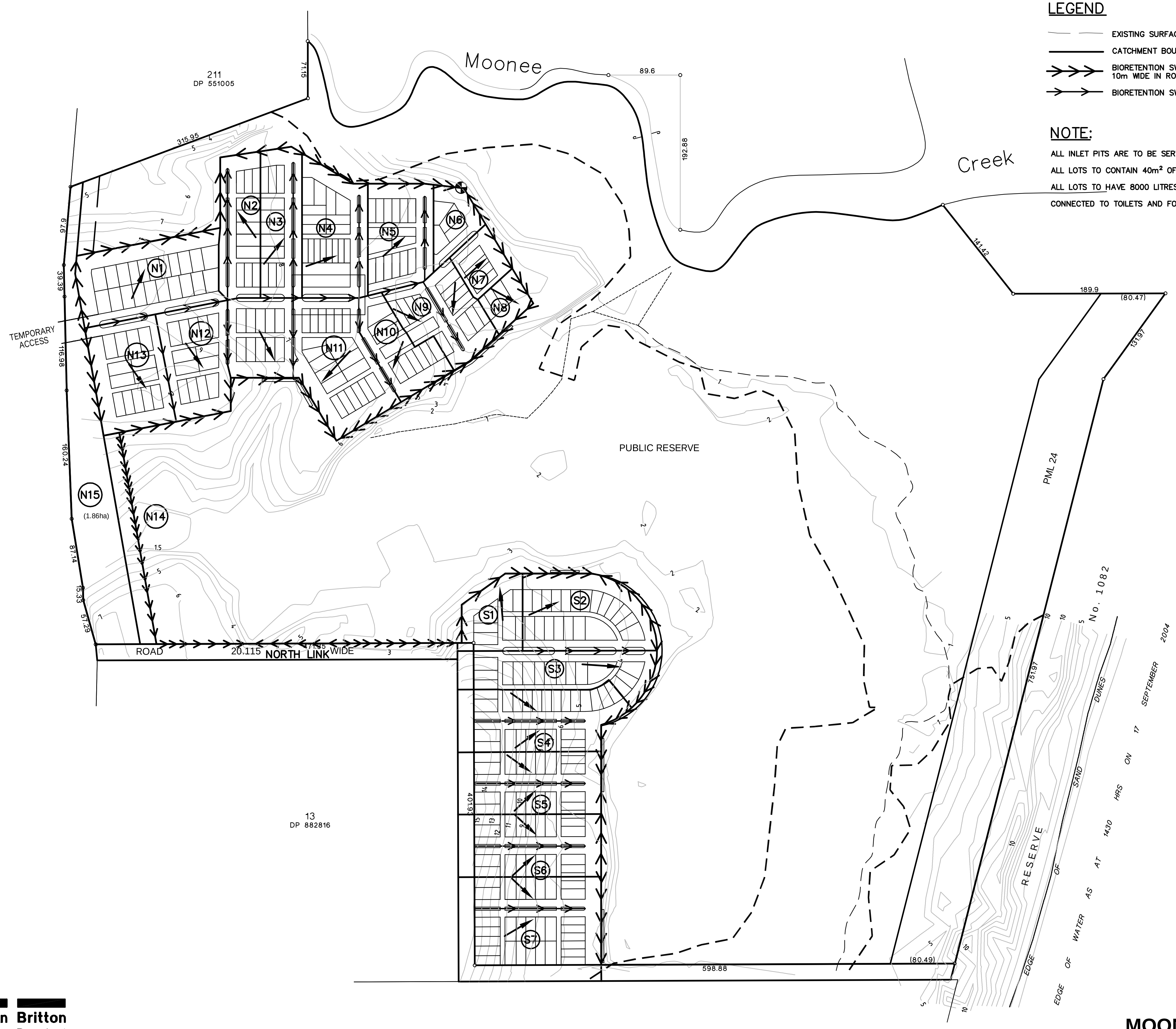
Managing Urban Stormwater **-** *Council Handbook,* Environment Protection Authority, 1996

Managing Urban Stormwater **-** *Soils and Construction* (*Blue Book*), NSW Department of Housing, 2004

Removal of Suspended Solids and Associated Pollutants by a Gross Pollutant Trap, Cooperative Research Centre for Catchment Hydrology, 1999

FIGURES

FIGURE 1



LEGEND

- EXISTING SURFACE CONTOUR (0.5m INTERVAL)
- CATCHMENT BOUNDARY
- BIORETENTION SWALE AROUND PERIMETER ON SITE 10m WIDE IN ROAD VERGES
- BIORETENTION SWALE IN MEDIAN 4m WIDE

NOTE:

ALL INLET PITS ARE TO BE SERVED WITH PIT INSERTS TO CAPTURE POLLUTANTS.

ALL LOTS TO CONTAIN 40m² OF RAIN GARDEN

ALL LOTS TO HAVE 8000 LITRES RAINWATER TANK CONNECTED TO TOILETS AND FOR OUTDOOR USE.

CATCHMENT PARAMETERS

SUB CATCHMENT	AREA (Ha)
NORTHERN	
N1	1.61
N2	0.91
N3	0.96
N4	1.29
N5	1.06
N6	0.43
N7	0.38
N8	0.29
N9	1.01
N10	0.77
N11	2.32
N12	1.09
N13	1.24
N14	0.53
N15	2.20
NORTH LINK	0.91
SOUTHERN	
S1	0.63
S2	1.42
S3	1.21
S4	1.52
S5	1.39
S6	1.39
S7	2.31
SOUTH LINK	0.88
TOTAL	27.77

0 50 100 150 200 250m
1:2500 (A1) 1:5000 (A3)

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consulting engineers

JOB No TITLE

MOONEE WATERS, COFFS HARBOUR
STORMWATER MANAGEMENT PLAN

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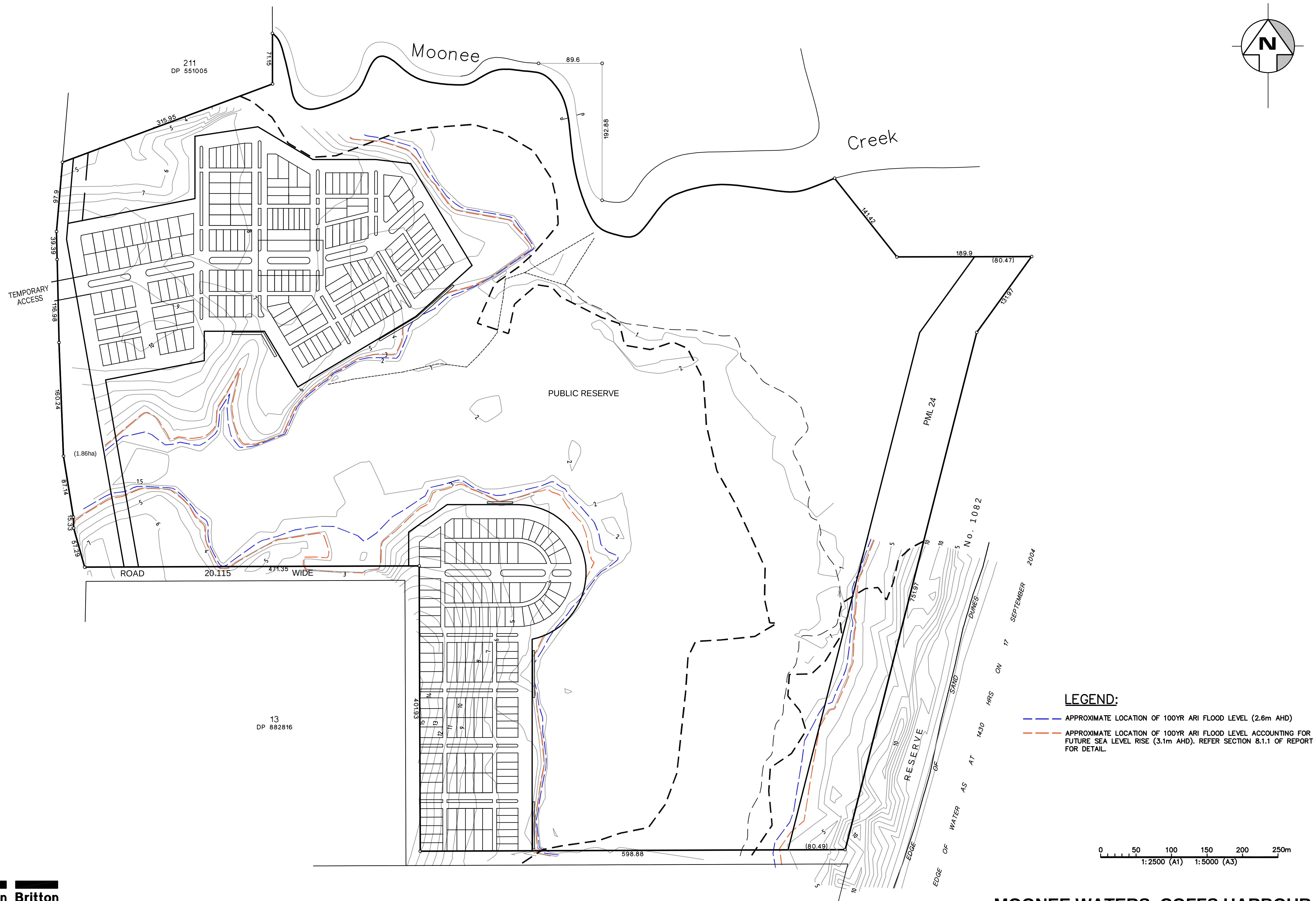
FIGURE 2



LEGEND:

- APPROXIMATE LOCATION OF 100YR ARI FLOOD LEVEL (2.6m AHD)
- APPROXIMATE LOCATION OF 100YR ARI FLOOD LEVEL ACCOUNTING FOR FUTURE SEA LEVEL RISE (3.1m AHD). REFER SECTION 8.1.1 OF REPORT FOR DETAIL.

MOONEE WATERS, COFFS HARBOUR
FLOOD MAP

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N:\5611 Mooney Waters - ARG\5611 Fig 2 04-10-07.dwg, FIGURE 2, 22/11/2007 3:54:18 PM

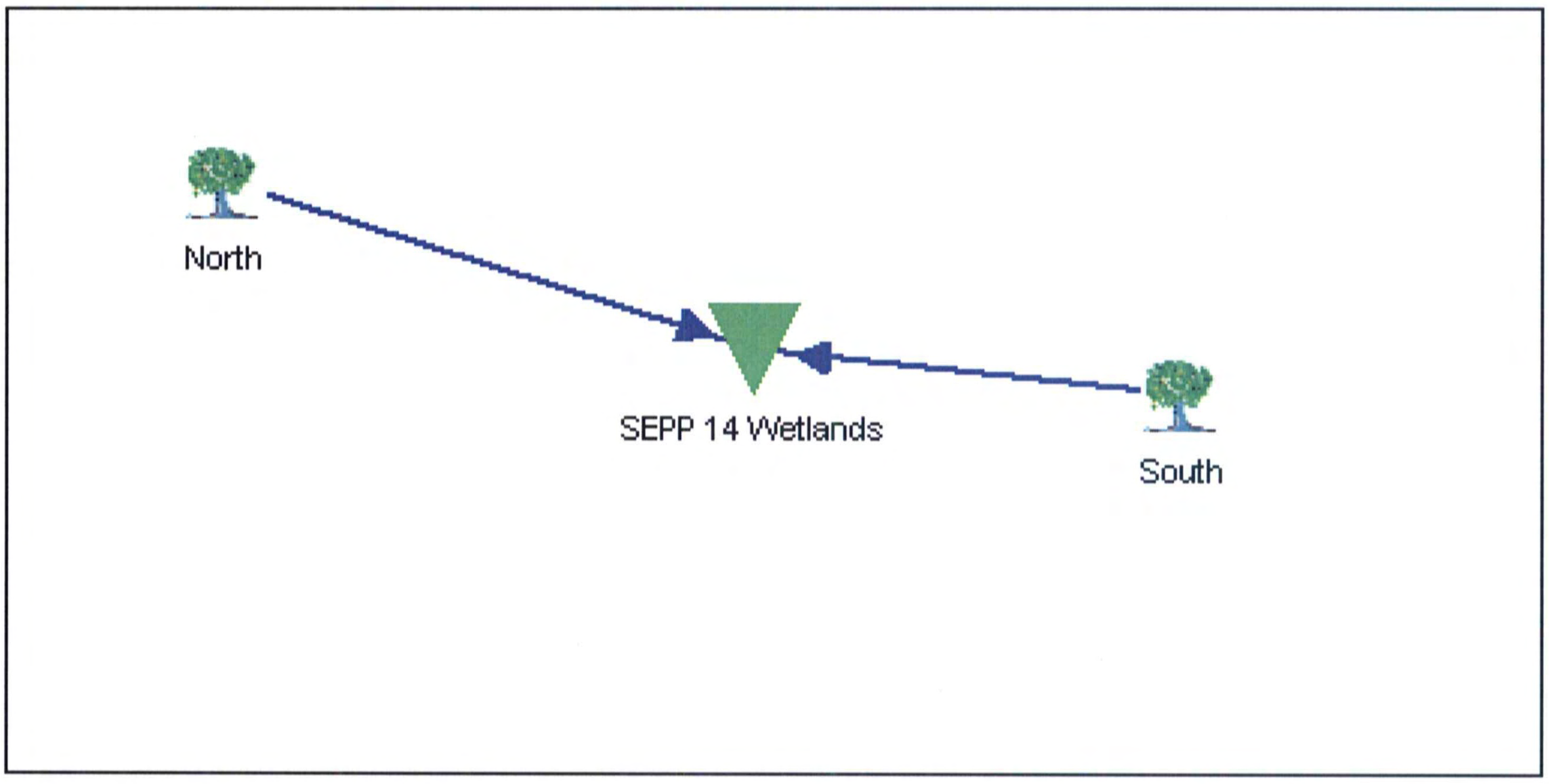
APPENDIX A – WATER BALANCE

Data - Developed With Treatment - Mooney Beach				
1.0	**General Catchment Data**	**Area (m2)**	**To Inf (%)**	
1.1	- Impervious Area to Rainwater Tanks	41400	0%	
1.2	- Impervious Area not to Rainwater Tanks	0	0%	
1.3	- Pervious Area to be Irrigated	13800	0%	50 sqm/lot
1.4	- Pervious Area not to be Irrigated	0	0%	
1.5	- Forested Area	0	0%	
1.6	- Infiltration system (inf)	0	-	
1.7	- wetland (assumes all site drains to wetland)	0	-	
1.8	- Total Area	55200	0%	
2.0	**Interception**			
2.1	- Proportion of Irrigated Pervious Area as Canopy	0%		
2.2	- Proportion of No Irrigated Pervious Area as Canopy	25%		
2.3	- Proportion of Forested Area as Canopy	25%		
2.4	- Maximum Canopy Storage	1.5	mm	
3.0	**Depression Storage**			
3.1	- Impervious Depression Storage	1.5	mm	
3.2	- Pervious Depression Storage	0.5	mm	
3.3	- Forested Depression Storage	1	mm	
4.0	**Forest Soil Moisture Storage**			
4.1	- Maximum Storage	80	mm	
4.2	- Initial Moisture Storage	70	mm	
4.3	- Storage Before Infiltration Occurs	60	mm	
4.4	- Deep Infiltration Rate	24	mm/day	
5.0	**Pervious Soil Moisture Storage**			
5.1	- Maximum Storage	80	mm	
5.2	- Initial Moisture Storage	70	mm	
5.3	- Storage Before Infiltration Occurs	60	mm	
5.4	- Deep Infiltration Rate	20	mm/day	
5.5	- Storage Before Watering	5	mm	
5.6	- Water Until Storage Reaches...	8	mm	
6.0	**Infiltration System**			
6.1	- Volume of Infiltration Storage	0	m^3	
6.2	- Initial Storage	0	m^3	
6.3	- Infiltration Rate	0	mm/day	
7.0	**Wetland Storage**			
7.1	- Volume to Macrophyte Bed Depth	0	m^3	
7.2	- Volume of Deep Zone	0	m^3	
7.3	- Maximum Storage	0	m^3	
7.4	- Initial Storage	0	m^3	
7.5	- Total Surface Area	0	m^2	
7.6	- Surface Area of Deep Zone	0	m^2	
8.0	**Rainwater Tank and Internal Reuse**			
8.1	- Maximum Rainwater Tank Volume	2208	m^3	
8.2	- Initial Rainwater Tank Volume	1104	m^3	
8.3	- Number of Equivalent Tenements with Re-use	276	ET	
8.4	- Estimated Daily Demand per ET	215	L	
9.0	**Average Aerial Evapotranspiration (*daily*)**	**Pervious**	**Forest**	**Water**
9.1	January	6.29	6.29	6.29
9.2	February	5.71	5.71	5.71
9.3	March	4.84	4.84	4.84
9.4	April	3.17	3.17	3.17
9.5	May	2.1	2.1	2.1
9.6	June	1.83	1.83	1.83
9.7	July	1.77	1.77	1.77
9.8	August	2.26	2.26	2.26
9.9	September	3.5	3.5	3.5
8.10	October	4.68	4.68	4.68
8.11	November	5.67	5.67	5.67
8.12	December	6.13	6.13	6.13

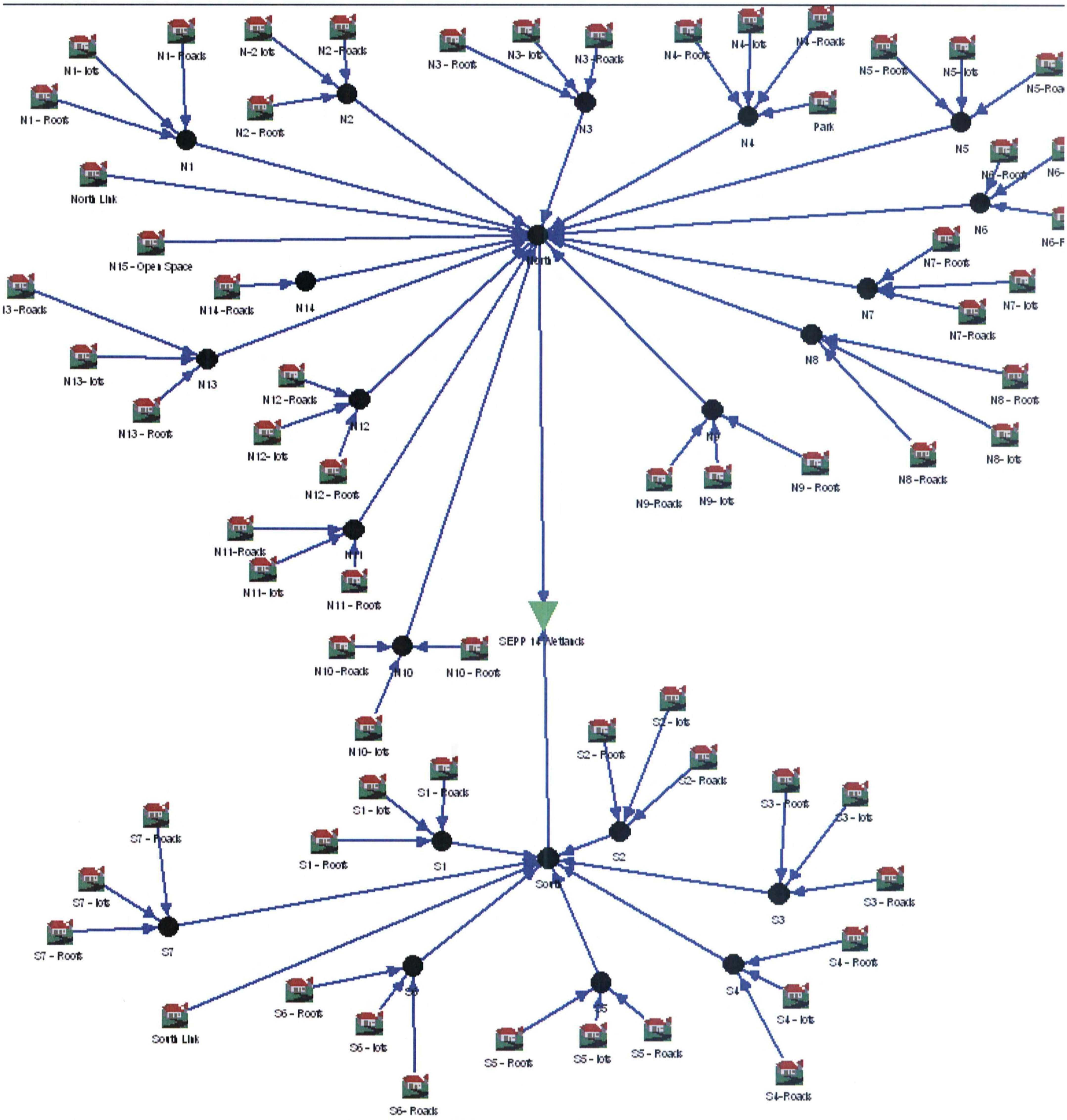
Summary - Mooney Beach				
Study Duration (years)	3			
Rainfall			**Infiltration System (Inf Sys)**	
- Rainfall Depth	1552.83	mm	- Flow from Rainwater Tanks	0
Rainfall Volumes			- Flow from Impervious Area (*no tank*)	0
- Impervious Area to Rainwater Tanks	64287	m^3	- Flow From Pervious Irrigated Area	0
- Impervious Area not to Rainwater Tanks	0	m^3	- Flow From Pervious (*non-irrigated*) Area	0
- Pervious Area to be Irrigated	21429	m^3	- Flow from Forested Area	0
- Pervious Area not to be Irrigated	0	m^3	- Direct Rainfall	0
- Forested Area	0	m^3		
- Infiltration Area	0	m^3	- Total Flow to Inf Area	0
- Wetland Area	0		- Overflow to Wetland	0
- Total Area	85716	m^3	- Evaporation	0
			- Infiltration	0
Rainwater Tanks Hydrology			- Change in Storage (averaged)	0
- Flow to Tanks	57703	m^3	Balance	0
- Domestic Water Required	5041	m^3		
- Reuse Demand (*including irrigation*)	27202	m^3	**Wetland System**	
- Spillage to Infiltration Area	0	m^3	- Flow Bypassing Infiltration Area	39653
- Spillage to Outlet	34864	m^3	- Flow from Infiltration Area	0
- Change in Storage	-37	m^3	- Direct Rainfall	0
Balance	716	m^3	- Evaporation	-39653
No of times Domestic Water Required	56		- Overflow to Outlet	39653
Runoff Coefficient into Tank	0.90		- Change in Storage (averaged)	0
Runoff Coefficient from Tank	0.54		Balance	0
Irrigated Area Hydrology			**Total Outflow**	
- Net Flow to Irrigation Area	2855	m^3	- Spillage from Wetland	39653
- Irrigation	5543	m^3		
- Infiltration	4324	m^3		
- Spillage to Infiltration Area	0	m^3	Total Site Runoff Coefficient	0.46
- Spillage to Outlet	4789	m^3		
- Change in Storage	-124	m^3		
Balance	-592			
No of times Irrigation Required	85			
Runoff Coefficient	0.22			
Impervious Area not to Tank Hydrology				
- Net Flow from Impervious Area	0	m^3		
- Spillage to Infiltration Area	0	m^3		
- Spillage to Outlet	0	m^3		
Balance	0			
Runoff Coefficient	#DIV/0!			
Forested Area Hydrology				
- Net Flow to Forested Area	0	m^3		
- Infiltration	0	m^3		
- Spillage to Infiltration Area	0	m^3		
- Spillage to Outlet	0	m^3		
- Change in Storage	0	m^3		
Balance	0			
Runoff Coefficient	#DIV/0!			
Pervious (*non-irrigated*) Area Hydrology				
- Net Flow to Pervious Area	0	m^3		
- Infiltration	0	m^3		
- Spillage to Infiltration Area	0	m^3		
- Spillage to Outlet	0	m^3		
- Change in Storage	0	m^3		
Balance	0			
Runoff Coefficient	#DIV/0!			

APPENDIX B – MUSIC MODELING

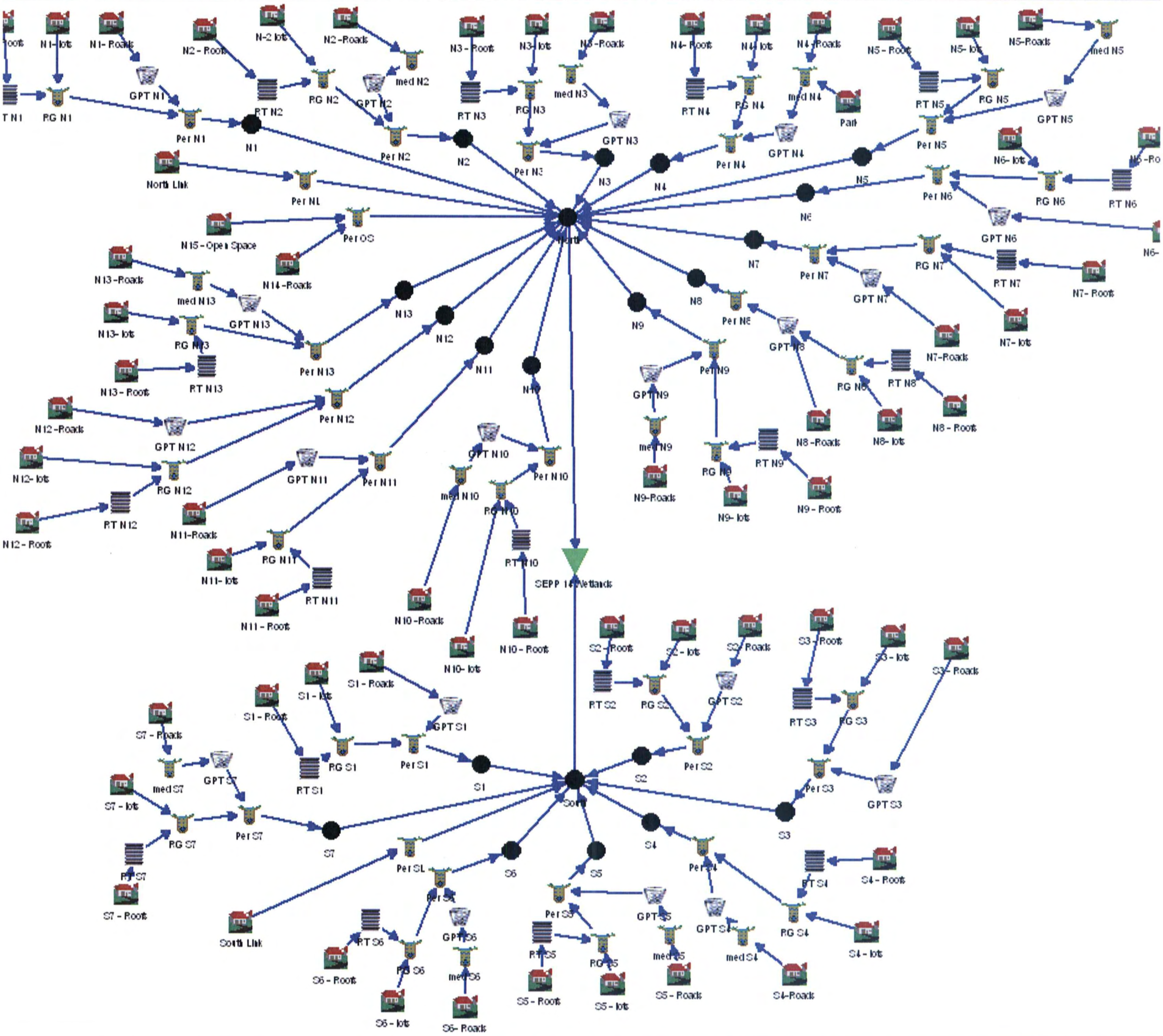
MUSIC – Existing Layout



'SIC – Proposed no Treatment Layout



MUSIC- Proposed Treated Layout



NORTHERN DEVELOPMENT

Catchment Name	Catchment Area (ha)	Lot Area (ha)	Roof Area (ha)	Yard Area (ha)	Park Area (ha)	Road Area (ha)	No of lots	Area RG (m2)	Vol of RW (kL)	Median Strip Area (m^2)	Perimeter Swale Area (m^2)
N1	1.61	0.9	0.315	0.585	0	0.71	21	840	168		1667
N2	0.91	0.4	0.165	0.235	0	0.51	11	440	88	280	400
N3	0.96	0.41	0.165	0.245	0	0.55	11	440	88	350	500
N4	1.29	0.57	0.255	0.315	0.18	0.54	17	680	136	630	900
N5	1.06	0.58	0.09	0.49	0	0.48	6	240	48	560	800
N6	0.43	0.17	0.06	0.11	0	0.26	4	160	32		800
N7	0.38	0.15	0.06	0.09	0	0.23	4	160	32		600
N8	0.29	0.125	0.045	0.08	0	0.165	3	120	24		1000
N9	1.01	0.56	0.195	0.365	0	0.45	13	520	104	490	700
N10	0.77	0.45	0.12	0.33	0	0.32	8	320	64	560	800
N11	2.32	1.11	0.45	0.66	0	1.21	30	1200	240		2600
N12	1.09	0.518	0.195	0.323	0	0.572	13	520	104		1067
N13	1.24	0.54	0.195	0.345	0	0.7	13	520	104	350	500
N14	0.53	0	0	0	0	0.53	0	0	0		2800
N15	2.2	0	0	0	2.2	0	0	0	0		
North Link	0.91	0	0	0	0	0.91	0	0	0		3833
Subtotal	**17.00**	**6.48**	**2.31**	**4.17**	**2.38**	**8.14**	**154**	**6160**	**1232**	3220	**18967**

SOUTHERN DEVELOPMENT

Catchment Name	Catchment Area (ha)	Lot Area (ha)	Roof Area (ha)	Yard Area (ha)	Park Area (ha)	Road Area (ha)	No of lots	Area RG (m2)	Vol of RW (kL)	Median Strip Area (m^2)	Perimeter Swale Area (m^2)
S1	0.63	0.27	0.105	0.165	0	0.36	7	280	56		1000
S2	1.42	0.7	0.315	0.385	0	0.72	21	840	168		2100
S3	1.21	0.55	0.225	0.325	0	0.66	15	600	120		1000
S4	1.52	0.86	0.15	0.71	0	0.66	10	400	80	350	500
S5	1.39	0.7	0.285	0.415	0	0.69	19	760	152	560	800
S6	1.39	0.75	0.3	0.45	0	0.64	20	800	160	560	800
S7	2.31	1.17	0.45	0.72	0	1.14	30	1200	240	700	1000
South Link	0.88	0	0	0	0	0.88	0	0	0		4500
Subtotal	**10.75**	**5**	**1.83**	**3.17**	**0**	**5.75**	**122**	**4880**	**976**	**2170**	**11700**
Total	**27.75**	**11.48**	**4.14**	**7.34**	**2.38**	**13.89**	**276.00**	**11040.00**	**2208.00**	**5390.00**	**30667.00**

Total treatment area is - 17% of site area

Scenario	Load Values (kg/year U.N.O)			
	TSS	TP	TN	CV (m^3/m^3)
Existing	3330.0	12.9	84.9	0.3
Developed (no treatment)	12.9	84.9	952.0	7.4
Developed (with treatment)	214.0	3.4	76.2	0.2

Exist

Flow (ML/yr)	139
Total Suspended Solids (kg/yr)	3.33E+03
Total Phosphorus (kg/yr)	12.9
Total Nitrogen (kg/yr)	84.9
Gross Pollutants (kg/yr)	9.52E+02

Developed No Treat

Flow (ML/yr)	235
Total Suspended Solids (kg/yr)	2.26E+04
Total Phosphorus (kg/yr)	42.9
Total Nitrogen (kg/yr)	473
Gross Pollutants (kg/yr)	5.20E+03

TSS	TP	TN	CV
22600	42.9	473	0.52
579%	233%	457%	

Developed Treat

Flow (ML/yr)	90.7
Total Suspended Solids (kg/yr)	2.14E+02
Total Phosphorus (kg/yr)	3.43
Total Nitrogen (kg/yr)	76.2
Gross Pollutants (kg/yr)	0.00E+00

TSS	TP	TN	CV
2.14E+02	3.43	76.2	0.20
3330	12.9	84.9	0.31
99%	92%	84%	61%