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UTS KURING-GAI CAMPUS REDEVELOPMENT

URBAN INFRASTRUCTURE MANAGEMENT STRATEGY

4975.01 –

February 2008

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PROJECT 4975.01 - UTS KURING-GAI CAMPUS REDEVELOPMENT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
Issue	Description of Amendment	Prepared by [date]	Verified by [date]	Approved by [date]		___________	
1	Draft	CM (16-02-04)	MST (16.2.04)	MST (6.2.04)		___________	
2	Final Draft	CM (21-05-04)	MST (21.5.04)	MST (21.5.04)		___________	
3	Final Draft	CM (7-06-04)	MST (7.06.04)	MST (7.06.04)		___________	
4	Final	CM (10-06-04)					
5	Reference to concept plan removed	CM (19-07-06)	CJM (19-07-06)	MST (19-07-06)			
6	Modelling carried out again for new layout	AM (11-02-08)	CJM (11-02-08)	[signature] 11.2.08			

CONTENTS

EXECUTIVE SUMMARY

This urban infrastructure management strategy has been prepared to support a Part 3A concept plan application for the UTS site at Ku-ring-gai. It addresses the following issues:

- Stormwater quality;
- Stormwater quantity;
- Provision of potable water;
- Provision of sewer reticulation;
- Provision of electricity reticulation;
- Telecommunications services; and
- Geological conditions.

A water sensitive urban design approach has been adopted for the proposed Part 3A concept plan application and re-zoning, with proposed controls to contribute to the long term improvement in receiving water quality and flow impacts on adjacent bushland. The revised concept plan (i.e. 382 dwellings) and this strategy incorporate a combination of at source controls such as rainwater tanks and bioretention swales along roadways. Further runoff treatment measures include bioretention basins, gross pollutant traps and a detention basin. These measures will:

- Reduce the number of stormwater outlets;
- Improve stormwater quality by reducing runoff pollutant loads significantly below existing rates;
- Improve stormwater discharge and reduce peak flow rates in the proposed 50 year ARI to natural 20 year ARI rates; and
- Ensure that the peak flow rates from the proposed development do not exceed the 5 year and 100 year ARI flow rates for the existing state;
- Allow for the reduction of potable water use by 45%.

The beneficial effect of some control measures have not been taken into account in the results presented as part of this assessment. Therefore the level of improvement achieved has been understated. The extent of control measures can be refined at subsequent approval stages in the knowledge that it is feasible to achieve the above objectives.

The proposed conceptual water management strategy for the Part 3A concept plan application and re-zoning conforms to best management practice and Councils relevant guidelines. The stormwater quality and quantity control measures proposed in this report will have the combined beneficial effect of improving the existing conditions of the surrounding bushland and the water quality in receiving water bodies.

The servicing of the site has been investigated and confirmation sought from Sydney Water, Energy Australia, Alinta, and Telstra that it is possible to service the proposed level of development at the

site. The responses from the service providers support the proposed rezoning application, and are included in **Appendix 1**. Water supply is adequate for fire fighting with the provision of a reticulated hydrant supply and water storage reservoir.

As established in the Parramatta Rail Link EIS, due to the underlying sandstone any settlement beneath the site as a result tunnelling during the construction of the Parramatta Rail Link will have negligible impact on surface buildings or underground service utilities proposed as part of the re-zoning application and potential development of the site, and is also not an impediment to re-zoning. It is considered that generally, with good engineering design, the site's geological conditions are likely to be suitable for urban development subject to detailed geotechnical investigations.

1. INTRODUCTION

WorleyParsons incorporating Patterson Britton and Partners has been engaged by CRI on behalf of The University of Technology Sydney (UTS) to prepare a report in support of a Part 3A concept plan application and re-zoning for their site at Ku-ring-gai with respect to urban infrastructure. The application is accompanied by a plan showing proposed catchment boundaries corresponding with the revised masterplan scheme of 382 dwellings (*refer* **Figure 1**).

This report assesses the impact of the development in the indicative development scheme on stormwater management issues, the servicing of the site and any geological impact of the Parramatta Rail Link. These issues include the assessment and management of stormwater quality and quantity and the provision of potable water, sewer, electricity, fire fighting and telecommunications services. The report has been prepared in accordance with Ku-ring-gai Council's (*Council's*) –*Water Management Development Control Plan – DCP 47 (amended April 2005)* and *Managing Urban Stormwater : Treatment Techniques* (*EPA, 1996*).

This report was originally undertaken in June 2004 and re-issued with minor amendments in July 2006. In January 2008 water quality and quantity modelling has been revised to reflect changes to the proposed master plan, which is now has been reduced to 382 dwellings.

1.1 Director General's Requirements

In response to the Part 3A project application (MP 06_0130), Director - General's requirements have been issued. The requirements relevant to this report are outlined below in **Table 1.1**

Table 1-1 Director General's Requirements

Key Assessment Requirements	**Report Section**
Environmental Impacts	
• Impacts on the Lane Cove National Park including erosion and sediment control, stormwater runoff, management implications, pets, weeds, edge effects, boundary encroachments, ecological connectivity, fire and location of asset protection zones and their impact on threatened species and their habitats	Erosion & sediment control is addressed in Section 5.10. Stormwater runoff quality is addressed in Section 5. Stormwater runoff quantity is addressed in Section 4.
• Details of the development's proposed sustainability measures including NatHERS	The water sensitive urban design approach covered in Section 3.

Key Assessment Requirements	Report Section
ratings, BASIX water sensitive urban design measures, energy efficiency, recycling and waste disposal	BASIX requirements are addressed in Section 6.
<u>Services</u> • Capacity of water, sewer, stormwater, gas, power and telecommunications infrastructure which will serve the project; and • Any upgrading works to infrastructure necessary to service the development and contributions applicable under any adopted contribution plans	Servicing and infrastructure upgrades are addressed in Section 2.

1.1.1 DECC (formerly DEC) Requirements

The Department of Environment and Climate Change (DECC) have provided advice and guidelines for the project. These include the environmental impacts need to assess, quantify, and report on:

- Impacts to the adjoining Lane Cove National Park – assess and demonstrate that the following potential impacts are addressed in accordance with the guidelines included at DECC Attachment 3; erosion and sediment control, stormwater runoff, management implications, pets, weeds, edge effects, boundary encroachments, visual, odour, noise, air quality impacts and amenity, and threats to ecological connectivity
- Water Cycle Management Strategy – incorporation of Water Sensitive Urban Design options (including how BASIX requirements are to be met), and recycling options

The *guidelines for developments adjoining DECC land* (Attachment 3 of DECC response) outline the following:

- **Erosion and Sediment Control**
  - Aim: No detrimental change in hydrological regimes, minimisation of erosion and prevention of sediment movement into DECC land during the construction and post – construction phases of development

- **Stormwater Runoff**
    - Aim: Minimise nutrient levels and flow regimes/patterns to mimic natural levels prior to reaching DECC land.
    - Stormwater detention systems shall be designed to ensure there is no increase in pre development peak flows from rainfall events having a 1 in 5 year and 1 in 100 year average recurrence interval (ARI)
    - Development proposals for areas adjacent to DECC land should incorporate stormwater detention systems (with appropriately managed buffer areas) within the development area to minimise stormwater discharge rates and prevent localised erosion
    - The discharge of polluted stormwater to DECC lands must be avoided as a high priority

These requirements are addressed in this water management report.

2. SERVICING STRATEGY

As part of the Director-General's requirements it is necessary to assess the existing capacity of the surrounding services and determine any upgrading works required to serve the proposed development. In order to undertake this assessment each of the essential service providers has been contacted. Each of the services is addressed below.

2.1 Potable Water

The UTS Kuring-gai campus is located in the Chatswood/Killara/Pymble water supply system. The supply is drawn from major mains along the Pacific Highway. There is a dedicated 200 mm diameter supply main from the highway along Bayswater, Ortona and Eton Roads. At Austral Avenue, the main decreases to a 150 mm diameter and then to a 100 mm diameter main which delivers water to the campus from Abingdon Road *(along Eton Road)*.

Adjacent to the security officer's residence there is a fire booster point to enable supply of increased quantities of water in the 100 mm diameter water main in the case of a fire.

A feasibility letter has been prepared by Sydney Water, Case Number 109935, which outlines Sydney Water's requirements for potable water. The proposed rezoning and potential development would require a water main augmentation of the 100mm CICL water main in Eton Road to a 150mm main.

A bushfire hazard assessment has been carried out for the subject site (*Eadie, 2007*), and this assessment requires that a reticulated hydrant supply serve the site. This must be addressed in subsequent designs. In addition to this, the Rural Fire Service (RFS) "would encourage consideration of an onsite water reservoir of 50,000 litres located central to the primary access". This would be located near the entrance to the site, and in accordance with the requirements of the local fire brigade.

Upon completion of the above requirements the proposed re-zoning and potential development can be supplied with potable water and provide adequate supply for fire fighting purposes.

2.2 Sewerage

The campus is within the East Lane Cove sewerage system. The East Lane Cove submain *(1350mm dia pipe)* passes diagonally under the site *(North West to south east)* at depth. There are two access chambers from this main within the campus. The site drains via a 225 mm diameter main along the western side of the site to a connection point south of the sites southern boundary.

A feasibility letter has been prepared by Sydney Water, Case Number 109935 that outlines Sydney Water's requirements for sewer (attached in **Appendix 1**). The standard and integrated lots at the northwest of the site, as well as three apartment buildings in that area would connect to the 150mm sewer main within adjoining vacant Lot 60 Lady Game Drive, near Lyle Avenue. The other apartment buildings and integrated lots would connect to the 375mm sewer main east of the site, towards Valley View Close.

Upon completion of the above requirements the proposed re-zoning and potential development can be appropriately served by the Sydney Water sewerage system. DSP charges would be detailed after a Section 73 Application.

2.3 Power

The campus power supply is from Eton Road with twin 1600 amp supply mains located generally along the main access road *(underground)* servicing substations in Film Australia and on the western end of Building 2. The underground supply line continues through the site to the southern boundary where it joins an overhead link line to the surrounding reticulation.

Correspondence from Energy Australia has confirmed that the existing HV cable that runs north to south through the middle of the site could service the site, with the addition of two kiosk substations. This confirms that the proposed re-zoning and potential development can be supplied with power by Energy Australia.

2.4 Gas

There is a special secondary main gas supply to the campus from Eton Road. The gas supply is aligned on the eastern side of the main access road and increases in size from 150 to 225 mm diameter.

It is Alinta's policy to extend natural gas infrastructure into all new residential developments wherever economically viable. A letter confirming the availability is attached in **Appendix 1**.

2.5 Telecommunications

The campus and Film Australia sites are served from a facility at the entrance on Eton Road. There is optical fibre supply to both sites.

The developer would be required to provide the cost for trench excavation during installation. Telstra advised that their preference is to share conduits with other services, primarily internal electricity reticulation. Should the existing capacity be less than that required for the development, Telstra would provide the required upgrades at their own cost.

The proposed re-zoning application and potential development would be supplied with sufficient telecommunications, including all design and planning prior to construction by Telstra.

2.6 Easements

At the northern end of the site, there is an easement for drainage of the Film Australia site near to the rear of properties along Abingdon Road and Kimo Street. Also, there is a 2m wide easement for power across Eaton Road serving Film Australia.

There is a right of carriageway diagonally across the site from north east to south west which is 20.115m wide.

2.7 Existing Geological Conditions

Assessment of the 1:100, 000 series geological maps indicates that the UTS Kuring-gai campus is underlain with Hawkesbury Sandstone which is a geological formation which underlays most areas of northern Sydney. Areas underlain with Hawkesbury Sandstone are typically topographically irregular and have a relatively thin mantle. This description is consistent with the conditions encountered on-site.

According to a CRI contamination audit report, "the geology for the area comprises the Hawkesbury Sandstone formation which includes uniform, fine to medium grained, quartz – rich weathered sandstone with minor siltstone and claystone interbeds. The soils tend to be sandy and slightly acidic".

A rail link between Parramatta and Chatswood has been constructed, with some tunnelling directly beneath the subject site.

An Environmental Impact Statement has been prepared for the Parramatta Rail Link by ERM Mitchell McCotter Pty Ltd and Kinhill Pty Ltd and completed in December 1999. This document discusses the existing geological conditions likely to be encountered during construction and the potential surface settlement that may arise in certain geological conditions. A review of the findings contained in the EIS reveals the following:-

- The tunnelling below the UTS Kuring-gai site is shown to be located under approximately 25m of cover to the ground at its shallowest point.

- Where tunnels are excavated in shale or sandstone and the cover of ground above the tunnel crown is at least 15m or more, surface settlement is not expected to exceed 1mm or 2mm above the tunnel centreline.

Given that the depth of tunnelling is greater then 15m below the subject site and the excavation is likely to be located in Hawkesbury Sandstone, the settlement trough formed above the tunnel in these cases will have negligible impact on surface buildings or underground service utilities proposed as part of the re-zoning application and potential development of the site.

Given the underlaying geological formation (Hawkesbury Sandstone) and the negligible impact created by the rail tunnel, it is considered that with good engineering design the site would be generally suitable for urban development. Notwithstanding this, prior to any future development occurring on the site, it is recommended that detailed geotechnical investigations be completed.

3. WATER MANAGEMENT STRATEGY

3.1 Objectives

The stormwater management strategy is based on the DECC Guidelines and Ku-ring-gai Council's (*Council's*) – *Water Management Development Control Plan – DCP 47 (amended April 2005)* and the recognition of the following major objectives.

- **Minimise Impacts on Water Quality -**

  Ensure there is no impact on water quality (*nutrients, sediment and gross pollutants*) during and following construction activities, and where possible improve existing conditions.

- **Minimise Impacts on Water Quantity -**

  Minimise the impact of flooding (*water quantity*) on downstream areas, to ensure the safety of people, property and the stability of channels, and where possible improve existing conditions.

3.2 Water Sensitive Urban Design

Often water sensitive urban design is narrowly defined in relation to only stormwater management, however in terms of achieving an environmentally sustainable development *(ESD)* it should also encompass potable water usage. For the UTS Kuring-gai site, the principles of water sensitive urban design *(WSUD)* have been applied to form the basis for a development which will demonstrate industry best practice commitment to ESD.

Integrated water management, a core principle of WSUD, includes the reduction of potable water demand, which would be achieved by the use of rainwater reuse tanks and water saving measures in residences. The State Government has a target of a 40% reduction in potable water use compared with traditional households for the Building Sustainability Index (*BASIX)* compliance.

3.3 Water Cycle Management Strategy

3.3.1 Overview

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

- maximise runoff quantity and quality controls at the source; and

- reduce annual pollutant load exported from the site compared with existing conditions.

In order to achieve these objectives, source controls such as rainwater tanks, bioretention swales and bioretention basins would be coupled with more common control measures such as gross pollutant traps and detention basins.

Bioretention swales would be incorporated into road reserves and garden areas where they can aesthetically enhance the visual impact of the development. The location of rainwater tanks and bioretention systems creates a mix of at-source and downstream controls. The combination of at-source and downstream controls would achieve the maximum reduction in the runoff pollutant load prior to discharge to the receiving water bodies. The elements of the water management strategy include:

- **source controls**
  - minimise areas of impervious surfaces to minimise runoff volume;
  - incorporate rainwater tanks with reuse of stormwater to reduce the volume of runoff and potable water use;
  - use water saving devices to reduce the domestic household demand for potable water; and
  - incorporate bioretention swales to remove fine sediment, nutrients, oils and greases.

- **downstream controls**
  - bioretention basins to remove additional fine sediment, nutrients, oils and grease;
  - gross pollutant traps at the outlets to capture litter, debris, coarse sediment, oils and greases; and
  - detention basin (using car park) to reduce the peak flow exiting the site.

3.3.2 Stormwater Treatment Train

Generally, the stormwater treatment flow path for runoff would be: -

- runoff from roofed areas would be collected and detained in rainwater tanks with an overflow by-pass to bioretention swales or the street drainage system;
- large impervious areas such as roads and car parks would be directed to bioretention swales where they would be filtered and treated biologically;
- flows would enter grassed bioretention basins located at the downstream areas of each major building where they would be filtered and treated biologically;

- excess flows from the bioretention swales and basins would flow to the pipe drainage system designed to cater for the 10year ARI event; and
- stormwater exiting the pipe drainage system would pass through a gross pollutant trap to remove remaining coarse sediment, litter, debris, oils and greases.

3.4 Conclusions

The industry best practice stormwater quality and quantity control measures proposed in this strategy will have the combined beneficial effects of improving the existing conditions of the surrounding bushland and the water quality in receiving water bodies.

Peak runoff flow rates would be reduced to significantly less than existing and even below those for natural conditions to ensure that erosion of flow paths and streams is not perpetuated.

The export of suspended solids, total nitrogen and total phosphorus would be reduced significantly in comparison to the existing state, thereby placing less pressure on native vegetation due to the nutrient load and weed infestation.

The demand for potable water will be reduced by at least 45% compared to than that of a traditional household with the introduction of water saving devices and rainwater tanks.

This more than achieves the State government's stated objective for new development to achieve a 40% reduction in potable water use. Finally the introduction of welded sewer pipes will further reduce the possibility of exfiltration of nutrients into the water cycle.

With the above strategies in place, stormwater can be effectively and appropriately managed and conditions in the surrounding bushland improved compared with the existing state as part of the proposed re-zoning application and potential development.

4. STORMWATER QUANTITY IMPACT ASSESSMENT

4.1 Existing Stormwater Drainage

The subject site is situated along a ridge line in West Lindfield and there are numerous small subcatchments draining to the surrounding area. To the south, east and west the site adjoins bushland contained within the Lane Cove National Park and to the north is the Film Australia site and residential areas. Stormwater exiting the site is discharged via 22 existing outlets into the adjacent bushland that in turn drains into a number of tributary creeks and ultimately the Lane Cove River.

A *Draft Stormwater Management Report for –UTS Ku-ring-gai Campus (Robyn Tuft & Associates, May 1999)* identifies the 22 subcatchments and details the existing stormwater treatments on site *(refer* **Figure 2***)*. A review of this document has been undertaken and the catchments have been assessed for the following parameters:

- Catchment area;
- Slope;
- Percentage impervious;
- Land use type; and
- Discharge receiving water body.

It was found that the catchment areas as reported by Robyn Tuft and Associates only varied slightly from areas calculated digitally and the digitally calculated areas have been adopted for this report. In addition there are some minor discrepancies with regards to the percentage impervious of some catchments. A site inspection was carried out on the 13th of October 2003 which confirmed the findings below.

The adopted catchment parameters are detailed in **Table 4.1** below.

Table 4-1 Existing Catchment Parameters

Sub Catchment	Area (m^2)	Slope (%)	Impervious (%)	Landuse	Discharge water body
1	781	2.1	95	Car parking, landscaping	Little Blue Gum Creek
2	7552	3.3	95	Car parking, landscaping	Little Blue Gum Creek
3	937	2.1	95	Car parking, landscaping	Little Blue Gum Creek

Sub Catchment	Area (m^2)	Slope (%)	Impervious (%)	Landuse	Discharge water body
40	4648	2.6	95	Car parking, landscaping	Little Blue Gum Creek
5	1065	3.6	20	Tennis courts landscaping	College Creek
7	16907	0.1(perv) 8.7(imp)	10	Tennis courts landscaping	College Creek
8	6886	11.3	50	Roads, landscaping (weeds at outlet)	College Creek
9	10631	2.9(perv) 5.7(imp)	10	Oval (dense weeds at outlet)	College Creek
10	4940	0.1(perv) 80(imp)	5	Oval, steep bank(dense weeds at outlet)	College Creek
11	7098	10	80	Buildings landscaping	College Creek
12	2199	15.4	75	Buildings landscaping (dense weeds)	Blue Gum Creek
13	3575	10.7	70	Buildings landscaping (dense weeds)	Blue Gum Creek
14	2807	12.7	50	Roads, landscaping (dense weeds)	Blue Gum Creek
15	913	30(perv) 8(imp)	40	Car parking, landscaping	Blue Gum Creek
16	3524	17.8	40	Car parking, landscaping (some weeds)	Blue Gum Creek
17	7395	14.3	40	Car parking, landscaping	Blue Gum Creek
18	7354	21	45	Car parking, landscaping	Blue Gum Creek
19	6213	4.5	45	Roads, landscaping	Blue Gum Creek
20	5240	4	60	Child care centre, Film Australia, road	College Creek

Sub Catchment	Area (m^2)	Slope (%)	Impervious (%)	Landuse	Discharge water body
21	13910	9	30	Buildings, roads landscaping (dense weeds)	Blue Gum Creek
22	6086	15.75	55	Roads, landscaping	Blue Gum Creek
Total	120,661	-	-	-	Lane Cove river

4.2 Minimum Requirements

Ku-ring-gai Council's – *Water Management Development Control Plan – DCP 47 (amended April 2005)* contains the design objectives for stormwater quantity management. These standards outline (in Section 6 of the DCP) the water quantity controls for discharge directly to bushland including:

a) Where the design engineer is of the opinion that an OSD would be detrimental to the catchment, the engineer shall submit calculations and modelling showing so. Waiving of OSD shall be subject to Council approval;
b) Mandatory rainwater tanks are required;
c) The number of run-off days from the post development site during the 1 in 50 year storm shall not exceed the state of nature case during the 1 in 20 year storm. This shall be achieved using an appropriate retention device; and
d) In addition to any mandatory rainwater tank, the developer shall propose an on-site retention (OSR) system that retains either the;
    - the first 20mm of rainfall from all roof areas, or
    - 5,000 L storage volume.

In addition, the DECC requirements (as discussed in **Section 1.1.1**) are to ensure that there is no increase in pre development peak flows from rainfall events having a 1 in 5 year and 1 in 100 year average recurrence interval (ARI).

4.3 RAFTS Hydrologic Model

Hydrologic modelling established specifically for the site was undertaken using Runoff Analysis and Flow Training Simulation (RAFTS). The model was used to estimate design flows under the state of nature, existing state, developed catchment and developed treated conditions.

RAFTS is a non-linear rainfall/runoff program developed by XP Software. RAFTS can be used to estimate peak flows for catchments, using actual storm events, or design rainfall data derived from *Australian Rainfall and Runoff (AR&R)* (*IEAust, 1987*).

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

- it accounts for spatial and temporal variation in storm rainfall across a catchment;
- it estimates discharge hydrographs at any location within the catchment;
- it accommodates variations in catchment characteristics;
- it is able to route hydrographs though detention basins; and
- it has successfully been widely used across NSW and is accepted by Councils and the Department of Water and Energy (DWE, formerly DNR).

4.3.1 Model Set-Up

The RAFTS parameters adopted for the model are shown in **Table 4.2**.

Table 4-2 RAFTS Hydrologic Parameters

Parameter	Value
Rainfall Losses	
Pervious initial loss	20 mm
Pervious continuing loss	5 mm/hr
Impervious initial loss	2.5 mm
Impervious continuing loss	0 mm/hr
Roughness	
Pervious	0.025
Impervious	0.015
BX factor	1

The existing 22 subcatchments as shown in **Figure 2** have been analysed to determine catchment-specific parameters including area, percentage impervious and weighted average catchment slope. A summary of the adopted existing state subcatchment parameters is shown in **Table 4.2**.

4.4 Existing Case

The existing conditions have been modelled to assess the degree to which flows would be reduced in the proposed development. Modelling has been carried out to determine existing flow rates in the 5 and 100 year ARI storm event. A summary of the flows is shown in **Table 4.4**.

4.4.1 Existing Catchment Parameters

The parameters adopted for the existing catchment RAFTS model are shown in **Tables 4.2** and **4.3**, and the catchment boundaries are shown in **Figure 2**. The proposed development would utilise area that is not currently included within the existing catchments identified by the *Robyn Tuft* Report, so the subcatchment for each creek includes a 'downstream external' catchment. This area has been measured and included in the model of existing catchments as a fully pervious catchment to account for the extra area included in the model of the proposed development. This ensures that the flows calculated from both the existing and proposed development models are for the correct total area, with altered imperviousness.

Table 4-3 RAFTS existing parameters

EXISTING				
Catchment	**Area Pervious**	**Area Impervious**	**Total Area**	**% Impervious**
Little Blue Gum Creek				
1	0.00	0.07	0.07	94.59%
2	0.04	0.72	0.76	94.74%
3	0.01	0.09	0.10	94.74%
4	0.02	0.44	0.46	95.65%
Sub-total	0.07	1.32	1.39	95.03%
Downstream External	0.98	0.00	0.98	
Revised sub-total	1.05	1.32	2.37	55.62%

EXISTING				
Catchment	**Area Pervious**	**Area Impervious**	**Total Area**	**% Impervious**
College Creek				
20	0.21	0.31	0.52	59.62%
9	0.96	0.11	1.07	10.28%
10	0.47	0.02	0.49	4.08%
5	0.09	0.02	0.11	18.18%
7	1.52	0.17	1.69	10.06%
8	0.34	0.34	0.68	50.00%
11	0.14	0.57	0.71	80.28%
Sub-total	3.73	1.54	5.27	29.22%
Downstream External	0.73	0.00	0.73	
Revised sub-total	4.46	1.54	6.00	25.65%
Blue Gum Creek				
12	0.05	0.16	0.21	76.19%
13	0.11	0.25	0.36	69.44%
14	0.14	0.14	0.28	50.00%
15	0.05	0.04	0.09	44.44%
16	0.21	0.14	0.35	40.00%
17	0.44	0.30	0.74	40.54%
18	0.40	0.33	0.73	45.21%
19	0.34	0.28	0.62	45.16%
21	0.97	0.42	1.39	30.22%
22	0.27	0.33	0.60	55.00%
Sub-total	2.98	2.39	5.37	44.51%
Downstream External	0.73	0.00	0.73	
Revised sub-total	3.71	2.39	6.10	39.19%
Lane Cove River				
TOTAL	6.78	5.25	14.48	

4.4.2 Existing Catchment Results

Results of the RAFTS modelling for the existing site are summarised in **Table 4.4** for the subcatchments draining to each creek around the site.

Table 4-4 RAFTS Results: Existing

Outlet Node	Peak flows (m^3/s)	
	Q_{5exist}	$Q_{100existing}$
Blue Gum Creek	2.43	4.11
Little Blue Gum Creek	0.94	1.60
College Creek	2.51	4.72
Lane Cove River	4.94	8.83

4.5 State of Nature Case

4.5.1 State of Nature Parameters

The parameters adopted for the state of nature (as required by Ku-ring-gai Council's DCP 47) RAFTS model are shown in **Table 4.5**. As with the model for the existing case, a downstream external catchment has been added to each Creek catchment to account for the extra area that is included in the model for the proposed development. For the state of nature conditions a 15% impervious area has been adopted for all catchments. This accounts for the rocky nature of the catchment.

Table 4-5 RAFTS: state of nature parameters

State of Nature				
Catchment	**Area Pervious**	**Area Impervious**	**Total Area**	**% Impervious**
Little Blue Gum Creek				
1	0.06	0.01	0.07	15%
2	0.65	0.11	0.76	15%
3	0.08	0.01	0.10	15%
4	0.39	0.07	0.46	15%
Sub-total	1.18	0.21	1.39	15%
Downstream External	0.84	0.15	0.98	15%
Revised sub-total	2.02	0.36	2.37	15%

State of Nature				
Catchment	**Area Pervious**	**Area Impervious**	**Total Area**	**% Impervious**
College Creek				
20	0.44	0.08	0.52	15%
9	0.91	0.16	1.07	15%
10	0.42	0.07	0.49	15%
5	0.09	0.02	0.11	15%
7	1.44	0.25	1.69	15%
8	0.58	0.10	0.68	15%
11	0.60	0.11	0.71	15%
Sub-total	4.48	0.79	5.27	15%
Downstream External	0.62	0.11	0.73	15%
Revised sub-total	5.10	0.90	6.00	15%
Blue Gum Creek				
12	0.18	0.03	0.21	15%
13	0.31	0.05	0.36	15%
14	0.24	0.04	0.28	15%
15	0.08	0.01	0.09	15%
16	0.30	0.05	0.35	15%
17	0.63	0.11	0.74	15%
18	0.62	0.11	0.73	15%
19	0.53	0.09	0.62	15%
21	1.18	0.21	1.39	15%
22	0.51	0.09	0.60	15%
Sub-total	4.56	0.81	5.37	15%
Downstream External	0.62	0.11	0.73	15%
Revised sub-total	5.18	0.91	6.10	15%
Lane Cove River				
TOTAL	10.22	1.80	14.48	15%

4.5.2 State of Nature Results

Results of the state of nature condition for the 20 year ARI storm modelling are summarised in **Table 4.6** for the catchments draining to each creek around the site. Full results for all locations for the critical storm event are contained in **Appendix 2**.

Table 4-6 RAFTS Results: State of Nature 20yr ARI

Outlet Node	Peak flows (m^3/s) Q $_{20natural}$
Blue Gum Creek	3.21
Little Blue Gum Creek	1.09
College Creek	3.38
Lane Cove River	6.59

4.6 Proposed Developed Conditions

The state of nature RAFTS model was modified to reflect the increase in impervious area and changes in topography for the redevelopment of the UTS site. The adopted hydrologic parameters are shown in **Table 4.1**, and the proposed catchment plan is shown on **Figure 1**.

4.6.1 Proposed Catchment Parameters

The parameters adopted for the proposed catchment RAFTS model are shown in **Table 4.7**.

Table 4-7 RAFTS: proposed parameters

PROPOSED				
Catchment	**Area Pervious**	**Area Impervious**	**Total Area**	**% Impervious**
Little Blue Gum Creek				
1	0.49	0.60	1.09	60.97%
2	0.61	0.35	0.97	48.62%
Sub-total	1.10	0.95	2.06	46.34%

PROPOSED				
Catchment	**Area Pervious**	**Area Impervious**	**Total Area**	**% Impervious**
College Creek				
3	0.37	0.45	0.81	42.79%
4	0.20	0.30	0.50	60.00%
5	0.33	0.24	0.57	54.44%
6	0.66	0.32	0.98	41.20%
7	1.33	0.15	1.47	13.51%
8	0.38	0.30	0.68	50.81%
9	0.32	0.27	0.58	48.02%
10	0.17	0.56	0.73	70.70%
Sub-total	0.10	0.12	6.34	1.85%
Blue Gum Creek				
11	0.10	0.12	0.22	62.69%
12	0.09	0.25	0.35	76.87%
13	0.19	0.12	0.31	38.00%
14	0.50	0.22	0.72	36.53%
15	0.46	0.25	0.71	39.88%
16	0.78	0.52	1.30	43.79%
17	0.14	0.34	0.48	70.00%
18	0.20	0.20	0.39	63.03%
19	0.63	0.42	1.05	40.00%
20	0.52	0.30	0.82	36.62%
Sub-total	3.62	2.73	6.35	42.96%
Lane Cove River				
TOTAL	4.82	3.80	14.74	

4.6.2 Proposed Retention

It is proposed to provide each standard lot and each integrated lot with a 5000L rainwater tank, and each unit within an apartment building with a 1,000L rainwater tank as required by Council. This satisfies the mandatory requirements outlined in Section 6.4 of DCP 47. **Table 4.8** shows the volume of storage provided by the proposed rainwater ranks.

Table 4-8 Mandatory Rainwater tanks

Landuse	DCP Requirement *(L/Lot)*	Number of proposed lots	Total Volume provided (m^3)
Standard Lot	5000	10	50
Integrated Lot	5000	25	125
Multi unit developments	1000	347	347

Rainwater tanks assist in reducing runoff in frequent events and contribute to runoff characteristics which are mimic natural conditions.

Research for the Upper Parramatta River Catchment Trust has identified that up to 30% of rainwater tank capacity can be accounted for as onsite retention (OSR). It is estimated, therefore, that 156m^3 of OSR volume will be provided within the proposed rainwater tanks.

DCP 47 requires that the site has an on-site retention system that retains the first 20mm of rainfall from all roof areas. This retention volume is readily accommodated within the rainwater reuse tanks and bioretention proposed for the site.

Runoff is also to be directed through the stormwater network of bioretention basins and swales, piped drainage and extended on-site detention basin providing more attenuation of flows.

Bioretention swales and basins have been provided as outlined in **Section 5** for water quality treatment purposes. The role of the bioretention swale is not to promote infiltration into the sub soils but into a specially constructed infiltration media. Given the lowered area created by the swales and basins, they also allow for the following extended storage on the surface:

- Bioretention swales at 4m wide and 0.3m deep – 0.75m^3/m,
  With 1475m of bioretention swales on the site, there is 1100m^3 retention.
- Bioretention basins at an average 0.3m depth – 0.3m^3/m^2.
  With 2250m^2 of bioretention basin there is 675m^3 retention

This amounts to a total of 3350m^3 of on-site retention. The details for retention/detention are provided in **Table 4.9**.

Table 4-9 On-Site Retention/Detention Used for Each Catchment

P 1	- Each standard lot to utilise a 5,000 L rain water tank, each integrated lot to utilise a 5,000L rain water tank; - Integrated lots runoff directed to a 122m^3 bioretention swale
P 2	- Each integrated lot to utilise a 5,000L rain water tank and an apartment building with a 32,000L rain water tank for re-use; - 99m^3 of bioretention swale ; - 185m^3 bioretention basin - 45m^3 of bioretention swale
P 3	- Apartment building with an 80,000L rain water tank for re-use; - 26m^3 of bioretention swale; - 39m^3 of bioretention swale
P4	- Runoff from P4 is directed into P5's first bioretention swale of volume 59m^3
P5	- Apartment building with a 40,000L rain water tank for re-use; - 59m^3 of bioretention swale; - 126m^3 bioretention basin
P 6	- Apartment building with an 80,000L rain water tank for re-use; - 58m^3 of bioretention swale - 229m^3 of bioretention basin;
P 7	- 167m^3 of bioretention swale. - 68m^3 of bioretention swale.
P 8	- Apartment building with a 49,000L rain water tank for re-use; - 142m^3 of bioretention basin
P 9	- 25m^3 of bioretention swale
P 10	- 86m^3 of bioretention swale
P11	- 44m^3 of bioretention swale
P 12	- 23m^3 of bioretention swale
P 14	- 88m^3 of bioretention swale
P15	- 65m^3 of bioretention swale
P16	- Apartment building with a 66,000L rain water tank for re-use; - 90m^3 of bioretention swale - 260m^3 of detention basin by ponding to 0.3m on car park
P17	- Runoff from P4 is directed into P18's bioretention swale of volume 96m^3.
P18	- 96m^3 of bioretention swale - Runoff from P17 and P18 is directed into P20's Gross Pollutant Trap.
P20	- Each integrated lot to utilise a 5,000L rain water tank for re-use; - 1 Gross Pollutant Trap

4.6.3 Proposed Developed Conditions (no detention) Flow Rates

Results of the proposed developed state (*no treatment*) modelling are summarised in **Table 4.10** for the subcatchments within the UTS Kuring-gai site. Full results for all locations during the critical storm event are contained in **Appendix 2**.

The change in land use would result in a number of existing stormwater outlets becoming obsolete. Each of the outlets in the proposed development would be located as close as possible to an existing outlet. The difference between the proposed development *(50 year ARI),* relative to the state of nature *(20 year ARI)* conditions, is to increase peak discharges and decrease the time of concentration.

Table 4-10 RAFTS Results: Proposed with no detention

Outlet Node	Peak flows (m^3/s)	
	Q *5proposed no detention*	**Q** *100proposed no detention*
Blue Gum Creek	2.62	4.39
Little Blue Gum Creek	0.65	1.19
College Creek	3.03	5.31
Lane Cove River	5.66	9.68

4.6.4 Proposed Developed Conditions (*with detention*) Flow Rates

The proposed development conditions have been modelled with detention storage to determine the peak flow rates that would be achieved with implementation of on-site retention/detention as described in **Table 4.9**.

A summary of the proposed developed conditions with treatment is shown in **Table 4.11** while full results for all locations in the critical storm event are contained in **Appendix 2**.

Table 4-11 RAFTS Results: Proposed with Detention

Outlet Node	Peak flows (m^3/s)	
	Q *5proposed with detention*	**Q** *100proposed with detention*
Blue Gum Creek	1.66	3.24
Little Blue Gum Creek	0.20	0.72
College Creek	1.01	2.52
Lane Cove River	1.87	5.76

4.7 Results Summary

4.7.1 20yr ARI State of Nature Vs 50 yr ARI Proposed

Results of the 20yr ARI state of nature vs. 50 yr ARI proposed storm modelling are summarised in **Table 4.12**. Full results for all locations for the critical storm event are contained in **Appendix 2**.

Table 4-12 RAFTS Results: 20yr state of nature vs 50 yr proposed

Outlet Node	Peak flows (m^3/s)		
	Q *20natural*	**Q** *50proposed No Treatment*	**Q** *50proposed treated*
Blue Gum Creek	3.21	3.89	2.51
Little Blue Gum Creek	1.09	1.05	0.39
College Creek	3.38	4.71	2.86
Lane Cove River	6.59	8.60	5.03

It should be noted that the 50 year ARI peak flow from the Little Blue Gum Creek subcatchment is less than the 20 year ARI natural. This is due to the increase in pervious area achieved by altering that subcatchment from an almost fully impervious car park to a residential area with pervious garden areas.

4.7.2 5 & 100 yr ARI Proposed vs Existing

Results of the 5yr and 100yr ARI proposed storm modelling are summarised in **Table 4.13** and **Table 4.14**. Full results for all locations for the critical storm event are contained in **Appendix 2**.

Table 4-13 RAFTS Results: 5yr Proposed Vs Existing

	Peak flows (m^3/s)		
Outlet Node	**Q** *5exist*	**Q** *5proposed No Treatment*	**Q** *5proposed treated*
Blue Gum Creek	2.43	2.62	1.66
Little Blue Gum Creek	0.94	0.65	0.20
College Creek	2.51	3.03	1.01
Lane Cove River	4.94	5.66	1.87

Table 4-14 – RAFTS Results: 100yr Proposed Vs Existing

	Peak flows (m^3/s)		
Outlet Node	**Q** *100exist*	**Q** *100proposed No Treatment*	**Q** *100proposed treated*
Blue Gum Creek	4.11	4.39	3.24
Little Blue Gum Creek	1.60	1.19	0.72
College Creek	4.72	5.31	2.52
Lane Cove River	8.83	9.68	5.76

This analysis demonstrates that it is feasible to meet the requirements of NSW Department of Environment and Climate Change guidelines (as attached to the Director General's Requirements) with the provision of retention volume. In addition, the proposed storage strategy significantly reduces the existing 5 and 100 year ARI peak flows below existing conditions as well as reducing 50yr proposed to below 20yr natural. Further analysis can be undertaken at subsequent approval stages to refine the storage requirements and as a means of accounting for the beneficial impact of pipe and infiltration media storage on control of runoff rates.

4.8 Discharge Outlets

Each of the outlets would be located as close as possible to a recognised existing outlet. The stormwater outlets would generally consist of a headwall followed by a shallow tail-out channel that is protected from scour with either rock rip-rap and/or suitable vegetation (*eg macrophytes in the invert that protect from scour velocities during high flows*).

5. STORMWATER QUALITY IMPACT ASSESSMENT

5.1 Council Requirements

Ku-ring-gai Council's (*Council's*) – *Water Management Development Control Plan – DCP 47 (amended April 2005)* contains the design objectives for stormwater quality management. These standards require (described in *Section 8.3.1)* the following reductions in the post development pollutant load that would be discharged from the site if no stormwater reuse or treatment measures were applied:

- Litter 70% reduction;
- Suspended solids 80% reduction;
- Total Phosphorus 45% reduction; and
- Total Nitrogen 45% reduction.

These criteria have been adopted for the key pollutant attenuation objectives. In addition, the existing state has been modelled to ensure that there is no increase in pollutant load export from the existing state as a result of the proposed development.

5.2 MUSIC Water Quality Model

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is a continual-run conceptual water quality assessment model developed by the Cooperative Research Centre for Catchment Hydrology (*CRCCH,* now *eWater*). 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.

To undertake the water quality assessment component of the stormwater management strategy, a long-term MUSIC model was established for the UTS Kuring-gai Campus site. The model was used to estimate the annual pollutant load generated under natural state and developed conditions for a mean rainfall year.

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.

5.3 Existing State Simulation

The adopted objective of the water quality management strategy is to achieve the required reductions outlined in **Section 5.1** and no net increase in pollutant export to receiving waters relative to existing state conditions. Therefore, the existing pollutant export from the site was estimated to establish the base case against which to measure the performance of proposed development.

The catchments defined in **Table 4.1** and **Figure 2** were adopted to create a MUSIC model for the UTS Kuring-gai site.

5.3.1 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 was necessary. Long term annual rainfall measurements for the region, as measured by the Bureau of Meteorology (West Lindfield) give the following rainfall statistics;

Mean - 1324.2mm/year

Max - 1905mm/year (1978)

Min – 721.3mm/year (1957)

This estimate was based on 42 complete years of record at this site, between 1950 and 1992 (*Bureau of Meteorology, 2004*). No pluviograph data to provide six minute rainfall records is available for this station.

Pluviograph data recorded at Sydney Observatory Hill was adopted for the analysis. The following records have been adopted and are considered to be representative of the average, maximum and minimum annual rainfall experienced at the UTS Kuring-gai site.

Mean – 1343mm/year (1983)

Wet – 1765mm/year (1984)

Dry – 840mm/year (1982)

Resultant mean – 1316mm/hr

5.3.2 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 5.1.**

Table 5-1 Monthly Areal Potential Evapotranspiration

Month	Areal Potential Evapotranspiration (mm)
January	175
February	135
March	125
April	80
May	58
June	45
July	45
August	60
September	89
October	125
November	151
December	165

5.4 Soil data and model calibration

A rainfall-runoff analysis was undertaken prior to modelling being undertaken. The model produced a natural state volumetric runoff coefficient 0.28 with the default soil parameters. This is considered to be an acceptable runoff coefficient for the subject site.

The following default soil parameters were adopted for the site: -

- field capacity 80mm
- soil capacity 120mm

- Initial storage 30mm
- coefficient '*a*' 200
- coefficient '*b*' 1.0

5.5 Pollutant concentrations

The event mean pollutant concentrations used for the various land-uses in the existing and developed catchments were derived from '*Urban Stormwater Quality: A Statistical Overview*' (*Duncan, February 1999*). The adopted pollutant concentrations are shown in **Table 5.2.** The existing land use types for each of the existing catchments is contained within **Table 4.1.**

Table 5-2 Adopted Runoff Pollutant Concentrations

	Pollutant Concentration (mg/L)		
	Suspended Solids	**Total Phosphorous**	**Total Nitrogen**
Source Values			
Urban (Music default)	158	0.355	2.63
Commercial (Duncan 2003)	140	0.25	2
Rural (Duncan 2003)	90	0.22	2
Roofs (Duncan 2003)	20	0.13	2
Roads (Duncan 2003)	270	0.5	2.2
Natural (Duncan 2003)	40	0.08	0.9
Local Existing Land Use			
Car parking, Roads	270	0.5	2.2
Tennis courts	140	0.25	2.
Oval	90	0.22	2
Buildings, Roofs	20	0.13	2
Child care centre, Film Australia, road	140	0.25	2
Undeveloped	40	0.08	0.9
Proposed			
Roofs	20	0.13	2
Roads	270	0.5	2.2
General Urban	158	0.25	2
Undeveloped	40	0.08	0.9

5.6 Existing State Pollutant Export

The MUSIC model, once setup for runoff, was used to simulate the pollutant export generated during a mean rainfall and evaporation year using the typical pollutant concentrations contained in **Table 5.3**.

The estimated annual export of pollutants at the outlets of the existing state subcatchments for a mean rainfall year are shown in **Table 5.3**.

Table 5-3 Annual Pollutant Export Loads – Existing State

Node / Location	Pollutant Load (kg/yr)		
	Suspended Solids	Total Phosphorous	Total Nitrogen
Blue Gum Creek	6070	11.7	69.4
Little Blue Gum Creek	3340	6.75	46.9
College Creek	2120	6.8	76.1
Total from site towards Lane Cove River	11500	25.3	192

5.7 Developed (*no treatment*) Pollutant Export

To assess the requirements of the water quality management strategy, the existing state model was modified to reflect the degree of proposed development. No treatment techniques were implemented in the developed (*no treatment*) model. The model was modified to reflect the impervious proportions of the subcatchments as defined in **Table 4.6**.

The estimated annual export of pollutants from the developed (*no treatment*) site for a mean rainfall year compared with the existing conditions are shown in **Table 5.4**.

It must also be noted that for developed conditions, sub – catchment 19 has been excluded from MUSIC modelling as the subcatchment will drain to existing curb gutters on Eton Rd.

Table 5-4 Annual Pollutant Export Loads – Developed State (No Treatment)

Node / Location	Pollutant Load (kg/yr)		
	Suspended Solids	Total Phosphorous	Total Nitrogen
Blue Gum Creek	5220	10.0	71.7
Little Blue Gum Creek	2030	3.89	30.6
College Creek	4210	8.68	81.3
Total from site towards Lane Cove River	11500	22.6	184

5.8 Proposed Treatment Strategy

The proposed water management for each subcatchment is as follows in **Table 5.5**, and shown in **Figure 1**.

Table 5-5 Proposed Water Quality Treatment for each catchment

P 1	❑ Each standard lot to utilise a 5,000 L rain water tank, each integrated lot to utilise a 5,000L rain water tank; ❑ 648m^2 bioretention swale (162m^2 filter area, 0.3m ponding depth)
P 2	❑ Each integrated lot to utilise a 5,000L rain water tank and an apartment building with a 32,000L rain water tank for re-use; ❑ 528m^2 of bioretention swale (132m^2 filter area, 0.3m ponding depth); ❑ 616m^2 bioretention basin (616m^2 filter area, 0.3m ponding depth); ❑ 239m^2 of bioretention swale (60m^2 filter area, 0.3m ponding depth)
P 3	❑ Apartment building with an 80,000L rain water tank for re-use; ❑ 132m^2 of bioretention swale (33m^2 filter area, 0.3m ponding depth); ❑ 206m^2 of bioretention swale (52m^2 filter area, 0.3m ponding depth);
P4	❑ Runoff from P4 is directed into P5's first bioretention swale of area 315m^2
P5	❑ Apartment building with a 40,000L rain water tank for re-use;

	❑ 315m^2 of bioretention swale (79m^2 filter area, 0.3m ponding depth);
P 6	❑ Apartment building with an 80,000L rain water tank for re-use; ❑ 763m^2 of bioretention basin (763m^2 filter area 0.3m ponding depth); ❑ 308m^2 of bioretention swale (77m^2 filter area, 0.3m ponding depth)
P 7	❑ 888m^2 of bioretention swale (222m^2 filter area 0.3m ponding depth).
P 8	❑ Apartment building with a 49,000L rain water tank for re-use; ❑ 472m^2 of bioretention basin (472m^2 f filter area 0.3m ponding depth).
P 9	❑ 132m^2 of bioretention swale (33m^2 filter area 0.3m ponding depth).
P 10	❑ 456m^2 of bioretention swale (1114m^2 filter area 0.3m ponding depth).
P11	❑ 232m^2 of bioretention swale (58m^2 filter area 0.3m ponding depth).
P 12	❑ 124m^2 of bioretention swale (31m^2 filter area 0.3m ponding depth);
P 14	❑ 468m^2 of bioretention swale (140m^2 filter area 0.3m ponding depth).
P15	❑ 348m^2 of bioretention swale (87m^2 filter area 0.3m ponding depth).
P16	❑ Apartment building with a 66,000L rain water tank for re-use; ❑ 492m^2 of bioretention swale (148m^2 filter area 0.3m ponding depth).
P17	❑ Runoff from P4 is directed into P18's first bioretention swale of area 512m^2.
P18	❑ 512m^2 of bioretention swale (128m^2 filter area 0.3m ponding depth). ❑ Runoff from P17 and P18 is directed into P20's Gross Pollutant Trap.
P20	❑ Each integrated lot to utilise a 5,000L rain water tank for re-use; ❑ 1 Gross Pollutant Trap

A brief description of water tanks, bioretention swales and gross pollutant traps is provided in the following sections.

5.8.1 Rainwater Tanks

Each standard lot to utilise a 5,000 L rainwater tank, each integrated lot to utilise a 5, 000L rainwater tank and each apartment is to utilise a 1,000 L /unit rainwater tank that will capture the stormwater collected on the roof. This water will be available for re-use for toilet flushing, clothes washing, car washing and external irrigation. The extent of control measures can be refined at subsequent approval stages in the knowledge that it is feasible to achieve the stated objectives.

5.8.2 Bioretention Swales and Basins

Bioretention swales and basins consist of low relief areas consisting of native grasses, shrubs and trees with an infiltration area. The swales would be gravel filled approximately 700mm deep with 200mm of sandy loam topsoil and 500mm wide wrapped in geotextile with a perforated pipe at the base. The perforated pipe in the trenches would be connected to the pipe drainage system. Typical sections of the proposed bioretention swales and basins are shown in **Figure 3**. The bioretention basins would be wider areas of open space heavily vegetated with a series of infiltration trenches through out the basin area.

The purpose of bioretention is to provide a filtering effect when the runoff flows on the surface through the vegetation to remove pollutants in the runoff. 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 exposed to sunlight and with turbulence introducing oxygen to the flows.

The role of the bioretention swales and basins is not to promote infiltration into the subsoils.

The proposed location of the bioretention systems is shown in **Figure 1**.

5.8.3 Gross Pollutant Trap

The Gross Pollutant Traps (GPT's) would capture litter, debris, coarse sediment, 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
- sediments up to 70%
- total phosphorous up to 30%
- total nitrogen up to 13%

Due to the level of treatment the stormwater will have already undergone prior to GPT's the capture rates for GPT's downstream of treatment devices have been reduced to more conservative values. The following treated capture rates have been adopted:-

- gross pollutants majority
- sediments up to 48%
- total phosphorous up to 18%
- total nitrogen up to 8%

5.9 Developed (*treated*) Pollutant Export

The water quality controls outlined in **Section 5.8** were incorporated into the developed MUSIC model as described above. The estimated annual export of pollutants from the developed (*with treatment*) site for a mean rainfall year are shown in **Table 5.6**.

Table 5-6 Performance of Proposed Water Quality Management Strategy

Node/Location	Suspended Solids Load (kg/yr)		
	Existing	Proposed Treated	Percentage Reduction Achieved
Blue Gum Creek	6070	873	86%
Little Blue Gum Creek	3340	260	92%
College Creek	2120	559	74%
Lane Cove River	11500	1690	85%

Node/Location	Total Phosphorous Load (kg/yr)		
	Existing	Proposed Treated	Percentage Reduction Achieved
Blue Gum Creek	11.7	3.44	71%
Little Blue Gum Creek	6.75	0.95	86%
College Creek	6.8	2.19	68%
Lane Cove River	25.3	6.58	74%

Node/Location	Total Nitrogen Load (kg/yr)		
	Existing	Proposed Treated	Percentage Reduction Achieved
Blue Gum Creek	69.4	38.5	45%
Little Blue Gum Creek	46.9	11.6	75%
College Creek	76.1	31.1	59%

Node/Location	Total Nitrogen Load (kg/yr)		
	Existing	Proposed Treated	Percentage Reduction Achieved
Lane Cove River	192	81.2	58%

Table 5.6 shows that the water quality objective of maintaining developed pollutant export rates to existing levels can be readily achieved at all outlets. The pollutant export into the receiving water bodies of the Lane Cove River, Blue Gum Creek, College Creek and Little Blue Gum Creek are significantly less then in the existing state as a result of incorporating the stormwater quality controls as shown in **Figure 1**. The development would therefore contribute to the long term improvement in water quality in these creeks.

Ku-ring-gai Council's (*Council's*) – *Water Management Development Control Plan – DCP 47 (* Section 8.3.1) requires the following reductions from the post untreated to post treated;

- Suspended solids 80% reduction
- Total Phosphorus 45% reduction
- Total Nitrogen 45% reduction

Table 5.7 shows that the catchments on the UTS site draining towards Blue Gum Creek, Little Blue Gum Creek, and College Creek satisfy the above requirements. The ultimate receiving water body (the Lane Cove Rive) satisfies Councils reduction requirements and less pollutant export is produced in the proposed treated model than the existing state.

Table 5-7 Percentage pollutant load reductions from proposed untreated to proposed treated

Node/Location	Suspended Solids Load (kg/yr)		
	Proposed Untreated	Proposed Treated	Percentage Reduction Achieved
Blue Gum Creek	5220	873	83%
Little Blue Gum Creek	2030	260	87%
College Creek	4210	559	87%
Lane Cove River	11500	1690	85%

Node/Location	Total Phosphorous Load (kg/yr)		
	Proposed Untreated	Proposed Treated	Percentage Reduction Achieved
Blue Gum Creek	10	3.44	66%
Little Blue Gum Creek	3.89	0.946	76%
College Creek	8.68	2.19	75%
Lane Cove River	22.6	6.58	71%

Node/Location	Total Nitrogen Load (kg/yr)		
	Proposed Untreated	Proposed Treated	Percentage Reduction Achieved
Blue Gum Creek	71.7	38.5	46%
Little Blue Gum Creek	30.6	11.6	62%
College Creek	81.3	31.1	62%
Lane Cove River	184	81.2	56%

5.10 Construction Phase

The development application for each stage will provide a sediment and erosion control plan designed in accordance with the NSW Department of Housing "*Managing Urban Stormwater – Soils and Construction*" (*Blue Book*) and to the satisfaction of Council's requirements. Staging of the development would minimise impacts during construction. These controls would ensure that there are no significant adverse impacts on receiving water quality during the construction stage.

6. WATER CYCLE MANAGEMENT

6.1 Potable Water Use Reduction

The State Government has a target of a 40% reduction in potable water use compared with traditional households for *BASIX Compliance*. This can be achieved through the provision of water re-use devices, conservation practises and recycling 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
- Water harvesting such as temporary water storage or rainwater tanks.

6.2 Water Saving Measures

The main uses of potable water in a traditional household (*refer **Table 6.1***) are garden irrigation (*23%*), shower (22%), toilet (*14%*) and washing machine (*18%*). These figures provided in **Table 6.1** were taken from studies used to develop the BASIX legislation.

Table 6.1 Typical Household Water Use

Area/Use	*Traditional Household*		*With Water Saving Devices*	
	Usage l/person/day	**Percentage of Total Use**	**Usage l/person/day**	**Reduction (%)**
Internal				
Shower	56.9	22%	37.1	35%
Toilet	35.2	14%	20.0	43%
Washing Machine	46.1	18%	32.0	31%
Kitchen Sink	12	5%	8.6	28%
Bathroom Basin	5.9	2%	4.2	28%
Dishwasher	3	1%	1.1	62%
Bath	8.7	3%	8.7	0%
Laundry Trough	4.9	2%	4.9	0%
Leaks	10	4%	10.0	0%
Sub Total	*182.7*	*70%*	*126.8*	*31%*

Area/Use	***Traditional Household***		***With Water Saving Devices***	
	Usage l/person/day	**Percentage of Total Use**	**Usage l/person/day**	**Reduction (%)**
External				
Garden Irrigation	61	23%	45.75	25%
Pool and Spa	10.5	4%	7.35	30%
Car Washing	6.4	2%	6.4	0%
Sub Total	*77.9*	*30%*	*59.5*	*24%*
TOTALS	**260.6**	**100%**	**186.3**	**29%**

It is recommended that the development incorporate flow restrictors in the kitchen and bathroom, AAA rated shower heads, dual flush toilets and AAAA rated dishwashers and washing machines. These alone would directly reduce total potable water usage by approximately 29%.

Water saving devices in combination with reuse of rainwater from rainwater tanks (described further in **Section 6.2**) for toilet flushing, washing clothes, car washing and irrigation would be implemented to achieve the minimum 40% reduction required by the State government (*BASIX*).

6.3 Rainwater Reuse

Section 6.4 of Ku-ring-gai Council DCP 47 (Part 6.4) requires that all single dwellings (subdivision) be equipped with a 5000L water tank and multi unit developments be equipped with a 1000L rainwater tank per unit. In addition it is required that all lots containing rainwater tanks shall use retained water for irrigation as a minimum, but it is also recommended that toilets and washing machines also be connected to the rainwater tank.

Runoff from roofs can be reused for various purposes including irrigation, car washing, toilet flushing and washing machines. This has the potential to make considerable reductions in potable water usage when used with water savings devices. With full substitution of these uses, the reduction in potable water usage would be 56% *(with the 18% reduction due to water saving devices – see* **Section 6.1**). However, full substitution would not be achieved at any location due to the variability of rainfall.

A water balance analysis was undertaken for the subject site using recorded daily rainfall data for Castle Cove (66080) from January 1984 to May 2004 (*average annual rainfall of 1340mm/yr*) and daily evaporation data over the same period recorded at Sydney Airport. The water balance was used to determine the efficiency of the 5000L rainwater tanks in each standard lot.

Three scenarios have been modelled with the first being a traditional household with no controls. The second scenario (*Option A*) includes the implementation of water saving devices as described in **Section 6.1**. The final scenario (*Option B*) includes rainwater for irrigation, car washing, toilet flushing and washing machines used in concert with water saving devices.

Table 6-2 Water Balance Summary – Water Usage (m^3/yr)

All volumes in (m^3/yr), for annual average	Traditional Household	Option - A	Option - B
Total potable water use	70,664	57,521	37,953
Potable Water Use Reduction (%)		**19%**	**46%**

The total potable water use decreases from 70,664m^3/yr in the traditional household model to 57,521m^3/yr with the introduction of water saving devices. This represents a reduction in potable water usage of 19%. The introduction of rainwater tanks further reduces the potable water usage to 37,953m^3/yr achieving a predicted saving of 46%.

The State government's requirement for a 40% reduction in potable water use can be achieved with a 5000L rainwater tank for each detached dwelling and 1000L for each unit. It is proposed to explore with Council the use of a range of rainwater tank sizes to suit the site and development constraints while still complying with the State government potable water use reduction target. For instance, slimline tanks can be more readily incorporated into a house design to provide an overall better design outcome in terms of visual and private open space amenity. These tanks have a maximum size of 4000L. These tanks could be used on detached housing with adequate tank sizes adopted for the units to ensure achievement of the 40% potable water use reduction target. Further analysis can be undertaken at subsequent approval stages to refine the tank sizes to achieve the required Environmentally Sustainable Design (ESD) targets and the best outcome for the overall design amenity for the site.

6.4 BASIX

6.4.1 Integrated Lots

A preliminary analysis was undertaken to assess an integrated lot within the development using the web based BASIX tool. The inputs utilised are shown in **Table 6.3**.

Table 6-3 Preliminary BASIX Assessment Inputs – Integrated Lots

Input	Value
Site area	400m^2
Roof area	120m^2
Total area of garden & lawn	200m^2
Area of garden planted with indigenous (low water demand) vegetation	100m^2
Showerhead rating	3 star
Toilets rating	3 star
Kitchen taps rating	3 star
Bathroom taps rating	3 star
Roof area diverted to tank	100m^2
Volume of tank	5,000L
Water reused from tank	Garden Toilets Laundry
Other Assumptions	Separate Dwelling 4 bedrooms No swimming pool No spa No on demand reticulation system No grey water No stormwater tank

This analysis determined that a rainwater tank of 5,000 litres along with water efficient fixtures and fittings would achieve a 47% reduction in potable water usage and as such, would satisfy the minimum 40% reduction requirement of BASIX legislation.

6.4.2 Apartments

An analysis of an apartment building within the development was also undertaken using the web based BASIX tool. Inputs were based on Building D, and utilised the assumptions shown in **Table 6.4**.

Table 6-4 Preliminary BASIX Assessment Inputs – Apartment Building

Input	Value
Number of dwellings	40
Roof area	1360m^2
Total area of garden & lawn	1600m^2
Area of garden planted with indigenous (low water demand) vegetation	100m^2
Showerhead rating	3 star
Toilets rating	3 star
Kitchen taps rating	3 star
Bathroom taps rating	3 star
Clothes washer	3 star
Dishwasher	3 star
2 bedroom unit	109m^2
3 bedroom unit	163m^2
Roof area diverted to tank per unit (=1360/40)	34m^2
Volume of tank per unit	1,000L
Water reused from tank	Laundry Toilets
Car Spaces	24

This BASIX analysis determined that a rainwater tank of 40,000 litres along with water efficient fixtures and fittings would achieve a 49% reduction in potable water usage and as such, would satisfy the minimum 40% reduction requirement of BASIX legislation.

7. CONCLUSIONS

The proposed development would be based on water sensitive urban design principles to minimise use of the scarce potable water resources and maximise the harvesting of urban runoff. The development would contribute to the long term improvement in water quality in the Lane Cove River. It will therefore provide significant benefits to the environment of the local area.

7.1 Water Quantity

A site specific water quantity assessment has shown that peak flows from the proposed development site are reduced. The 50 year ARI peak flow from the proposed development would be less than the peak flow from the 20 year ARI state of nature scenario, satisfying Ku-ring-gai Council's requirements. The peak flows for the proposed development would also be less than the existing peak flows for the 5 year and 100 year ARI events, as required by DECC.

Overland flows would be contained within road carriageways and the product of the depth and velocity would not exceed $0.4m^3/s$.

7.2 Runoff Water Quality

The stormwater treatment strategy outlined in **Section 5** incorporating best practice water sensitive urban design would be a feature of the development. Runoff to the creeks around the site would contain approximately 85% less sediments, 70% less phosphorous and 55% less nitrogen compared with proposed untreated conditions. This represents a significant contribution to the health of the Lane Cove River.

To achieve the above pollutant reductions it is recommended that the following stormwater treatment measures be implemented:

Treatment Device	Masterplan Recommendations
Rainwater Tanks	5kL per standard and integrated lot, 1kL for each apartment.
Bioretention Swales	Total of 1475m long; 4m wide.
Bioretention Basins	Approximately $2250m^2$
Gross Pollutant Traps	All major trunk drainage line downstream of residential development

7.3 Potable water use

Water saving devices and rainwater reuse on each lot would be implemented in order to achieve a 40% reduction in potable water usage and as such, satisfy BASIX requirements.

8. REFERENCES

Bureau of Meteorology (2001), *Climate Atlas of Australia, Evapotranspiration*, in conjunction with the Cooperative Research Centre for Catchment Hydrology, ISBN 0 642 32049 9

Duncan, Hugh P (1999), "Urban Stormwater Quality: A Statistical Overview", *Cooperative Research Centre for Catchment Hydrology Report 99/3*, February

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Barry Eadie Consulting Pty Ltd (19 September 2007, Version C) *Bushfire Hazard Assessment, University of Technology, Sydney Ku-ring-gai site.*

Institute of Engineers Australia (1987) *Australian Rainfall and Runoff*

Ku-ring-gai Council (*amended April 2005*) *Water Management Development Control Plan – DCP 47.*

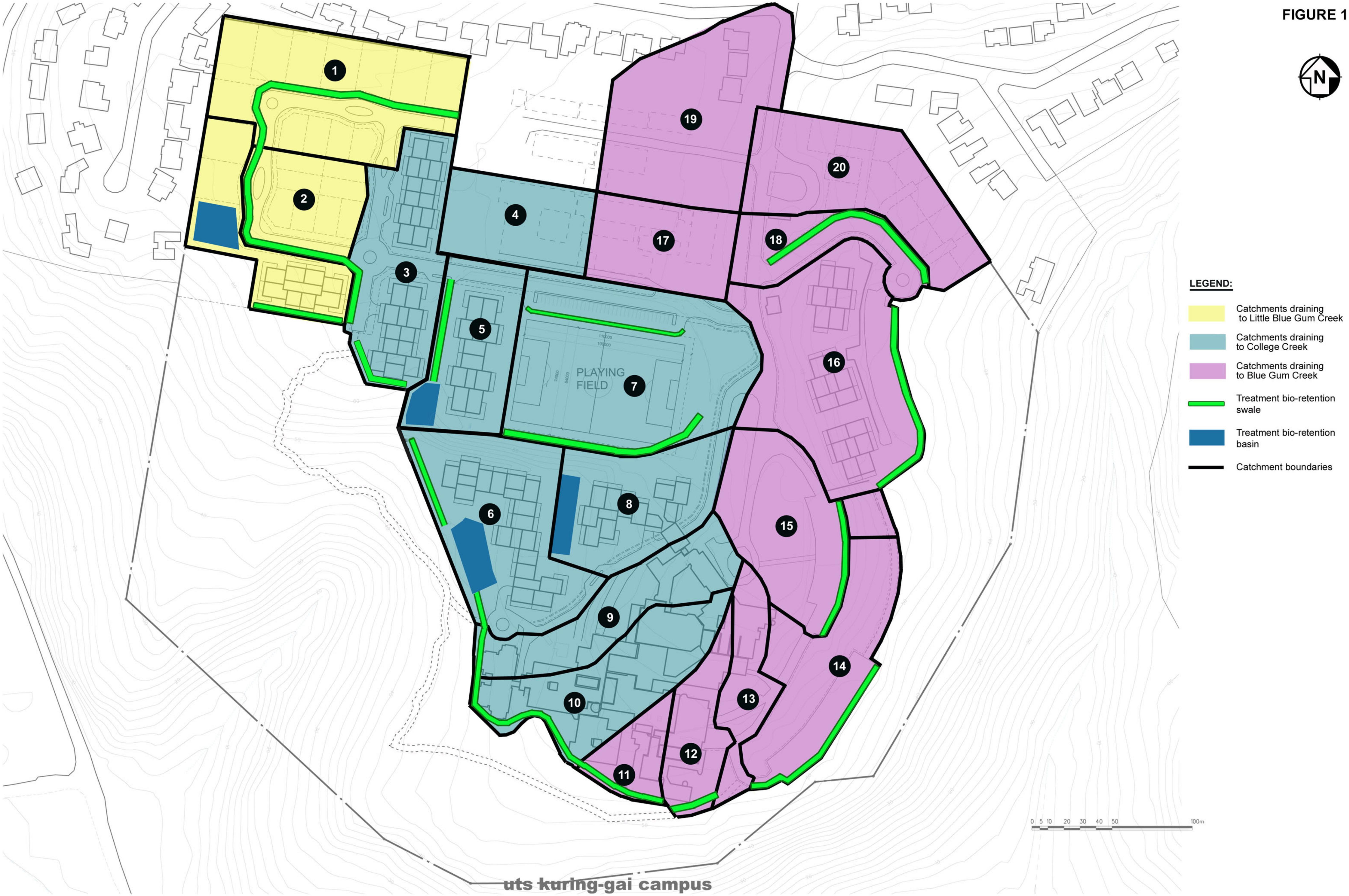
NSW Department of Housing (1998) *Managing Urban Stormwater – Soils and Construction* (*Blue Book*).

Robyn Tuft & Associates (May 1999*) Draft Stormwater Management Report for –UTS Ku-ring-gai Campus.*

URS (October 2003) *Investigation of Options to Minimise Potable Water Demand and Reduce Wastewater Flows.*

FIGURES

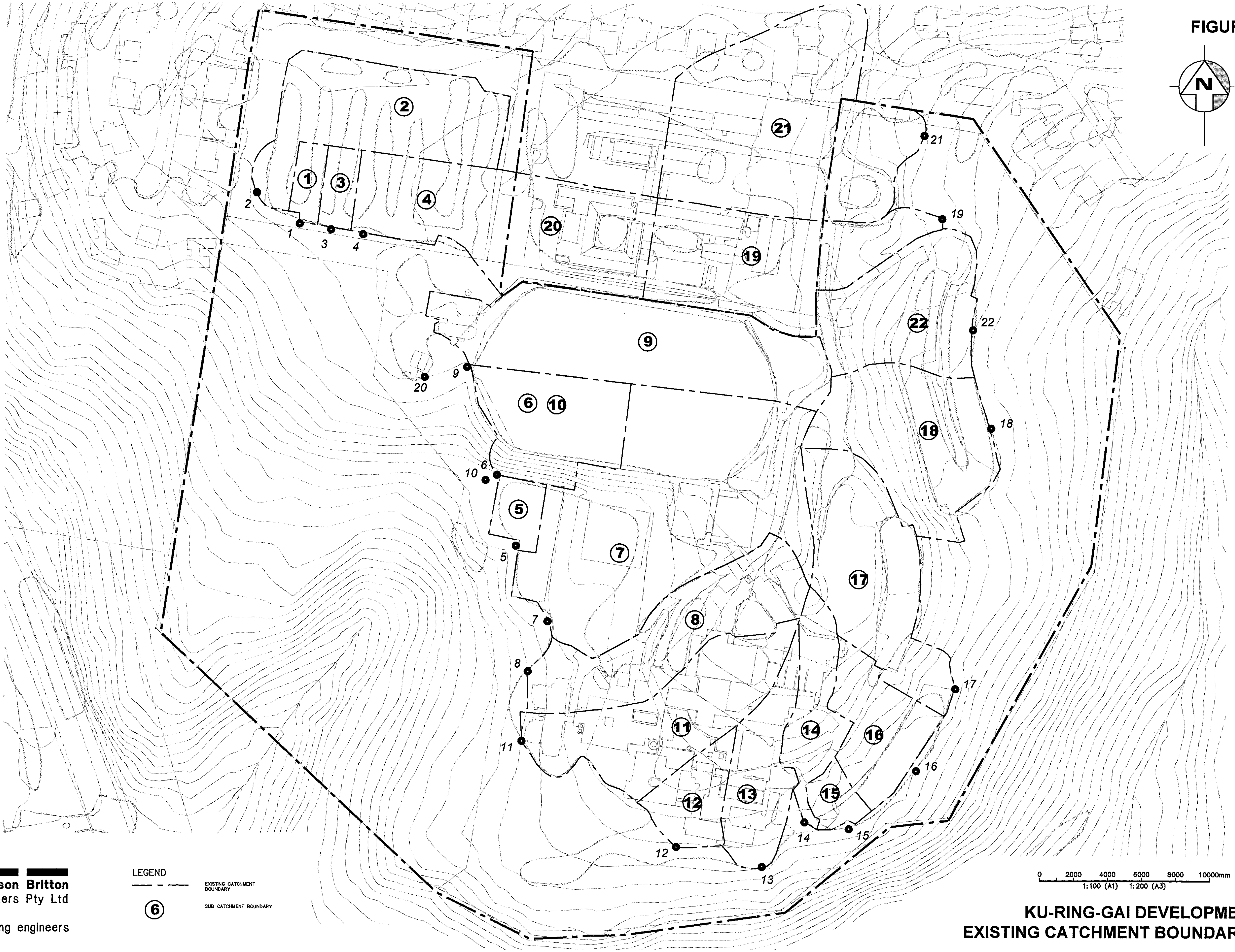
FIGURE 1



KURING-GAI DEVELOPMENT
PROPOSED CATCHMENT BOUNDARIES

J4975/FIG1_ProposedCatchmentBoundaries

FIGURE 2



Patterson Britton
& Partners Pty Ltd

consulting engineers

4975-01 DWG

KU-RING-GAI DEVELOPMENT
EXISTING CATCHMENT BOUNDARYS

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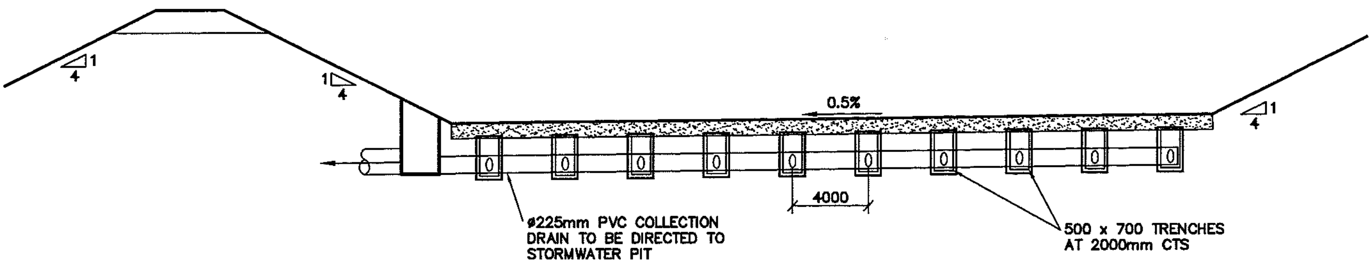
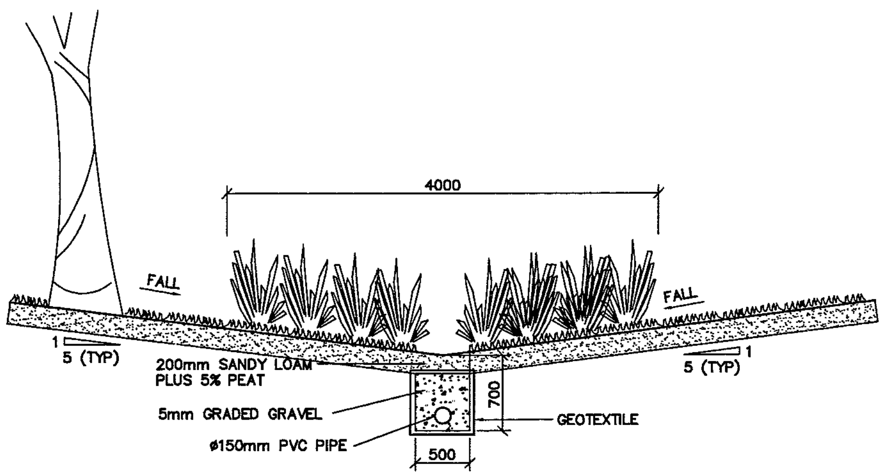
FIGURE 3



SECTION 1
1H: 2V

TYPICAL SECTION THROUGH BIORETENTION BASIN



TYPICAL CROSS SECTION THROUGH
BIORETENTION SWALE
NTS

TYPICAL SECTION THROUGH BIO-RETENTION BASIN AND SWALE

Appendix 1 - Responses from service providers

Sydney WATER

Case Number: 109935

5 February 2008

Patterson Britton & Partners P/L
c/- Qalchek P/L

FEASIBILITY LETTER

Developer:	**Patterson Britton & Partners P/L**
Your reference:	**PM 4741**
Development:	**Lots 2 (D.P 1043043) & Lot 5 (D.P 32292) Eton Road, Lindfield**
Development Description:	**Proposed redevelopment of the UTS Ku-ring-gai campus – 382 dwellings in total - 10 large lots, 25 integrated lots & 347 apartments as per the State Significant Site Amendment plan dated January 2008.**
Your application date:	**28 November 2007**

Dear Applicant

This Feasibility Letter (Letter) is a guide only. It provides general information about what Sydney Water's requirements could be if you applied to us for a Section 73 Certificate (Certificate) for your proposed development. **The information is accurate at today's date only.**

If you obtain development consent for that development from your consent authority (this is usually your local Council) they will require you to apply to us for a Section 73 Certificate. You will need to submit a new application (and pay another application fee) to us for that Certificate by using your current or another Water Servicing Coordinator (Coordinator).

Sydney Water will then send you either a:

- Notice of Requirements (Notice) and Works Agreement (Agreement); or
- Certificate.

These documents will be the definitive statement of Sydney Water's requirements.

There may be changes in Sydney Water's requirements between the issue dates of this Letter and the Notice or Certificate. The changes may be:

1. Developer Charges

(a) Adjustment of charges due to the Consumer Price Index (CPI);

(b) Adjustment of charges because of a scheduled review by the Independent Pricing and Review Tribunal (IPART). After that review and registration of the new charges, Sydney Water has to apply those charges; or

(c) If there is rezoning of any land within the development proposal then new charges will apply.

2. Reticulation Recovery Charges

These charges recover part of the cost of works that have been paid for by Sydney Water or other developers and that benefit your development. This charge has been made before your points of connection have been determined. If your completed designs show that your development will be connected to other main/s, the charge may be changed and/or you may need to construct other works.

3. Changing the Proposed Development

If you change your proposed development, e.g. the development description or the plan/site layout, after today, the requirements in this Letter could change when you submit your new application.

Also, if you decide to do your development in stages then you must submit a new application (and pay another application fee) for each stage.

What You Must Do To Get A Section 73 Certificate

To get a Section 73 Certificate you must do the following things. You can also find out about this process by visiting www.sydneywater.com.au ➢ Building Developing and Plumbing ➢ Developing Your Land.

1. **Obtain Development Consent from the consent authority for your development proposal.**

2. **Engage a Water Servicing Coordinator (Coordinator).**

   You must engage your current or another authorised Coordinator to manage the design and construction of works that you must provide, at your cost, to service your development. Before you engage another Coordinator you must write and tell Sydney Water.

   For a list of authorised Coordinators, either visit www.sydneywater.com.au ➢ Building Developing and Plumbing ➢ Developing Your Land or call **13 20 92.**

   The Coordinator will be your point of contact with Sydney Water. They can answer most questions that you might have about the process and developer charges and can give you a quote or information about costs for services/works (including Sydney Water costs).

3. **Works Agreement**

   After the Coordinator has submitted your new application, they will receive the Sydney Water Notice and Works Agreement. You will need to sign and lodge **both originals** of that Agreement with your nominated Coordinator.

   The agreement sets out for this development:
   - your responsibilities;
   - Sydney Water's responsibilities; and
   - the Coordinator's responsibilities.

   You must do all the things that we ask you to do in that Agreement. This is because your development does not have Water and Sewer services and you must construct and pay for the following works extensions under this Agreement to provide these services.

   After Sydney Water has signed the documents, one of them will be returned to your Coordinator.

   Note: The Coordinator must be fully authorised by us for the whole time of the Agreement.

4. Water and Sewer Works

4.1 Water

Each lot in your subdivision must have a frontage to a water main that is the right size and can be used for connection.

Sydney Water has assessed your application and found that:

- **The local 150 mm water supply system in Eton Road has sufficient capacity to accommodate the proposed development. Therefore you must construct a water main extension from the existing 150 mm water main in Eton road to serve all 382 dwellings in your development (see sketch on page 5)**.

- **To provide domestic water to the total development you will need to connect to the Sydney Water main. This connection must comply with the *National Plumbing and Drainage Code AS 3500* and *NSW Code of Practice for Plumbing and Drainage*. You may have to include isolation valves on either side of the connection(s) to the Sydney Water main.**

  For example, a single meter on:

  (a) each vertical block of residential units whether subdivided or unsubdivided (e.g. if your development has tower buildings, you must provide a meter for each building off one or more connections to the main);

  (b) each mixed development use type whether subdivided or unsubdivided (e.g. if your mixed development has both a residential and a commercial area, you must provide a meter for each area usually off one connection to the main). Note that if there is more than one commercial area, you must provide a separate meter for each commercial area off that connection; and

  (c) each non-residential Strata, Stratum or Torrens (within a Community) Title subdivided lot with a demand for water. You will need a separate private water service for each lot.

  Note:
  Where a number of non-residential units are not subdivided, separate services and metering to each unit is not required as Sydney Water will look to the owner for payment of all rates and charges. For example, a shopping centre where all shops remain in one ownership.

  To meet the preceding guidelines, either:
  - **a single connection to the Sydney Water main may be branched; or**
  - **if you would rather separate connections for each use type/area, you can apply to us for that.**

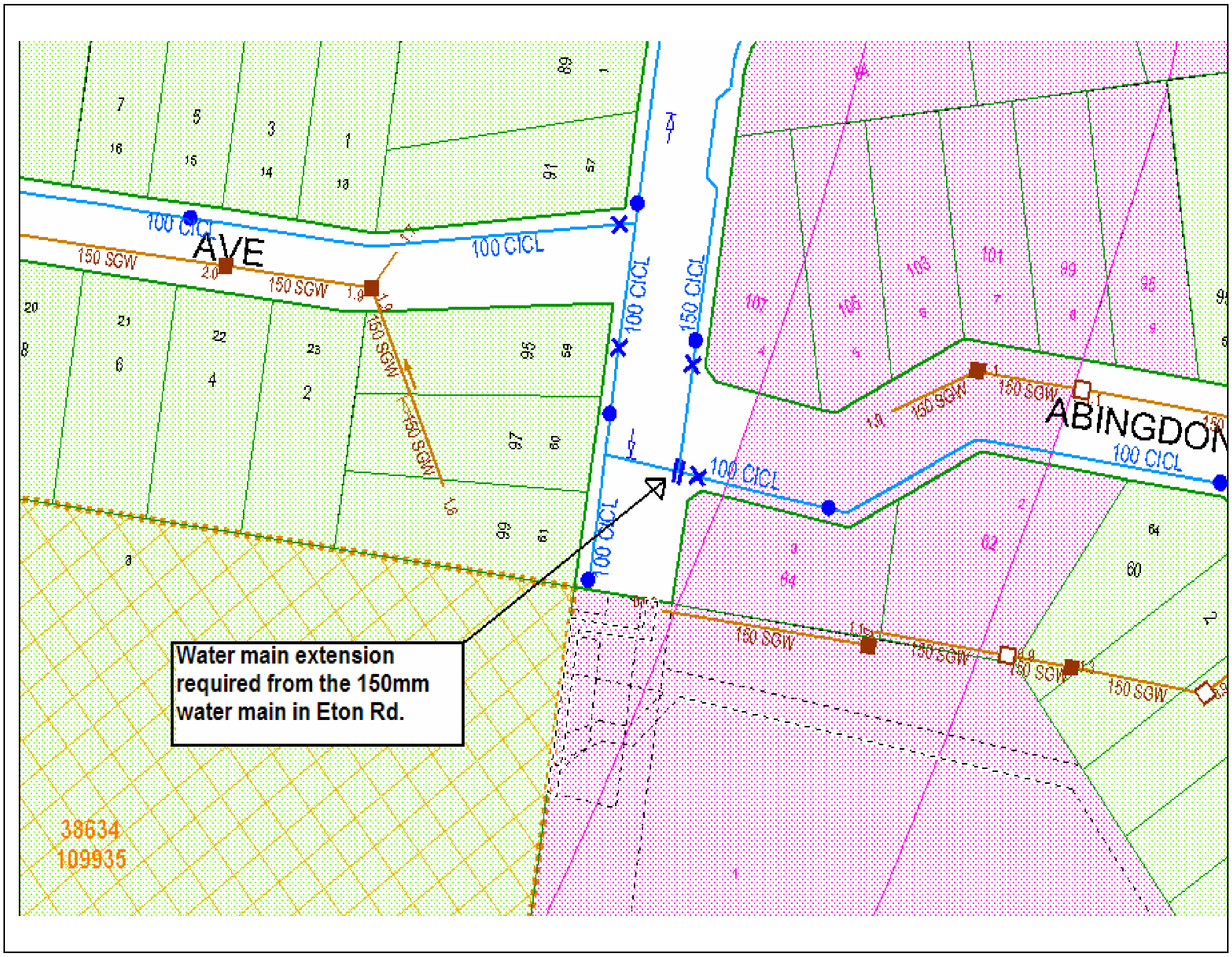
  A vertical building may be plumbed with a common riser, with either:
  - **a ring main on each floor with tee off-takes at each unit; or**

- **individual metered services to each unit that will allow housing of individually tagged meters in the one location.**

The location of the meter servicing a residential vertical building generally must be in the commercial area after all commercial off-takes.

Sydney Water will supply enough meters to meet the above guidelines but we will not provide any check meters. All meters must be placed in an accessible area that should be either:

- **no more than one metre inside the property boundary; or**
- **in a location acceptable to Sydney Water, e.g. in the commercial area after all commercial off-takes.**



4.2 Sewer

Each lot in your subdivision must have a sewer main that is the right size and can be used for connection. That sewer must also have a connection point within each lot's boundaries.

Sydney Water has assessed your application and found that:

- **You must construct a sewer main extension to serve all 382 dwellings in the development. See below for details.**
- **The existing 375 mm sewer main located in the vacant land South-East of the proposed development (Lot 2 Lady Game Drive – shown on the sketch below as Figure 1) has sufficient capacity to accommodate the three storey 40 unit building, both of the five storey 80 & 49 unit buildings, the 3xfour storey 22 unit buildings and the 13 integrated lots.**
- **The existing 150 mm sewer main within the vacant land - west of the proposed development (Lot 60 Lady Game Drive – shown on the sketch on Page 7 as Figure 2) has sufficient capacity to accommodate the 10 single lots, 12 integrated small lots, the three storey 36 unit medium density building and the two four storey 32 & 44 unit medium density buildings.**
- **The existing 375 mm sewer main is protected by an existing Sydney Water easement, prior to designing any works you will need to contact Sydney Water's Property Group for permission and conditions in using this easement – your Water Servicing Coordinator can assist you with this.**

<u>Figure 1.</u>

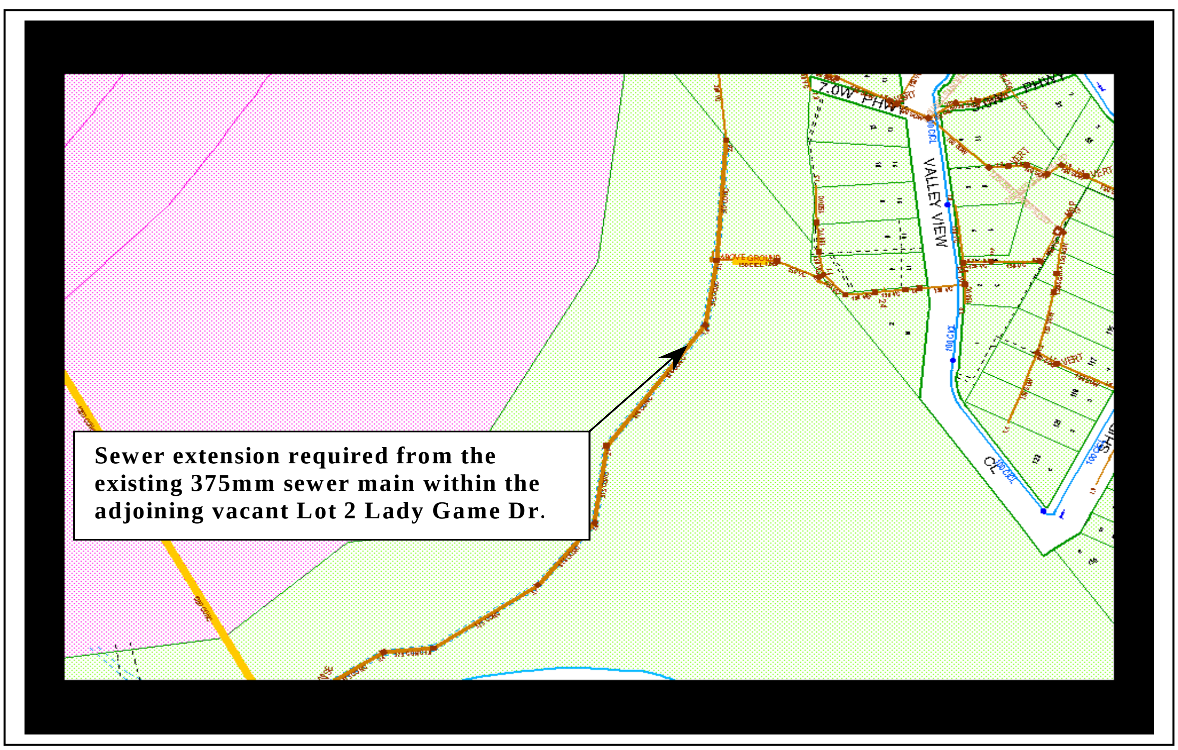
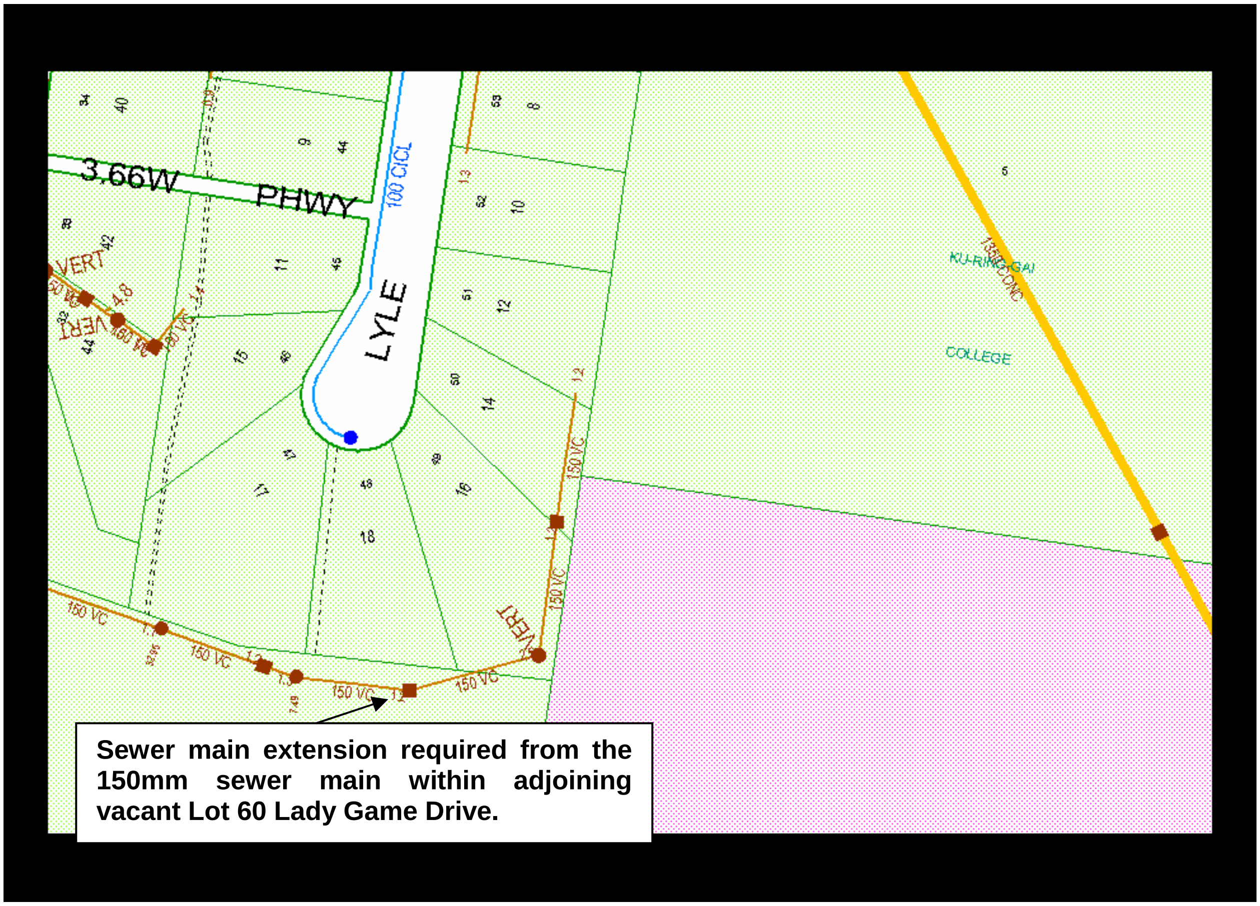


Figure 2



4.3 Ancillary Matters

4.3.1 Asset adjustments

After Sydney Water issues this Notice (and more detailed designs are available), Sydney Water may require that the water main/sewer main/stormwater located in the footway/your property needs to be adjusted/deviated. If this happens, you will need to do this work as well as the extension we have detailed above at your cost. The work must meet the conditions of this Notice and you will need to complete it **before we can issue the Certificate**. Sydney Water will need to see the completed designs for the work and we will require you to lodge a security. The security will be refunded once the work is completed.

4.3.2 Entry onto neighbouring property

If you need to enter a neighbouring property, you must have the written permission of the relevant property owners and tenants. You must use Sydney Water's **Permission to Enter** form(s) for this. You can get copies of these forms from your Coordinator or the Sydney Water website. Your Coordinator can also negotiate on your behalf. Please make sure that you address all the items on the form(s) including payment of compensation and whether there are other ways of designing and constructing that could avoid or reduce their impacts. You will be responsible for all costs of mediation involved in resolving any disputes. Please allow enough time for entry issues to be resolved.

4.3.3 Costs

When you construct these works you will need to pay project management, survey, design and construction costs **directly to your suppliers**. Other costs may include Sydney Water charges for:

- water main shutdown and disinfection;
- connection of new water mains to Sydney Water system(s);
- design and construction audit fees;
- **contract administration on project finalisation**;
- creation or alteration of easements etc.;
- some Customer Contract services (e.g. Customer redress);
- water usage charges where water has been supplied for building activity purposes prior to disinfection of a newly constructed water main.

Your Coordinator can tell you about these costs.

5. Developer Charges

Development Servicing Plan (DSP)	**Basis of Calculation**	**Charge ($) for Applicable period (05/02/08-05/02/08)**
Pymble - Killara - Chatswood Water DSP Area	**Residential** Development Density >180 dwellings per ha band 382 dwellings @ $0=$0 ***less*** **Credit of $0 for previous payment/ use**	$Nil
East West Lane Cove Sewer DSP Area	**Residential** Development Density >180 dwellings per ha band 382 dwellings @ $0=$0 ***less*** **Credit of $0 for previous payment/ use**	$Nil
Reticulation Recovery	*Not Applicable* See Note below	$Nil See Note below
DEVELOPER CHARGES TOTAL: *[OFFICE USE – Invoice Charges total – Developer $Nil]*		**$Nil**

Notes:

- After your Coordinator submits the **Section 73 Subdivider/Developer Compliance Certificate** Application, the **Notice** will detail the Developer Charges for your development.

Payment of charges:

- **You must pay your DSP charge before you will be given permission to connect your development to Sydney Water's water/sewer systems.**
- You have to pay these charges directly to Sydney Water and you must have an invoice. Your Coordinator can arrange the invoice. **Payment is by cash or bank cheque only and you can pay at a Sydney Water Customer Service Centre or by post with your invoice.** You must tell your Coordinator when you have made that payment.

Also:

- **DSP charges** are a contribution towards the cost of systems (e.g. treatment plants), which serve your development. We have no power to change these costs because they are decided by IPART. If you want more information visit the IPART website www.IPART.nsw.gov.au. If there is a dispute, the cost of arbitration will be shared equally by you and Sydney Water (see *IPART Act 1992, Section 31*).
- **Reticulation Recovery Charges** recover part of the cost of works that have been paid for by Sydney Water or other developers and that benefit your development. This charge is calculated before your points of connection have been determined. If your completed designs show that your development will be connected to other main/s, the Reticulation Recovery charge may be changed and/or you may need to construct other works.

6. Stamping and Approval of your Building Plans

You must have your building plans stamped and approved **before the Certificate can be issued. In any case, building construction work MUST NOT commence until Sydney Water has granted approval.** Approval is needed because construction/building works may affect Sydney Water's assets (e.g. water and sewer mains).

Your Coordinator can tell you about the approval process including:

- Your provision, if required, of a "Services Protection Report" (also known as a "pegout"). This is needed to check whether the building and engineering plans show accurately where Sydney Water's assets are located in relation to your proposed building work. Your Coordinator will then either approve the plans or make requirements to protect those assets before approving the plans;
- Possible requirements;
- Costs; and
- Timeframes.

Your can also find information about this process (including technical specifications) if you either:

- visit www.sydneywater.com.au ➢ Building Developing and Plumbing ➢ Building and Renovating. Here you can find Sydney Water's *Guidelines for Building Over/Adjacent to Sydney Water Assets;* or
- call 13 20 92.

Notes:

- **The Certificate will not be issued until the plans have been approved and, if required, Sydney Water's assets are altered or deviated;**
- **You can only remove, deviate or replace any of Sydney Water's pipes using temporary pipework if you have written approval from Sydney Water's Development Operations Branch. You must engage your Coordinator to arrange this approval; and**
- **You must obtain our written approval before you do any work on Sydney Water's systems. Sydney Water will take action to have work stopped on the site if you do not have that approval. We will apply Section 44 of the *Sydney Water Act 1994*.**

OTHER THINGS YOU NEED TO DO:

Shown below are other things you need to do that are NOT a requirement for the Certificate. They may well be a requirement of Sydney Water in the future because of the impact of your development on our assets. You must read them before you go any further.

(1) Large Water Service Connection

A water main is available to provide your development with a domestic supply. The size of your development means that you will need a connection larger than the standard domestic 20 mm size for the apartment blocks.

To get approval for your connection, you will need to lodge an application with a Quick Check Agent or at a Sydney Water Customer Centre. You, or your hydraulic consultant, may need to supply the following:

- A plan of the hydraulic layout;
- A list of all the fixtures/fittings within the property;
- A copy of the fireflow pressure inquiry issued by Sydney Water;
- A pump application form (if a pump is required);
- All pump details (if a pump is required).

You will have to pay an application fee.

Sydney Water does not consider whether a water main is adequate for fire fighting purposes for your development. We cannot guarantee that this water supply will meet your Council's fire fighting requirements. The Council and your hydraulic consultant can help.

(2) Disused Sewerage Service Sealing

Please do not forget that you must pay to disconnect all disused private sewerage services and seal them at the point of connection to a Sydney Water sewer main. This work must meet Sydney Water's standards in the NSW Code of Practice for Plumbing and Drainage (the Code) and be done by a licensed drainer. The licensed drainer must arrange for an inspection of the work by a Sydney Water plumbing and draining inspector. After Sydney

Water's inspector has looked at the work, the drainer can issue the Certificate of Compliance. The Code requires this.

(3) Soffit requirements

Please be aware that floor levels must meet Sydney Water's soffit requirements for property connection and drainage.

(4) Possible future costs

The requirements in this Notice relate to your Certificate application only. Sydney Water may be involved with other aspects of your development and there may be other fees or requirements. These include:

- construction/building plan stamping fees;
- plumbing and drainage inspection costs;
- the installation of backflow prevention devices;
- large water connections; and
- council fire fighting requirements. (It will help you to know what the fire fighting requirements are for your development as soon as possible. Your hydraulic consultant can help you here.)

No warranties or assurances can be given about the suitability of this document or any of its provisions for any specific transaction. It does not constitute an approval from Sydney Water and to the extent that it is able, Sydney Water limits its liability to the reissue of this Letter or the return of your application fee. You should rely on your own independent professional advice.

END

Attention: Chris Moon
Phone: 02 9957 1619
Facsimile:

Worley Parsons

Lvl 4, 104 Mount Street
North Sydney NSW 2060

Transfield Services (Australia) Pty Ltd
ABN 11093 114 553
Locked Mail Bag 1001

Pinkenba QLD 4008

Phone: 1800 803 241
Facsimile: 07 3246 6801
E-mail:

QLDLAC@transfieldservices-et.com

11 January 2008

Our ref: Nofo5216
Your ref:

Dear Sir/Madam

TELECOMMUNICATIONS NETWORK INFRASTRUCTURE NOTIFICATION

Telstra Corporation Limited (Telstra) has received a request for telecommunications network infrastructure for the following development:

LOT NUMBERS REQUESTED FOR NETWORK	PLAN NUMBER
Subdivision of UTS KU-RING-GAI CAMPUS	

NAME OF DEVELOPMENT & LOCATION
UTS KU-RING-GAI CAMPUS Redevelopment West Lindfield NSW 2070

The Universal Service Obligation (USO) requires Telstra to ensure that standard telephone services (STS) are reasonably accessible to all people in Australia on an equitable basis wherever they reside or carry on business.

Accordingly, as the primary universal service provider, Telstra is obliged to take all reasonable steps to fulfil the USO and will ensure the USO is fulfilled for the purposes of the proposed development. Please note that should a telecommunications supplier other than Telstra be chosen to provide telecommunications services to the above development, Telstra reserves the right to assess the commercial viability of installing duplicate telecommunications infrastructure.
To confirm whether Telstra has provisioned telecommunications network infrastructure at the proposed development, a Telecommunications Infrastructure Provisioning Confirmation Letter can be issued upon request.
Telstra is not responsible to any recipient of this notification or anyone else who relies upon this notification for any loss or damage suffered in connection with this notification and excludes, to the maximum extent permitted by law, any liability which may arise as a result of the issue of this notification or its content.

If you have any enquiries or require any further information, please contact me at the above address.
Yours sincerely,

Rene' Crowley
Transfield Services (Australia) Pty Limited
Telecommunication Services
On behalf of Telstra Corporation Limited

McMillan, Andrew (PBP)

From: Jonathan Hopson [jhopson@energy.com.au]

Sent: Monday, 11 February 2008 1:52 PM

To: McMillan, Andrew (PBP)

Subject: RE: UTS Ku-Ring-Gai servicing

Andrew,

Whilst I have not performed a detailed analysis of our network (typically, this analysis is not performed until we receive a formal application for supply), I wish to advise that sufficient capacity will be made available, at the 11kV level, to this development. It is likely that EnergyAustralia will need to augment our network to provide this capacity and there may be a time delay associated with this work.

This does not, however, preclude the possibility that customer funded connection works may be required to supply this development. In particular, the substation(s) and the dedicated 11kV cabling/connections as per EnergyAustralia's document, ES10 "Requirements for Electricity Supply to Developments", available at www.energy.com.au.

This email is valid for a period of 12 months from this date and our full requirements are subject to a formal application for supply. Changes in our policy will affect the validity of this advice.

Regards,

Jonathan Hopson
Team Leader - Planning & Supply Negotiations - Sydney Outer North Area
EnergyAustralia

Level 1, Building 1, 51-59 Bridge Rd, Hornsby NSW 2077

P. 9477 8282
F. 9477 8220
M. 0438 325 875
jhopson@energy.com.au

"McMillan, Andrew \(PBP\)" <Andrew.McMillan@WorleyParsons.com>	To	"Jonathan Hopson" <jhopson@energy.com.au>
	cc	
08/02/2008 03:48 PM	Subject	RE: UTS Ku-Ring-Gai servicing

Hi Jonathon,

As discussed yesterday, can you please confirm that the two kiosk substations for the development (at your estimated loads of 1700A – 2400A) could be serviced by the existing HV cable running north to south through the middle of the site?

Regards,

Andrew McMillan
Engineer - Urban Infrastructure
WorleyParsons

Tel: +61 2 9957 1619
Fax: +61 2 9957 1291
Patterson Britton and Partners
Level 4
104 Mount Street
North Sydney
NSW 2060
AUSTRALIA

From: Jonathan Hopson [mailto:jhopson@energy.com.au]
Sent: Friday, 18 January 2008 3:16 PM
To: Porter, Sean (PBP)
Cc: McMillan, Andrew (PBP); Moon, Chris (PBP)
Subject: Re: UTS Ku-Ring-Gai servicing

Sean,

Whilst I have not performed a detailed analysis of your proposed load (you need to provide a detailed load assessment as part of a formal application for supply), in my experience developments of this scale would typically warrant 2 kiosk substations. This is written on the assumption of a reasonable maximum demand for the development, which I have assumed to be between 1700A to 2400A.

The final determination of the capacity requirements may only be determined following a formal application for supply with a detailed load assessment. The ultimate size and location of the kiosks is subject to the detailed design process.

Regards,
Jonathan Hopson
Team Leader - Planning & Supply Negotiations - Sydney Outer North Area
EnergyAustralia

Level 1, Building 1, 51-59 Bridge Rd, Hornsby NSW 2077

P. 9477 8282
F. 9477 8220
M. 0438 325 875
jhopson@energy.com.au

"Porter, Sean \(PBP\)" <Sean.Porter@WorleyParsons.com>	To	<jhopson@energy.com.au>
	cc	"Andrew McMillan" <andrewm@patbrit.com.au>, "Moon, Chris \(PBP\)" <Chris.Moon@WorleyParsons.com>
16/01/2008 11:18 AM	Subject	UTS Ku-Ring-Gai servicing

Hi Jonathon,

Please find included below an exchange of emails between Andrew McMillan, Chris Moon, and yourself before Christmas to provide a more detailed background.

Since this exchange of emails, consultation with community groups has resulted in more open space areas being provided. Consequently, there are going to be fewer dwellings (between 350 and 400). The revised yields are given below.

Standard Lot	10
Integrated Lot	25
Multi unit developments (50% 2 bed, 50% 3 bed)	347

At this stage of the project WorleyParsons are investigating the provision of services to the site. Essentially, we are after a letter from Energy Australia that states that the site can be serviced by indicative number of kiosks or sub-stations.

At this stage the service investigation is high-order and as such does not require specific details or arrangements.

Should you have any queries please contact us on 9957 1619.

Regards

Sean Porter
Engineer
WorleyParsons
Tel: +61 9957 1619
Fax: +61 9957 1291
Patterson Britton and Partners
PO Box 515, North Sydney, NSW, 2059

January 17, 2008

Alinta AGN Ltd

ABN 87 003 004 322

Level 15, 1 O'Connell St
Sydney NSW 2000

Locked Bag 5001
Royal Exchange NSW 1225

Telephone: (02) 9270 4500
Facsimile: (02) 9270 4501

Worley Parsons
ATTN: Sean Porter
Level 7
116 Miller Street
North Sydney NSW 2060

Dear Sean

RE: Former UTS Ku-Ring-Gai Campus

Natural Gas is available in the vicinity to supply this development.

Our mains are installed in the allocated space within the footpath area.

Caution should be exercised when carrying out any road works that may expose the Natural Gas mains existing at this location. For excavation security you should call **1100** before commencement of any earth works to verify Utility locations.

If any single property requires connection to the existing main please contact a Natural Gas Retailer.

If the site is to be developed for a Medium Density type application, please contact me for an information form. The completion of this form will enable a formal offer of connection to Natural Gas to be made.

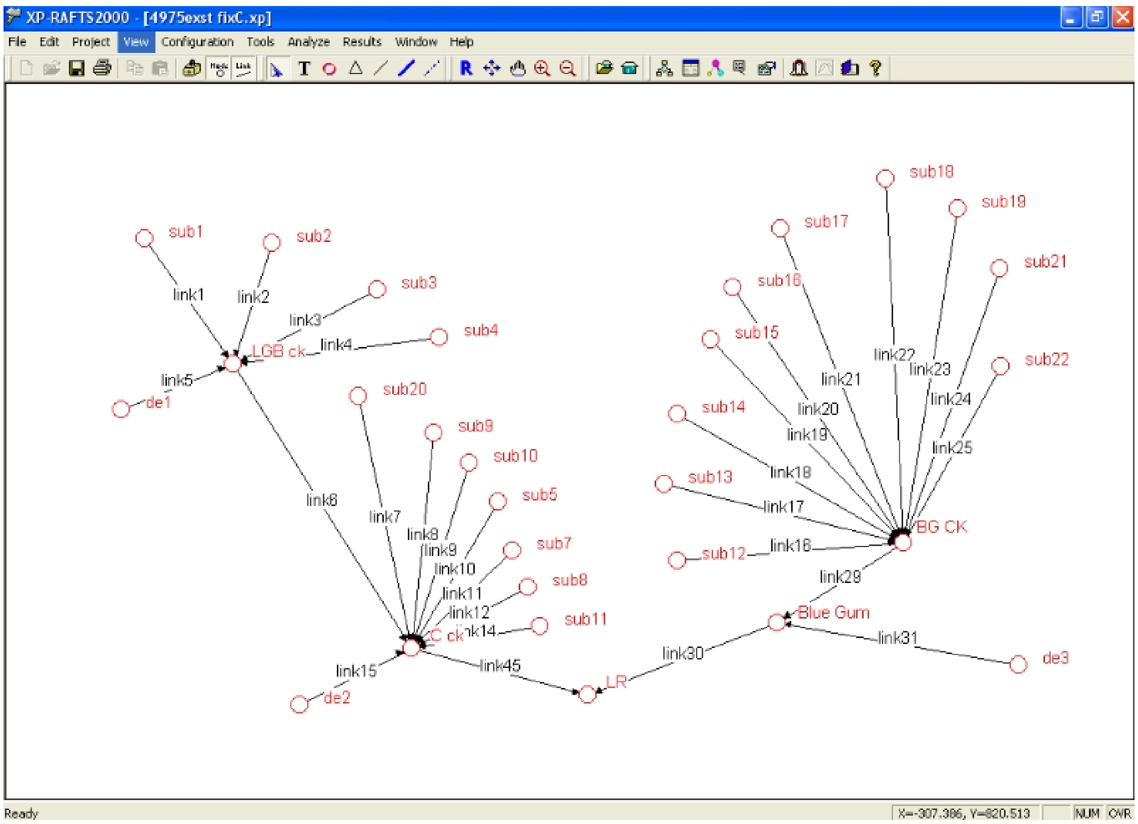
Thank you for your inquiry. If further information or assistance is required, please do not hesitate to contact me on 02 9270 4690.

Yours faithfully,

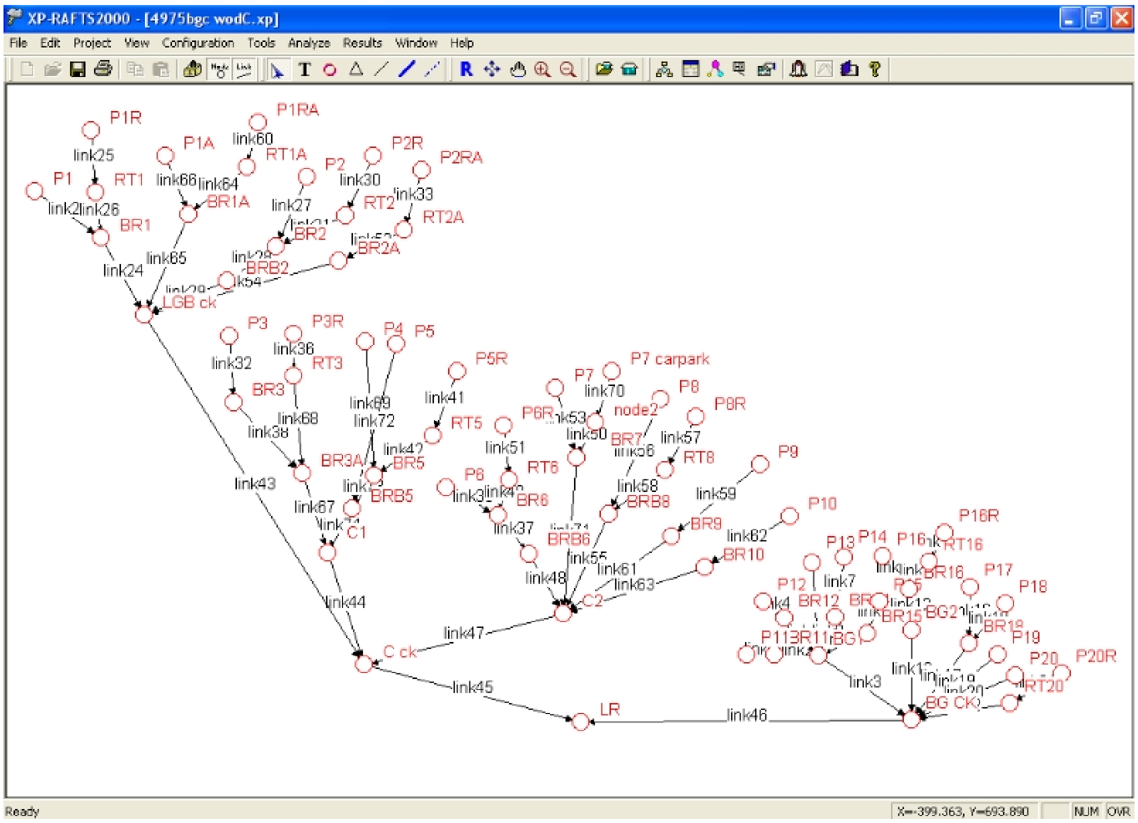
Hardy Martin
Network Development
Alinta AGN Limited

Appendix 2 - RAFTS Results

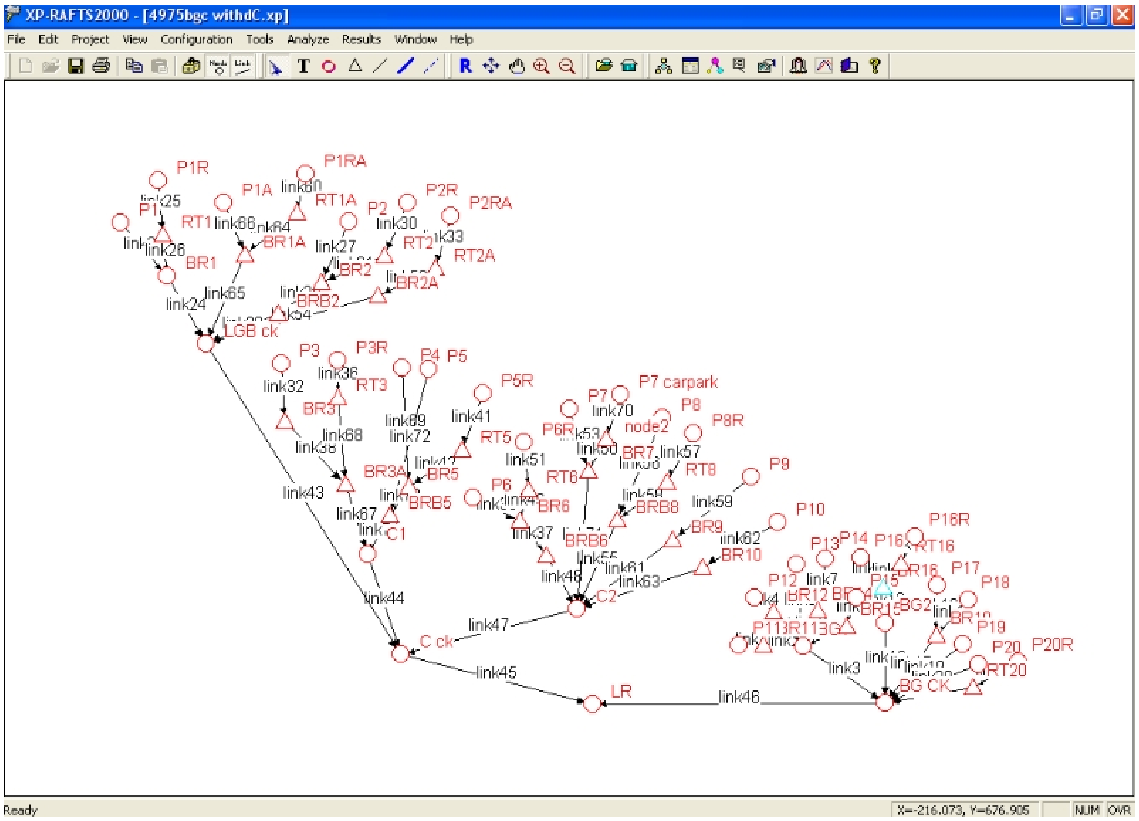
RAFTS MODEL – EXISTING



RAFTS MODEL – PROPOSED WITHOUT DETENTION



RAFTS MODEL – PROPOSED WITH DETENTION



5 Year ARI post back to 5 year ARI existing							
Duration		***Storm Number***	***Time to peak basin outflow [min]***	***Peak inflow to head of link [m^3/s]***	***Peak basin storage [m^3]***	***Peak outflow from basin [m^3/s]***	
Existing - Little Blue Gum Creek							
15		1	7	0.6139		0.6139	
30		2	15	0.6885		0.6885	
60		3	25	0.8018		0.8018	
90		4	30	0.9415		0.9415	
120		5	35	0.8161		0.8161	
180		6	45	0.5186		0.5186	
270		7	74	0.4594		0.4594	
360		8	109	0.3302		0.3302	
540		9	288	0.2898		0.2898	
720		10	408	0.2902		0.2902	
Existing - College Creek							
15		1	7	1.322		1.322	
30		2	15	1.649		1.649	
60		3	25	2.08		2.08	
90		4	30	2.513		2.513	
120		5	35	2.113		2.113	
180		6	45	1.5		1.5	
270		7	75	1.382		1.382	
360		8	120	1.107		1.107	
540		9	300	0.9722		0.9722	
720		10	420	0.9826		0.9826	
Existing - Blue Gum Creek							
15		1	7	1.096		1.096	
30		2	15	1.638		1.638	
60		3	25	2.111		2.111	
90		4	30	2.427		2.427	
120		5	35	2.128		2.128	
180		6	45	1.318		1.318	
270		7	74	1.163		1.163	
360		8	112	0.8344		0.8344	
540		9	294	0.728		0.728	
720		10	412	0.7297		0.7297	
Existing - Lane Cove River (TOTAL)							
15		1	7	2.419		2.419	
30		2	15	3.287		3.287	
60		3	25	4.191		4.191	
90		4	30	4.94		4.94	
120		5	35	4.241		4.241	
180		6	45	2.818		2.818	
270		7	75	2.544		2.544	
360		8	120	1.941		1.941	
540		9	300	1.7		1.7	
720		10	420	1.712		1.712	
Developed without detention - Little Blue Gum Creek							
15		1	7	0.3749		0.3749	
30		2	15	0.4346		0.4346	
60		3	25	0.5487		0.5487	
90		4	30	0.6538		0.6538	
120		5	35	0.5516		0.5516	
180		6	45	0.3844		0.3844	
270		7	75	0.3471		0.3471	

5 Year ARI post back to 5 year ARI existing							
Duration		*Storm Number*	*Time to peak basin outflow [min]*	*Peak inflow to head of link [m³/s]*	*Peak basin storage [m³]*	*Peak outflow from basin [m³/s]*	
360		8	120	0.2551		0.2551	
540		9	300	0.2227		0.2227	
720		10	420	0.2233		0.2233	
Developed without detention - College Creek							
15		1	7	1.543		1.5430	
30		2	15	1.923		1.9230	
60		3	25	2.512		2.5120	
90		4	30	3.031		3.0310	
120		5	35	2.533		2.5330	
180		6	45	1.718		1.7180	
270		7	75	1.533		1.5330	
360		8	120	1.122		1.1220	
540		9	300	0.9787		0.9787	
720		10	420	0.9817		0.9817	
Developed without detention - Blue Gum Creek							
15		1	7	1.249		1.2490	
30		2	15	1.931		1.9310	
60		3	25	2.388		2.3880	
90		4	30	2.624		2.6240	
120		5	35	2.402		2.4020	
180		6	44	1.38		1.3800	
270		7	74	1.216		1.2160	
360		8	103	0.8719		0.8719	
540		9	290	0.7612		0.7612	
720		10	410	0.7629		0.7629	
Developed without detention - Lane Cove River (TOTAL)							
15		1	7	2.793		2.7930	
30		2	15	3.854		3.8540	
60		3	25	4.9		4.9000	
90		4	30	5.655		5.6550	
120		5	35	4.935		4.9350	
180		6	45	3.097		3.0970	
270		7	75	2.747		2.7470	
360		8	120	1.993		1.9930	
540		9	300	1.74		1.7400	
720		10	420	1.744		1.7440	
Developed with detention - Little Blue Gum Creek							
15		1	10	0		0.0000	
30		2	33	0.0142		0.0142	
60		3	40	0.063		0.0630	
90		4	31	0.0776		0.0776	
120		5	50	0.0391		0.0391	
180		6	95	0.0351		0.0351	
270		7	92	0.0477		0.0477	
360		8	124	0.0495		0.0495	
540		9	313	0.079		0.0790	
720		10	419	0.0861		0.0861	
Developed with detention - College Creek							
15		1	15	0.1159		0.1159	
30		2	14	0.4267		0.4267	
60		3	31	0.7006		0.7006	
90		4	32	0.9373		0.9373	

5 Year ARI post back to 5 year ARI existing							
Duration		***Storm Number***	***Time to peak basin outflow [min]***	***Peak inflow to head of link [m³/s]***	***Peak basin storage [m³]***	***Peak outflow from basin [m³/s]***	
120		5	40	0.6845		0.6845	
180		6	50	0.3403		0.3403	
270		7	75	0.7384		0.7384	
360		8	115	0.3257		0.3257	
540		9	278	0.329		0.3290	
720		10	417	0.4473		0.4473	
Developed with detention - Blue Gum Creek							
15		1	7	0.3269		0.3269	
30		2	16	0.9064		0.9064	
60		3	26	1.661		1.6610	
90		4	30	0.9387		0.9387	
120		5	35	0.8533		0.8533	
180		6	42	0.9151		0.9151	
270		7	76	0.7415		0.7415	
360		8	112	0.692		0.6920	
540		9	292	0.5696		0.5696	
720		10	404	0.5122		0.5122	
Developed with detention - Lane Cove River (TOTAL)							
15		1	15	0.3907		0.3907	
30		2	16	0.9064		0.9064	
60		3	26	1.661		1.6610	
90		4	30	1.784		1.7840	
120		5	40	1.373		1.3730	
180		6	42	0.9151		0.9151	
270		7	75	1.228		1.2280	
360		8	110	0.7294		0.7294	
540		9	283	0.8297		0.8297	
720		10	417	0.7913		0.7913	

100 Year ARI post back to 100 year ARI existing							
Duration		***Storm Number***	***Time to peak basin outflow [min]***	***Peak inflow to head of link [m^3/s]***	***Peak basin storage [m^3]***	***Peak outflow from basin [m^3/s]***	
Existing - Little Blue Gum Creek							
15		1	10	1.222		1.222	
30		2	15	1.465		1.465	
60		3	25	1.52		1.52	
90		4	30	1.598		1.598	
120		5	35	1.484		1.484	
180		6	44	0.8544		0.8544	
270		7	74	0.7524		0.7524	
360		8	109	0.5435		0.5435	
540		9	284	0.4762		0.4762	
720		10	404	0.4748		0.4748	
Existing - College Creek							
15		1	10	3.096		3.096	
30		2	15	3.875		3.875	
60		3	25	4.314		4.314	
90		4	30	4.724		4.724	
120		5	35	4.207		4.207	
180		6	45	2.792		2.792	
270		7	75	2.47		2.47	
360		8	120	1.877		1.877	
540		9	300	1.631		1.631	
720		10	420	1.636		1.636	
Existing - Blue Gum Creek							
15		1	10	3.174		3.174	
30		2	15	3.77		3.77	
60		3	25	3.901		3.901	
90		4	30	4.105		4.105	
120		5	35	3.842		3.842	
180		6	45	2.182		2.182	
270		7	74	1.921		1.921	
360		8	108	1.384		1.384	
540		9	290	1.207		1.207	
720		10	410	1.205		1.205	
Existing - Lane Cove River (TOTAL)							
15		1	10	6.27		6.27	
30		2	15	7.644		7.644	
60		3	25	8.216		8.216	
90		4	30	8.83		8.83	
120		5	35	8.049		8.049	
180		6	45	4.974		4.974	
270		7	75	4.386		4.386	
360		8	120	3.26		3.26	
540		9	300	2.838		2.838	
720		10	420	2.84		2.84	
Developed without detention - Little Blue Gum Creek							
15		1	10	0.82		0.8200	
30		2	15	1.034		1.0340	
60		3	25	1.12		1.1200	
90		4	30	1.185		1.1850	
120		5	35	1.08		1.0800	
180		6	45	0.6644		0.6644	
270		7	75	0.5837		0.5837	

100 Year ARI post back to 100 year ARI existing							
Duration		***Storm Number***	***Time to peak basin outflow [min]***	***Peak inflow to head of link [m^3/s]***	***Peak basin storage [m^3]***	***Peak outflow from basin [m^3/s]***	
360		8	118	0.422		0.4220	
540		9	300	0.3683		0.3683	
720		10	420	0.3678		0.3678	
Developed without detention - College Creek							
15		1	10	3.702		3.7020	
30		2	15	4.709		4.7090	
60		3	25	5.028		5.0280	
90		4	30	5.306		5.3060	
120		5	35	4.884		4.8840	
180		6	45	2.924		2.9240	
270		7	74	2.566		2.5660	
360		8	120	1.859		1.8590	
540		9	299	1.622		1.6220	
720		10	419	1.619		1.6190	
Developed without detention - Blue Gum Creek							
15		1	10	3.659		3.6590	
30		2	15	4.07		4.0700	
60		3	25	4.157		4.1570	
90		4	29	4.385		4.3850	
120		5	35	4.137		4.1370	
180		6	38	2.277		2.2770	
270		7	68	2.008		2.0080	
360		8	110	1.443		1.4430	
540		9	290	1.259		1.2590	
720		10	410	1.257		1.2570	
Developed without detention - Lane Cove River (TOTAL)							
15		1	10	7.361		7.3610	
30		2	15	8.779		8.7790	
60		3	25	9.185		9.1850	
90		4	30	9.675		9.6750	
120		5	35	9.022		9.0220	
180		6	45	5.197		5.1970	
270		7	74	4.569		4.5690	
360		8	120	3.301		3.3010	
540		9	300	2.88		2.8800	
720		10	420	2.876		2.8760	
Developed with detention - Little Blue Gum Creek							
15		1	8	0		0.0000	
30		2	25	0.1789		0.1789	
60		3	25	0.2076		0.2076	
90		4	29	0.3954		0.3954	
120		5	40	0.3587		0.3587	
180		6	43	0.1826		0.1826	
270		7	78	0.1928		0.1928	
360		8	142	0.1436		0.1436	
540		9	287	0.1998		0.1998	
720		10	399	0.1613		0.1613	
Developed with detention - College Creek							
15		1	10	0.8565		0.8565	
30		2	17	1.244		1.2440	
60		3	26	1.972		1.9720	
90		4	30	2.307		2.3070	

100 Year ARI post back to 100 year ARI existing							
Duration		***Storm Number***	***Time to peak basin outflow [min]***	***Peak inflow to head of link [m ^{3} /s]***	***Peak basin storage [m ^{3}]***	***Peak outflow from basin [m ^{3} /s]***	
120		5	41	2.497		2.4970	
180		6	46	1.091		1.0910	
270		7	73	1.137		1.1370	
360		8	105	1.169		1.1690	
540		9	288	0.8514		0.8514	
720		10	409	0.649		0.6490	
Developed with detention - Blue Gum Creek							
15		1	10	2.265		2.2650	
30		2	12	2.965		2.9650	
60		3	23	2.561		2.5610	
90		4	30	3.235		3.2350	
120		5	35	3.05		3.0500	
180		6	39	1.452		1.4520	
270		7	70	1.473		1.4730	
360		8	104	1.039		1.0390	
540		9	288	0.8454		0.8454	
720		10	398	0.9414		0.9414	
Developed with detention - Lane Cove River (TOTAL)							
15		1	10	3.121		3.1210	
30		2	12	2.965		2.9650	
60		3	25	3.519		3.5190	
90		4	30	5.542		5.5420	
120		5	35	5.309		5.3090	
180		6	37	2.149		2.1490	
270		7	75	2.106		2.1060	
360		8	105	1.731		1.7310	
540		9	288	1.697		1.6970	
720		10	398	1.314		1.3140	

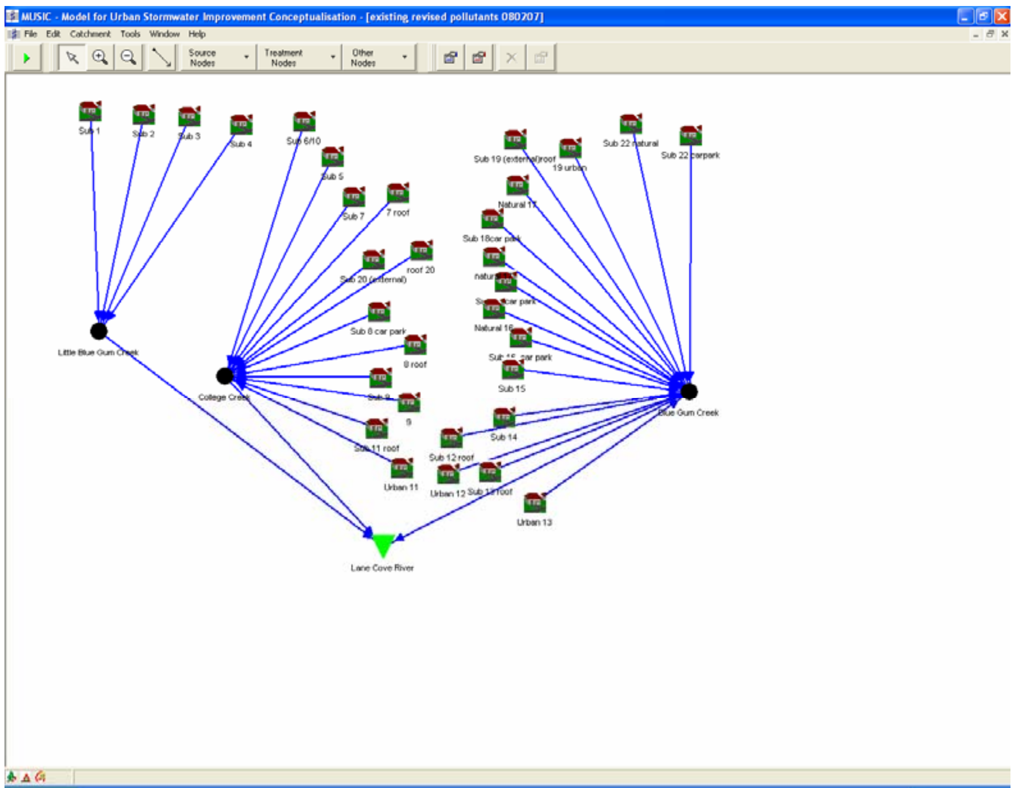
50 Year ARI post back to 20 year ARI natural								
Duration		***Storm Number***	***Time to peak basin outflow [min]***	***Peak inflow to head of link [m3/s]***	***Peak basin storage [m3]***	***Peak outflow from basin [m3/s]***		
20 Year ARI NATURAL								
Natural - Little Blue Gum Creek								
15		1	15	0.4357		0.4357		
30		2	15	0.7067		0.7067		
60		3	25	0.9427		0.9427		
90		4	30	1.086		1.086		
120		5	38	0.955		0.955		
180		6	45	0.6709		0.6709		
270		7	75	0.5885		0.5885		
360		8	120	0.4249		0.4249		
540		9	300	0.37		0.37		
720		10	420	0.3706		0.3706		
Natural - College Creek								
15		1	15	1.324		1.324		
30		2	15	2.319		2.319		
60		3	25	2.927		2.927		
90		4	30	3.383		3.383		
120		5	38	2.923		2.923		
180		6	45	2.138		2.138		
270		7	75	1.917		1.917		
360		8	120	1.477		1.477		
540		9	300	1.283		1.283		
720		10	420	1.291		1.291		
Natural - Blue Gum Creek								
15		1	13	1.43		1.43		
30		2	15	2.651		2.651		
60		3	25	2.985		2.985		
90		4	30	3.208		3.208		
120		5	35	2.939		2.939		
180		6	45	1.739		1.739		
270		7	75	1.528		1.528		
360		8	114	1.093		1.093		
540		9	296	0.9525		0.9525		
720		10	416	0.9537		0.9537		
Natural - Lane Cove River (TOTAL)								
15		1	13	2.682		2.682		
30		2	15	4.97		4.97		
60		3	25	5.913		5.913		
90		4	30	6.591		6.591		
120		5	35	5.795		5.795		
180		6	45	3.877		3.877		
270		7	75	3.445		3.445		
360		8	120	2.57		2.57		
540		9	300	2.235		2.235		
720		10	420	2.245		2.245		

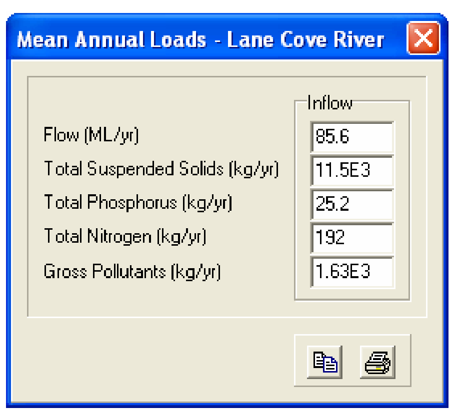
50 Year ARI post back to 20 year ARI natural									
Duration		*Storm Number*	*Time to peak basin outflow [min]*	*Peak inflow to head of link [m3/s]*	*Peak basin storage [m3]*	*Peak outflow from basin [m3/s]*			
50 Year ARI PROPOSED									
Developed without detention - Little Blue Gum Creek									
15		1	10	0.6877		0.6877			
30		2	15	0.8612		0.8612			
60		3	25	0.9823		0.9823			
90		4	30	1.047		1.0470			
120		5	35	0.9511		0.9511			
180		6	45	0.5923		0.5923			
270		7	75	0.5197		0.5197			
360		8	120	0.3759		0.3759			
540		9	299	0.3281		0.3281			
720		10	419	0.3277		0.3277			
Developed without detention - College Creek									
15		1	10	3.004		3.0040			
30		2	15	4.006		4.0060			
60		3	25	4.424		4.4240			
90		4	30	4.705		4.7050			
120		5	35	4.291		4.2910			
180		6	45	2.602		2.6020			
270		7	75	2.283		2.2830			
360		8	119	1.655		1.6550			
540		9	299	1.444		1.4440			
720		10	419	1.443		1.4430			
Developed without detention - Blue Gum Creek									
15		1	10	2.931		2.9310			
30		2	15	3.624		3.6240			
60		3	25	3.698		3.6980			
90		4	30	3.89		3.8900			
120		5	35	3.672		3.6720			
180		6	38	2.028		2.0280			
270		7	68	1.789		1.7890			
360		8	110	1.286		1.2860			
540		9	290	1.122		1.1220			
720		10	401	1.12		1.1200			
Developed without detention - Lane Cove River (TOTAL)									
15		1	10	5.935		5.9350			
30		2	15	7.63		7.6300			
60		3	25	8.121		8.1210			
90		4	30	8.596		8.5960			
120		5	35	7.964		7.9640			
180		6	45	4.63		4.6300			
270		7	74	4.067		4.0670			
360		8	120	2.94		2.9400			
540		9	300	2.565		2.5650			
720		10	420	2.562		2.5620			

50 Year ARI post back to 20 year ARI natural								
Duration		***Storm Number***	***Time to peak basin outflow [min]***	***Peak inflow to head of link [m3/s]***	***Peak basin storage [m3]***	***Peak outflow from basin [m3/s]***		
50 Year ARI PROPOSED								
Developed with detention - Little Blue Gum Creek								
15		1	8	0		0.0000		
30		2	24	0.1021		0.1021		
60		3	36	0.1498		0.1498		
90		4	30	0.3189		0.3189		
120		5	43	0.3218		0.3218		
180		6	75	0.1691		0.1691		
270		7	80	0.1492		0.1492		
360		8	116	0.1116		0.1116		
540		9	286	0.1234		0.1234		
720		10	414	0.1192		0.1192		
Developed with detention - College Creek								
15		1	8	0.5121		0.5121		
30		2	17	1.089		1.0890		
60		3	24	1.976		1.9760		
90		4	30	2.651		2.6510		
120		5	40	2.47		2.4700		
180		6	40	1.301		1.3010		
270		7	78	0.7956		0.7956		
360		8	108	1.116		1.1160		
540		9	279	0.7203		0.7203		
720		10	412	0.5308		0.5308		
Developed with detention - Blue Gum Creek								
15		1	10	1.497		1.4970		
30		2	16	2.041		2.0410		
60		3	25	2.411		2.4110		
90		4	30	2.511		2.5110		
120		5	34	2.166		2.1660		
180		6	44	1.329		1.3290		
270		7	66	1.434		1.4340		
360		8	97	0.9031		0.9031		
540		9	298	0.7993		0.7993		
720		10	411	1		1.0000		
Developed with detention - Lane Cove River (TOTAL)								
15		1	10	1.77		1.7700		
30		2	15	2.613		2.6130		
60		3	24	3.239		3.2390		
90		4	30	5.162		5.1620		
120		5	40	4.059		4.0590		
180		6	40	2.053		2.0530		
270		7	66	2.133		2.1330		
360		8	108	1.726		1.7260		
540		9	279	1.226		1.2260		
720		10	411	1.185		1.1850		

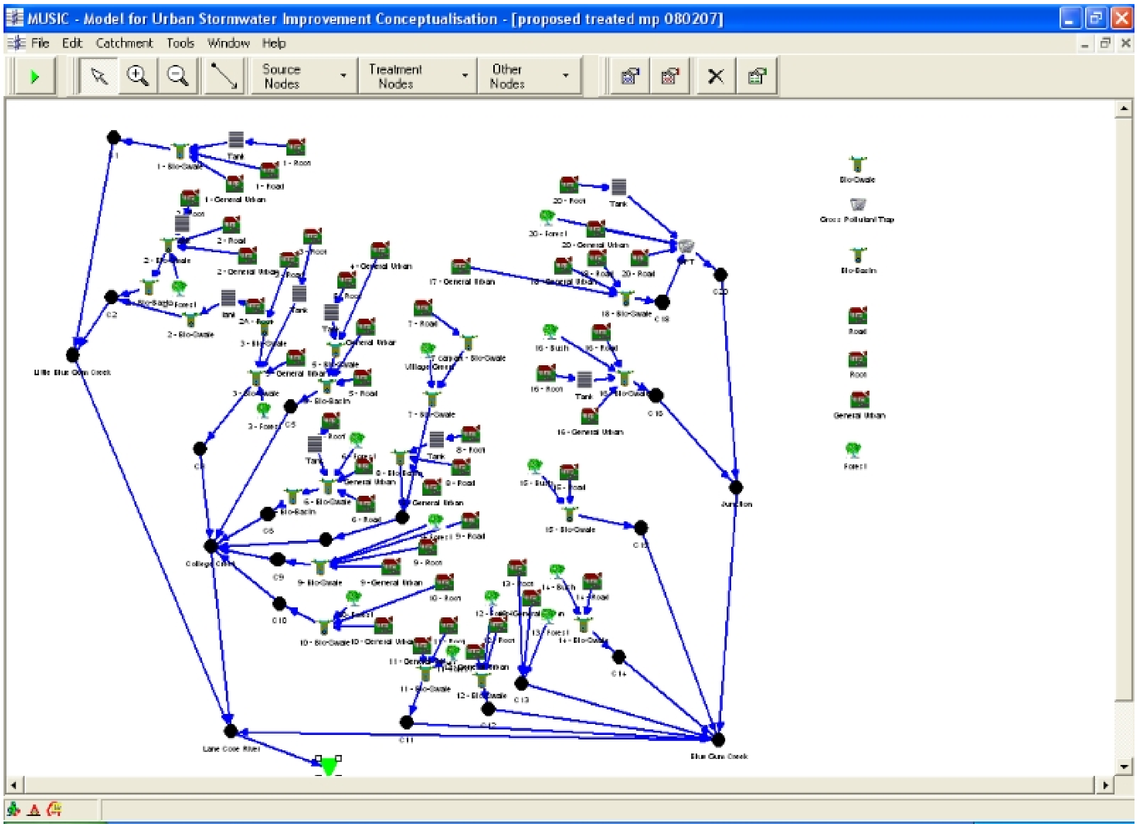
Appendix 3 - MUSIC Results

EXISTING MUSIC MODEL





PROPOSED MUSIC MODEL



Treatment Train Effectiveness - Receiving Node

	Sources	Residual Load	% Reduction
Flow (ML/yr)	96.9	66.5	31.4
Total Suspended Solids (kg/yr)	11.5E3	1.69E3	85.2
Total Phosphorus (kg/yr)	22.6	6.58	70.9
Total Nitrogen (kg/yr)	184	81.2	55.8
Gross Pollutants (kg/yr)	1.93E3	47.8	97.5