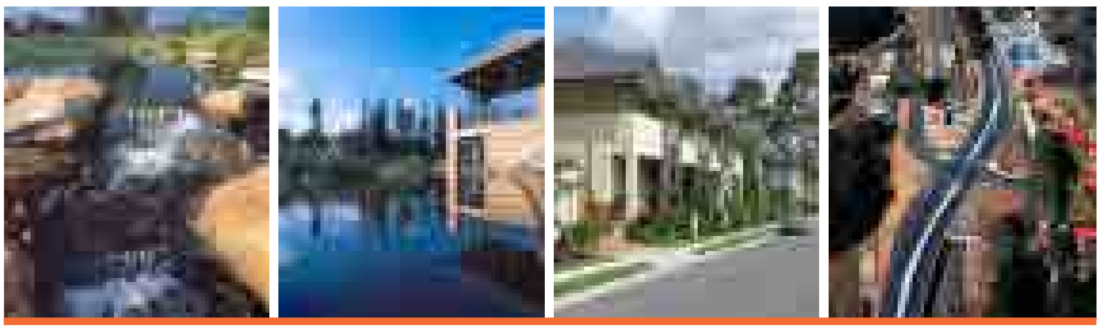
Area 20 Precinct, Rouse Hill

Water Cycle Management Strategy Report Incorporating Water Sensitive Urban Design Techniques



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WATER CYCLE MANAGEMENT STRATEGY INCORPORATING WATER SENSITIVE URBAN DESIGN TECHNIQUES

- DOCUMENT CONTROL SHEET -

Issue No.	Amendment	Prepared By & Date	Checked By and Date	Approved By and Date
A	Preliminary Draft	DG (21-9-09)	PM (24-9-09)	PM (24-9-09)
B	Draft Exhibition Issue	DG (18-6-10)	PM (22-6-10)	PM (22-6-10)
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D	Revised Exhibition Issue	DG (27-10-10)	PM (27-10-10)	PM (27-10-10)

Flood levels presented in this report are suitable for planning purposes only

AREA 20 PRECINCT, ROUSE HILL

WATER CYCLE MANAGEMENT STRATEGY INCORPORATING WATER SENSITIVE URBAN DESIGN TECHNIQUES

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1. EXECUTIVE SUMMARY

1.1. Project Objective

J. Wyndham Prince Pty Ltd in close consultation with the Department of Planning, Blacktown City Council and Sydney Water have prepared a Water Cycle Management Strategy Incorporating Water Sensitive Urban Design to integrate with the Master Planning process for the Area 20 Precinct, Rouse Hill. The strategy has been prepared to conform with statutory requirements and industry best practice for stormwater management in this catchment. Sufficient detail is provided to integrate with and support the Development Planning process for the release area and to identify the size and cost of Section 94 components relating to Stormwater Management in the release area.

The overall water cycle management objectives for the release area were identified as:

***Environmental* –** Provision of appropriately designed, functional water quality facilities, salinity management, retention of existing trees, habitat revegetation and ecosystem enhancement; limitation of downstream discharge peaks and velocities; soft bioengineering treatments to reflect natural stream functions; ecologically sustainable; adopt principles of total catchment management and water sensitive urban design; conform with statutory water quality requirements; maintenance of environmental flows and inundation patterns in creeks and wetlands.

***Urban Amenity* –** Provision of a water cycle management strategy that identifies and controls limits of flood affectation; provision of aesthetic design forms that enhance urban amenity and address proposed adjacent land uses (residential, recreational and transport); views into and out of drainage corridors (security, public safety, amenity); water quality (visual amenity and public health).

***Engineering Considerations* –** Effective management and control of peak discharges, discharge velocities, and flood levels to pre-development and ecologically sustainable levels; industry best practice technical analysis of catchment hydrology and system hydraulic performance, soft sustainable bioengineering treatments, delineation of flood extents and identification of flood risk.

Economics - provision of a cost effective, functional trunk drainage system that optimises performance, keeps maintenance costs and requirements to an acceptable level, keeps land take to a minimum, provides maximum value for expenditure of public monies and focuses on ecological sustainability.

1.2. Statutory Requirements

The recommendations contained in the following guidelines have also been considered in the master planning process.

- Growth Centres Development Code 2006
- Blacktown City Council Engineering Guide for Development 2005
- Blacktown City Council Draft Water Sensitive Urban Design (WSUD) Handbook 2008
- Blacktown City Council Draft Integrated Water Cycle Management Development Control Plan 2009

- Department of Environment, Climate Change and Water Technical Guidelines

1.3. Methodology

The water cycle master planning process has involved considerable consultation and a number of Workshops have been undertaken to receive input from stakeholders. This consultation has included:

- Blacktown City Council
- Department of Planning
- Sydney Water
- Department of Water and Energy (By Specialist Riparian Consultant)

The investigation included the following technical tasks:

Hydrology	Undertake detailed hydrological analyses of the catchments, determine the magnitude of a range of storm flows.
Hydraulics	Review of previous hydraulic studies undertaken by others and additional hydraulic analysis of alternate watercourse and retention basin strategies to determine peak flood levels, velocities, flow widths and flood extents.
Water Quality Modelling	Undertake a detailed water quality analysis for the release area to determine post development pollutant loads and evaluate the performance of proposed water quality treatment techniques.
Options/Treatment Techniques	Identify and evaluate a range of suitable treatment techniques to address water quality and water quantity objectives.
Preferred Treatment	Determine size, location, cost, maintenance and performance of preferred treatment techniques.

1.4. Proposed Water Cycle Strategy

A range of structural stormwater management techniques and options were identified as being suitable for managing the discharge of peak flows (water quantity) and pollutants (water quality) for the Area 20 Precinct. These are summarised as follows:

Water Quantity: Regional (end of line) and Local (on lot) Detention Basins (Wet, Dry), Below ground storage tanks (public and private). It is noted that Area 20 falls within a catchment where a regional stormwater management strategy has been implemented, referred to as the Rouse Hill Stage 1 Area Trunk Drainage Strategy (Ref. 1). The Rouse Hill Stage 1 Area Trunk Drainage Strategy does not include any regional water quantity management facilities within the Area 20 Precinct.

Water Quality: A range of lot based, street level and subdivision scale treatments including vegetated swales and filter strips, sand filters, bioretention systems, permeable pavements, infiltration trenches and basins, wetlands and rainwater tanks.

Each of these management techniques were evaluated and compared with consideration of a range of Environmental, Social/Amenity, Economic, Maintenance and Engineering criteria.

The strategy proposed as being most suitable for the Area 20 Precinct is a combination of options including:

Water Quality

A treatment train consisting of:

On Lot Treatments

- Appropriate waterwise landscaping practices (resident education, native gardens, mulch, micro-irrigation).
- Implementation of water efficient fittings and appliances in all dwellings (dual flush toilet, AAA shower heads, water efficient taps and plumbing).
- Minimisation of impervious areas.
- Reticulated recycled water or BASIX compliant water tanks.

Street Level Treatments

- Proprietary gross pollutant traps.

Subdivision / Development Treatments

- Bioretention Raingardens located within the public reserves and adjacent to the riparian corridors.

Water Quantity

- As the Area 20 Precinct falls within the catchment serviced by the regional Rouse Hill Stage 1 Area Trunk Drainage Strategy (Ref. 1), no additional detention basins are proposed within the precinct to mitigate larger, less frequent peak flows. The water quality basins proposed will provide some attenuation of the lesser, more frequent peak flows.
- Limiting the post development stream forming flow duration so that it is no more than 3 – 5 times that of the pre-development stream forming flow duration.

A general arrangement plan indicating proposed locations for the water quality and water quantity treatments for the Area 20 Precinct is included in Figure 4.

1.5. Conclusion

The water cycle management strategy for the developed site provides a basis for the detailed design and development of the site to ensure that the following objectives for stormwater management and site discharge are achieved:

Environmental	Existing stands of vegetation within the trunk drainage corridor retained; existing water bodies with ecological value retained; downstream and in-channel frequent discharge peaks and velocities limited to avoid scouring, siltation and flora and fauna impacts; water quality elements proposed to remove gross pollutants and nutrients from the urban catchments; ecological health and biodiversity within the riparian corridors maintained and enhanced.
Urban Amenity	Limits of flood 1% affectation have been defined and future development can conform with requirements for freeboard and public safety; quality passive recreational amenity can be provided for the incoming community.
Engineering Considerations	Peak discharges of frequently occurring storms, peak velocities and flood levels controlled to conform with Council's technical requirements; water quality elements provided to conform with performance and maintenance requirements.
Economics	The water cycle management strategy is functional; delivers the required technical performance; avoids environmental degradation and pressure on downstream ecosystems and infrastructure; and provides for a 'soft' sustainable solution for stormwater management within the release area.

The water cycle management strategy proposed for the Area 20 Precinct development site is functional; delivers the required technical performance; avoids environmental degradation and pressure on downstream ecosystems and infrastructure; and provides for a 'soft' sustainable solution for stormwater management within the release area. The water cycle management concept is illustrated on Figure 4.

2. INTRODUCTION

The Area 20 Precinct is located in Rouse Hill and forms part of the North West Growth Centres. The Precinct consists of approximately 245 hectares of land falling within the Blacktown Local Government Area.

The Department of Planning has engaged JWP to prepare a Water Cycle Management Strategy to inform the precinct planning process and support the rezoning process for the Precinct.

This report details the procedures used and presents the results of investigations undertaken by J. Wyndham Prince Pty Ltd in developing a Water Cycle Management Strategy that incorporates the principles of Water Sensitive Urban Design (WSUD) to integrate with and inform the Precinct Planning process for the Area 20 site.

The objective of this investigation is to identify the stormwater issues to be taken into account in the development application, detailed design and development of the Area 20 Precinct, to identify appropriate options and locations for the control of the quantity and quality of stormwater leaving the site, and to identify the land areas required to implement the recommended options. The outcomes identified by the investigation will then be incorporated into the Section 94 processes and Contributions Plan. Additionally, a Flood Impact Assessment and Evacuation Strategy was completed for the Precinct.

The investigation addresses engineering considerations whilst placing a strong focus on conserving and enhancing the bio-diversity, ecological health and positive water quality benefits within the existing riparian corridors to provide an integrated natural resource for the incoming residents.

The investigation involved the following specific tasks:

- Liaise with the Department of Planning, Blacktown City Council and Sydney Water to determine their specific requirements for development of the Precinct;
- Investigate a range of stormwater management and water sensitive urban design measures suitable for the site. Liaise with Blacktown City Council and the Department of Planning and identify the most appropriate strategy for the Area 20 Precinct site;
- Undertake a hydrologic analysis to determine the peak 2, 20, 100, 200 and 500 year ARI and PMF post development flows for use in the hydraulic model;
- Undertake a Flood Impact Assessment and develop an Evacuation Strategy for the site;
- Consider the impact of the proposed railway bridge on Second Ponds Creek;
- Undertake a water quality analysis and determine the minimum treatment device areas required to achieve Blacktown City Council's and the Department of Environment and Climate Change's water quality targets;
- Undertake a Stream Erosion Index assessment to ensure that the post development stream forming flow duration is no greater than 3 – 5 times the pre-development duration;

- Prepare detailed concept designs for any measures required to achieve the water quality and quantity objectives;

- Prepare a Water Cycle Management Concept Plan;

- Prepare a Water Cycle Management and Water Sensitive Urban Design Strategy Report to support the rezoning for the Area 20 Precinct, detailing the investigations, findings, calculations and design details.

3. PREVIOUS REPORTS / STUDIES

Two relevant studies have previously been undertaken that relate to stormwater management on Second Ponds Creek. These investigations considered flooding for the entire Caddies Creek catchment, for which Second Ponds Creek is one of many tributaries. The initial investigation was undertaken by GHD in 1998 and a review was undertaken by Sinclair Knight Merz (SKM) in 2009. A brief description of each is given below.

GHD (1998) *Rouse Hill Stage 1 Area Trunk Drainage – Strategy Review* (Ref. 1)

Although a copy of this report was not provided by Sydney Water, a summary of the investigation is described within the SKM Review Report (Ref. 2) as follows:

- Assessment of the pre-development hydrologic, flooding and water quality conditions, including modelling approaches;
- Definition and justification of the stormwater design objectives in relation to hydrology and water quality, to mitigate the impacts of the development;
- Assessment of the post development hydrologic, flooding and water quality conditions relating to Stage 1 development conditions and ultimate development conditions, with mitigation controls in place; and
- Recommendations for a stormwater strategy comprised of stormwater controls, including flood detention basins and water quality controls, to mitigate the impacts of the development.

It is noted that the GHD strategy is Sydney Water's current adopted strategy.

SKM (2009) *Rouse Hill Integrated Stormwater Strategy Review* (Ref. 2)

This report summarised the investigation work and results by SKM in reviewing the Rouse Hill Trunk Drainage Strategy undertaken previously by GHD. The SKM study included reviewing the hydrologic, hydraulic and water quality modelling previously undertaken by GHD and updating the modelling based on current topographic information, current landuse and current zoning information. The SKM investigation identified several potential issues with the hydrologic and hydraulic modelling previously undertaken by GHD.

In the absence of specific guidelines from BCC and the Department of Environment Climate Change and Water (DECCW), the primary reference sources adopted for our assessment of the hydrological impacts associated with Climate Change, were:

1. *NSW Climate Change Action Plan: Summary of Climate Change Impacts Sydney Region, October 2008*, (Ref. 3) prepared by the NSW Department of Environment and Climate Change;
2. *Practical Consideration of Climate Change – Floodplain Risk Management Guideline, October 2007*, (Ref. 4) prepared by the NSW Department of Environment and Climate Change;
3. *Climate Change in the Hawkesbury-Nepean Catchment, 2007*, (Ref. 5) prepared by the Commonwealth Scientific and Industrial Research Organisation; and

4. *Climate Change in Australia – Observed Changes and Projections, October 2007*, (Ref. 6) prepared by Australian Government Bureau of Meteorology.

A sensitivity analysis of the impact that increased peak flows (resulting from the Climate Change assessment) would have on freeboard allowances was undertaken in accordance with *Draft Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments, October 2009* Department of Environment, Climate Change and Water as well as *Blacktown City Council Engineering Guide for Development – 2005.* (Ref. 7)

4. THE EXISTING ENVIRONMENT

4.1. The Site

The Area 20 Precinct, which totals approximately 245 hectares, is located between Schofields and Windsor Roads, Rouse Hill. The development area included in the investigation is roughly triangular in shape and is bordered by existing rural properties to the west, Windsor Road to the east and Schofields Road to the south. The western boundary of the precinct has been roughly defined by the existing ridgeline. The actual western precinct boundary coincides with the existing boundaries of the lots where the majority of the property is able to be drained back to the Area 20 Precinct.

The majority of the Area 20 Precinct site is made up of existing rural residential properties. However the site also includes Rouse Hill Regional Park, which is to be maintained, Rouse Hill Anglican College, which is also to be maintained, a caravan park and quarry.

The location of the Area 20 Precinct is indicated in Plate 1 below and is shown in more detail in Figure 1.

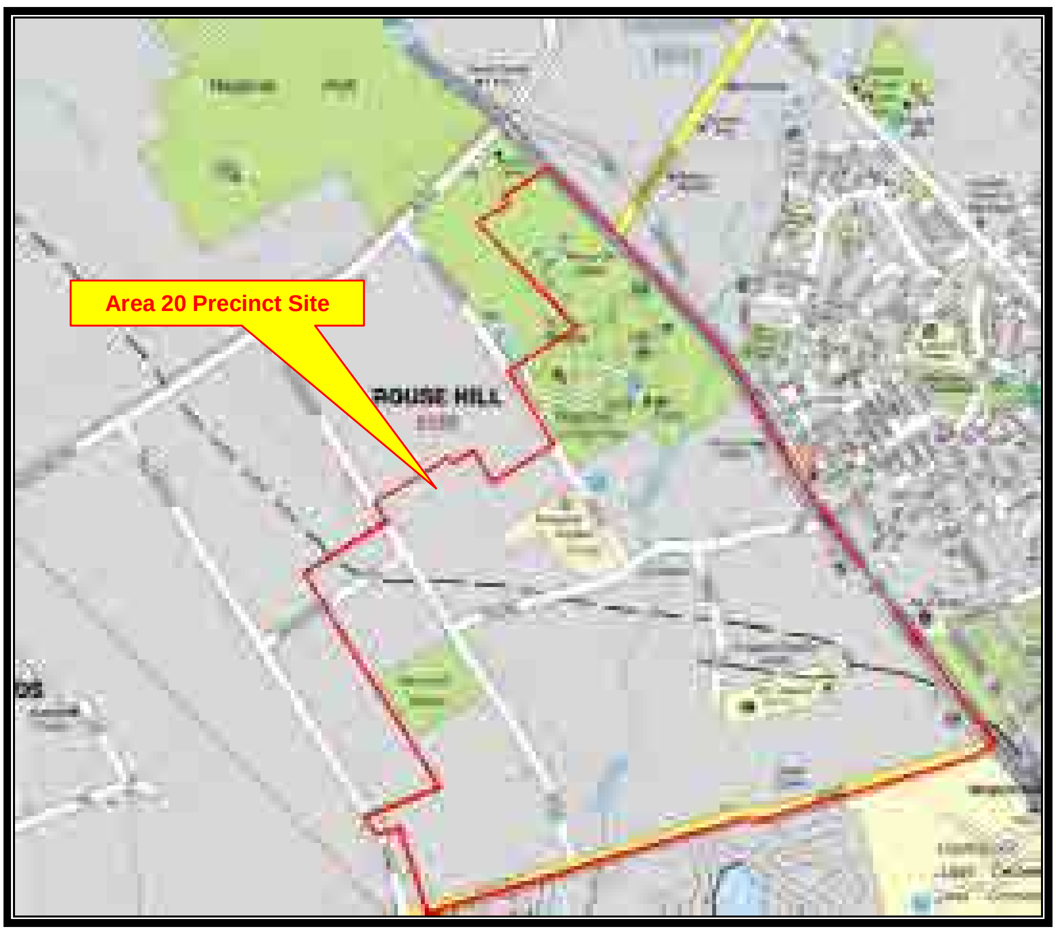


Plate 1: Location of the Area 20 Precinct Development Site

4.2. Existing Drainage Configuration

The Area 20 Precinct site is bisected by Second Ponds Creek. The entire site, except for a small pocket in the south east corner and the western fringes, drains to Second Ponds Creek. The small south eastern pocket, of approximately 8 hectares, drains toward Windsor Road and eventually to Caddies Creek.

A portion of the lots (approximately 11 hectares of land) on the western fringes of the site drain to First Ponds Creek (part of the Wianamatta Creek catchment). It is understood that Blacktown Council would be unlikely to support diversion of this portion of the site back to Second Ponds Creek. Development of this portion of the site would therefore likely require interim water quantity and quality management measures until the land to the west was rezoned and permanent measures constructed. It was beyond the extent of this investigation to consider water cycle management measures (interim or permanent) for this portion of the site.

The site is broken up by a number of internal ridge lines creating several discharge points to Second Ponds Creek. Plate 2 below summarises the flow directions under existing conditions. The existing drainage catchments are shown on Figure 2.

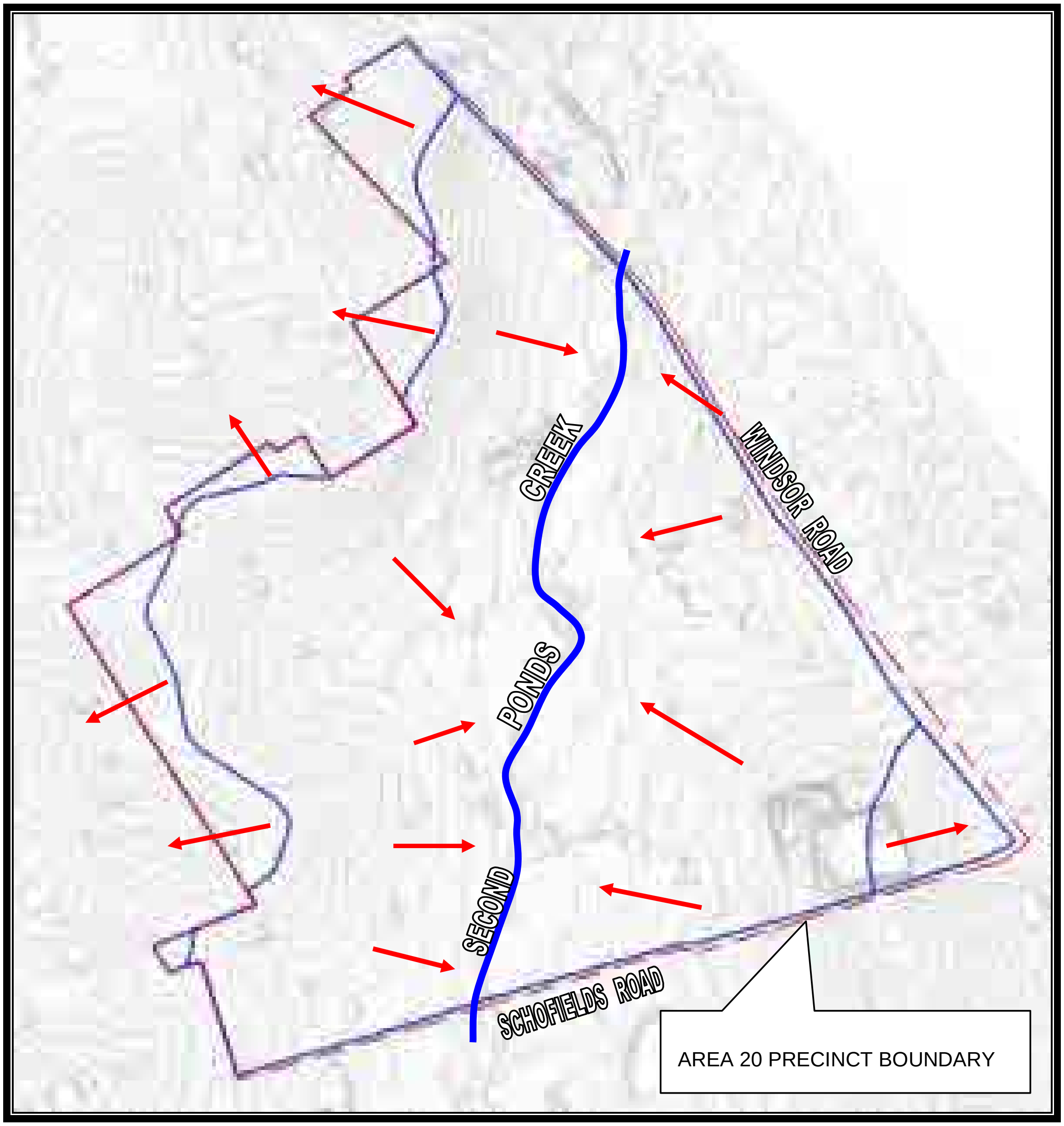


Plate 2: Direction of Flows Under Existing Conditions

4.3. The Proposed Development

As part of the Precinct Planning process, an Indicative Layout Plan (ILP) has been prepared identifying the various land uses proposed for the site. The land use for the site includes low, medium and high density residential, environmental living, light industrial, schools, community facilities, riparian corridor, parks and drainage. The North West Rail Corridor also extends through the southern portion of the site. A railway station and associated carparking is proposed in the south west corner, along with a stabling yard on the western boundary extending into the adjacent lands. The ILP is included in Attachment A.

With an overall area of approximately 245 hectares, the Area 20 Precinct development will involve the creation of up to approximately 2300 residential allotments, the construction of 13 water quality raingardens and the construction and dedication of new roads. The quality management elements will be constructed adjacent to the Second Ponds Creek riparian corridor.

The proposed Area 20 Precinct development is shown below in Plate 3.

Plate 3 – Proposed Area 20 Precinct Indicative Layout Plan

5. DEVELOPMENT GUIDELINES, OPPORTUNITIES AND CONSTRAINTS

The following guidelines were considered in developing the Water Cycle Management and WSUD strategy.

5.1. Growth Centres Development Code

The Growth Centres Development Code (Ref. 8) identifies the following matters for consideration with regard to Water Sensitive Urban Design and stormwater management:

- Stormwater management strategies should be based on the objectives and principles of Water Sensitive Urban Design. They should promote water reuse and maximise potable water conservation;
- Existing waterways and riparian zones should be conserved and enhanced where possible;
- Stormwater management strategies should be developed and implemented in a manner which considers and addresses potential salinity hazards;
- Stormwater management strategies should be adopted by the ILP to maximise efficient use of land and facilitate adequate allocation of land for stormwater management purposes;
- The ILP should be planned, designed and undertaken in a manner which allows for appropriate control of erosion and sediment pollution;
- A treatment train approach should be used, incorporating structural stormwater treatment measures at the primary, secondary and tertiary levels as necessary to comply with the stormwater management targets;
- The design of stormwater management systems should be integrated with the planning of road layout and design, given the potential benefits of incorporating suitable WSUD elements into road corridors;
- Stormwater reuse, retention and detention strategies should be used to minimise changes to the hydrological (or flow) regime of receiving waterways;
- Urban stormwater should not be discharged to areas of native bushland unless such discharge cannot be avoided. High levels of stormwater treatment and flow retention or detention should be implemented where such a discharge occurs to limit soil erosion and weed growth within areas of native vegetation;
- Management of stormwater should be considered on a subcatchment basis to employ source control techniques in preference to highly centralised ‘end-of-pipe’ treatment measures wherever practicable;
- Trunk drainage routes and dual carriageways should be aligned where possible, to allow use of centre medians for WSUD drainage systems;
- WSUD drainage systems may be incorporated into other roads and streets, where practicable and compatible with other design issues, including safety requirements of the relevant Road Authority;

- Any development within the 1:100 ARI flood level and the PMF should be designed to provide for emergency access;
- Critical infrastructure, such as major roads and rail, are to be located above the 1:100 flood level wherever possible;
- Evacuation routes that continually rise from residential properties to higher land should be provided.

5.2. Department of Environment, Climate Change and Water (DECCW)

The DECCW, formerly the Department of Environment and Conservation (DEC) and Environment Protection Authority (EPA), has set guidelines for stormwater quality from urban developments in their Interim Recommended Parameters for Stormwater Modelling – North-West and South-West Growth Centres (Ref. 9). This document nominates quantitative post construction phase stormwater management objectives for the reduction of various pollutants for a range of new developments. The retention criteria for the site are nominated as follows:

Total Phosphorous	65% retention of average annual load
Total Nitrogen	45% retention of average annual load
Suspended Solids	85% of average annual load for particles 0.5 mm or less
Gross Pollutants	90% retention of material greater than 5mm

The DECCW guidelines also nominate a ‘stream erosion index’ target of 3.0 – 5.0, where the stream erosion index is defined as the post-development duration of flows greater than the ‘stream-forming flow’ divided by natural duration of flows greater than the ‘stream-forming flow’. For the purposes of these objectives, the ‘stream forming flow’ is defined as 50% of the 2-year flow rate estimated for the catchment under natural conditions.

5.3. Blacktown City Council Draft Integrated Water Cycle Management Development Control Plan

Although the Integrated Water Cycle Management DCP is still in draft form and has not yet been adopted by Council, it has been considered in preparation of the Area 20 Water Cycle Management Strategy.

Blacktown City Council’s Draft Integrated Water Cycle Management DCP (Ref. 10) aims to:

- Protect and enhance natural river systems.
- Minimise potable water demand and wastewater generation.
- Match the natural water runoff regime as closely as possible.
- Mitigate the impacts of development on water quality.
- Mitigate the impacts of development on groundwater.

- Ensure any changes to the existing groundwater regime do not adversely impact upon adjoining properties.
- Integrate water cycle management measures into the landscape and urban design to maximise amenity.
- Minimise the potential impacts of development and other activity on the aesthetic, recreational and ecological values of receiving waters.
- Minimise soil erosion and sedimentation resulting from site disturbing activities.
- Ensure the principles of ecologically sustainable development are applied in consideration of economic, social and environmental values in water cycle management.

5.4. Blacktown City Council Draft WSUD Handbook (Parts 1 to 5)

Although the WSUD Handbook is still in draft form and has not yet been adopted by Council, it has been considered in preparation of the Area 20 Water Cycle Management Strategy. Blacktown City Council's Draft WSUD Handbook (Ref. 11) aims to:

1. Reduce potable water demand through the use of water efficient appliances and landscaping, stormwater harvesting and reuse and wastewater treatment and reuse;
2. Minimise wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities and/or to release to receiving waters and their aquatic environments;
3. Treat urban stormwater to meet water quality objectives for reuse and/or discharge to receiving waters, with emphasis on the use of vegetation and soils for filtering and biological treatment purposes as well as integration of stormwater treatment into the landscape;
4. Protect natural systems in order to preserve water related environmental, recreational and cultural values;
5. Optimise the urban water cycle to ensure catchment and aquatic ecosystem health is enhanced and/or maintained;
6. Preserve the natural hydrological regime of catchments, through detention and retention, rather than rapid conveyance of stormwater, and;
7. Use stormwater in the urban landscape to maximise its visual and recreational amenity.

5.4.1. Performance Targets

5.3.1.1 Water Conservation

- New residential dwellings, including a residential component within a mixed use building and serviced apartments intended or capable of being strata titled, are to demonstrate compliance with State Environmental Planning Policy – Building Sustainability Index (BASIX).

- For any water use within public open space (e.g. irrigation, water features, open water bodies / pools) an alternative water source must be identified to meet at least 80% of all demand.

5.3.1.2 Stormwater Quality

- 90% reduction in the post development average annual gross pollutant (>5mm) load.
- 85% reduction in the post development average annual load of Total Suspended Solids (TSS) load.
- 65% reduction in the post development average annual load of Total Phosphorus (TP) load.
- 45% reduction in the post development average annual load of Total Nitrogen (TN) load.

5.3.1.3 Waterway Stability Management

For all prescribed developments containing waterways characterised by the Department of Water and Energy, the post development duration of flows greater than the "stream-forming flow" should be no greater than 3-5 times the natural duration of this flow. "Stream-forming flow" is defined as 50% of the 2 year flow rate estimated for the catchment under normal conditions.

5.5. Department of Water and Energy (DWE) Requirements

A separate Riparian Constraints Assessment (Ref. 12) was completed by Eco-Logical Australia, which included liaison and a field inspection with DWE. As a result of the investigation, Second Ponds Creek has been identified as a Category 1 stream. DWE have agreed that a Core Riparian Zone (CRZ) be established for Second Ponds Creek that corresponds to the Area 20 certified land boundary (i.e. land that is protected for biodiversity purposes – Ref. 13). Given that the width of the CRZ provided by the certified boundary is greater than DWE would ordinarily require, a vegetated buffer is not required. A plan showing the extent of the CRZ is included in Attachment B.

5.6. Salinity

Salinity is the accumulation of mineral salts in the soil, groundwater and surface waters. Dry land salinity results when these soluble salts are transported to the surface by rising water table. The groundwater itself can also cause soluble salts to migrate under the ground surface and emerge as saline seepage in low lying areas. Salinity can lead to vegetation loss, weed invasion, soil structure decline and in some cases structural damage to buildings.

5.6.1. Salinity and Groundwater Control Measures

Groundwater **recharge** and **discharge** can both result in rising water tables and saline groundwater seepage. A Land Capability and Contamination Assessment was undertaken by WSP Environmental (Ref. 14) to investigate and make recommendations on salinity and groundwater for the Area 20 Precinct. The study found that:

- Surface soils (0.0. to 0.5 metres below ground level) are classified as non-saline to slightly saline;
- Sub-surface soils (0.5 to 4.0 metres below ground level) are classified as non-saline to moderately saline, with saline levels generally increasing with depth;
- No soil samples were classified as very saline or highly saline;
- Groundwater was found to be saline to very saline;
- Surface water in Second Ponds Creek was found to be slightly saline;
- The areas in the immediate vicinity of the creek have the highest potential for salinity impacts.

Salinity management measures should be implemented for the Area 20 Precinct development in accordance with the recommendations outlined in the WSP Environmental report and the WSROC Western Sydney Salinity Code of Practice (Ref. 15).

5.7. Water Sensitive Urban Design (WSUD)

Water Sensitive Urban Design aims to minimise the hydrological impacts of urban development and maximise the multiple use benefits of a stormwater system.

Australian Runoff Quality (Ref. 16) identifies the objectives of WSUD to include:

- Reducing potable water demand through water efficient appliances, rainwater and grey water reuse.
- Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities and/or release to receiving waters.
- Treating urban stormwater to meet water quality objectives for reuse and/or discharge to surface waters.
- Preserving the natural hydrological regime of catchments.

Australian Runoff Quality also identifies WSUD as the adoption of the following planning and design approaches that integrate the following opportunities into the built form of cities and towns:

- Detention, rather than rapid conveyance of stormwater.
- Capture and use of stormwater as an alternative source of water to conserve potable water.
- Use of vegetation for filtering purposes.
- Protection of water-related environmental, recreational and cultural values.
- Localised water harvesting for various uses.

5.8. Stormwater Management Objectives

5.8.1. Overall Objectives

The overall site stormwater management objectives were identified as follows:

Environmental Provision of appropriately designed, functional water quality facilities, limitation of downstream discharge peaks and velocities and maintenance of existing downstream water quality. Maintenance of environmental flows to ecosystems downstream of the site.

Urban Amenity Provision of a water cycle management strategy that identifies and controls limits of flood affectation and provision of aesthetic design forms that enhance amenity.

Engineering Considerations Effective management and control of peak discharges, discharge velocities, site detention, and water quality; industry best practice technical analysis of catchment hydrology and system hydraulic performance.

Economics Provision of a cost effective, functional site drainage system that optimises performance, provides maximum value for expenditure and keeps on-going maintenance requirements to a minimum.

5.8.2. Specific Development Objectives

In accordance with the principles of Ecologically Sustainable Development (ESD), the area needs to be designed, developed and maintained in accordance with the following stormwater management objectives:

- Preserve the ecological integrity of the identified riparian zones.
- Restrict development to above the 1% AEP flood level.
- Incorporate water sensitive urban design principles within the development.
- Ensure post-development water quality complies with Council's and the DECCW's requirements.
- Provision of a sustainable aquatic environment that preserves the potential for creating habitat for locally indigenous flora and fauna.
- Minimise Council's maintenance requirements for open space, litter control structures and nutrient and sediment removal devices.
- Enhance the biodiversity, ecological health and positive water quality benefits within the Second Ponds Creek corridor to provide an integrated natural resource for the incoming residents.

5.9. Opportunities

In the design of any urban drainage scheme it is desirable to build on the naturally occurring physical and environmental assets of the site to maximise the quality of the ultimate living environment. In particular water should be recognised as an important resource that can enhance and bring a focus to areas accessible to the whole community.

For the Area 20 Precinct site there are major opportunities to:

- Maintain, rehabilitate and enhance the Second Ponds Creek riparian corridor;
- Maximise habitat retention along the riparian corridor to provide sustainable aquatic and terrestrial ecosystems;
- Integrate open space areas and riparian corridors;
- Potentially incorporate a water reuse scheme to irrigate the public reserve and proposed playing field.

5.10. Constraints

The constraints to be considered in the preparation of a drainage strategy for this site include:

- Steep site topography may require special treatment to reduce scour and erosion;
- Areas of non-certified land have been identified within the site where development is restricted;
- Water Quality objectives will require allocation of land for water quality control structures;
- Existing site soil salinity and groundwater salinity constraints;
- Water use activities that can cause unnatural charging of groundwater and create rising watertables (e.g. over-irrigation of public areas, sports fields, private lawns and private gardens).

6. WATER CYCLE MANAGEMENT STRATEGY CONCEPT

The Water Cycle Management Strategy proposed for the Area 20 Precinct development has been prepared with consideration of the statutory requirements and guidelines listed in Section 5 of this report. The strategy focuses on mitigating the impacts of the development on the total water cycle and maximising the environmental, social and economic benefits achievable by utilising responsible and sustainable stormwater management practices.

6.1. Existing Rouse Hill Trunk Drainage Strategy

A stormwater management / trunk drainage strategy (Ref. 1), covering water quantity and quality management measures, was developed by GHD on behalf of the Rouse Hill Infrastructure Consortium during the late 1990's. Sydney Water is the authority for management of the trunk drainage infrastructure incorporated within the strategy.

The Rouse Hill Trunk Drainage Strategy considers all of the catchments and water courses making up the Caddies Creek catchment, including Second Ponds Creek and the Area 20 Precinct. The strategy proposes regional water quantity and quality control basins located throughout the catchment. This infrastructure has already been implemented through funding by developers and Government. The strategy does not include any existing or future works within the Area 20 Precinct.

It is acknowledged that water quality standards, modelling techniques and technology has evolved since the Rouse Hill Trunk Drainage Strategy was developed and it is therefore appropriate that to manage stormwater quality within the Area 20 Precinct. Water quality treatment will therefore be provided within Area 20, as discussed further in Section 9. However, water quantity control is addressed through the provision of regional detention basins, located external to the site. This approach has been discussed and supported by Sydney Water, who will have ongoing responsibility of the infrastructure into the future, including any upgrading works, if necessary.

6.2. Water Quality Management Options

A range of stormwater management techniques and options considered for the management of nutrients and suspended solids discharging from the site are summarised as follows:

6.2.1. Vegetated Swales and Buffers

Swales are formed, vegetated depressions that are used for the conveyance of stormwater runoff from impervious areas. They provide a number of functions including:

- removing sediments by filtration through the vegetated surface;
- reducing runoff volumes (by promoting some infiltration to the sub-soils); and
- delaying runoff peaks by reducing flow velocities.

Swales are typically linear, shallow, wide, vegetation lined channels. They are often used as an alternative to kerb and gutter along roadways but can also be used to convey stormwater flows in recreation areas and car parks.

Comment: The grade of the land within the Area 20 Precinct in most cases is too steep (> 3%) for swales and buffers. Swales and buffers within urban residential streets are not recommended due to the large number of culvert crossings required for driveways, safety concerns, increased number of GPT's required and significant maintenance requirements. Swales and buffers may possibly be considered at development application stage as one off elements within central medians on collector roads or other similar locations where the above issues are not applicable.

6.2.2. Sand Filters

Sand filters typically comprise of a bed of filter medium through which stormwater is passed to treat it prior to discharging to the downstream stormwater system. The filter media is usually sand, but can also contain sand/gravel and peat/organic mixtures. Sand filters provide a number of functions including:

- removing fine to coarse sediments and attached pollutants by infiltration through a sand media layer; and

- delaying runoff peaks by providing retention capacity and reducing flow velocities.

Sand filters can be constructed as either small or large scale devices. Small scale units are usually located in below ground concrete pits (at residential/lot level) comprising of a preliminary sediment trap chamber with a secondary filtration chamber. Larger scale units may comprise of a preliminary sedimentation basin with a downstream sand filter basin-type arrangement.

Comment: Sand filters are generally suited to smaller catchments. They are inefficient when compared to bio-retention systems and require frequent maintenance.

6.2.3. Permeable Pavement

Permeable pavements, which are an alternative to typical impermeable pavements, allow runoff to percolate through hard surfaces to an underlying granular sub-base reservoir for temporary storage until the water either infiltrates into the ground or discharges to a stormwater outlet. They provide a number of functions including:

- removing some sediments and attached pollutants by infiltration through an underlying sand/gravel media layer;

- reducing runoff volumes (by infiltration to the sub-soils); and

- delaying runoff peaks by providing retention/detention storage capacity and reducing flow velocities.

Commercially available permeable pavements include pervious/open-graded asphalt, no fines concrete, modular concrete blocks and modular flexible block pavements.

There are two main functional types of permeable pavements:

- infiltration (or retention) systems – temporarily holding surface water for a sufficient period to allow percolation into the underlying soils; and

- detention systems – temporarily holding surface water for short periods to reduce peak flows and later releasing into the stormwater system.

Comment: Permeable paving is best suited to catchments with low sediment loads and low vehicle weights such as small car parks and low traffic streets. They are susceptible to clogging and can require a high amount of ongoing maintenance.

6.2.4. Infiltration Trenches and Basins

Infiltration trenches temporarily hold stormwater runoff within a sub-surface trench prior to infiltrating into the surrounding soils. Infiltration trenches provide the following main functions:

- removing sediments and attached pollutants by infiltration through the sub-soils;
- reducing runoff volumes (by infiltration to the sub-soils); and
- delaying runoff peaks by providing detention storage capacity and reducing flow velocities.

Infiltration trenches typically comprise of a shallow, excavated trench filled with reservoir storage aggregate. The aggregate is typically gravel or cobbles but can also comprise of modular plastic cells (similar to a milk crate). Runoff entering the system is stored in the void space of the aggregate material or modular cells prior to percolating into the surrounding soils. Overflow from the trench is usually to downstream drainage system. Infiltration trenches are similar in concept to infiltration basins, however trenches store runoff water below ground within a pit and tank system, whereas basins utilise above ground storage.

Comment: Infiltration trenches and basins are not appropriate for clay soils or where there is potential for salinity issues. Infiltration trenches and basins are therefore not recommended for the Area 20 site.

6.2.5. Constructed Wetlands

Constructed wetlands can take the form of either a surface or sub surface system.

Surface Conventional wetlands.

Sub Surface Gravel filled shallow wetland.

Wetlands are shallow water body systems, densely vegetated with emergent aquatic macrophytes. Wetlands are effective in trapping suspended solids, as well as chemical and biological uptake of pollutants.

Comment: Wetlands are effective in removing sediment and nutrient loads typically generated from urban development. They do however require a large footprint area in relation to the catchment size. Wetlands also require a significant amount of maintenance.

6.2.6. Bio-Retention Systems

Bio-retention systems consist of a filtration bed with either gravel or sandy loam media and an extended detention zone typically from 100-300 mm deep designed to detain and treat first flush flows from the upstream catchment. They typically take the form of an irregular bed or a linear swale and are located within the verge area of a road reserve or extend within the bushland corridors or other open space areas. The surface of the bio-retention system can be grassed or mass planted with water tolerant species. Filtration beds of bio-retention systems are typically 0.6 metres deep.

Comment: Bio-retention systems are an effective and efficient means of treating pollutants from urban developments when part of an overall treatment train. Bio-retention systems require a reasonable amount of maintenance during the vegetation establishment phase.

6.2.7. Cartridge Filtration Systems

Cartridge filtration systems are underground pollution control devices that treats first flush flows. The units consists of a vault containing a number of cartridges each loaded with media that targets specific pollutants. Each cartridge has a maximum treatable flowrate of approximately 1 litre per second, and the unit can accommodate up to 24 cartridges providing a maximum treatable flowrate of 24 litres per second.

Comment: Cartridge filtration systems are an efficient means of treating pollutants from urban developments as they are typically located underground and therefore do not require additional landtake. As cartridge systems have a low treatable flow rate, additional "buffer" storage is usually provided to keep the capital costs down. Cartridge filtration systems also need to be supplemented with additional treatment devices to achieve pollutant reduction targets. This requires significant height differences between the inlet to the filtration system and the discharge point from the supplementary system. It also generally results in expensive capital and ongoing maintenance costs.

6.2.8. Rainwater Tanks

Rainwater tanks are sealed tanks designed to contain rainwater collected from roofs. Rainwater tanks provide the following main functions:

- allow the reuse of collected rainwater as a substitute for mains water supply, for use for toilet flushing, laundry, or garden watering;
- when designed with additional storage capacity above the overflow, provide some on-site detention, thus reducing peak flows and reducing downstream velocities; and
- it may be permissible to use rainwater tanks for internal hot water supply.

The water collected can be reused as a substitute for mains water supply either indoors (toilet flushing and laundry) or outdoors (garden watering). Rainwater tanks can be either above ground or underground. Above ground tanks can be placed on stands to prevent the need of installing a pump to distribute the water. Such systems are referred to as gravity systems. Pressure systems require a pump and can be either above or below ground tanks.

Tanks can be constructed of various materials such as ColorbondTM, galvanised iron, polymer or concrete.

Each of these management techniques were evaluated and compared with consideration of a range of Environmental, Social/Amenity, Economic, Maintenance and Engineering criteria.

Comment: Rainwater tanks are effective in removing suspended solids and a small amount of nutrient pollutants. They are also effective in reducing overall runoff volumes. It is understood that Sydney Water will not permit rainwater tanks to be installed as reticulated recycled water will be provided for the development.

6.3. Proposed Stormwater Control Strategy

The stormwater management strategy proposed for the site focuses on minimising the impacts of the development on the total water cycle and maximising the environmental, social and economic benefits achievable by utilising responsible and sustainable stormwater management practices.

A critical consideration is the ecological sustainability of the Second Ponds Creek Riparian corridor through the site. To maintain stormwater quality at the required levels, a “treatment train” approach is proposed where various types of pollutants are removed by a number of devices acting in series. The stormwater management treatment train will consist of the following elements.

WATER QUALITY

Street Level Treatments

Inlet Pit Filter Inserts and Gross Pollutant Traps (GPTs)

GPT devices are typically provided at the outlet to stormwater pipes. These systems operate as a primary treatment to remove litter, vegetative matter, free oils and grease and coarse sediments prior to discharge to a downstream (Secondary and Tertiary) treatment devices. They can take the form of trash screens or litter control pits, filter pit inserts and wet sump gross pollutant traps.

Note, it is our view that inlet pit filter inserts have several advantages over end of pipe GPT’s, such as providing a dry, at source collection of litter,

vegetative matter and sediment as

well as allowing for staged construction works without having to provide additional / temporary GPT units. This is particularly relevant for Area 20 due to the fragmented ownership and the likely stagnated nature of future development. Pit filter inserts will provide an at source mechanism for treatment of gross pollutants as development proceeds throughout the site. Alternatively, end of pipe GPT's, may result in Council maintaining a large number of interim structures due to the fragmented ownership.

However, we also note that Council prefers the use of end-of-pipe proprietary solutions (e.g. CDS) in the capture of gross pollutants. GPT's have been excluded from the MUSIC water quality modelling for the site. Therefore, the choice of either system will not affect the modelling results. Council approved GPT units are to be provided from urbanised catchments prior to discharging to water quality devices or Second Ponds Creek.

Subdivision / Development Treatment

Bio-retention Raingardens

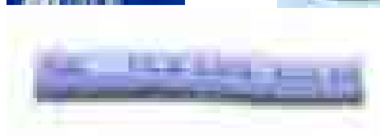
Thirteen bio-retention "raingardens" are proposed within the development. The bio-retention raingardens will be appropriately sized to achieve the nutrient reduction targets proposed in the Blacktown City Council Draft WSUD Handbook (Ref. 11) for the development site. These targets are consistent with recently proposed DECC targets specified for the Growth Centres. The bio-retention raingardens will also attenuate first flush flows to reduce the risk of stream erosion on Second Ponds Creek. The location of the thirteen raingardens are shown on Figure 4. Refer to Section 6.5 for further discussion.

WATER QUANTITY

On Lot Treatments

- Implementation of water efficient fittings and appliances in all dwellings (dual flush toilet, AAA shower heads, water efficient taps and plumbing).
- Minimisation of impervious areas.
- The provision of a future reticulated recycled water main to the site and/or rainwater tanks on each allotment, along with implementation of the above water efficient devices, will satisfy the requirements of BASIX.





Subdivision / Development Treatment

Regional Detention Ponds	Peak storm flow attenuation up to the 100 year ARI event is addressed through the provision of regional detention storages located externally to the Area 20 Precinct.
Stream Erosion Index	Limiting the post development stream forming flow duration so that it is no more than 3 – 5 times that of the pre-development stream forming flow duration.

Key features of the proposed strategy are as follows:

Social:

- Integration of bio-retention raingarden systems with the overall landscape strategy for the estate to create an integrated-natural resource for the incoming and wider community.
- Enhanced visual amenity (views out of and through the riparian corridor).
- Flood affectation and public safety issues identified and controlled.
- Provision of aesthetic soft design forms that enhance urban and environmental amenity.

Environmental:

- Limited downstream and in-channel discharge peaks and velocities to avoid scouring, siltation and flora and fauna impacts

- Enhanced ecological health and biodiversity within the riparian corridors.

- Provision of gross pollutant traps, wetlands and bio-retention systems to achieve water quality capable of sustaining Second Ponds Creek aquatic ecosystems.

- Limitation of frequent wetting flows and peak velocities to avoid creek bed/bank erosion and sedimentation. Peak storm flow attenuation is addressed through provision of regional detention basins located external to the Area 20 Precinct.

- A holistic and interdisciplinary approach to the management of urban salinity, using an approach to construction, stormwater management, building and landscaping practices, consistent with the WSROC Western Sydney Salinity Code of Practice (Ref. 15) and in accordance with the recommendations by WSP Environmental (Ref. 14).

- Provision of extensive deep rooted vegetation in strategic areas to intercept ground water flows and generate natural groundwater discharge processes (evapotranspiration).

- Extensive revegetation of allotments, streetscapes, and bio-retention systems to manage urban salinity and provide habitat.

- Provision of reticulated recycled water or rainwater tanks within the development to reduce reliance on potable water supplies by using recycled water as a resource.

Economic:

- Minimisation of land take consistent with the achievement of environmental and social objectives.

- Proposed water quality improvement measures that keep recurrent maintenance tasks and costs to a minimum.

The water cycle management strategy proposed for the Area 20 Precinct development site is functional; delivers the required technical performance; avoids environmental degradation and pressure on downstream ecosystems and infrastructure; and provides for a ‘soft’ sustainable solution for stormwater management within the release area. The water cycle management concept is illustrated on Figure 4.

6.4. Litter and Sediment Control

Local drainage throughout the development should be filtered to remove litter & coarse sediment prior to discharge into the downstream drainage systems, raingardens and the riparian corridors. Devices to achieve litter and sediment control come in various forms, such as inlet pit filter inserts, cast in situ and precast gross pollutant traps as well as wet sump and self cleansing units.

We understand that Blacktown City Council will not accept pit filter inserts, therefore it is proposed that Council approved proprietary gross pollutant trap structures be provided to capture litter, vegetative matter, coarse sediment prior to discharge to the downstream treatment devices. An appropriate unit should be selected such that it intercepts a minimum 90% of the sediment of size 0.15 mm and greater. It is expected that the site drainage strategy would require approximately 18 of these structures (at least one per raingarden and discharge point to the drainage reserves). Where possible, dewatering lines will be provided to each GPT unit to facilitate drainage of the sumps. These dewatering lines will be discharged to heavily vegetated sections of the raingardens, as appropriate, to provide for nutrient stripping of the supernatant water.

At the development application phase we recommend that the acceptance of pit filter inserts be reviewed by Council as an appropriate solution for the development, given the highly fragmented ownership and potential for Council to have to maintain a high number of alternate end of pipe GPT's which would be necessary to supplement development of land holdings in the upper catchment prior to development of the fringe of Second Ponds Creek.

6.5. Bio-Retention "Raingarden" System

Thirteen raingardens are proposed throughout the development site. Twelve of the raingardens are located adjacent to the Second Ponds Creek Riparian Corridor and one adjacent to Windsor Road within the far south east corner of the site.

The raingardens consist of a relatively shallow organic sandy loam bed (0.6 m) which will be densely vegetated with native sedges and/or grasses. This device would be designed to receive, convey and treat 3 month ARI flows from the upstream catchments.

Treatment is attained by detention of flows, direct filtration and nutrient stripping by bio-films which establish on the surface of the media bed. The organic sandy loam bed and plant system minimises evaporation losses and the raingardens will be designed to prevent seepage losses and to avoid groundwater salinity impacts.

The proposed raingardens servicing the development will have an extended detention zone of 300mm which will service the first flush and base flows from the urban development. The general features and configuration of the proposed raingardens is detailed in Table 6.1. A discharge control structure will be configured to promote extended detention times for the treatment flows.

The size of the raingardens have been determined using MUSIC modelling (Refer to Section 9). The performance of the devices are detailed in Section 9.5 of this report. The configuration of the systems are indicated on Figure 4. Typical sections and details for the raingardens are shown on Figure 5.

It is recommended that prior to completion of the construction and housing phases of the Precinct the raingarden floor be utilised as a sedimentation control pond. The commissioning of the raingarden should only occur once sediment loads in the catchment are adequately controlled, so that the risk of clogging of the media bed is acceptable (refer to Section 6.8).

Table 6.1

BIO-RETENTION RAINGARDENS
GENERAL FEATURES AND CONFIGURATION

Storage Properties	
Extended Detention Depth (m)	0.3
Seepage Loss (mm/hr)	0
Infiltration Properties	
Filter Area (m^2)	1.1% of catchment area
Filter Depth (m)	0.6
Filter Media Particle Diameter (mm)	0.45
Saturated Hydraulic Conductivity (mm/hr)	100
Outlet Properties	
Overflow Weir Width (m)	2.0

Maintenance requirements for the raingarden would typically involve plant replacement, weed control, repair of erosion and structural damage and removal of localised sediment build-up. This would be undertaken on a quarterly basis on average.

6.6. Water Quantity Management

Water quantity management for the Area 20 Precinct is achieved through provision of the Rouse Hill Regional Trunk Drainage scheme (Ref. 1). This scheme includes regional detention basins located throughout the catchment (external to the Area 20 Precinct) to mitigate the impact of urbanisation on peak flow runoff. No additional detention facilities are proposed within the Area 20 Precinct as part of the Rouse Hill scheme.

6.7. Construction Stage

Erosion and sediment control measures are to be implemented during the construction phase in accordance with the requirements of Blacktown City Council and the guidelines set out by Landcom (the "Blue Book" Ref. 17).

As the operation of "bio-retention" type water quality treatment systems are sensitive to the impact of sedimentation, these controls should generally be maintained until the majority of site building works are complete. Alternatively, a very high level of at source control on individual allotments during the building and site landscaping works, which is regularly inspected by Council officers, would be required.

6.8. Interim Treatment Measures

The raingarden media bed should be protected throughout the civil and housing construction phases of the development. The floor of the raingarden should be lined with either a layer of turf or a sacrificial upper media bed layer and planting that would need to be replaced upon 80% completion of housing construction.

Upon 80% completion of housing construction within the catchment, the turf or sacrificial layer can be removed, replaced and the final planting completed.

6.9. Long Term Management

Regular maintenance of the stormwater quality treatment devices is required to control weeds, remove rubbish, and monitor plant establishment and health. Some sediment build-up may occur on the surface of the raingardens and may require removal to maintain the high standard of stormwater treatment.

Proper management and maintenance of the water quality control systems will ensure long-term, functional stormwater treatment. It is strongly recommended that a site-specific Operation and Maintenance (O & M) Manual is prepared for the system. The cost of preparing this manual should be a component of the Section 94 scheme. The O & M manual will provide information on the Best Management Practices (BMP's) for the long-term operation of the treatment devices. The manual will provide site-specific management procedures for:

- Maintenance of the GPT structures including rubbish and sediment removal.
- Management of the raingarden including plant monitoring, replanting guidelines, monitoring and replacement of the filtration media and general maintenance (i.e. weed control, sediment removal).

6.10. Stormwater Monitoring Programme

A stormwater monitoring programme should be implemented to ensure the water quality eco-medians and bioretention systems continue to operate as efficiently as possible. The management system should involve regular in-situ testing of the hydraulic conductivity of the media bed. The procedure recommended for testing the in-situ hydraulic conductivity has been described in detail by the Facility for Advancing Water Biofiltration (FAWB) and is reproduced as Attachment C in this report.

Should the testing show a deficiency in the hydraulic conductivity, it is recommended that the following rectification procedure be implemented:

- Determine the filtration bed level (RL) at which the hydraulic conductivity falls below the minimum recommended value.
- Remove the portion of media bed above this level and replace with material in accordance the original specification.

It is recommended that the stormwater monitoring programme be included in the Operation and Maintenance Manual.

7. HYDROLOGIC ANALYSIS

The hydrologic analyses for this study were undertaken using the rainfall - runoff flood routing model XP-RAFTS (Runoff and Flow Training Simulation with XP Graphical Interface) (Ref. 18 & 19). As no detention basins are proposed within the Area 20 Precinct, the hydrologic analysis was undertaken primarily to determine peak flow rates for input to the hydraulic model.

7.1. Previous Modelling

Two previous sets of hydrologic models (incorporating existing and ultimate developed conditions) have been prepared by GHD and SKM for the entire Caddies Creek catchment, for which Second Ponds Creek is a tributary. These are broad scale models that were prepared primarily to determine peak flows for input into flood models. A copy of both sets of models were provided by Sydney Water. It is noted that the GHD XP-Rafts hydrologic model is Sydney Water's current adopted model.

The SKM post development model was adopted as the base model for the Area 20 investigation, being the most up to date and providing a better representation of the detention basin outlet operations, as discussed further in Section 8.3. This model was modified within the Area 20 Precinct by further splitting of the subcatchments to more accurately represent the development scenario in the ILP and distribution of pervious and impervious areas.

7.2. Comparison of Impervious Areas

The previous GHD and SKM XP-Rafts models allow approximately 60% of impervious area for the subcatchments located within the Area 20 Precinct. The JWP modified XP-Rafts model results in an impervious area of approximately 62%, taking into account the riparian corridors, Rouse Hill Regional Park, the sports fields and 85% impervious within the residential areas.

7.3. Sub-Catchments (Post Development)

Sub-catchment areas contributing to this drainage system were determined from the Indicative Layout Plan for the site. Catchment boundaries for the developed areas contributing to the drainage system are shown on Figure 3 and the catchment details are provided in Attachment D.

7.4. Rainfall Data & XP-Rafts Parameters

Rainfall data used in the hydrologic study is consistent with the Sydney Water adopted model for the storms previously assessed and also considered in this investigation (2, 20 and 100 year ARI and PMF). For the two additional storms assessed (200 and 500 year ARI), the design rainfall intensity-frequency-duration (I.F.D.) data for the site was established from Table 3.0 in Appendix D of Blacktown City Council's Engineering Guide for Development (Ref. 7).

The pern (n) values and losses adopted for the catchments in the XP-Rafts modelling are consistent with those in Sydney Water's adopted model and are summarised in Table 7.1.

Table 7.1

XP-RAFTS PARAMETERS

Parameter	Catchment Condition	Adopted Value
Pern		
	Existing Pervious	0.035
	Urban Pervious	0.025
	Urban Impervious	0.015
Losses		
Initial Loss	Pervious Catchment	15.0
Continuing Loss	Pervious Catchment	2.5
Initial Loss	Impervious Catchment	1.5
Continuing Loss	Impervious Catchment	0.0

7.5. Rouse Hill Anglican College Detention Basin

An existing detention basin is located within the Rouse Hill Anglican College site, adjacent to Rouse and Worcester Roads. Stage-storage-discharge relationships were determined for the basin and included in the XP-Rafts model.

7.6. Discharge Estimates

For the Area 20 Precinct planning purposes, discharge estimates were derived for the developed catchments for storms with Average Recurrence Intervals (A.R.I.'s) of 2, 20 and 100 years along with the PMF. Additionally, the 500 year ARI storm was also assessed to determine flood extents for use in the Flood Evaluation Study. A range of storm durations from 60 minutes to 72 hours were analysed to determine the critical storm duration for each sub-catchment.

The 2, 20 and 100 year A.R.I. and PMF peak flows at Rouse and Windsor Roads are presented in Table 7.2. The XP-RAFTS modelling outputs are provided in Attachment D.

Table 7.2

SUMMARY OF PEAK 2, 20 & 100 YEAR ARI AND PMF PEAK FLOWS AT ROUSE & WINDSOR ROADS (WITH AND WITHOUT DEVELOPMENT IN AREA 20 PRECINCT)

Scenario	Peak Flow (m^3/s) - Rouse Road				Peak Flow (m^3/s) - Windsor Road			
	Average Recurrence Interval				Average Recurrence Interval			
	2 Year	20 Year	100 Year	PMF	2 Year	20 Year	100 Year	PMF
Area 20 Undeveloped	35.8	67.9	90.6	625.8	37.0	71.0	95.2	640.4
Area 20 Developed	35.9	66.2	87.6	606.0	36.3	67.6	90.1	611.2

The results presented in Table 7.2 show that the Area 20 Precinct development will actually result in a decrease in peak flows within the site (at Rouse and Windsor Roads) for all events except the 2 year ARI at Rouse Road. This can be explained by the timing of peak flows within Second Ponds Creek. Urbanisation of the Area 20 Precinct will result in stormwater runoff discharging to Second Ponds Creek more quickly than in the existing case and the timing of these flows, therefore, do not coincide with timing of peak flows from the upper catchment.

A comparison of peak flows from the other hydraulic models prepared during previous investigation are presented below in Table 7.3.

Table 7.3

COMPARISON SUMMARY OF PEAK 2, 20 & 100 YEAR ARI AND PMF ULTIMATE CASE FLOWS AT ROUSE & WINDSOR ROADS

Model	Peak Flow (m^3/s) - Rouse Road				Peak Flow (m^3/s) - Windsor Road			
	Average Recurrence Interval				Average Recurrence Interval			
	2 Year	20 Year	100 Year	PMF	2 Year	20 Year	100 Year	PMF
GHD [1]	28.0	50.9	63.9	619.8	29.5	54.6	69.2	654.1
SKM	32.7	60.0	82.8	513.4	34.8	64.2	89.5	545.8
JWP	35.9	66.2	87.6	606.0	36.3	67.6	90.1	611.2

Notes: 1. Peak flows extracted from GHD HEC-RAS model

The summary of peak flows in Table 7.3 show a good correlation with those determined by SKM, particularly for the 100 year ARI case at Windsor Road. We understand that the GHD hydrologic and hydraulic models are the Sydney Water adopted models. The peak flows determined in this investigation are conservative when compared to Sydney Water's adopted ultimate case model.

7.7. Climate Change Sensitivity Assessment

Preliminary assessments of hydrologic impacts, resulting from changes to rainfall patterns as a consequence of Climate Change, were undertaken to determine the impact of such changes on the performance of the proposed Trunk Drainage system. These assessments followed the sensitivity analysis procedures recommended in the *NSW Climate Change Action Plan, DECC (October 2008)* (Ref. 3). A copy of the Climate Change assessment is provided in Attachment E.

In summary:

- Summer runoff depths are expected to increase by a maximum of 26%; and
- The 40-year 24-hour duration rainfall intensity is expected to increase by a maximum of 12%.
- The net average annual runoff is expected to fluctuate with an overall minor increase.

Consequently for the purposes of this assessment, the worst-case scenario of projected increased rainfall intensities (15% increase) and runoff depths (25% increase based on rainfall intensities increased by 15%), were adopted.

This approach has been referred to DECCW for comment and has been confirmed as "a pragmatic approach to considering the impacts of Climate Change on urban drainage systems."

A discussion of the impacts of climate change on flood levels is discussed in Section 8.8.2.

8. FLOOD MODELLING

The flood modelling of Second Ponds Creek was undertaken using the 1D steady state HEC-RAS model (Ref. 20). WaterRide, a GIS-based software tool developed by Worley Parsons, was used for flood mapping and creating the flood difference maps.

The ultimate case, including the Area 20 Precinct development, flooding scenario was modelled considering the 2, 20 and 100 year ARI and PMF events. Flood modelling of the 500 year ARI event was also undertaken for use in the Flood Safety Evaluation (refer to Section 8.10 and Attachment H). Flood modelling for the ultimate scenario was undertaken to determine the impact of the Area 20 development on the flood levels in Second Ponds Creek.

8.1. Background

Flood modelling for Second Ponds Creek was originally completed by GHD as part of the Rouse Hill Infrastructure Corporation (RHIC) development. The flood modelling undertaken by GHD was completed using the HEC-RAS steady state model. The modelling included existing case and ultimate case scenarios. The ultimate case model has been progressively updated over the years to reflect additional development that has occurred or has been planned within the catchment.

Sydney Water recently commissioned Sinclair Knight Merz (SKM) to undertake a review of the GHD modelling. A draft report was prepared by SKM in 2009 (Ref. 2) summarising the results of the investigation. The report identified potential deficiencies with the modelling previously undertaken by GHD. In particular, the review identified issues with the modelling of basin outlets within the XP-Rafts hydrologic model, which was used to determine peak flows for input to HEC-RAS. As a result, the ultimate case peak flows and, subsequently, flood levels determined by GHD were generally lower than those determined by SKM.

It is noted that the XP-Rafts hydrologic model and HEC-RAS hydraulic model developed by GHD remain Sydney Water’s current adopted models.

8.2. 1D Vs 2D Flood Modelling

During the early phases of the investigation, discussions were held with Blacktown City Council and Sydney Water regarding the adequacy of the existing 1D HEC-RAS model or whether a 2D hydraulic model was required for the precinct planning process. It was generally agreed that the HEC-RAS model would be satisfactory, provided the likely conservative nature of the 1D model did not disadvantage landowners on the fringe of the floodplain by over estimating flood levels. Council particularly noted the northern extents of Rouse Hill Regional Park, where the channel and overbanks are less pronounced and the floodplain is flatter, along with the hydraulic affects of the old Windsor Road bridge, as potential concerns with the 1D model. As there is no urban development proposed within this vicinity, the use of the 1D model in estimating flood levels is considered appropriate. The backwater effect caused by the restricted opening at the old Windsor Road bridge does extend upstream into the Rouse Hill Regional Park. However, the hydraulic grade of the flood surface increases toward the southern extents of the Park and before reaching the proposed urban development areas. Therefore, it is expected that complex hydraulic conditions that are not able to be modelled as well in the 1D model would be contained in the portion of Second Ponds Creek not proposed for residential development.

The Department of Planning and Blacktown City Council reached an agreement that no filling would be undertaken within the 100 year ARI flood extents, regardless of whether there was any impact on flood levels.

8.3. Hydrologic Modelling

Sydney Water provided a copy of both the GHD and SKM ultimate case XP-Rafts hydrologic models for the entire Caddies Creek catchment, for which Second Ponds Creek is a tributary. As discussed above, the SKM review identified problems with the GHD XP-Rafts and therefore the SKM model, which addressed these issues, was considered to be the more appropriate to adopt as a base model. Gross checks were undertaken on the SKM XP-Rafts model, particularly with regards to basin outlet stage-discharge relationships. However, J. Wyndham Prince has not been engaged to undertake a detailed peer review of the GHD or SKM XP-Rafts models and as such we are not able to confirm that the models present an accurate representation of flood flows in Second Ponds Creek. However, the flows adopted in this investigation are more conservative than those in Sydney Water's adopted model and are therefore suitable for planning purposes and to support the preparation of the Indicative Layout Plan.

Due to the size of the model, the desire to minimise the analysis times and the need to assess only Second Ponds Creek for the Area 20 investigation, the model was trimmed to include only Second Ponds Creek. As the XP-Rafts model was setup as part of a much more broad scale investigation, it was also modified to include additional subcatchment areas representing the Area 20 site.

It was noted that the GHD and SKM model included Basin 42 (located within the adjacent The Ponds development) as on online basin. As this basin has been constructed off-line and services only a small catchment, the effect of the basin was conservatively ignored in the hydrologic assessment. It also appears that modelling of the storage within the detention basin online to Second Ponds Creek, located immediately upstream of Keirle Road within The Ponds development, does not include the earthworks that were undertaken to shape the ultimate formation of the basin embankment. The stage-storage relationship for this basin was determined by JWP from a digital terrain model available from previous work in The Ponds development and input in the XP-Rafts model.

The revised SKM ultimate model and the model incorporating the proposed Area 20 Precinct development were run. Peak flows for the 2, 20 and 100 year ARI and PMF storms were extracted from the XP-Rafts models for use in the HEC-RAS models for comparison purposes. PMP intensities adopted in the modelling are consistent with those described in the report by SKM (Ref. 2).

8.4. Review of Previous HEC-RAS Modelling

Both the SKM and GHD HEC-RAS ultimate scenario models were provided by Sydney Water. The SKM model was generally considered the more appropriate model to use for the Area 20 assessment, due mainly to the cross sections being aligned such that they are perpendicular to the contours and do not intersect at bends in the creek. There was however one exception. In reviewing the SKM model it was apparent that it did not include recent earthworks that had occurred within The Ponds development, located adjacent to the upstream (southern) boundary of the Area 20 site. The GHD HEC-RAS model had been revised to include these works. As the sections in both models were located at the same locations, the GHD section data was substituted in the SKM model for sections located within The Ponds development.

J. Wyndham Prince has not been engaged to undertake a detailed peer review of the GHD and SKM HEC-RAS models and as such we are not able to confirm that the models present an accurate representation of flood flows and levels for the Second Ponds Creek watercourse.

8.5. Mannings 'n' Roughness

A Mannings value of 0.09 was adopted for the channel within the Area 20 Precinct. While this is a reasonably conservative value, it allows for potential future stream restoration works and erosion measures that may be undertaken by Sydney Water.

A Mannings value of 0.105 was adopted for the overbanks within the Area 20 Precinct, This is reflective of the extent of bush regeneration works that are likely to occur within the riparian corridor over time.

The Mannings values adopted in the modelling are consistent with the value adopted by GHD in The Ponds development, immediately upstream of the site.

8.6. Hydraulic Structures

The hydraulic structures (bridges, culverts, weirs, etc) included in the SKM model provided by Sydney Water were adopted in this investigation.

An additional bridge was added to the model representing the proposed rail crossing over Second Ponds Creek within the Area 20 Precinct. The bridge has been located approximately 500mm above the 100 year ARI flood level and would therefore only become inundated in extreme events. It is noted that the proposed railway bridge alignment is slightly skewed in relation to the orientation of the cross sections upstream and downstream. However, as the bridge will become inundated only in extreme storm events, it is expected that there would be minimal to no impact on flood levels resulting from the misalignment.

8.7. Sensitivity Analysis for Climate Change

As discussed in Section 7.7, a sensitivity analysis was undertaken to determine the likely impact of climate change on storm intensities (for the 100 year ARI event). In the absence of specific guidelines from DECCW or Blacktown City Council, the analysis concluded that an increase in rainfall intensities of 15% provides a pragmatic approach to considering the impacts of Climate Change on urban drainage systems.

Revised 100 year ARI ultimate development scenario peak flows were extracted from the XP-Rafts model, representing an increase in rainfall intensities of 15%, and input to the HEC-RAS hydraulic model for assessment. The results of the analysis are summarised in Section 8.8.2.

8.8. Results Comparison

The HEC-RAS models were run / compared for the 2, 20 and 100 yr ARI and PMF events for the four following scenarios:

1. JWP Existing Scenario, excluding Area 20 (which is undeveloped).
2. JWP Ultimate scenario, including Area 20 Precinct development.
3. GHD Ultimate scenario (Sydney Water's current adopted model).
4. JWP Ultimate scenario incorporating the climate change sensitivity analysis, including Area 20 Precinct development.

8.8.1. Flood Level Results Comparison - Area 20 Existing and Ultimate Development Scenarios (Flood Model Scenarios 1 and 2)

2 Year ARI

A summary of the results for the 2 year ARI event are shown in Table 8.1. Generally, the results of the JWP HEC-RAS assessment for the 2 year ARI event show a minor decrease in the flood levels of up to 30mm within the Area 20 Precinct as a result of the development. This is primarily as a result of a decrease in 2 year ARI peak flows, as discussed in Section 7.6. There is a decrease in the 2 year ARI flood level of 170mm and an increase in velocities of 0.25 metres/second immediately upstream of the proposed rail bridge There are some minor increases in flood levels of up to 20mm within the Area 20 Precinct site.

Table 8.1

COMPARISON OF PEAK FLOOD LEVELS
2 YEAR ARI

JWP (AREA 20 UNDEVELOPED)				JWP (AREA 20 DEVELOPED)			Differences		Comment
River Sta	Q Total (m3/s)	W.S. Elev (m)	Vel Chnl (m/s)	Q Total (m3/s)	W.S. Elev (m)	Vel Chnl (m/s)	W.S. Elev Post - Exist (m)	Vel Chnl Post - Exist (m/s)	
4996	30.2	46.87	0.54	30.2	46.87	0.54	0	0	
4985	Bridge			Bridge				0	Schofields Rd
4972	30.2	46.57	1.15	30.2	46.57	1.15	0	0	U/S Bdy Area 20
4928	30.2	46.2	0.94	30.2	46.18	0.98	-0.02	0.04	
4798	30.2	45.98	0.42	30.2	45.91	0.44	-0.07	0.02	
4685	30.2	45.71	1.22	30.2	45.54	1.47	-0.17	0.25	
4680				Bridge					Rail Bridge
4568	30.85	44.67	1.4	31.53	44.69	1.41	0.02	0.01	
4477	30.85	44.28	0.73	31.53	44.27	0.75	-0.01	0.02	
4392	32.8	43.98	0.87	32.24	43.97	0.85	-0.01	-0.02	
4304	32.8	43.66	0.84	32.98	43.66	0.85	0	0.01	
4218	32.8	43.27	1.17	32.98	43.24	1.20	-0.03	0.03	
4139	35.83	43.03	0.57	32.98	43.02	0.53	-0.01	-0.04	
4027	35.83	42.77	0.74	35.94	42.77	0.74	0	0	
3975	35.83	42.68	0.63	35.94	42.69	0.63	0.01	0	
3880	35.83	42.48	0.84	35.94	42.49	0.84	0.01	0	
3870	Bridge			Bridge					Rouse Rd
3856	35.83	42.33	1.06	35.94	42.33	1.07	0	0.01	
3798	35.83	42.01	1.16	35.94	42.01	1.16	0	0	
3727	35.83	41.71	0.78	35.94	41.71	0.78	0	0	
3624	36.46	41.31	0.86	35.92	41.30	0.86	-0.01	0	
3533	36.46	40.94	0.63	35.92	40.93	0.63	-0.01	0	
3465	36.46	40.58	0.98	35.92	40.57	0.98	-0.01	0	
3378	36.46	40.39	0.62	35.92	40.38	0.62	-0.01	0	
3286	36.46	40.22	0.53	35.92	40.21	0.53	-0.01	0	
3227	36.46	40.01	0.83	35.92	40.00	0.83	-0.01	0	
3141	36.96	39.93	0.32	36.29	39.92	0.32	-0.01	0	
3025	36.96	39.43	2.22	36.29	39.42	2.20	-0.01	-0.02	
3021	Bridge			Bridge					Windsor Rd (Old)
3011	36.96	39.4	1.61	36.29	39.39	1.59	-0.01	-0.02	
2991	36.96	39.33	0.69	36.29	39.32	0.68	-0.01	-0.01	D/S Bdy Area 20
2972	Bridge			Bridge					Windsor Rd
2950	36.96	38.76	1.1	36.29	38.75	1.09	-0.01	-0.01	
2882	36.96	38.42	0.57	36.29	38.41	0.56	-0.01	-0.01	
2796	37.93	37.82	1.73	37.32	37.81	1.74	-0.01	0.01	
2691	37.93	37.6	0.59	37.32	37.59	0.59	-0.01	0	
2621	37.93	37.26	1.63	37.32	37.26	1.61	0	-0.02	
2519	37.93	36.91	0.53	37.32	36.90	0.53	-0.01	0	
2355	37.93	35.94	1.72	37.32	35.93	1.73	-0.01	0.01	
2250	37.93	35.48	1.16	37.32	35.47	1.15	-0.01	-0.01	
2098	37.93	35.13	1.04	37.32	35.11	1.04	-0.02	0	
2005	37.93	34.89	1.06	37.32	34.88	1.06	-0.01	0	
1948	37.93	34.78	1.04	37.32	34.77	1.04	-0.01	0	
1907	37.93	34.68	1.25	37.32	34.66	1.24	-0.02	-0.01	
1900	Bridge			Bridge					Withers Rd
1890	37.93	34.08	3.06	37.32	34.06	3.07	-0.02	0.01	

20 Year ARI

A summary of the results for the 20 year ARI event are shown in Table 8.2. Generally, the results of the JWP HEC-RAS assessment for the 20 year ARI event show a decrease in the flood levels of up to 150mm within the Area 20 Precinct as a result of the development. This is primarily as a result of a decrease in 20 year ARI peak flows, as discussed in Section 7.6. There are some minor increases in flood levels of up to 20mm within the Area 20 Precinct site.

Table 8.2

COMPARISON OF PEAK FLOOD LEVELS 20 YEAR ARI

JWP (AREA 20 UNDEVELOPED)				JWP (AREA 20 DEVELOPED)			Differences		Comment
River Sta	Q Total (m3/s)	W.S. Elev (m)	Vel Chnl (m/s)	Q Total (m3/s)	W.S. Elev (m)	Vel Chnl (m/s)	W.S. Elev Post - Exist (m)	Vel Chnl (m/s)	
4996	53.04	47.1	0.85	53.04	47.10	0.85	0	0	
4985	Bridge			Bridge					Schofields Rd
4972	53.04	46.93	1.49	53.04	46.92	1.50	-0.01	0.01	U/S Bdy Area 20
4928	53.04	46.58	1.09	53.04	46.58	1.10	0	0.01	
4798	53.04	46.31	0.55	53.04	46.29	0.56	-0.02	0.01	
4685	53.04	46.01	1.32	53.04	45.95	1.45	-0.06	0.13	
4680				Bridge					Rail Bridge
4568	54.86	45.09	1.55	56.96	45.11	1.56	0.02	0.01	
4477	54.86	44.77	0.8	56.96	44.76	0.83	-0.01	0.03	
4392	59.91	44.48	1.08	58.67	44.47	1.07	-0.01	-0.01	
4304	59.91	44.17	0.98	59.94	44.16	1.00	-0.01	0.02	
4218	59.91	43.81	1.3	59.94	43.76	1.37	-0.05	0.07	
4139	67.85	43.61	0.69	59.94	43.58	0.63	-0.03	-0.06	
4027	67.85	43.4	0.78	66.22	43.37	0.79	-0.03	0.01	
3975	67.85	43.33	0.61	66.22	43.30	0.62	-0.03	0.01	
3880	67.85	43.11	1.2	66.22	43.09	1.18	-0.02	-0.02	
3870	Bridge			Bridge					Rouse Rd
3856	67.85	42.88	1.49	66.22	42.85	1.47	-0.03	-0.02	
3798	67.85	42.54	1.4	66.22	42.51	1.40	-0.03	0	
3727	67.85	42.22	1.02	66.22	42.18	1.02	-0.04	0	
3624	69.57	41.77	1.07	66.37	41.73	1.07	-0.04	0	
3533	69.57	41.48	0.68	66.37	41.41	0.69	-0.07	0.01	
3465	69.57	41.29	0.89	66.37	41.21	0.92	-0.08	0.03	
3378	69.57	41.18	0.63	66.37	41.08	0.65	-0.10	0.02	
3286	69.57	41.13	0.38	66.37	41.02	0.40	-0.11	0.02	
3227	69.57	41.1	0.43	66.37	40.98	0.45	-0.12	0.02	
3141	71.02	41.08	0.27	67.58	40.95	0.30	-0.13	0.03	
3025	71.02	40.86	1.62	67.58	40.71	1.65	-0.15	0.03	
3021	Bridge			Bridge					Windsor Rd (Old)
3011	71.02	39.82	2.28	67.58	39.79	2.22	-0.03	-0.06	
2991	71.02	39.77	0.96	67.58	39.74	0.94	-0.03	-0.02	D/S Bdy Area 20
2972	Bridge			Bridge					Windsor Rd
2950	71.02	39.13	1.41	67.58	39.10	1.38	-0.03	-0.03	
2882	71.02	38.74	0.76	67.58	38.71	0.74	-0.03	-0.02	
2796	72.97	38.2	1.82	69.63	38.17	1.80	-0.03	-0.02	
2691	72.97	37.97	0.71	69.63	37.95	0.70	-0.02	-0.01	
2621	72.97	37.52	2.13	69.63	37.50	2.12		-0.01	
2519	72.97	37.22	0.63	69.63	37.19	0.62	-0.03	-0.01	
2355	72.97	36.44	1.74	69.63	36.39	1.74	-0.05	0	
2250	72.97	36.04	1.42	69.63	35.99	1.40	-0.05	-0.02	
2098	72.97	35.73	1.21	69.63	35.68	1.20	-0.05	-0.01	
2005	72.97	35.57	1.16	69.63	35.52	1.15	-0.05	-0.01	
1948	72.97	35.44	1.37	69.63	35.39	1.34	-0.05	-0.03	
1907	72.97	35.25	1.78	69.63	35.2	1.74	-0.05	-0.04	
1900	Bridge			Bridge					Withers Rd
1890	72.97	34.65	3.34	69.63	34.61	3.31	-0.04	-0.03	

100 Year ARI

A summary of the results for the 100 year ARI event are shown in Table 8.3. Generally, the results of the JWP HEC-RAS assessment for the 100 year ARI event show a decrease in the flood levels of up to 280mm within the Area 20 Precinct as a result of the development. This is primarily as a result of a decrease in 100 year ARI peak flows, as discussed in Section 7.6. There are some minor increases in flood levels of up to 10mm within the Area 20 Precinct site.

There are minor decreases in the flood levels upstream of the Area 20 Precinct site of up to 40mm. There are minor decreases to 100 year ARI flood levels downstream of the site.

Table 8.3

**COMPARISON OF PEAK FLOOD LEVELS
100 YEAR ARI**

JWP (AREA 20 UNDEVELOPED)				JWP (AREA 20 DEVELOPED)			Differences		Comment
River Sta	Q Total (m3/s)	W.S. Elev (m)	Vel Chnl (m/s)	Q Total (m3/s)	W.S. Elev (m)	Vel Chnl (m/s)	W.S. Elev Post - Exist (m)	Vel Chnl (m/s)	
4996	68.3	47.53	0.91	68.3	47.53	0.91	0	0	
4985	Bridge			Bridge					Schofields Rd
4972	68.3	47.11	1.69	68.3	47.11	1.69	0	0	U/S Bdy Area 20
4928	68.3	46.77	1.19	68.3	46.77	1.19	0	0	
4798	68.3	46.47	0.63	68.3	46.46	0.63	-0.01	0	
4685	68.3	46.14	1.39	68.3	46.13	1.41	-0.01	0.02	
4680				Bridge					Rail Bridge
4568	71.43	45.31	1.51	73.58	45.31	1.55	0	0.04	
4477	71.43	45.01	0.85	73.58	44.98	0.89	-0.03	0.04	
4392	79.06	44.7	1.21	76.31	44.67	1.18	-0.03	-0.03	
4304	79.06	44.39	1.05	76.31	44.36	1.04	-0.03	-0.01	
4218	79.06	44.03	1.38	76.31	44.01	1.37	-0.02	-0.01	
4139	79.06	43.86	0.68	76.31	43.84	0.66	-0.02	-0.02	
4027	90.61	43.68	0.79	87.6	43.66	0.78	-0.02	-0.01	
3975	90.61	43.62	0.65	87.6	43.6	0.64	-0.02	-0.01	
3880	90.61	43.35	1.46	87.6	43.34	1.42	-0.01	-0.04	
3870	Bridge			Bridge					Rouse Road
3856	90.61	43.16	1.75	87.6	43.12	1.72	-0.04	-0.03	
3798	90.61	42.79	1.55	87.6	42.76	1.54	-0.03	-0.01	
3727	90.61	42.46	1.13	87.6	42.42	1.13	-0.04	0	
3624	93.06	42	1.17	88.12	41.96	1.14	-0.04	-0.03	
3533	93.06	41.69	0.77	88.12	41.66	0.74	-0.03	-0.03	
3465	93.06	41.5	1	88.12	41.48	0.96	-0.02	-0.04	
3378	93.06	41.36	0.74	88.12	41.36	0.7	0	-0.04	
3286	93.06	41.29	0.45	88.12	41.29	0.42	0	-0.03	
3227	93.06	41.26	0.5	88.12	41.26	0.47	0	-0.03	
3141	95.2	41.23	0.34	90.1	41.24	0.32	0.01	-0.02	
3025	95.2	41.19	0.48	90.1	40.91	2.01	-0.28	1.53	
3021	Bridge			Bridge					Windsor Rd (Old)
3011	95.2	40.05	2.66	90.1	40	2.58	-0.05	-0.08	
2991	95.2	40.02	1.12	90.1	39.97	1.09	-0.05	-0.03	D/S Bdy Area 20
2972	Bridge			Bridge					Windsor Rd
2950	95.2	39.33	1.58	90.1	39.29	1.55	-0.04	-0.03	
2882	95.2	38.93	0.85	90.1	38.9	0.83	-0.03	-0.02	
2796	99.13	38.36	2.03	94.36	38.34	1.99	-0.02	-0.04	
2691	99.13	38.11	0.8	94.36	38.09	0.78	-0.02	-0.02	
2621	99.13	37.69	2.09	94.36	37.66	2.1	-0.03	0.01	
2519	99.13	37.4	0.68	94.36	37.37	0.67	-0.03	-0.01	
2355	99.13	36.74	1.69	94.36	36.69	1.7	-0.05	0.01	
2250	99.13	36.39	1.54	94.36	36.33	1.52	-0.06	-0.02	
2098	99.13	36.11	1.28	94.36	36.05	1.27	-0.06	-0.01	
2005	99.13	35.98	1.21	94.36	35.91	1.2	-0.07	-0.01	
1948	99.13	35.83	1.55	94.36	35.76	1.53	-0.07	-0.02	
1907	99.13	35.6	2.06	94.36	35.54	2.01	-0.06	-0.05	
1900	Bridge			Bridge					Withers Rd
1890	99.13	34.92	3.56	94.36	34.88	3.53	-0.04	-0.03	

PMF

A summary of the results for the PMF event are shown in Table 8.4. Generally, the results of the JWP HEC-RAS assessment for the PMF event show a decrease in the flood levels of up to 980mm within the Area 20 Precinct downstream of the proposed rail bridge (and 1.96 metres at the downstream boundary) as a result of the development. This is primarily as a result of a decrease in PMF peak flows, as discussed in Section 7.6. PMF flood levels increase by up to 860mm immediately upstream of the rail bridge.

PMF flood levels increase by up to 90mm immediately upstream of the Area 20 Precinct site. There are minor decreases to PMF flood levels downstream of the site.

Table 8.4

COMPARISON OF PEAK FLOOD LEVELS
PMF

JWP (AREA 20 UNDEVELOPED)				JWP (AREA 20 DEVELOPED)			Differences		Comment
River Sta	Q Total (m3/s)	W.S. Elev (m)	Vel Chnl (m/s)	Q Total (m3/s)	W.S. Elev (m)	Vel Chnl (m/s)	W.S. Elev Post - Exist (m)	Vel Chnl (m/s)	
4996	527.44	49.32	1.15	527.44	49.41	1.1	0.09	-0.05	
4985	Bridge			Bridge					Schofields Rd
4972	527.44	48.99	1.38	527.44	49.36	1.12	0.37	-0.26	U/S Bdy Area 20
4928	527.44	48.83	1.55	527.44	49.28	1.22	0.45	-0.33	
4798	527.44	48.47	1.33	527.44	49.11	0.98	0.64	-0.35	
4685	527.44	48.12	1.79	527.44	48.98	1.12	0.86	-0.67	
4680									Rail Bridge
4568	527.44	47.48	2.19	527.44	47.47	2.22	-0.01	0.03	
4477	527.44	47.1	1.66	527.44	47.07	1.69	-0.03	0.03	
4392	537.74	46.8	1.74	550.98	46.73	1.86	-0.07	0.12	
4304	572.03	46.48	1.72	558.35	46.37	1.78	-0.11	0.06	
4218	572.03	46.2	1.69	558.35	46.05	1.76	-0.15	0.07	
4139	572.03	46.01	1.23	558.35	45.83	1.3	-0.18	0.07	
4027	625.82	45.78	1.4	605.96	45.55	1.47	-0.23	0.07	
3975	625.82	45.67	1.38	605.96	45.4	1.57	-0.27	0.19	
3880	625.82	45.49	1.37	605.96	45.15	1.56	-0.34	0.19	
3870	Bridge			Bridge					Rouse Road
3856	625.82	45.25	1.52	605.96	45.12	1.58	-0.13	0.06	
3798	625.82	45.08	1.82	605.96	44.92	1.93	-0.16	0.11	
3727	625.82	44.84	1.66	605.96	44.63	1.78	-0.21	0.12	
3624	635.67	44.53	1.65	607.43	44.23	1.77	-0.3	0.12	
3533	635.67	44.26	1.44	607.43	43.89	1.57	-0.37	0.13	
3465	635.67	44.1	1.55	607.43	43.64	1.83	-0.46	0.28	
3378	635.67	43.96	1.33	607.43	43.4	1.58	-0.56	0.25	
3286	635.67	43.86	0.9	607.43	43.24	1.07	-0.62	0.17	
3227	635.67	43.82	0.95	607.43	43.16	1.15	-0.66	0.2	
3141	640.39	43.76	0.85	611.24	43.05	1.04	-0.71	0.19	
3025	640.39	43.67	1.07	611.24	42.83	1.57	-0.84	0.5	
3021	Bridge			Bridge					Windsor Rd (Old)
3011	640.39	43.56	1.61	611.24	42.58	3.06	-0.98	1.45	
2991	640.39	43.55	0.91	611.24	41.59	3.89	-1.96	2.98	D/S Bdy Area 20
2972	Bridge			Bridge					Windsor Rd
2950	640.39	41.5	3.7	611.24	41.43	3.6	-0.07	-0.1	
2882	640.39	41.11	1.88	611.24	41.04	1.85	-0.07	-0.03	
2796	658.52	40.06	4.14	631.21	40.01	4.07	-0.05	-0.07	
2691	658.52	39.96	1.22	631.21	39.91	1.2	-0.05	-0.02	
2621	658.52	39.83	1.44	631.21	39.78	1.42	-0.05	-0.02	
2519	658.52	39.74	0.94	631.21	39.7	0.92	-0.04	-0.02	
2355	658.52	39.57	1.44	631.21	39.53	1.4	-0.04	-0.04	
2250	658.52	39.43	2.12	631.21	39.39	2.06	-0.04	-0.06	
2098	658.52	39.23	1.93	631.21	39.21	1.87	-0.02	-0.06	
2005	658.52	39.05	2.44	631.21	39.03	2.35	-0.02	-0.09	
1948	658.52	38.92	2.56	631.21	38.92	2.46	0	-0.1	
1907	658.52	38.79	2.74	631.21	38.8	2.62	0.01	-0.12	
1900	Bridge			Bridge					Withers Rd
1890	658.52	38.02	3.31	631.21	37.92	3.32	-0.1	0.01	

8.8.2. Flood Level Results Comparison – JWP Ultimate Development and Sydney Water Adopted Ultimate Development (Flood Model Scenarios 2 and 3)

100 Year ARI

A summary of the 100 year ARI flood levels determined for both the Sydney Water adopted and JWP models are shown in Table 8.5. For the 100 year ARI event, the majority of flood levels in the southern portion of the Area 20 site (south of Rouse Road) increase in the JWP model, up to 430mm. There are minor decreases of up to 60mm. The differences can be attributed to the higher flows in the JWP model and variations in channel invert levels between the two models, as shown in Table 8.5.

The 100 year ARI flood levels within the northern portion of the site (between Rouse and Windsor Roads) all decrease except immediately downstream of Rouse Road where there is a 150mm increase. The 100 year ARI flood levels decrease by up to 2.48 metres over those in the Sydney Water adopted model. This can be explained by the difference in location of the old Windsor Road bridge in the models, as well as the geometry of the channel / floodplain in the area. The old Windsor Road bridge, which has a much narrower opening than the new bridge, has been inserted at different locations in the models. The Sydney Water adopted model appears to have included the old bridge at the section which represents the approximate location of the new bridge. Hence, when comparing sections at similar locations, the flood levels in the JWP model are much lower immediately upstream of the new Windsor Road bridge as there is no longer the constriction caused by the narrower old bridge opening. It is also noted that the Sydney Water adopted model does not include the new Windsor Road bridge.

It is also noted that the channel section immediately upstream of the old Windsor Road bridge differ in the models. The Sydney Water adopted model section is narrower than the JWP section and the overbank levels are also higher. The combination of these two factors results in the section acting as a major constriction and causes the velocities to decrease and increase flood levels. This effect transfers almost all the way back to Rouse Road.

Due to the nature of the terrain adjacent to Second Ponds Creek, the increases in flood levels within Area 20 do not result in a significant increase in flood extents from those in Sydney Water's adopted model. Furthermore, in some cases, due to updated survey data, the flood extents determined in this investigation are less than those in Sydney Water's adopted model, despite the increase in peak flows.

The flood extents for the ultimate case 2, 20 and 100 year ARI storm events as well as the PMF are shown on Figure 6. The 100 year ARI flood extents from Sydney Water's adopted model are also shown on Figure 6.

Table 8.5

COMPARISON OF GHD & JWP PEAK FLOOD LEVELS
100 YEAR ARI

GHD (Sydney Water Adopted Model)				JWP				Differences	Comment
River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	River Sta	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	W.S. Elev JWP-GHD (m)	
6000	45	48.31	50.44	5687	60.06	48.31	51.15	0.71	
5977.5	Bridge			5640	Bridge				Greenview Pde
5900	45	47.58	49.88	5580	60.06	47.58	50.27	0.39	
5800	45	47.53	49.36	5474	60.06	47.53	49.54	0.18	
5710	45	47.68	49.01	5373	60.06	47.68	49.12	0.11	
5600	45	47.69	48.19	5261	60.06	47.69	48.46	0.27	
5500	50	45.66	47.58	5180	64	45.66	47.91	0.33	
5400	50	45.02	47.15	5107	64	45.02	47.78	0.63	
5290	53.9	44.22	46.99	5017	68.3	44.31	47.59	0.6	
5285	53.9	44.02	46.99	4996	68.3	44.36	47.53	0.54	
5277.5	Bridge			4985	Bridge				Schofields Rd
5270	53.9	44.1	46.73	4972	68.3	44.34	47.11	0.38	U/S Bdy Area 20
5260	53.9	44.13	46.7	4928	68.3	44.08	46.77	0.07	
5100	50.81	43.45	46.34	4798	68.3	43.61	46.46	0.12	
5000	50.81	43	45.83	4685	68.3	43.23	46.13	0.3	
				4680					Rail Bridge
4900	50.81	43.11	45.3	4568	73.58	42.81	45.31	0.01	
4800	50.81	42.44	45.03	4477	73.58	41.44	44.98	-0.05	
4700	50.81	41.78	44.73	4392	76.31	40.91	44.67	-0.06	
4600	50.81	41.16	44.38	4304	76.31	40.19	44.36	-0.02	
4500	56.61	40.52	44.02	4218	76.31	40.01	44.01	-0.01	
4400	56.61	40.48	43.71	4139	76.31	40.47	43.84	0.13	
4300	56.61	40.24	43.47	4027	87.6	40.17	43.66	0.19	
4160	56.61	39.84	43.17	3975	87.6	40.2	43.6	0.43	
4150	56.61	39.93	43.15	3880	87.6	39.81	43.34	0.19	
4145	Bridge			3870	Bridge				Rouse Road
4120	56.61	39.29	42.97	3856	87.6	39.48	43.12	0.15	
4000	56.61	38.88	42.78	3727	87.6	38.82	42.42	-0.36	
3900	63.9	38.94	42.63	3624	88.12	38.79	41.96	-0.67	
3800	63.9	38.48	42.56	3533	88.12	38.73	41.66	-0.9	
3700	63.9	37.68	42.52	3465	88.12	37.59	41.48	-1.04	
3600	63.9	37.47	42.49	3378	88.12	37.25	41.36	-1.13	
3500	63.9	37.49	42.47	3286	88.12	38.34	41.29	-1.18	
3400	63.9	37.55	42.46	3227	88.12	38.11	41.26	-1.2	
3300	63.9	37.44	42.46	3141	90.1	38.08	41.24	-1.22	
				3021	Bridge				Windsor Rd (Old)
3160	63.9	36.76	42.45	3011	90.1	37.39	40	-2.45	
3150	63.9	38.25	42.45	2991	90.1	37.63	39.97	-2.48	D/S Bdy Area 20
3145	Bridge			2972	Bridge				Windsor Rd (JWP)
3120	63.9	36.64	39.5	2950	90.1	36.95	39.29	-0.21	
3000	69.2	36.42	39.17	2882	90.1	36.37	38.9	-0.27	
				2796	94.36	36.6	38.34	-0.23	
2820	69.2	34.64	38.57	2691	94.36	35.65	38.09	-0.48	
2700	69.2	33.74	37.72	2621	94.36	35.5	37.66	-0.06	
2600	69.2	35.18	37.49	2519	94.36	35.7	37.37	-0.12	
2450	69.2	33.3	37.18	2355	94.36	34.93	36.69	-0.49	
2360	69.2	32.12	36.82	2250	94.36	33.58	36.33	-0.49	
2200	74.13	31.35	36.5	2098	94.36	33.53	36.05	-0.45	
2100	74.13	31.76	36.39	2005	94.36	33.05	35.91	-0.48	
2005	74.13	33.28	36.28	1948	94.36	32.24	35.76	-0.52	
2000	74.13	33.8	36.27	1907	94.36	32.16	35.54	-0.73	
1990	Bridge			1900	Bridge				Withers Rd
1980	74.13	33	35.57	1890	94.36	32.23	34.88	-0.69	

8.8.3. Climate Change Impacts On Flood Levels (Flood Model Scenarios 2 and 4)

The results of the climate change sensitivity analysis indicate that there will be increases to the 100 year ARI flood levels of up to 370mm on Second Ponds Creek as a result of climate change. However, this increase will be within the existing Rouse Hill Regional Park where there is no proposed development. The maximum increase within the area proposed for future residential development is 180mm.

The *Draft Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments, October 2009* Department of Environment, Climate Change and Water addresses the issue of the *"variation in sensitivity of estimated design flood levels to flood flow"* through the use of a 0.5 m freeboard, on floodplains. *"This freeboard includes a component related to climate change impacts on flood levels in both coastal and non-coastal areas"*. Whilst this information is designed to assist with Floodplain Risk Management planning, *it "provides only a relatively small allowance to accommodate some of the projected increases in rainfall intensity of flood-producing storm events associated with climate change, which has currently not been accurately quantified"*. Consequently confirmation of the amount of freeboard, which can be allocated to Climate Change impacts in local catchments, is still to be confirmed. The amount of freeboard required above the Designated Flood Levels in the channels and basins impacts on the area of land required as Trunk Drainage Reserve.

Increases in flood depths due to Climate Change of the magnitude predicted within the proposed urban zones of Area 20 (i.e. up to 180mm) can be accommodated within the normal 500mm freeboard requirements of Blacktown City Council.

A summary of the results of the climate change assessment for the 100 year ARI event are included in Table 8.6.

Table 8.6

COMPARISON OF PEAK FLOOD LEVELS
100 YEAR ARI CLIMATE CHANGE SENSITIVITY ASSESSMENT

River Sta	Pre Climate Change		Post Climate Change		Differences	Comment
	Q Total (m3/s)	W.S. Elev (m)	Q Total (m3/s)	W.S. Elev (m)	W.S. Elev (m)	
5687	60.06	51.15	71.04	50.43	-0.72	
5640	Bridge		Bridge			Greenview Pde
5580	60.06	50.27	71.04	50.41	0.14	
5474	60.06	49.54	71.04	49.65	0.11	
5373	60.06	49.12	71.04	49.21	0.09	
5261	60.06	48.46	71.04	48.48	0.02	
5229	60.06	48	71.04	48.21	0.21	
5180	64	47.91	76.07	48.15	0.24	
5107	64	47.79	76.07	48.06	0.27	
5017	68.3	47.59	80.91	47.91	0.32	
4996	68.3	47.53	80.91	47.85	0.32	
4985	Bridge		Bridge			Schofields Rd
4972	68.3	47.12	80.91	47.25	0.13	U/S Bdy Area 20
4928	68.3	46.77	80.91	46.9	0.13	
4798	68.3	46.48	80.91	46.59	0.11	
4685	68.3	46.17	80.91	46.25	0.08	
4680			Bridge			
4568	74.82	45.32	85.96	45.45	0.13	
4477	74.82	44.99	85.96	45.13	0.14	
4392	76.4	44.67	89.05	44.82	0.15	
4304	76.4	44.36	91.54	44.52	0.16	
4218	76.4	44.01	91.54	44.18	0.17	
4139	76.4	43.84	91.54	44	0.16	
4027	87.45	43.65	102.59	43.83	0.18	
3975	87.45	43.6	102.59	43.78	0.18	
3880	87.45	43.34	102.59	43.49	0.15	
3870	Bridge		Bridge			Rouse Rd
3856	87.45	43.12	102.59	43.28	0.16	
3798	87.45	42.76	102.59	42.9	0.14	
3727	87.45	42.42	102.59	42.55	0.13	
3624	87.96	41.96	103.44	42.09	0.13	
3533	87.96	41.66	103.44	41.79	0.13	
3465	87.96	41.47	103.44	41.6	0.13	
3378	87.96	41.35	103.44	41.47	0.12	
3286	87.96	41.29	103.44	41.39	0.1	
3227	87.96	41.26	103.44	41.36	0.1	
3141	89.95	41.23	105.67	41.33	0.1	
3025	89.95	40.9	105.67	41.29	0.39	
3021	Bridge		Bridge			Windsor Rd (Old)
3011	89.95	40	105.67	40.14	0.14	
2991	89.95	39.97	105.67	40.11	0.14	D/S Bdy Area 20
2972	Bridge		Bridge			Windsor Rd
2950	89.95	39.29	105.67	39.41	0.12	
2882	89.95	38.9	105.67	39.01	0.11	
2796	94.18	38.33	110.86	38.43	0.1	
2691	94.18	38.09	110.86	38.16	0.07	
2621	94.18	37.66	110.86	37.76	0.1	
2519	94.18	37.37	110.86	37.48	0.11	
2355	94.18	36.68	110.86	36.86	0.18	
2250	94.18	36.33	110.86	36.54	0.21	
2098	94.18	36.05	110.86	36.28	0.23	
2005	94.18	35.9	110.86	36.15	0.25	
1948	94.18	35.76	110.86	36.01	0.25	
1907	94.18	35.53	110.86	35.76	0.23	
1900	Bridge		Bridge			Withers Rd
1890	94.18	34.88	110.86	35.01	0.13	

8.8.4. Flood Extent Mapping

Flood extent mapping was undertaken for the JWP ultimate 2, 20 and 100 year ARI and PMF case scenarios as well as the climate change sensitivity analysis (Scenario 3) for the 100 year ARI event. The flood extent mapping is shown on Figures 6 and 7. Difference mapping for climate change assessment was also created using the WaterRide package to allow a visual comparison of the correlation in flood levels and flood inundation extents between the two scenarios. The difference map is shown in Figures 8.

8.9. Drainage Reserves

Two drainage reserves are proposed within the Area 20 Precinct where the subcatchments exceed 15 hectares or flows from subcatchments approaching 15 hectares in area are concentrated to one point before discharging to Second Ponds Creek. The location of the drainage reserves are shown on Figure 4. The drainage reserves have been sized using Manning's calculations utilising design peak 100 year ARI flows extracted from the XP-Rafts model.

The calculations for the drainage reserves are included in Attachment F.

The impact of climate change on the function of the drainage reserves has been assessed and can be accommodated within the first 200 mm of the available 500 mm freeboard.

The impact of climate change on the function of the drainage easements was also assessed and will not result in a depth of flow greater than 200 mm or a velocity depth product greater than 0.4.

The calculations for the impact of climate change on the drainage reserves / easements are included in Attachment G.

8.10. Flood Safety Evaluation

A Flood Safety Evaluation was undertaken by Molino Stewart Pty Ltd to assess the flood safety aspects of the proposed Area 20 development. The evaluation found that storm events up to and including the PMF posed a low risk to life for residents within the proposed Area 20 development. The Flood Safety Evaluation is included in Attachment H. The flood hazard mapping for the 100 year ARI and PMF events are shown on Figures 9 and 10, respectively.

9. WATER QUALITY ANALYSIS

The water quality analysis for this study was undertaken using the model MUSIC (Model for Urban Stormwater Improvement Conceptualisation) version 3.01 (Ref. 21). This water quality modelling software was developed by the Cooperative Research Centre (CRC) for Catchment Hydrology, which is based at Monash University and was first released in July 2002. Version 3.01 was released in May 2005.

The model provides a number of features relevant for the development:

- It is able to model the potential nutrient reduction benefits of gross pollutant traps, constructed wetlands, grass swales, bio-retention systems, sedimentation basins, infiltration systems and it incorporates mechanisms to model stormwater re-use as a treatment technique;
- It provides mechanisms to evaluate the attainment of water quality objectives;
- Allows for a Stream Erosion Index assessment.

The MUSIC modelling was undertaken to demonstrate that the water cycle management system proposed for the development will result in reductions in overall post-development pollutant loads and concentrations being discharged from the proposed development and that these discharges comply with the designated target objectives.

9.1. Catchments

A MUSIC model was established for the proposed stormwater management system for the Area 20 Precinct development. The extent of the catchments is shown on Figure 3 and Plate 4 shows the general arrangement of the MUSIC model.

In accordance with Blacktown City Council's Draft WSUD Policy (2008) (Ref. 11) an overall fraction impervious of 0.85 was adopted (new residential lot including half road). The catchments were split into roofs, roads, other impervious area, pervious area and natural, as appropriate to represent each post development subcatchment within the Area 20 development.

All urbanised areas will discharge to the water quality elements prior to discharge to Second Ponds Creek.

The general arrangement of the MUSIC model for the treatment train is shown on Plate 4.

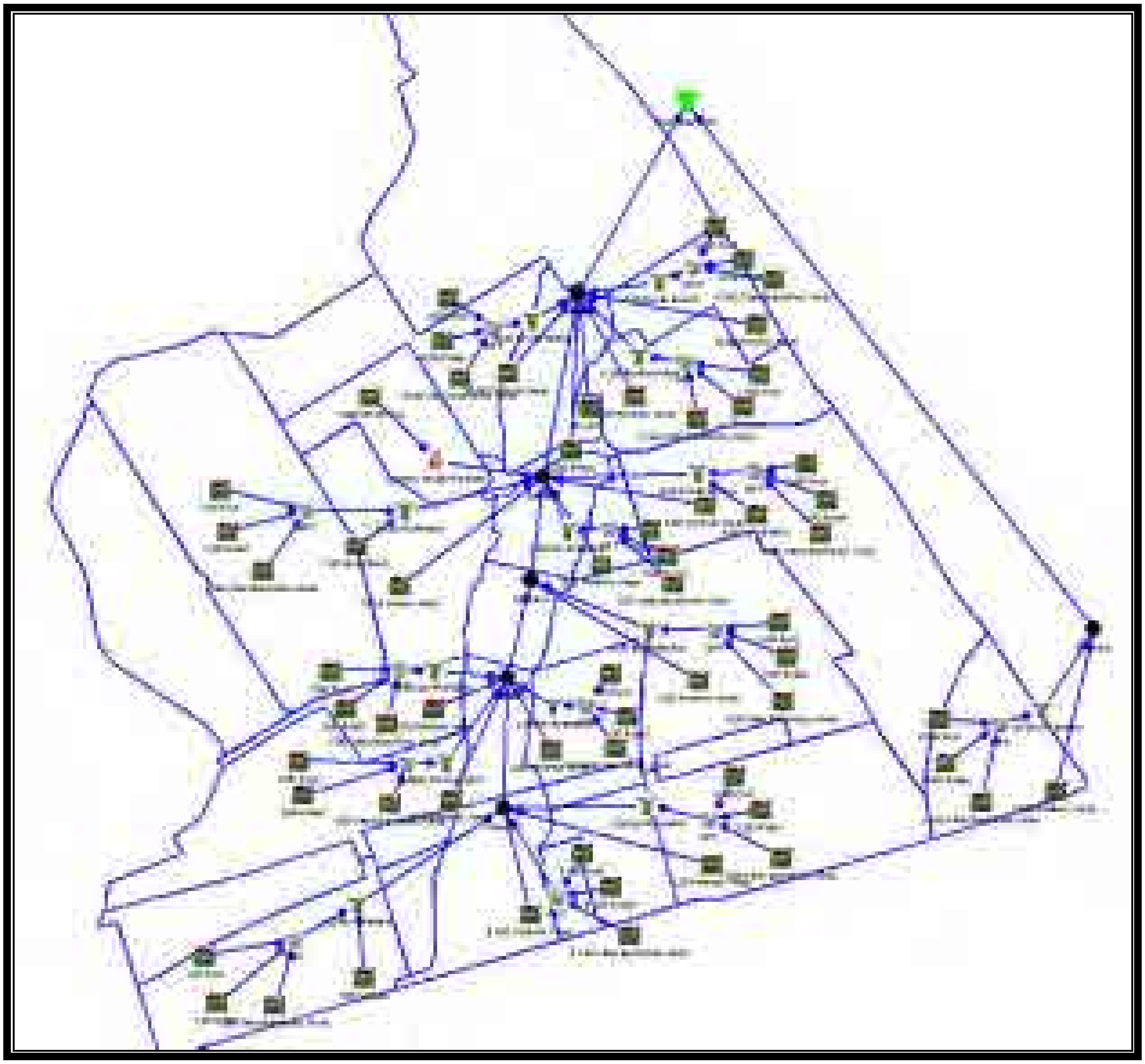


Plate 4: MUSIC Model Layout
(8622MU_2.sqz)

9.2. Rainfall Data

The MUSIC model is able to utilise rainfall data based on 6 minute, hourly, 6 hourly and daily time steps. A 6 minute time step was used in the analysis which was chosen in accordance with the recommendations for selecting a time step within the MUSIC Users Manual (Ref. 21).

Rainfall records for the area were provided by Blacktown City Council. The nearest rainfall station to the site with a reasonable period of 6 minute rainfall data for a suitably representative period of rainfall for the site nominated by Council was:

Station No	Location	Years of Record	Type of Data
67033	Liverpool	1967 - 1976	6 minute

It is understood that Blacktown Council have modified the data supplied by the Bureau of Meteorology for the Liverpool site to rectify a significant amount of missing data between 1974 – 1976. The mean annual rainfall in the data set supplied by Council is 857mm, while the mean annual rainfall available from the Bureau of Meteorology's long term data for the station closest to Area 20 (Seven Hills) is 915mm.

The rainfall and potential evapo-transpiration data for the period analysed is shown on the graph which is provided in Plate 5.

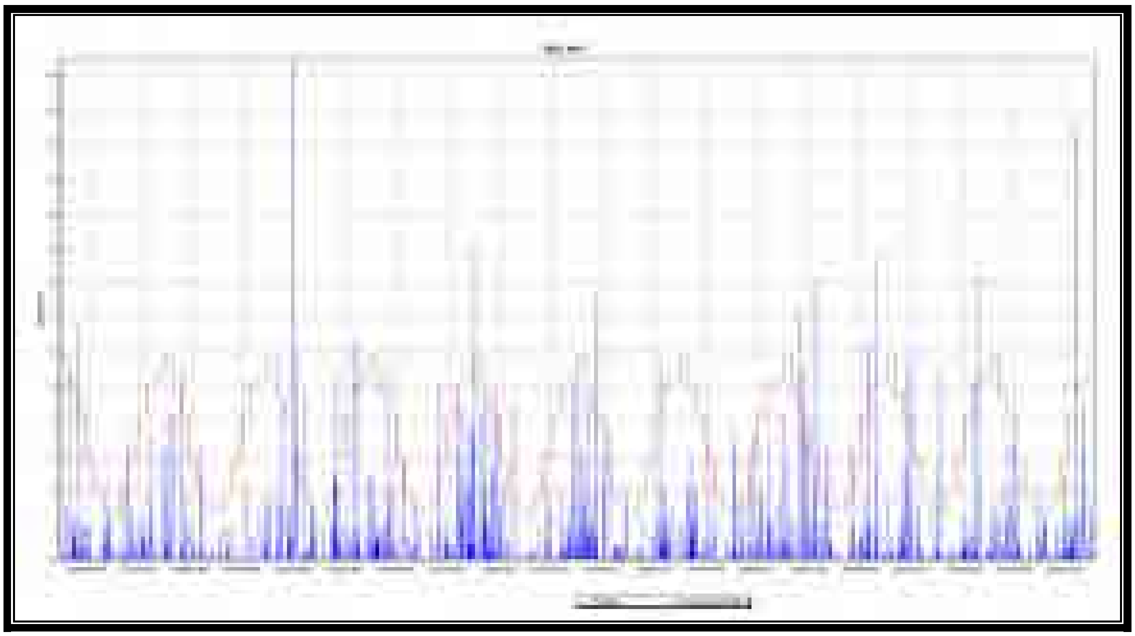


Plate 5: Rainfall & Evapo-Transpiration Data Adopted For Area 20 Precinct

9.3. Pollutant Loading Rates

In the absence of site specific data, the soil / groundwater parameters and pollutant loading rates adopted for the natural and urban catchments of the Area 20 site are based on the recommended parameters provided by the Department of Environment and Climate Change for areas within Western Sydney (Ref. 9) and the Cooperative Research Centre for Catchment Hydrology (Ref. 22). The adopted parameters are presented in Tables 9.1 and 9.2. These values are consistent with those nominated in Blacktown Council's draft WSUD Handbook (Ref. 11) for urban areas.

Table 9.1

ADOPTED SOIL / GROUNDWATER PARAMETERS FOR THE SITE (Source: DECC Technical Note – Ref. 9)

	Units	Urban	Non-Urban
Impervious Area Parameters			
Rainfall threshold (Road 1, Roof 0.5)	mm/day	1.4	1.4
Pervious Area Parameters			
Soil storage capacity	mm	170	210
Initial storage	% of capacity	30	30
Field capacity	mm	70	80
Infiltration capacity coefficient - a		210	175
Infiltration capacity coefficient - b		4.7	3.1
Groundwater Properties			
Initial depth	mm	10	10
Daily recharge rate	%	50	35
Daily baseflow rate	%	4	20
Daily deep seepage rate	%	0	0

Table 9.2

ADOPTED ANNUAL POLLUTANT EVENT MEAN CONCENTRATIONS (Source: CRCCH – Ref. 22)

	Natural		Roofs		Roads		Remaining Urban	
Pollutant	Base Flow (mg/L)	Storm Flow (mg/L)	Base Flow (mg/L)	Storm Flow (mg/L)	Base Flow (mg/L)	Storm Flow (mg/L)	Base Flow (mg/L)	Storm Flow (mg/L)
TSS	6.03	39.8	-	20.0	-	269	15.8	141
TP	0.030	0.079	-	0.129	-	0.501	0.141	0.251
TN	0.302	0.891	-	2.00	-	2.19	1.29	2.00

9.4. Treatment Device Performance

The location and size of the proposed raingardens is shown on Figure 4. The bio-retention sizes and design assumptions that were used are presented in Table 6.1.

The expected sediment and nutrient removal performance of the raingardens was determined using the default equations and parameters provided in the MUSIC model (Ref. 21). The water quality reduction mechanisms in MUSIC are based on an exponential decay equation referred to as the k – C* curve (refer to Wong et al. – Ref. 23).

The performance parameters used in the MUSIC model are summarised in Table 9.3.

It is assumed that trash and gross sediments will be effectively removed prior to entering the raingardens by the proposed GPT units. In order to reduce the ongoing maintenance requirements for the raingardens, the GPTs should be selected on the basis that they intercept, as a minimum, 90% of the sediment loads greater than 0.15 mm diameter. It is noted that any TSS or nutrient removal benefits afforded by GPT's have been conservatively excluded from the water quality modelling.

Table 9.3

MUSIC – PERFORMANCE PARAMETERS

	Bio-Retention	
Pollutant	**k (m/yr)**	**C* (mg/L)**
TSS	8000	20.000
TP	6000	0.130
TN	500	1.400

9.5. Pollutant Load Estimates

Total annual pollutant load estimates were derived using MUSIC for the developed site incorporating the proposed water quality treatment system.

The estimated annual pollutant loads and reductions are presented in Table 9.4.

Table 9.4

SUMMARY OF ESTIMATED MEAN ANNUAL POLLUTANT LOADS AND REDUCTIONS

	Mean Annual Loads (kg/yr)		
	TSS	**TP**	**TN**
Total Development Source Loads	167,000	321	2,280
Minimum Reduction Reqd. (%)	**85%**	**65%**	**45%**
Minimum Reduction Required (kg/yr)	141,950	209	1,026
Total Residual Load to Second Ponds Creek	22,200	87.2	1,250
Total Reduction Achieved (kg/yr)	144,800	234	1,030
Total Reduction Achieved (%)	**86.7%**	**72.8%**	**45.2%**

9.6. Discussion of Modelling

The performance of the proposed water quality management strategy for the Area 20 development obtained from the MUSIC model, as summarised in Table 9.4, shows that:

- In order to achieve the objective of an 85% reduction in TSS from the proposed Area 20 development, the minimum TSS reduction is 141,950 kg/yr. The MUSIC modelling predicts that TSS is reduced by 144,800 kg/yr. The water quality management strategy therefore achieves the target reductions for TSS.

- In order to achieve the objective of a 65% reduction in TP from the proposed Area 20 development, the minimum TP reduction is 209 kg/yr. The MUSIC modelling predicts that TP is reduced by 234 kg/yr. The water quality management strategy therefore achieves the target reductions for TP.

- In order to achieve the objective of a 45% reduction in TN from the proposed Area 20 development, the minimum TN reduction is 1,026 kg/yr. The MUSIC modelling predicts that TN is reduced by 1,030 kg/yr. The water quality management strategy therefore achieves the target reductions for TN.

The proposed bio-retention raingardens will meet the requirements specified in Blacktown City Council's Draft WSUD Handbook (Ref. 11) and the DECC water quality objectives (Ref. 9).

10. WATERWAY STABILITY MANAGEMENT AND STREAM EROSION INDEX

10.1. Introduction

Both the Department of Environment and Climate Change and Blacktown City Council have recently released draft guidelines (Ref. 9, 10 and 11) to address the risk of stream erosion from the urbanisation of catchments.

Stream erosion is assessed using a measure of the increase in the relative frequency in flows from the site greater than the identified "stream forming flow" resulting from urbanisation of the catchment. This measure is referred to as the Stream Erosion Index. The stream erosion index assessment is considered to be an appropriate means of assessing and addressing the impacts of urbanisation on the frequency of regular flows to the riparian corridor.

The stream erosion index is defined by the Department of Environment and Climate Change as the post development duration of flows greater than the 'stream forming flow' divided by natural duration of flows greater than the 'stream forming flow'. The 'stream forming flow' is defined as 50% of the 2 year ARI flow rate estimated for the catchment under natural conditions. The DECC guidelines recommend a stream erosion index of between 3.5 – 5, while Council's Draft WSUD Handbook recommends an index of 3 – 5.

10.2. Modelling

A typical catchment of 10 hectares draining to Second Ponds Creek was modelled using MUSIC to determine the stream erosion index. The catchment was split into nodes representing the roofs, roads, other impervious area and pervious areas, with a total impervious area of 85%, consistent with the water quality modelling described in Section 9. A bio-retention node representing a raingarden of 1,100m^2 (1.1% of catchment area) was incorporated in the model, again consistent with the water quality modelling.

The pre and post development scenarios were modelled in MUSIC as it allows a continuous simulation assessment and easy extraction of the flows and durations. A Forest node with 0% impervious was adopted to represent the pre development case.

10.3. Stream Forming Flow

The 2 year ARI flow was determined using Probabilistic Rational Method calculations. From this the stream forming flow was determined to be 0.305m^3/sec for the typical 10 hectare catchment within the Area 20 site, as shown below in Table 10.1.

Table 10.1

DETERMINATION OF STREAM FORMING FLOW

PRM - PROBABILISTIC RATIONAL METHOD - SMALL RURAL CATCHMENTS

LOCATION			**AREA 20 PRECINCT - ROUSE HILL**	
COEFFICIENTS LOCATION		**=**	BLACKTOWN	
TOTAL SITE AREA	(Ar)	=	10.00 ha.	
Time of Conc.	(tcr)	=	19.01 min.	
West of Line		=	0	(1=yes, 0=no)
Runoff Coefficient	(C10)	=	0.5	(Volume 2 ARR - 1987)
Elevation	(El)	=	50.00 m	

ARI (yr)	C	I (mm/hr)	Q (cu.m/s)
1	0.310	46.3	0.399
2	0.370	59.4	0.610
5	0.440	75.5	0.923
10	0.500	84.8	1.177
20	0.560	97.1	1.510
50	0.617	113.0	1.939
100	0.678	125.1	2.358
50% of 2 Year			0.305

Ten years of six minute rainfall data was used in the simulation. The rainfall data described in Section 9.2 was adopted for the assessment.

The results of the stream erosion index assessment are summarised in Table 10.2 below.

Table 10.2

STREAM EROSION INDEX

Development Scenario	No. Times Stream Forming Flow Exceeded	Duration of Stream Forming Flow Exceedance (mins)	Stream Erosion Index (Post / Pre)
Pre Development	109	654	
Post Development	497	2982	4.6

10.4. Discussion of Modelling

The results of the modelling as summarised in Table 10.2 shows that:

- For the pre development case the stream forming flow is exceeded 109 times or approximately 654 minutes for the 11 years of rainfall data assessed.

- Urbanisation of the catchment, including provision of the WSUD elements and detention basin, will result in the stream forming flow being exceeded 497 times or 2982 minutes for the 11 years of data assessed.

- This arrangement results in the attainment of a Stream Erosion Index of 4.6, which is within Blacktown City Council's and the Department of Environment and Climate Change's recommended values.

- The provision of WSUD elements within the Area 20 Precinct development will assist in minimising the impact of urbanisation on the waterway stability of Second Ponds Creek.

11. DETAILED CONCEPT DESIGNS

Detailed concept designs were prepared for each of the proposed water quality bioretention basins. Estimates of quantities and preliminary cost estimates were also prepared for each of the basins. This information will assist Blacktown City Council in the preparation of the Section 94 plan for the development.

The basins have been designed to achieve a balance of cut and fill for each individual element, as required by Blacktown Council. This requirement has meant that the bed of the bioretention basins have had to be raised higher than otherwise would have been necessary to achieve the balance. In turn, this will require additional filling for the land adjacent to Second Ponds Creek to allow the roads and lots within this zone to be able to drain to the basins. At development application stage, opportunities should be explored to lower the bioretention basins as much as possible to minimise the extent of additional fill required within the development.

The detailed concept designs and estimate of quantities are included in Attachment I.

11.1. Preliminary Construction Cost Estimates

A summary of the costs associated with the construction of the bio-retention raingarden basins and their associated vegetation are presented in a simplified form in Table 11.1. A more detailed breakdown of the Estimate of Quantities and the associated construction estimate for each basin is provided in Attachment I.

Table 11.1

SUMMARY OF RAINGARDEN CONSTRUCTION COSTS

NO.	ITEM	AMOUNT Exc GST$
1	RAINGARDEN 1	$794,000.00
2	RAINGARDEN 2	$890,000.00
3	RAINGARDEN 3	$618,000.00
4	RAINGARDEN 4	$392,000.00
5	RAINGARDEN 5	$366,000.00
6	RAINGARDEN 6	$1,132,000.00
7	RAINGARDEN 7	$1,740,000.00
8	RAINGARDEN 8	$936,000.00
9	RAINGARDEN 9	$291,000.00
10	RAINGARDEN 10	$543,000.00
11	RAINGARDEN 11	$545,000.00
12	RAINGARDEN 12	$415,000.00
13	RAINGARDEN 13	$514,000.00
	RAINGARDENS TOTAL	**$9,176,000.00**

12. SUMMARY & CONCLUSION

The Water Cycle Management Strategy for Area 20 Precinct has been prepared to inform the Precinct planning process and support the rezoning process for the site. The strategy has been prepared to conform with the statutory requirements and industry best practice for stormwater management in this catchment.

The Water Cycle Management Strategy consists of a treatment train consisting of on lot treatment, street level treatment and subdivision / development treatment measures. The structural elements proposed for the development consists of:

- Proprietary GPT units at each stormwater discharge point.
- Thirteen proposed bio-retention raingardens of total area 16,385m².

Existing Sydney Water regional detention basins, external to the Area 20 development site, will manage peak discharges in Second Ponds Creek to Sydney Water requirements.

The Sydney Water adopted hydraulic model was reviewed and updated recently by SKM (Ref. 2) to correct the peak input flows resulting from some identified inconsistencies with the hydrology model. The hydraulic model was further modified as part of this investigation to more accurately represent the proposed land use break up within Area 20 and the landform within the upstream The Ponds residential development, along with some additional minor inconsistencies with the hydrology. The proposed rail bridge within the Area 20 Precinct was also included in the updated hydraulic model. The hydrology modelling undertaken shows that urbanisation of the Area 20 Precinct will, in most cases, reduce peak flows from the existing levels within and downstream of the site. This is due to the timing of peak flows from the development in relation to the peak flows from the large upstream catchment.

A comparison of flood model results for the Second Ponds Creek catchment with and without development in the Area 20 Precinct shows that urbanisation will, for the majority of cases, reduce flood levels. This is due to the decrease in peak flow rates as a result of urbanising the catchment, as discussed above.

When comparing the flood model results obtained in this investigation and those in Sydney Water's adopted model, there is an increase of up to 430mm in the 100 year ARI flood levels within the Area 20 development. The increases in flood levels are a result of increased flows and differences in creek invert levels. Despite the increase is flood levels, the flood extents do not vary greatly from Sydney Water's adopted extents. In some cases the 100 year ARI flood extents are less than Sydney Water's current adopted extents (despite increases in the peak flows) due to the more up to date terrain model adopted in the current modelling.

Climate Change impacts have been assessed on the basis of increasing the flows in Second Ponds Creek by 15% and reviewing the associated risks to adjoining infrastructure and fill levels. The increase in peak flows resulting from a 15% increase in rainfall intensity resulted in a reduction of up to approximately 180 mm in the freeboard allowed for the 100 year ARI flood levels. According to *the Draft Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments, October 2009* Department of Environment, Climate Change and Water, the 0.5 m freeboard allowance in floodplains is capable of absorbing small increases in flood levels resulting from Climate Change impact assessments. Consequently, the Blacktown City Council standard 0.5 metre freeboard allowance is recommended to be retained.

Provision of the proposed water quality treatment devices within the development will ensure that the post development stormwater discharges will meet Blacktown Council's and the Department of Environment and Climate Change's water quality objectives for the Area 20 Precinct development.

The provision of WSUD elements within the Area 20 Precinct development will assist in minimising the impact of urbanisation on the waterway stability of Second Ponds Creek and comply with the Department of Environment, Climate Change and Water Stream Erosion Index and water quality targets.

The proposed Water Cycle Management Strategy for the developed site provides a basis for the detailed design and development of the site to ensure that the environmental, urban amenity, engineering and economic objectives for stormwater management and site discharge are achieved.

13. REFERENCES

1. GHD (1998). Rouse Hill Stage 1 Area Trunk Drainage – Strategy Review

2. SKM (2009). Rouse Hill Integrated Stormwater Strategy Review

3. NSW Department of Environment and Climate Change (2008) NSW Climate Change Action Plan: Summary of Climate Change Impacts Sydney Region, (October 2008)

4. NSW Department of Environment and Climate Change (2007) Practical Consideration of Climate Change – Floodplain Risk Management Guideline, (October 2007)

5. CSIRO (2007) Climate Change in the Hawkesbury-Nepean Catchment

6. Australian Government Bureau of Meteorology (2007) Climate Change in Australia – Observed Changes and Projections (October 2007)

7. Blacktown City Council (2005). Engineering Guide for Development

8. Growth Centres Commission (2006). Development Code

9. Department Of Environment And Climate Change. Technical Note – Interim Recommended Parameters for Stormwater Modelling – North-West and South-West Growth Centres

10. Blacktown City Council (2009). Draft Integrated Water Cycle Management DCP

11. Blacktown City Council (2008). Draft WSUD Handbook Parts 1 to 5

12. Eco Logical Australia (2009). Area 20 Precinct Planning Study – Riparian Constraints Assessment (Draft)

13. Growth Centres Commission (2007). Growth Centres – Conservation Plan – Exhibition Draft

14. WSP Environmental (2009). Area 20 Precinct – Land Capability and Contamination Assessment (Draft)

15. WSROC (2003). Western Sydney Salinity Code of Practice

16. Engineers Australia (2006). Australian Runoff Quality – A Guide To Water Sensitive Urban Design

17. Landcom (2004). Managing Urban Stormwater – Soils and Construction – 4th Edition

18. WILLING & PARTNERS PTY. LTD. (1994). Runoff Analysis & Flow Training Simulation. Detailed Documentation and User Manual, Version 4.0

19. WILLING & PARTNERS PTY. LTD. (1996). Runoff Analysis & Flow Training Simulation. Addendum, Version 5.0

20. US ARMY CORPS OF ENGINEERS (2001) - HEC-RAS River Analysis System – Users Manual - Version 3.0

21. CRC For Catchment Hydrology (2005). MUSIC Model for Urban Stormwater Improvement Conceptualisation – User Guide Version 3

22. CRC For Catchment Hydrology (2004). Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures – A Review and Gap Analysis. Technical Report 04/8

23. Wong, T.H.F., Duncan, H.P., Fletcher, T.D & Jenkins G.A. (2001). A Unified Approach to Modelling Stormwater Treatment, - Proceedings of the 2nd South Pacific Stormwater Conference, Auckland, New Zealand, 27-29 June 2001, pp 319-327

Figures