Menangle Park Contributions Plan 2020

CAMPBELLTOWN CITY COUNCIL

APPENDIX E
TRUNK STORMWATER MANAGEMENT STRATEGY

CONTENTS

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Summary of Drainage Strategy

Landcom

November 2011

1. INTRODUCTION

The drainage strategy at Menangle Park requires a combination of detention basins, water quality treatment measures and floodway stabilisation measures to safely convey stormwater runoff through the development and discharge it into the Nepean River.

Numerous reports and plans have been created in relation to the Menangle Park Drainage Strategy. The focus of this report is to draw together the key information and provide a summary of what is proposed in the Drainage Strategy at Menangle Park.

The changes to the drainage strategy alter the quantity management elements but do not affect the water quality elements.

2. BACKGROUND

1.1 GHD – Local Flooding and Stormwater Quantity Management Plan – May 2010

In May 2010 Landcom and Campbelltown City Council appointed GHD to prepare a Flooding and Stormwater Quantity Management Plan for the Menangle Park Release Area. This report identified that eleven detention basins were required for the WSUD of Menangle Park. The total cost of these basins, along with associated drainage/stabilisation and half road constructions works were costed at $28,434,447 (see breakup in Table 1). A copy of the Flooding and Stormwater Quantity Management Plan is included as Attachment A

The GHD report considered the quantity management agreement aspects of the drainage strategy while AECOM addressed the quality management aspects in their Menangle Park WSUD Strategy (June 2010), The reports were coordinated to ensure that quantity and quality aspects worked together in forming the overall strategy for Menangle Park. As the quality aspects have not changes since the June 2010 report they are not listed here.

Landcom and Council reviewed the report and identified that an opportunity may exist, due to the unique location of the urban release within the catchment and site characteristics, to redirect the stormwater management investment away from basin construction and into the naturalised stream stabilisation and improvement works. The objective being to still meet the quality objectives while providing enhanced environmental outcomes and reduced operational costs.

1.2 Alternative Drainage Strategy – Landcom Letter to NSW Office of Water – August 2010

Landcom forwarded a preliminary alternative drainage strategy to the NSW Office of Water in August 2010. The letter identified that the only basins that were required to be constructed were Basins 7, 8 and 13. The letter advised that funds should be redirected away from hard infrastructure provisions and into environmental works that will provide a greatly improved outcome for both the environment (in terms of stability and quality of riparian corridors) and the community (in terms of environmental quality and reduced ongoing maintenance costs).

In considering the alternate strategy it was identified that altering the quantity management aspects of the proposal would not alter the quality management aspects as presented in the AECOM June 2010 report.

A copy of the Letter from Landcom to NSW Office of Water is included as Attachment B.

Table 1 Original Drainage Strategy

ORIGINAL DRAINAGE STRATEGY							
	Area (Basin) (m²)	Rate ($/m²)	Area (Half Road) (m²)	Half Road Length (m)	Rate Road ($/m²)	Total Cost $ (ex. Roads)	Total $ (inc. Roads)
1. Land Costs							
DB2	15,000	$45				$675,000	$675,000
DB4	15,000	$45	3,358		$45	$675,000	$826,110
DB4a	5,500	$45	4,568		$80	$247,500	$612,940
DB5	5,500	$30				$165,000	$165,000
DB6	6,000	$45	4,298		$45	$270,000	$463,410
DB7*	18,600	$80	4,333		$80	$1,488,000	$1,834,640
DB8*	18,800	$55	4,098		$55	$1,034,000	$1,259,390
DB9	11,000	$35				$385,000	$385,000
DB11	7,000	$70	1,653		$70	$490,000	$605,710
DB12	23,000	$50	2,235		$50	$1,150,000	$1,261,750
DB13*	14,000	$50	948		$50	$700,000	$747,400
Subtotal Land Costs						$7,279,500	$8,836,350
2. Works Cost							
DB2						$1,329,000	$1,329,000
DB4			3,358	386	$1,421	$1,269,000	$1,817,454
DB4a			4,568	525	$1,421	$866,000	$1,612,080
DB5						$837,000	$837,000
DB6			4,298	494	$1,421	$988,000	$1,689,982
DB7*			4,333	498	$1,421	$865,169	$1,572,580
DB8*			4,098	471	$1,421	$1,302,347	$1,971,404
DB9						$1,213,000	$1,213,000
DB11			1,653	190	$1,421	$980,000	$1,249,980
DB12			2,235	257	$1,421	$1,954,000	$2,319,037
DB13*			948	109	$1,421	$1,391,000	$1,545,835
Trunk drainage leading into Basin 12						$2,440,745	$2,440,745
Subtotal Works						$15,435,261	$19,598,097
TOTAL LAND + WORKS						$22,714,761	$28,434,447

* costs from Draft Contributions Plan

1.3 Alternative Drainage Strategy - Letter of support – NSW of Office of Water – August 2010

The NSW Office of Water forwarded Landcom a letter indicating support for the proposed alternative strategy proposed. The Office of Water stated that the alternative strategy would lead to lower establishment costs to Landcom and much lower future maintenance costs to Council for achieving a similar or better environmental outcome.

A copy of the Letter from Office of Water to Landcom is included as Attachment C.

1.4 GHD – Review of Drainage Options Report – November 2011

Following the support from the Office of Water, GHD were engaged to investigate the effectiveness and feasibility of the alternative drainage strategy. The study built on prior works in the "Local Flooding and Stormwater Quality Management Plan". This review identified that there was merit in considering channel stabilisation works rather than implementing basins. It was therefore identified that Basins 2, 4, 4a, 5, 6, 9, 11 and 12 could be removed and alternatively channel stabilisation works could be carried out instead.

A copy of the Review of Drainage Options Report is included as Attachment D.

3.0 SUMMARY OF ALTERNATE DRAINAGE STRATEGY

Table 2 provides a summary of what is proposed within the alternative drainage strategy. It can be seen that a number of basins have been removed. The total cost of these basins, along with associated drainage/stabilisation and half road constructions works were costed at $18,602,785. A copy of the SMEC Urban Trunk Drainage Plan is included as attachment E.

Table 2 Alternate Drainage Strategy

ALTERNATE DRAINAGE STRATEGY							
	Area (Basin) (m²)	Rate ($/m²)	Area (Half Road) (m²)	Half Road Length (m)	Rate ($/m²)	Total Cost $ (ex. Roads)	Total $ (inc. Roads)
1. Land Costs							
DB7	18,600	$80	4,333		$80	$1,488,000	$1,834,640
DB8	18,800	$55	4,098		$80	$1,034,000	$1,361,840
DB12	23,000	$50				$1,150,000	$1,150,000
DB13	14,000	$50	948		$50	$700,000	$747,400
Overland Flow Path to S2	600	$70	174	20	$70	$42,000	$54,180
Subtotal						$4,414,000	$5,093,880
2. Works Cost							
DB7			4,333	498	$1,421	$865,169	$1,572,580
DB8			4,098	471	$1,421	$1,302,347	$1,971,404
DB13			948	109	$1,421	$925,560	$1,080,395
Overland Flow Path to S2			174	20	$1,421	$410,273	$438,683
Trunk drainage leading into Basin 12						$2,440,745	$2,440,745
Channel stabilisation Howes Ck (Corridor 1-3)						$3,704,704	$3,704,704
Channel stabilisation S1 + S2 (Playing Fields)						$1,724,451	$1,724,451
Channel stabilisation HR1 & HR2						$575,943	$575,943
Subtotal						$11,949,192	$13,508,905
TOTAL LAND + WORKS						$16,363,192	$18,602,785

Note: the above table addresses the elements that have changed in between the GHD 2010 report and the GHD 2011 review. As the quality management aspects have not change these are not considered. The comparison recognises that a portion of the former Basin 12 is still required to provide for a portion of the quality management works in this catchment and hence the cost of acquiring this land is retained in the strategy.

3.0 CONCLUSION

The alternative drainage strategy recognises the unique site characteristics and seeks to delete unnecessary drainage infrastructure and redirect funds into existing floodway stabilisation works. GHD assessments demonstrate that eight (8) of the eleven (11) previously proposed detention basins can be deleted from the trunk drainage works scope without compromising the performance of the trunk drainage system. The drainage strategy has changed from 11 detention basins to 3 detention basins with stream bed stabilisation in lieu of the deleted basins. The benefits gained from this change include;

- A reduction in overall capital expenditure from $28,434,447 to $18,602,785; ensuring the required flood management outcomes are delivered at a minimum cost;
- An investment of $6m in natural creek stabilisation
- A reduction in ongoing operational costs through a reduction from 11 to 3 basins

The AECOM June 2010 water quality components remain unchanged component of the overall strategy.

Background Documents;

- Attachment F - MPk Acquisition Table, Lean & Hayward – September 2011
- Attachment G - Menangle Park Land Acquisition Valuation – October 2011

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MENANGLE PARK WSUD STRATEGY

REPORT PREPARED BY AECOM

June 2010

campbelltown city council

LANDCOM

Menangle Park WSUD Strategy

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CONTENTS

1 INTRODUCTION

The Menangle Park release area is located in south-western Sydney, south-east of Camden and south-west of Campbelltown. The site is within Campbelltown LGA, and is bounded by the Nepean River to the south, the rail corridor to the west, the South Western Freeway and Menangle Road to the east, and a Sydney Water supply channel and coal washery to the north.

The major landholders at Menangle Park include Landcom and Campbelltown Council. AECOM has been engaged to prepare a Water Sensitive Urban Design (WSUD) Strategy for Menangle Park. This WSUD Strategy Report outlines:

- Background information about previous and concurrent studies relevant to the site(Section 2)
- The proposed development (Section 3).
- The nature of the site (Section 4).
- Objectives for WSUD (Section 5).
- Constraints and Opportunities for WSUD (Section 6).
- WSUD Strategy (Section 7).
- Maintenance Considerations (Section 8)
- Costing (Section 9)
- Conclusions (Section 10)

WATER SENSITIVE URBAN DESIGN

Water Sensitive Urban Design (WSUD) encompasses the water related aspects of ecologically sustainable development (ESD). WSUD can integrate the urban built form (including urban landscapes) and the urban water cycle - potable water, wastewater, and stormwater. Protection of aquatic ecosystems is achieved through potable water conservation, wastewater minimisation, and stormwater management. (Figure 1.1)

The following guiding principles of WSUD are centred on achieving integrated water cycle management solutions for new urban release areas and urban renewal developments aimed at:

- Reducing potable water demand through water efficient fittings and appliances, rainwater harvesting and wastewater reuse.
- Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities and/or to release to receiving waters.
- Treating urban stormwater to meet water quality objectives for reuse and/or discharge to receiving waters.
- Using stormwater in the urban landscape to maximise the visual and recreational amenity, and habitat value of developments.

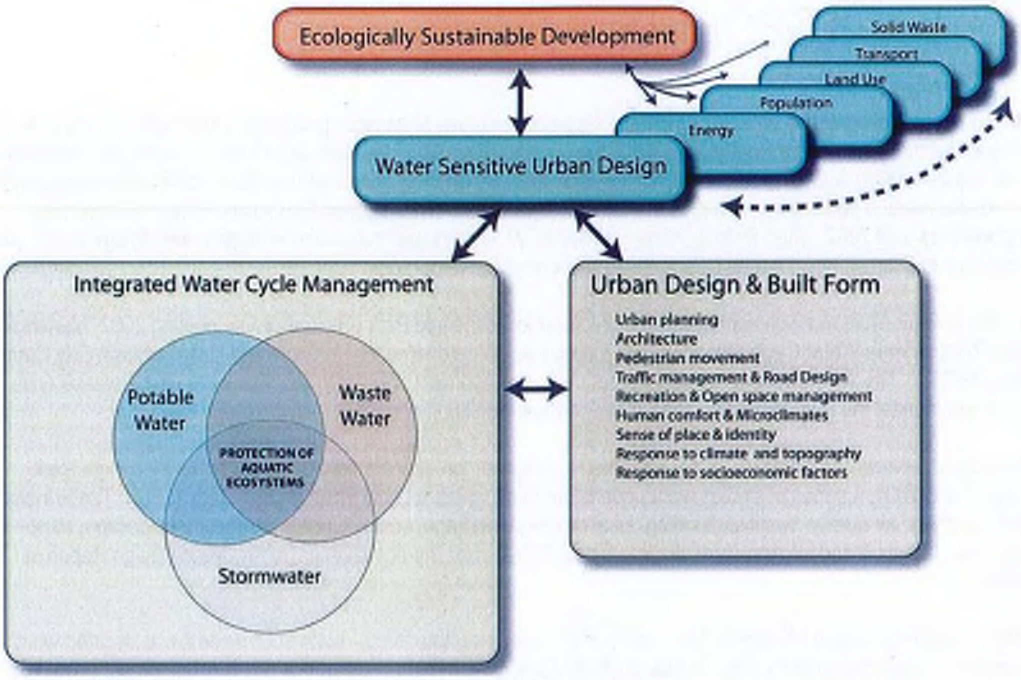


Figure 1.1 - WSUD Framework

2 BACKGROUND

Menangle Park is located in an environmentally sensitive area, due to its close proximity to the Nepean River. Under the (repealed) *Clean Waters Regulations 1972*, the Nepean River was classified as a Class P (Protected) waterway. This required a high level of protection against wastewater nutrient pollution. Pollution from urban stormwater runoff would also need to be similarly managed to protect the waterway. These constraints limited urban development opportunities until 2002, when Sydney Water and the NSW EPA agreed that advancements in technology should make it possible to address these issues sufficiently to allow urban development.

In 2002 a water cycle management study was prepared for Menangle Park (Ecological Engineering 2002 "Menangle Park Release Area Water Cycle Management Options Report", prepared for Landcom and Campbelltown City Council, August 2002). This report developed broad water cycle management options for the Menangle Park Release Area, which would meet the requirements of the Class P waters regulation and other relevant objectives.

Since 2002, several other studies were undertaken to progress the development opportunities at Menangle Park. During 2003-2004, a series of studies were undertaken to complete a Local Environment Study (LES). These included land capability, air quality, bushfire, flooding, local drainage, heritage, ecology, noise, visual and landscape, socio-economic, transport and infrastructure studies. The LES informed the development of an Urban Design Report in 2005.

Plans for development at Menangle Park were put on hold during late 2005 – early 2006 while it was decided whether to undertake coal mining at the site. In May 2006 the State government decided that urban development should be pursued at the site. In light of this decision and to facilitate development, the LES studies are currently being updated, and a draft Local Environment Plan (LEP) is being prepared.

In November 2008 The Department of Planning has agreed in principle to lowering the yield from 4,200 to 3,600.

A Flora, Fauna and Aquatic Assessment was prepared by Ecological Australia (March 2009) describing the condition of vegetation and the constraints in relation to fauna and aquatic habitat.

Flood studies of the Nepean River and its tributaries were undertaken by GHD and by Campbelltown Council. This work defined the flood detention basin sizing required to attenuate stormwater runoff from the developed catchments to maintain predevelopment peak flow rates and to respond to constraints of existing infrastructure.

A Riparian Corridor Assessment Report was prepared by GHD in December 2007. The report recommended a riparian corridor network for the site. A site visit with the NSW Office for Water (formerly DWE) and Office of the Hawkesbury Nepean in October 2009 resulted in some refinement of the riparian corridor network. An updated Riparian Corridor Assessment Report was prepared in December 2009.
A Vegetation 'Offset Strategy' (GHD, December 2009), describes the impact that the development will have on existing vegetation and the areas where rehabilitation and replanting are proposed.

The structure plan for the site has been developed by Urbis in collaboration with the project team. The PCG are intending to exhibit the LEP, Development Control Plan (DCP) and Section 94 Contributions Plan in early-2010.

This WSUD Strategy draws on earlier studies for the Menangle Park site, and interactions with the project team through the refinement of the structure plan for the site. It outlines the design of mitigation measures that can address the impacts of urbanisation on hydrology and water quality.

3 PROPOSED DEVELOPMENT

The site is currently made up of low density rural residential development (Figure 3.1), concentrated on the eastern side of the rail line, opposite the Harness Racing Park. The Glenlee coal washery is located to the north-west of the site (adjacent to the Nepean River). Glenlee House (a heritage item of state significance) is located in the northern part of the site, on the eastern side of the rail line.

Figure 3.1: Existing low density rural residential in the central/northern part of Menangle Park. Note the coal washery marking the north western site boundary in the top left. The new town centre would be located at the bottom left.

The development is constrained particularly by:

- Existing infrastructure including major roads (South Western Freeway and Menangle Road) and the railway line.
- Heritage properties (Glenlee House).
- The existing harness racing club (Menangle Park Paceway).
- Flood extents, particularly in the Nepean River.
- Vegetation of high ecological significance.
- Proposed alignment of the Spring Farm Parkway (a major new road linking areas to the north and east of the site).

Topographic and access constraints also affect some parts of the development (Urbis, Civitas Partnership, 2005). In addition, there are several valuable resources on site, including sand, coal and natural gas. Extraction of these resources may impact on the development immediately or at some time in the future.

The proposed development is for 3,400 residential lots (Figure 3). The estimated occupancy is 3.4 people / dwelling (Social Report), resulting in a total of 11,560 residents.

The majority of lots are 540 – 700m², with larger lots (1,000 – 1,500 and 2,000m² +) located in the northern and southern parts of the site and in areas adjacent to the South Western Freeway and Menangle Road. Smaller lots (350 – 390m²) are concentrated in a new town centre and along the southern waterway corridor. Employment lands are proposed adjacent to a rail siding at the north of the site, between the Glenlee Coal Washery and Glenlee House. A primary school is proposed to the north of the town centre.

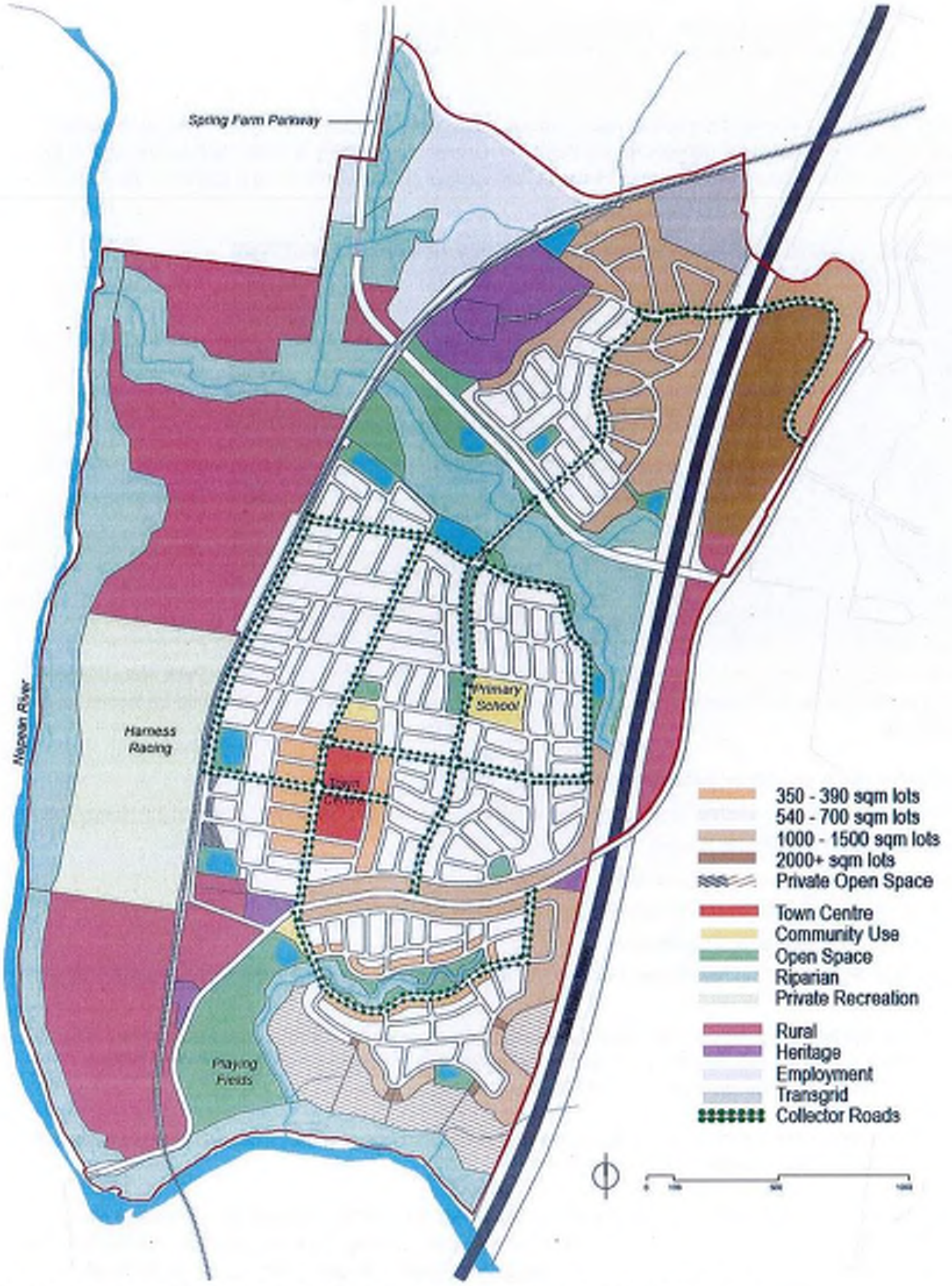


Figure 3.2 Structure Plan (Urbis,24/5/2010) - proposed development layout (3,400 lots)

4 NATURE OF THE SITE

The following sections outline key site characteristics that are relevant to the WSUD strategy, including information on climate, catchments and drainage, water quality, aquatic ecology, topography, geology, groundwater, soils and resources. In this document only the key facts are covered; other reports contain more detail on specific topics. Where relevant the text refers to these other more detailed reports.

4.1 CLIMATE

The rainfall in the area totals on average around 800 mm per year, but rainfall can be highly variable, from around 500 to 1200 mm per year at the 10th and 90th percentiles respectively. A plot of average monthly rainfall at the Campbelltown Swimming Centre (approximately 7 km away) is shown in Figure 4.1. On average rainfall is lowest in winter and early spring (July-September) and highest in summer to early autumn (January-March).

Evaporation at Menangle Park can be described by the data from Prospect Reservoir. This is also shown in Figure 4.1. Evaporation data varies slightly from Prospect (average 44.9mm/month) to the nearby Elizabeth Macarthur site (average 49.9mm/month). The Prospect evaporation data is adequate for water quality modelling for the site.

Figure 4.1 shows that the driest period typically occurs during spring and summer, when rainfall is relatively low and evaporation high.

Figure 4.1 Monthly rainfall and evaporation (data source: Bureau of Meteorology)

There are no pluviograph records in close proximity to the site. The nearby Elizabeth Macarthur site provides only daily rainfall data. In order to find a suitable pluviograph record to represent long-term rainfall conditions at the site, a comparison was undertaken between mean annual rainfall data and mean annual number of rain days for available stations in the region. The data was sourced from the Bureau of Meteorology and the results of this analysis are shown in Table 4.1.

Table 4.1: Comparison between rainfall statistics for different stations

Station	Mean annual rainfall (mm)	Mean annual number of rain days
Campbelltown Swimming Centre (**reference gauge**)	799.1	107.4
Liverpool pluvio station	851.2	109.4
Penrith pluvio station	814.4	83.7
Richmond RAAF pluvio station	782.7	110.2
Lucas Heights pluvio station	1010.7	119.8

Based on the comparison in Table 4.1, Richmond RAAF is considered the most suitable pluviograph station to use at Menangle Park. There is a 40 year data record available from Richmond.

4.2 CATCHMENTS AND DRAINAGE

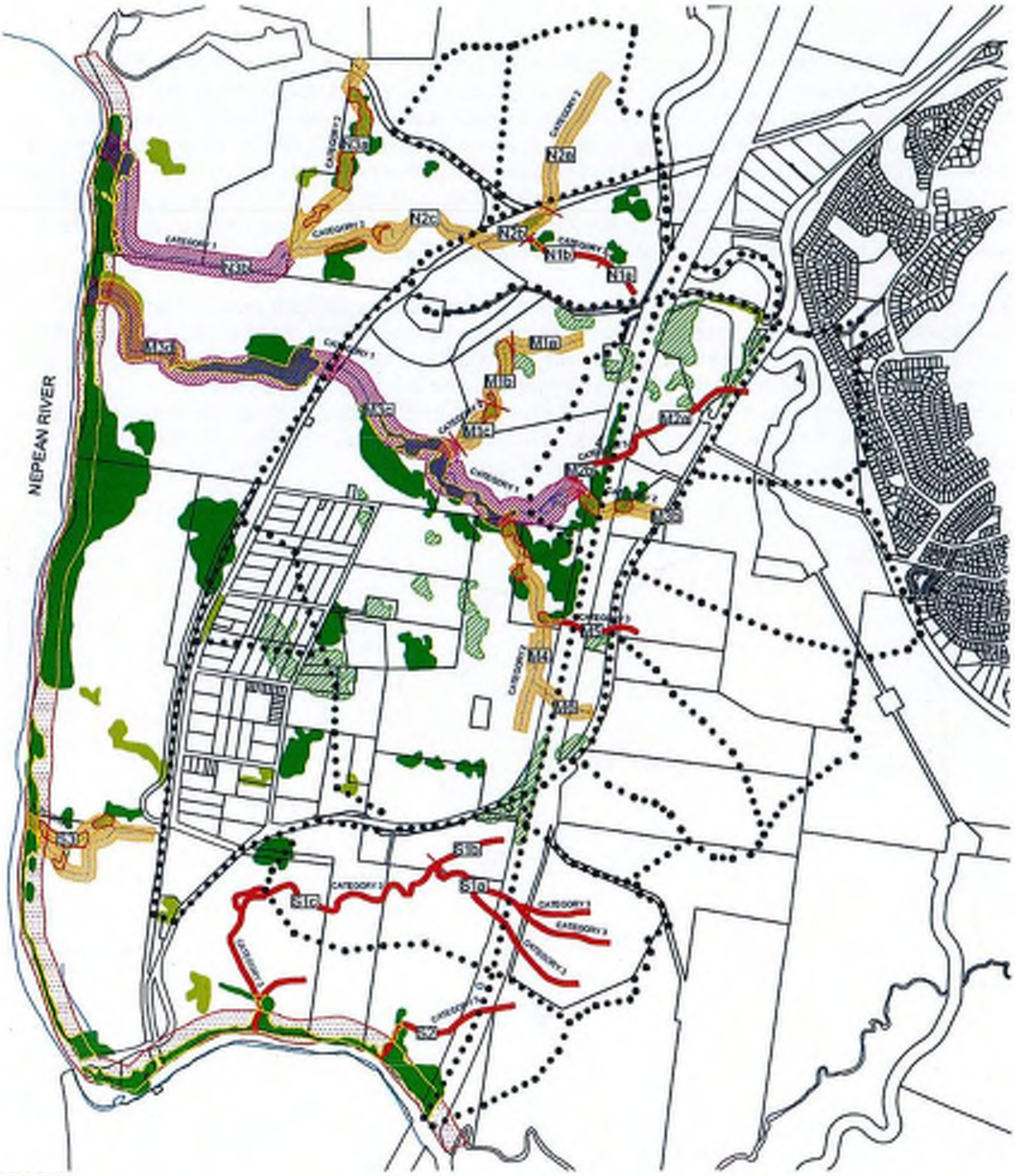
The NSW Office of Water (NOW, the former Department of Natural Resources or DNR) categorises watercourses based on environmental objectives. In brief, these are:

- Category 1 – Environmental Corridor. To provide biodiversity linkages by maintaining connectivity for aquatic and terrestrial fauna and flora between key destinations. Requires a setback of 20 - 40 m of core riparian zone and 10 m buffer from the top of each bank.
- Category 2 – Terrestrial and Aquatic Habitat. To provide basic habitat and preserve a natural functioning watercourse. Requires a setback of 20 m of core riparian zone and 10 m buffer from the top of each bank.
- Category 3 – Bank Stability and Water Quality. To enhance water quality and prevent erosion. Requires a setback of 10 m from the top of each bank.

The watercourses of the site have been categorised by NOW. The site is drained by several tributaries of the Nepean River. These have been named in previous studies as Creeks N, M, S1, S2 and S3. They are shown in Figure 4.2 and have the following characteristics:

- Creek N drains the northern part of the site (approx 160 ha including the existing coal washery). It also receives flows from upstream of the site. It has been diverted around the coal washery and joins the Nepean River at Bergins Weir, adjacent to the coal washery. The downstream end of Creek N is a Category 1 stream.
- Creek M is the largest creek in the release area and drains approximately 410 hectares of the site as well as receiving flows from upstream of the site. On the eastern side of the site it has several branching tributaries and it drains to the west to join the Nepean River just south of the coal washery. A large part of Creek M has been identified by NOW as a Category 1 stream.
- Creek S1 drains approximately 90 ha in the south-eastern part of the site. It joins the Nepean River between the railway and the Main Southern Freeway. It also receives flows from upstream of the site. Creek S1 has been identified by NOW as a Category 3 stream.
- Creek S2 drains the south-eastern corner of the site (approx 30 ha), as well as receiving some upstream flows. It joins the Nepean River a short distance downstream of the Main Southern Freeway. Creek S2 has been identified by NOW as a Category 3 stream.
- Creek S3 drains part of the western side of the site to join the Nepean River just south of the harness racing club. Creek S3 has been identified by NOW as a Category 2 stream.

In addition to these categorised creeks, some of the area in the southern and western parts of the site drains directly into the Nepean River, including a small drainage line which conveys flow from part of the Menangle Park village area beneath the railway line and to the north of the Harness Racing Club. Further discussion on these creeks as the receiving waters for stormwater runoff from Menangle Park site is provided in section 6.



LEGEND

EXISTING WATERCOURSE	CATEGORY 1 BUFFER	LOW CONDITION VEGETATION	S1a EXISTING STREAM LABELS
CADASTRE	CATEGORY 2 BUFFER	MODERATE CONDITION VEGETATION	EXISTING STREAM BOUNDARIES
100M BUFFER TO NEPEAN RIVER	CATEGORY 3 BUFFER	HIGH CONDITION VEGETATION	APPROXIMATE CATCHMENT EXTENT

Figure 4.2 Waterways, significant vegetation and riparian categorisation (modified from GHD base figure)

4.3 AQUATIC ECOLOGY

An aquatic ecology assessment was undertaken in 2003 (Bio-Analysis 2003). This report identified pre-development aquatic ecology conditions on the site. It included assessments of habitat, macroinvertebrates and fish, including threatened and endangered species. The Flora, Fauna and Aquatic Assessment prepared by Ecological Australia (March 2009) describes the aquatic habitat within the study area as highly degraded, ranking from poor to moderate in habitat value (Figure 4.3). This is attributed to land clearance, agricultural activities, loss of riparian vegetation, erosion and sedimentation. The assessment did not cover the other waterways on the site. Areas of moderate habitat value were identified where these waterways join the Nepean River. Aquatic habitat is otherwise described as poor, with a section of slightly better condition mapped along the main (Category 1) watercourse that runs through the site.

Some riparian vegetation remains along this category 1 watercourse and these protected sections of watercourse retain geomorphic values, with a small channel within the wide floodplain of primarily alluvial sands. The majority of the vegetation in the riparian area is disturbed pasture with several significant weed infestations (e.g. Blackberry).
An important opportunity exists to enhance riparian vegetation and habitat value along this corridor.
An Endangered Ecological Community (EEC) is identified within the floodplain (Sydney Freshwater Wetlands, to the south of locations 7 & 8 in Figure 4.3, also mapped as high conservation vegetation in Figure 4.2). The freshwater wetlands are a foraging/roosting area for the Japanese/Latham's Snipe.

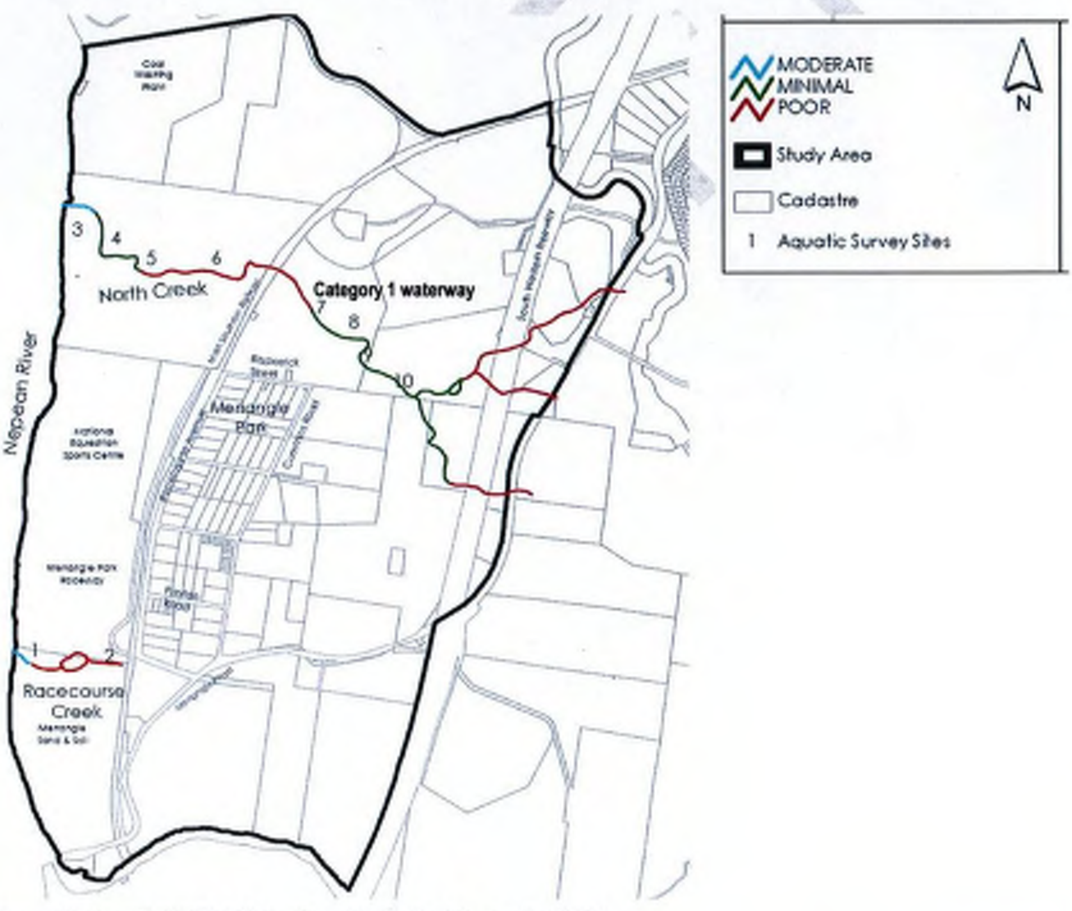


Figure 4.3 Aquatic Habitat Value from Ecological Australia (2003)

4.4 WATER QUALITY

At present, the areas of residential development on site are not serviced by sewer and the presence of septic systems is having some impact on water quality. GHD (2004) reported that faecal coliform concentrations exceeded guidelines for the Nepean River in previous water quality analysis results. This was thought to have been due to the failure of onsite wastewater treatment systems, and the pumping of these systems to the stormwater network. The Flora, Fauna and Aquatic Assessment prepared by Ecological Australia (March 2009) documented macroinvertebrate SIGNAL analysis indicated severe water pollution at 7 of the 10 sites investigated.

There are also stock and horses on site at present, which may also contribute to faecal coliform contamination, as well as suspended solids and nutrients in urban runoff.

4.5 TOPOGRAPHY

Slopes on the site range from less than 3% in the low-lying areas alongside the creeks and the Nepean River, increasing gradually to a maximum of around 15-25% on the top of hills. There are isolated slopes greater than 25% such as existing road and railway embankments. The slope analysis from the 2004 Land Capability Study (Douglas Partners) is included as Figure 4.4.

Generally the stormwater treatment measures proposed in this report are best suited to slopes of 1- 3% and therefore the dark blue areas in Figure 4.4 present ideal opportunities for WSUD treatment elements.

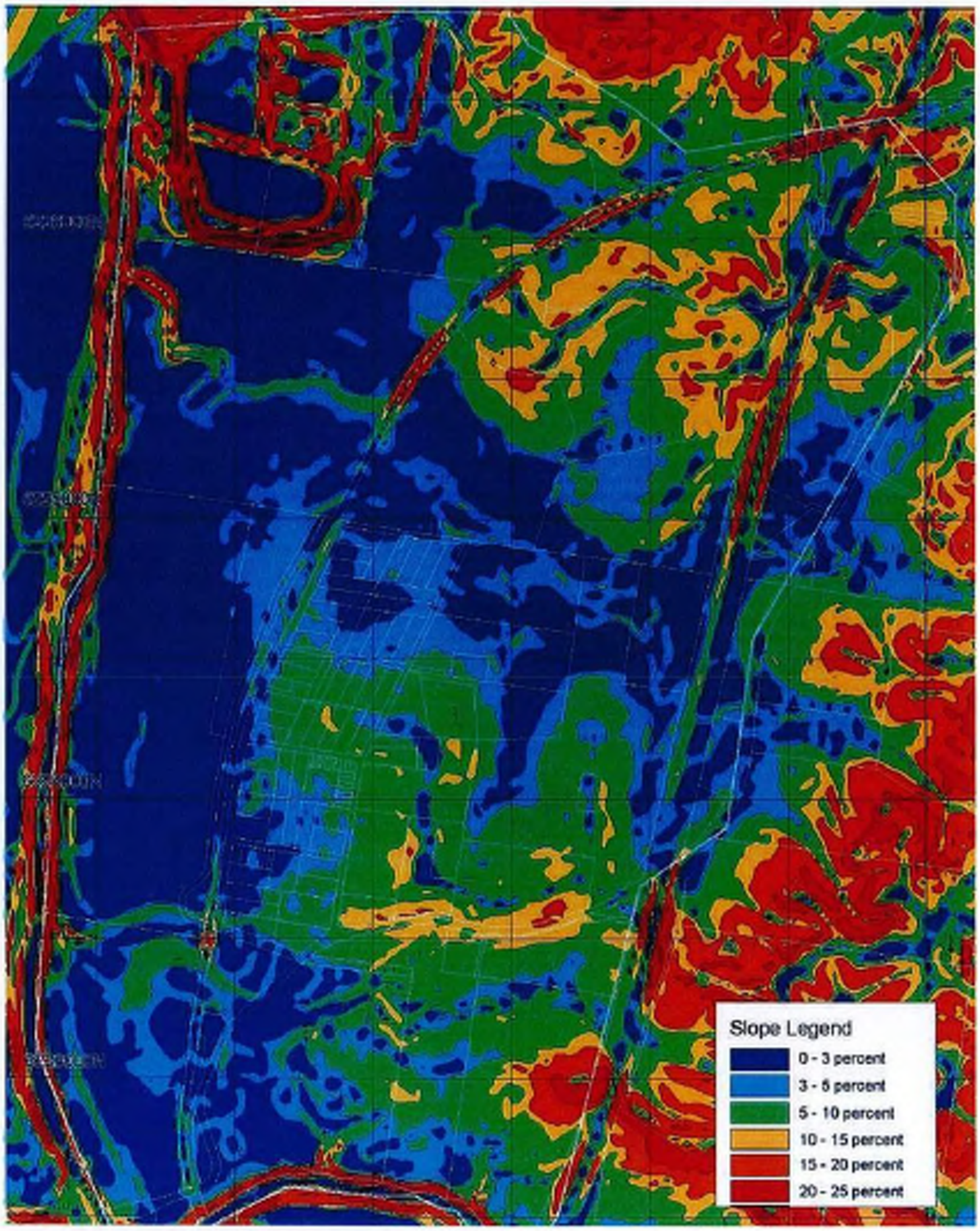


Figure 4.4 Slope analysis from Douglas Partners (2004)

4.6 GEOLOGY, GROUNDWATER & SOILS

The site is predominantly underlain by Wianamatta Group shales. These weather to clayey soils with relatively low permeability. In the central part of the site there is an extensive wind blown sand deposit. The elevation of the site at more than 60 m AHD means that there is a negligible risk of Potential Acid Sulphate Soils (PASS) (Douglas Partners 2004).

Salinity is a potential issue, particularly in the vicinity of the more elevated drainage lines in the north and south of the site (Douglas Partners 2004). Due to this issue, it would be important to ensure that stormwater treatment measures in these areas, including basins, wetlands, ponds and bioretention systems, are lined to avoid impacts on groundwater. Infiltration measures should be avoided in areas where salinity is identified.

Douglas Partners (2004) found that groundwater on the site was generally shallow and saline, particularly in the Wianamatta Group shales. This could be an issue where excavations are undertaken on site, potentially intercepting the shallow groundwater table and resulting in saline groundwater collecting in the base of the excavated area. This may need to be monitored and liners used where saline groundwater is expressed if water management features are to be incorporated into the excavated areas.

The soils on site, both those weathered from the Wianamatta Group shales and the windblown sand, have high erosion hazard ratings and therefore are susceptible to erosion from increased stormwater flows.

In 2009, Douglas Partners undertook a review of the status of the Land Capability Study written in 2004 to identify if the status of any of the identified site issues had changed in light of more recent designs or information. This review confirmed that the findings of the 2004 study were still applicable, and it made several recommendations to update the salinity, hydrogeological and contamination assessments with more detailed assessments once more detailed site plans and cut/fill analyses were available.

4.7 RESOURCES

There are deposits of coal and natural gas (coal bed methane) at considerable depths under the site. Coalfields underlie the entire release area at depths of around 550-750m (MG Planning, 2004). Closer to the surface there are deposits of wind blown sand.

Sand deposits are concentrated in two areas in the central and western parts of the site, shown in Figure 4.5. The extent of extraction of sand and soil that has occurred adjacent the Nepean River is indicated (southern part of western deposit). Extraction is proposed in part of the western sand deposit, and this will occur before urban development commences. It is understood that this will result in lowered surface levels, however re-filling can be undertaken to some extent. Sand mining will not occur in the other deposit in the central part of the site (eastern deposit).

Extraction of either or both coal and gas may occur in the future and could result in the following impacts relevant to the WSUD strategy:

- Subsidence of the ground surface.
- Differential settlement.
- Damage to infrastructure (including drainage network)
- Changes to drainage patterns.
- Water quality impacts.

Any resource extraction (including sand mining) may have a significant operational water demand. The potential to meet this demand with harvested stormwater from urban areas should be investigated.

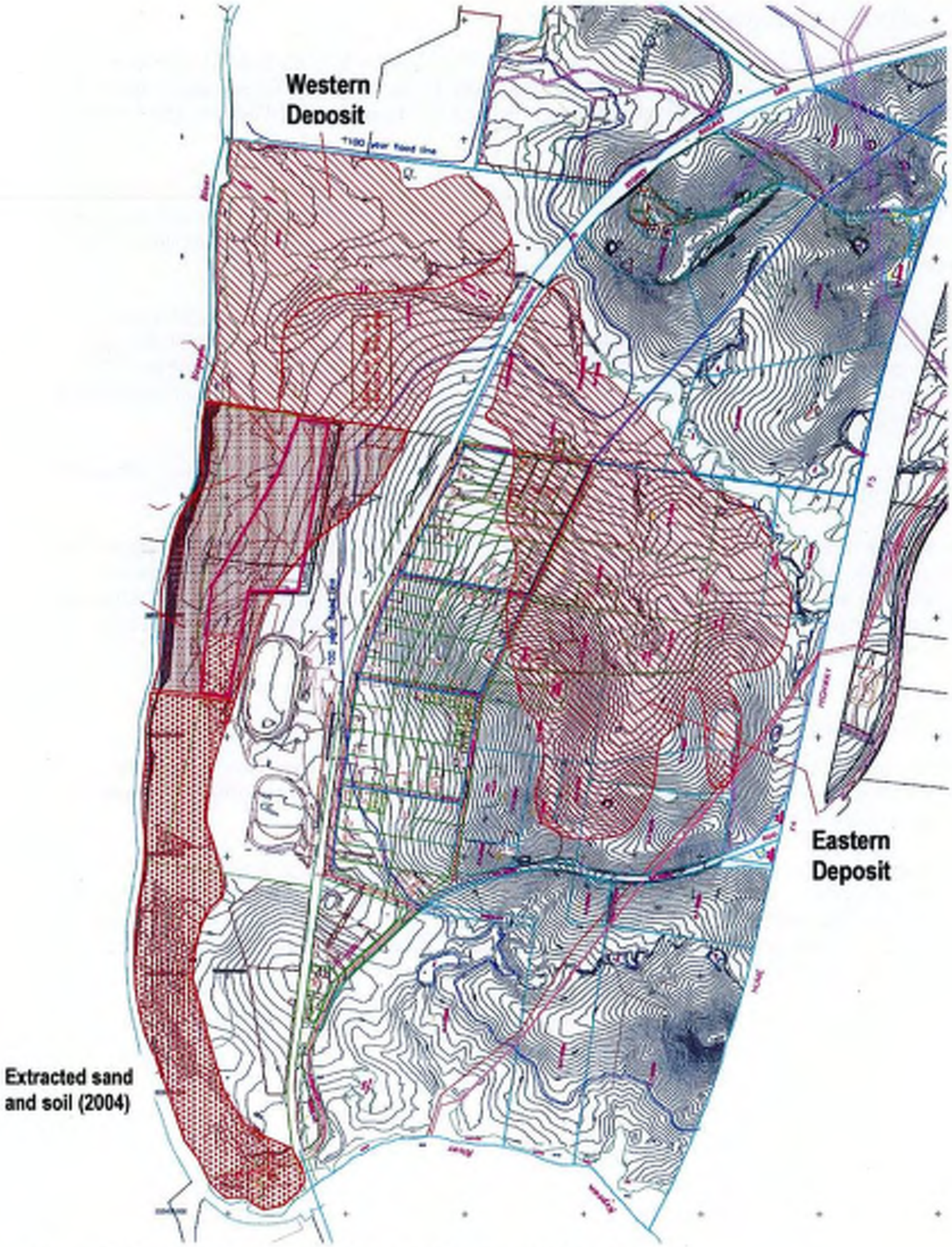


Figure 4.5 Sand and soil deposits at Menangle Park (Harvest Scientific, 2010)

5 WSUD OBJECTIVES

The WSUD principles and objectives presented in Section 1 of this report can be detailed in terms of performance targets to be achieved by the Menangle Park Development. These targets are outlined in Table 5.1.

The targets proposed are consistent with Landcom's WSUD policy and targets, and in many cases extend the minimum standards of State-wide water management objectives for new developments established by the NSW Government. The adoption of more stringent Stormwater Pollution Control targets reflects the ecological importance of the receiving waters and the commitment of Campbelltown City Council and Landcom to mitigate impacts of urban development on the sensitive receiving environment of the Nepean River. Rezoning is proposed for 2010, and development is likely to occur over at least the next decade. Therefore, it is appropriate that planning and the establishment of targets for ecological protection should pre-empt the increasing importance of enhancing sustainability and biodiversity outcomes.

Table 5.1: WSUD objectives for Menangle Park

Objective	Performance Measure and Target
1. Water Conservation	Combination of water efficiency and reuse options for a 45+ % reduction on the benchmarked water use.[1] Stretch target 60+% reduction on the benchmarked water use. Where a reticulated non-potable (recycled) water supply is available the target reduction is increased to 60% with a stretch target for a 70+% reduction on the benchmarked water use.[2]
2. Stormwater Pollution Control [3]	55% reduction in the mean annual load of Total Nitrogen (TN).[3]
	70% reduction in the mean annual load of Total Phosphorus (TP).
	85% reduction in the mean annual load of Total Suspended Solids (TSS).
3. Flow Management [4]	Maintain 1.5 year ARI peak discharge to pre-development magnitude. Stream Erosion Index [4] (SEI) of 2. *Stretch target:* Stream Erosion Index target of 1 (limit the erosion potential of urban waterways to the pre-development erosion potential).
4. Flood Protection	Maintain the 5 year – 100 year ARI peak discharges to pre-development magnitude.
5. Riparian Corridor Management	Provision of riparian corridors to meet the NSW Office of Water's requirements.
6. Wastewater Pollution Control	No dry weather sewer overflows Restrict wet weather sewer overflows to a maximum of 10 overflows each 10 years

Notes:

1. The water conservation target extends the compliance requirement under the NSW government's BASIX scheme for a 40% reduction from the benchmark water use of 90,340 L/p/year (247 L/p/d). A 40% reduction from the benchmark water use is equivalent to 149 L/p/d, a 45% reduction is equivalent to 136 L/p/d).

2. Landcom's WSUD Policy (2010) has identified targets and stretch targets for water conservation for lots and apartments in areas with and without reticulated non-potable water supply. For single residential lots in areas with no reticulated non-potable (recycled) water supply available (target 45% reduction, stretch target 60+% reduction). For single residential lots in areas with reticulated non-potable (recycled) water supply available (target 60% reduction, stretch target 70+% reduction).

Notes for Table 5.1 (continued)

3. The stormwater pollution control and flow management targets in Table 5.1 reflect the recommendations of a report (AECOM 2009) into water quality measures required to meet water quality objectives appropriate for the Hawkesbury Nepean River System consistent with investigations by the Healthy Rivers Commission (HRC) and the commitments of the Statement of Joint Intent (SOJI), 2001. These target reductions exceed Landcom's baseline reduction targets for a 45% reduction in TN, 65% reduction in TP and 85% reduction in TSS.

4. The purpose of the flow management target is for waterway stability - to minimise the impact of frequent events on natural waterways and to minimise bed and bank erosion. The SEI is the ratio of pre to post development erosion potential. The SEI target of 2 implies that post-development stormwater management must limit the increase in erosion potential of urban waterways to no more than twice the pre-development erosion potential. The combination of maintaining the 1.5 year ARI peak discharge to predevelopment magnitude and inclusion of stormwater treatment of frequent storm events (typically up to the 3 month ARI) will limit the SEI to between 1 – 2.

5. The riparian corridor management target is consistent with the NSW Office of Water's classification system and management requirements. The requirements for riparian corridor widths have been established for the site through collaboration with the NSW Office of Water, with the streams identified in Figure 2 and further information provided in the Ecological Assessment Report (GHD).

6. The wastewater pollution control targets are proposed due to the sensitivity of the Nepean River receiving waters.

Discussion of each of the objectives and targets in Table 3 is presented below.

1. Water Conservation

The target for a 45% reduction in potable water use compared to a base case scenario (247 L/p/d) of water consumption is complemented by targets to secure alternative water sources for irrigation, to appropriately use recycled water and to provide dual reticulation as a future proofing investment. Landcom's WSUD policy (Project Planning) targets include:

- At least 80% of water use within public open space (e.g. irrigation, top up of water features/ponds) is to be supplied by alternative water sources other than mains potable water.
- Where reticulated recycled water is available, it must be used for appropriately matched uses such as toilet flushing, garden watering, cold water laundry etc.
- All new developments must incorporate a dual water reticulation system to supply non-potable water. Providing this dual reticulation is a future proofing investment to ensure that developments can be serviced at present, and in the future, with water from diverse sources.

Planning and development of the Menangle Park site will occur over the coming decade. It is anticipated that over this period, environmental target (particularly in relation to water conservation) will become more stringent and with the increasing cost of water, conservation measures will be accepted and expected by the community.

A stretch target of a 60 – 70+% reduction on the BASIX benchmark water usage is proposed. Adopting this stretch target for potable water conservation is considered appropriate for the Menangle Park site, to demonstrate more sustainable urban development. This target can be met through a range of water conservation strategies as presented in section 7.2 of this report. Landcom has commissioned a study to develop the water, wastewater and recycled water servicing for the Menangle Park and broader area.

2. Stormwater quality controls

Nepean River Receiving Environment

In May 2006, the *Clean Waters Regulations 1972* was repealed and replaced by the *Protection of the Environment Amendment Act 2005*. Instead of the classification system that defined the Nepean River in this section as "Class P", or Protected Waters, the new Act uses a framework based on the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* 2000 where waterways are classified according to their environmental values, such as swimming, boating, water supply, agriculture and aquatic ecosystems. Regulatory authorities need to consider both the environmental values and the practical measures that can be undertaken at a site to protect the environmental values. This means that while the intent of the legislation is similar to the *Clean Waters Regulations 1972*, the specific requirements may differ from site to site.

Water from the Nepean and downstream Hawkesbury River is extracted and treated to provide some of the drinking water for many of Western Sydney's residents, through the Orchard Hills and North Richmond Water Filtration Plants. Water quality controls for these river systems are important to maintain and improve ecosystem health, and to protect the water supply resource for the western Sydney region.

Stormwater quality objectives

There are management objectives that were investigated by the Healthy Rivers Commission (HRC) and through a Statement of Joint Intent (SOJI) in 2001 for sustainable management of the Hawkesbury Nepean River System in response to the Final Reports of the Healthy Rivers Commission Independent Inquiry (released August 1998 and April 1999). All agencies and Councils are responsible for adopting the water quality objectives to use as guidelines for planning purposes. The specified water quality objectives for nutrients are nominated as the criteria to be adopted for the initial phases of an adaptive management regime for water quality. With the special condition dedicated to the protection of the Hawkesbury Nepean River as represented in the SOJI, more stringent targets are recommended.

An investigation was undertaken (AECOM, 2009) to determine appropriate stormwater quality targets for the Menangle Park site, discharging to the Hawkesbury-Nepean River System, that reflect the intent of the SOJI. The analysis led to the recommendation that an appropriate frequency of compliance to the stipulated SOJI water quality targets be set at 93% and 97% of the time for TP and TN concentrations respectively. The recommended corresponding load-based targets for pollutant load reduction of TSS, TP and TN are 85%, 70% and 55%. This represents more stringent stormwater quality targets than are typically adopted currently across Sydney and Australia which nominate pollutant load reduction of 85%, 65% and 45% for TSS, TP and TN.

With the stretch target for stormwater quality for Menangle Park, it will be necessary to incorporate WSUD solutions that extend the conventional WSUD approach. This will involve the bioretention systems that are specifically designed for enhanced nitrogen removal. The report documenting this analysis is included as an Appendix to the Menangle Park WSUD Strategy. The strategy for delivering the identified water quality target is presented in section 7.3 of this report.

3. Flow Management Targets

The flow management targets nominated for Menangle Park are typical of requirements for urban development in NSW. The 1.5 year ARI peak reduction target aims to mitigate erosion of receiving waterways. The 5 year ARI standard is relevant to drainage system design in residential areas, while the 100 year ARI standard is relevant to design of overland flow paths and is the standard for property protection and mitigation of flood hazard.

Recent investigations and refinement of the procedure for defining the stormwater management objective for reducing geomorphic impacts of urban waterways have led to a recommendation of a different measure, the stream erosion index (SEI). In NSW, the Department of Environment, Climate Change and Water (DECCW) has set an objective for waterway geomorphic protection which has been adopted by the Growth Centre Commission for urban developments within designated 'growth centres' of greater Sydney. The recommended method by DECCW is based upon computing the pre- and post-development erosion potential of the receiving waterway. The measures of erosion potential during pre- and post-development conditions are based on calculating the magnitude and duration in which flows exceeds the "channel forming flow". It is anticipated that post-development will result in more frequent occurrence of conditions where stream flow exceeds the channel forming flow of the natural waterway. The NSW objective stipulates this to correspond to 50% in magnitude of the 2-year ARI peak discharge for the catchment in its natural (pre-development) condition.

The SEI is calculated as the ratio of the stream erosion potential of a waterway post-catchment development to the stream erosion potential corresponding to a waterway in an undeveloped natural catchment. The stormwater management objective is for the SEI to range between 1 to 2. This implies that post-development stormwater management must limit the increase in erosion potential of urban waterways to no more than twice pre-development erosion potential, and ideally should match the predevelopment erosion potential. The combination of maintaining the 1.5 year ARI peak discharge to predevelopment magnitude and inclusion of stormwater treatment of frequent storm events (typically up to the 3 month ARI) will limit the SEI to between 1 – 2.

4. Flood Management Targets

The flood management targets nominated for Menangle Park are typical of requirements for urban developments and aim to mitigate impacts of both nuisance flooding associated with the capacity of drainage infrastructure and potentially hazardous flooding in major storm events. Detention basins are used to maintain the pre-development storm discharges in the post-development drainage design scenario for storm discharges for the 5 year to 100 year ARI events. Further details are provided in GHD's Flood Study for the site (GHD, 2010).

5. Riparian Corridor Management

The riparian corridors have been categorised by the NOW. This categorisation sets the rehabilitation targets for these waterways, as per the DWE (2000) Water Management Act 2000. Successful outcomes for riparian corridor management depend on appropriate water quality and flow management, as these parameters provide the foundation of waterway health.

6. Wastewater discharge controls

Given the sensitive receiving environment, limiting sewage discharge to the Nepean River is important. This can be achieved by designing to minimise both leakage in dry weather (exfiltration from the sewer network) and overflows in wet weather (when the sewer capacity can be exceeded due to water seeping into the sewers and illegal connections of household downpipes / stormwater pipes into the sewer network).

A previous Ecological Engineering WSUD report (2002) stated that it would be necessary to prevent overflows from sewers, wastes, pumping stations, treatment works or other parts of a sewerage system into Class P waters. Even though the legislation has changed in relation to 'Class P waters', it is recommended that these are still reasonable objectives for the Menangle Park site. For this reason, some of the proposed targets included:

- No dry weather sewer overflows.
- Restrict wet weather sewer overflows to a maximum of 10 overflows each 10 years.

Sewerage design for the site should aim to minimise exfiltration and infiltration.

6 WSUD OPPORTUNITIES AND CONSTRAINTS

This section summarises key opportunities and constraints to WSUD that should be considered throughout the Master Planning process.

6.1 OPPORTUNITIES

Key opportunities for WSUD presented by this site are:

- Stormwater treatment can be located outside the development footprint along the floodplain of Category 1 'waterway M'. Water treatment wetlands can be located outside the required riparian corridor, on land that is too flood prone for development. These will improve the habitat value of the floodplain by adding wetlands that can be supported by appropriately designed urban hydrology.
- WSUD treatment elements can be designed to be complementary to the riparian corridors, with biodiverse plantings that enhance the waterway rehabilitation measures.
- Where sandy deposits occur (refer Figure 4.5), infiltration of treated runoff may be possible. This is likely to be possible along the Category 1 'waterway M' and in parts of the drainage reserve through the central part of the site that conveys runoff from the central catchment to 'waterway M'. The use of infiltration measures should consider the hydrologic requirements for the existing freshwater wetlands and the expected pathways of infiltrated water and groundwater.
- The impacts on urban hydrology from the proposed development at S1, S2 and S3 can be accommodated for in the design of the rehabilitated waterway. Rehabilitation of these waterways will significantly increase habitat values and amenity and improve water quality.
- Where flood detention basins occur, water quality treatment areas can be co-located in a portion of the detention basins.
- Alternative supplies of water to meet urban water demands can be supplied by water harvesting from roofs and other impervious surfaces associated with the urban development.
- The size of downstream treatment areas can be reduced by integrating water quality treatment systems into the streetscape. These also provide attractive, passively irrigated landscapes.

6.2 CONSTRAINTS

Key constraints to WSUD related to site characteristics are:

- The need to protect the receiving waters of the Nepean River to a standard as agreed in the Statement of Joint Intent (HRC 2001)
- The need to protect vegetation of significant conservation value and riparian zones of creeks on site to the extent required by DECCW (DWE 2008) and agreements with the NSW Office of Water.
- The small size of the detention basins precludes the use of wetlands in some instances where they would be desirable.
- All soils on site are prone to erosion by scour
- Shale derived soils throughout most of the site have sodic subsoils and groundwater in shale derived soils is saline
- Potential for subsidence and differential settlement associated with any coal and gas resource extraction.
- Existing Menangle Park Village and fixed elements of the proposed development, and the location of proposed roads.

The Nepean River is a sensitive receiving environment and is located immediately downstream of the proposed development with a limited buffer zone. Creeks N, M, S1, S2 and S3 all flow directly into the Nepean. The Hawkesbury-Nepean river system downstream of Menangle Park has environmental values including aquatic ecosystems, recreation (including primary contact recreation), irrigation water supply and human consumption of aquatic foods (HNCMA, 2006). Environmental objectives for the Nepean River were investigated by the Healthy Rivers Commission (HRC) as part of their process of inquiry into the Hawkesbury-Nepean system.

Nutrients are a particular concern in the Hawkesbury-Nepean, as the river system is subject to large nutrient loads from urban stormwater runoff and wastewater flows. This has sometimes resulted in algal blooms in the river system, and as urban development continues in the catchment, it is important to manage this risk. Water quality objectives were recommended by the HRC as a starting point for the initial phases of an adaptive management regime. They recommended that for most pollutants, the ANZECC *Water Quality Guidelines for Fresh and Marine Waters* should be adopted. However for nutrients they set objectives specific to the Hawkesbury-Nepean. For tributary streams in urban areas a recommended concentration of 1mg/L of Total Nitrogen and 0.5 mg/L of Total Phosphorus was proposed.

Equivalent load-based objectives have been determined to reflect the intent of the water quality objectives recommended by the HRC. (AECOM, March 2009) The analysis led to the recommendation that an appropriate frequency of compliance to the stipulated water quality targets be set at 93% and 97% of the time for TP and TN concentrations respectively. The recommended corresponding load-based targets for pollutant load reduction of TSS, TP and TN are 85%, 70% and 55%.

In order to meet these targets at Menangle Park, stormwater treatment and wastewater management that minimise nutrient inputs into the Nepean River will be essential.

In addition to the Nepean River, the creeks on site support both aquatic and terrestrial habitat. These creeks need to be protected by:

- Managing the quantity and flow patterns of stormwater runoff, to preserve the natural geomorphology.
- Managing the quality of stormwater runoff into the creeks and riparian zones, to preserve ecosystem health.
- Preserving the riparian zones in line with NSW Office of Water and DECCW's requirements.
- Managing the invasion of weeds in the creek and riparian zone and planting/encouraging the growth of locally indigenous species.

Existing development is already having some impact on the creeks on site. Developments such as the freeway, harness racing club, rural development (including the development upstream of the site), and coal washery have impacted the stream through modifications such as dams, substantial clearing of riparian and catchment vegetation, the construction of roads and culverts across waterways. These activities have impacted the stream form and water quality of the waterways.

The WSUD strategy seeks to mitigate the existing impacts on the waterways of the development site, in addition to the future anticipated impacts of urbanisation. The selection and design of WSUD measures must also consider topography, soil and groundwater characteristics. The key considerations at Menangle Park are:

- Potential salinity impacts from saline soils and groundwater can be managed by maintaining the hydrogeological regime as similar as possible to its natural state. Stormwater treatment measures that increase infiltration to groundwater should be avoided in saline areas, and major excavations are best avoided if they are likely to intersect the water table.
- Soils are relatively erosive and therefore it is important to manage potential erosion impacts of development. Stormwater treatment measures that slow flow velocities by retaining and/or detaining water can be designed to manage this risk.

Potential subsidence and differential settlement following any coal and gas resources extraction are difficult to predict in a quantitative manner, therefore it is difficult to design in advance for this issue. Some of the potential impacts that could occur are

- Increased infiltration to the sewerage network and associated risk of sewer overflows.
- Changed drainage patterns on the surface and in the groundwater system.

The sewerage system can be designed to some extent to cope with this risk, however other aspects would need to be managed adaptively if and when impacts occur.

6.3 WATERWAYS

The following table summarises the condition and characteristics of each of the waterways on site, and describes how the WSUD strategy responds to these conditions. The categorisation refers to the DECCW riparian classification.

Table 6.1: Condition of Northern Waterways (see Figure 6.1: Northern Waterways)

Stream	Category	Condition	Strategic Response
N1	3	Form: Natural geomorphological features mostly absent. Stream highly modified by clearing, grazing and the construction of dams Vegetation: Mostly cleared, remnant pockets of scattered trees belonging to Shale Plains Woodland EEC.	▪ Flow mitigation in flood detention basin 13. ▪ Bioretention system located within in flood detention basin ▪ Runoff conveyed in pipes through urban development
N2	2	Form: Natural geomorphological features mostly absent. Stream highly modified by clearing, grazing and the construction of dams. Vegetation: Mostly cleared of trees, pasture grasses present. Passes through a stand of Riparian Woodland (RFFOCFP – EEC) and Shale Plains Woodland (CPW-EEC) in good to moderate condition	▪ Wetlands to be integrated with the master planning for the employment zone. The water quality treatment areas can provide a buffer to the rehabilitated riparian zones. Flat topography on floodplain ideal for wetland cells to treat runoff from minor catchments. ▪ N2a is outside site boundary. Rehabilitated riparian corridor to begin in lower reaches of N2c. To be rehabilitated as Category 2 waterway.
N3a	1	Form: Natural geomorphological features present where stream is protected by riparian vegetation. Vegetation: Waterway passes through stands of Shale Plains Woodland (CPW-EEC) in good to moderate condition	▪ N3a is outside site boundary. N3a to be rehabilitated as Category 2 waterway.
N3b	2	Form: Waterway has been diverted around Coal Washery	▪ N3b is outside site boundary. N3b rehabilitated as Category 1 waterway.

Figure 6.1: Northern Waterways (see also figure 4.2 for naming of minor waterway reaches)

Table 6.2: Condition of Central Waterways (see Figure 6.2: Central Waterways)

Stream	Category	Condition	Strategic Response
M1	2	Form: Natural geomorphological features mostly absent. Stream highly modified by clearing, grazing and the construction of dams. Vegetation: Mostly cleared of trees, pasture grasses present. remnant pockets of scattered trees belonging to Shale Plains Woodland EEC	▪ Flow mitigation in flood detention basin 4 ▪ Water quality managed in detention basin and floodplain wetland systems ▪ Runoff conveyed in pipes through urban development
M2	3	Form: Natural geomorphological features heavily impacted by culverts and dams Vegetation: Mostly cleared of trees, pasture grasses present. remnant pockets of scattered trees belonging to Shale Plains Woodland EEC	▪ Flat topography along drainage line upstream of freeway presents ideal location for a stormwater treatment wetland. Alternatively streetscape bioretention. ▪ Waterway designed as integrated drainage easement
M3b	2	Form: Natural geomorphological features heavily impacted by culverts and dams Vegetation: Mostly cleared of trees, pasture grasses present.	▪ Drains external catchment, therefore no water quality treatment required ▪ Rehabilitate as Category 2 waterway
M3c	1	Form: Wide floodplain with small channel. Floodplain comprises alluvial sands that would be prone to erosion if hydrology is altered by development Vegetation: High value vegetation along much of the riparian corridor. High value freshwater wetlands occur on the floodplain. Disturbed pasture elsewhere. Several significant weed infestations such as Blackberry	**WSUD Strategy** ▪ Flow mitigation in flood detention basins 2, 4, 5, 6, 12. ▪ Water quality treatment to be incorporated into flood detention basins and in wetlands on the floodplain. Discharge to be delivered to the floodplain as dispersed, sheet flow. Wetlands to be located outside areas of high value vegetation. **Waterway rehabilitation** ▪ Waterway rehabilitation design to engage the floodplain as much as possible for flows above approx 1:3month ARI. Wetlands to complement existing vegetation communities.
M3d	1	Vegetation: High value vegetation (Freshwater Wetlands) along upstream section. Downstream section heavily infested by exotic species	▪ M3d is outside site boundary ▪ Will be impacted by sandmining and then rehabilitated.

Figure 6.2: Central Waterways (see also figure 4.2 for naming of minor waterway reaches)

Table 6.2: Condition of Central Waterways (continued) - see Figure 6.2 above

Stream	Category	Condition	Strategic Response
M4	2	Form: Some remnant geomorphic features of value remain including ponds and channel Vegetation: High value vegetation along parts of the riparian corridor. Disturbed pasture elsewhere. Several significant weed infestations such as Blackberry	**WSUD Strategy** ▪ As for M3c – detention basins and wetlands on the floodplain. Wetlands located outside areas of high value vegetation. **Waterway rehabilitation** ▪ As for M3c – engage the floodplain and integrate floodplain storage.
M5	3	Form: Natural geomorphological features heavily impacted by culverts and dams Vegetation: Mostly cleared of trees, pasture grasses present	▪ Large allotments provide opportunity for on-site water quality treatment ▪ Rehabilitate as drainage corridor to convey runoff
M6	2	Form: Natural geomorphological features heavily impacted by culverts and dams Vegetation: Mostly cleared of trees, pasture grasses present	▪ Large allotments provide opportunity for on-site water quality treatment ▪ Rehabilitate as drainage corridor to convey runoff

Table 6.3: Condition of Southern Waterways (see Figure 6.3: Southern Waterways)

Stream	Category	Condition	Strategic Response
S1	3	Form: catchment and channel highly disturbed from extensive grazing and dams. Few geomorphic features of value. When catchment is developed, will be prone to erosion if not rehabilitated Vegetation: Catchment and riparian corridor mostly cleared of native vegetation. Pasture grasses and weeds occur throughout. Valuable stand of vegetation at confluence with Nepean. Few vegetation constraints on rehabilitation throughout most of waterway	**WSUD Strategy** ▪ Flow mitigation in flood detention basin 9 ▪ Water quality treatment to be incorporated into riparian zone buffer and into flood detention basin 9 **Waterway rehabilitation** ▪ Waterway to be designed and rehabilitated to accommodate future urban hydrology ▪ Grade control (for several metres drop) required at confluence with Nepean ▪ Revegetation to accommodate stream form
S2	3	Form: catchment and channel highly disturbed from extensive grazing and dams. Few geomorphic features of value. When catchment is developed, will be prone to erosion if not rehabilitated. Grade control (for several metres drop) required at confluence with Nepean Vegetation: Catchment and riparian corridor mostly cleared of native vegetation. Pasture grasses and weeds occur throughout. Valuable stand of vegetation at confluence with Nepean. Few vegetation constraints on rehabilitation throughout most of waterway	**WSUD Strategy** ▪ Flow mitigation in flood detention basin 11. ▪ Water quality treatment to be incorporated into flood detention basin and along drainage pathway through large lots. **Waterway rehabilitation** ▪ Waterway to be designed and rehabilitated to accommodate future urban hydrology ▪ Flow path for basin discharge to be rehabilitated as a naturalised waterway to convey flows to Nepean River. ▪ Grade control (for several metres drop) required at confluence with Nepean
S3	2	Form: catchment and channel highly disturbed from sand mining, construction activities, grazing and dams. Few geomorphic features of value. When catchment is developed, will be prone to erosion if not rehabilitated. Existing on-line wetland in poor condition. Vegetation: Catchment mostly cleared of native vegetation. Pasture grasses and weeds occur throughout. Valuable stand of vegetation at confluence with Nepean, and extending approx 200m upstream from confluence. Few vegetation constraints on rehabilitation throughout the rest of the waterway.	**WSUD Strategy** ▪ Water quality treatment to be incorporated into streetscape and into flood detention basin ▪ Existing wetland to be rehabilitated for water quality treatment **Waterway rehabilitation** ▪ Waterway to be designed and rehabilitated to accommodate future urban hydrology. Waterway design can mostly accommodate existing vegetation of high value ▪ Grade control (for several metres drop) required at confluence with Nepean

Figure 6.3: Southern Waterways

Table 6.4: Condition of Village Drainage Line (see Figure 6.4: Village Drainage line)

Stream	Category	Condition	Strategic Response
V1	n/a	Drainage pathway culvert beneath rail way, through constructed broad sandy channel just north of the Harness Track. No flow path to Nepean (natural infiltration in very sandy area and landform modification from sand mining). Rural catchment. No natural channel or riparian vegetation.	▪ Water quality treatment – bioretention in detention basin 7 and streetscape. ▪ Rehabiliation of drainage line integrated with master plan for Harness Racing Track. Vegetation and erosion protection along drainage line. Potential harvesting/reuse of Basin 7 discharge prior to infiltration.

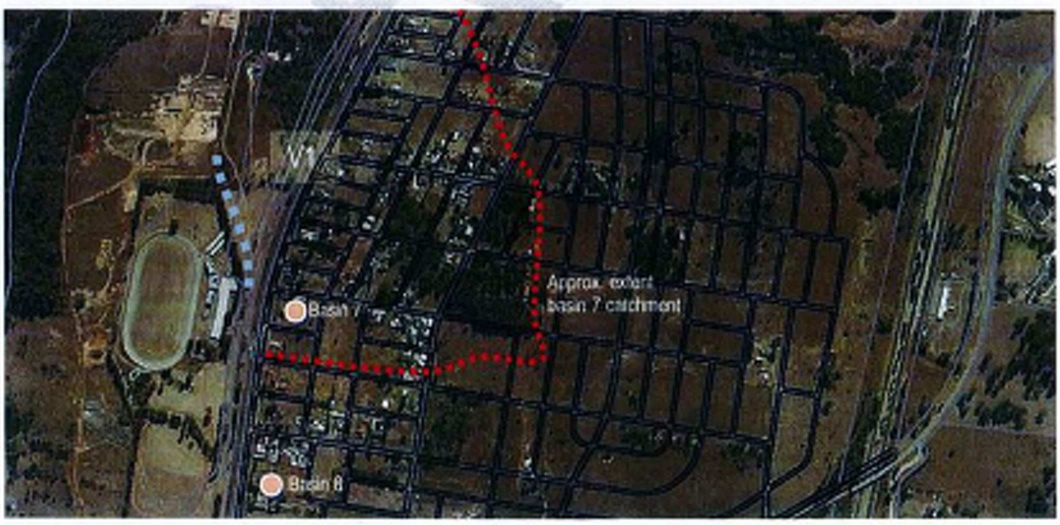


Figure 6.4: Village Waterway/Drainage line

7 WSUD STRATEGY

The WSUD Strategy proposes elements to meet the objectives outlined in section 5 for:

- potable water conservation,
- stormwater quality control,
- flow management,
- riparian corridor management and
- wastewater pollution control.

This section outlines a predevelopment and post development water balance to highlight the need for WSUD measures to mitigate urban impacts. This is followed by sections that address each of the WSUD objectives. Within each section the strategy is outlined and the measures proposed are discussed. Time series analysis using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) enables water balance modelling, water quality simulations and assessment of rainwater harvesting options to inform the concept design of the proposed WSUD elements and to demonstrate compliance to the water management objectives for the site.

7.1 WATER BALANCE

Predevelopment (existing)
The total development area for Menangle Park covers approximately 423ha (395 ha if the Transgrid and Glenlee Historic site are excluded). The volume of rainfall over this 423 ha area in an average year totals 3,422 ML, based on average annual rainfall of 809 mm/yr (presented in Section 4). The resulting average annual estimates of runoff and infiltration are dependent on a range of factors including topography, vegetation coverage and soil characteristics. MUSIC modelling with generic soil profile parameters suggests predevelopment runoff is approximately 457 ML/yr (less than 15% of rain falling on the site). Thus infiltration and evapotranspiration account for more than 85% of the rainfall onto the predevelopment site. An illustration of the predevelopment water balance is provided in Figure 7.1. This provides the basis for comparison with the post development case.

Post development
The urban water balance for the post development scenario is illustrated in Figure 7.2. The impervious area associated with the development is estimated at 270 ha corresponding to an impervious percentage of 64%. This impervious area includes roads, roofs, footpaths and other hard surfaces. Rainfall onto the impervious areas of the site for the post development scenarios will typically be rapidly conveyed to receiving environments (Nepean River and its tributaries) with traditional drainage design.

The quantity of runoff is significantly increased (more than 4-fold), from 457 in the pre-development case to 2100 ML/yr. In the post development scenario, 60% of rain falling on the site leaves as stormwater runoff (compared with 15% in the pre-development scenario). Infiltration and evapotranspiration is less than half that of the predevelopment case (reduced from 2,965 ML/yr to 1322 ML/yr).

Development of the site will deliver an expected yield of 3,400 dwellings and an estimated 11,560 residents (3.4 people per dwelling). The determination of this estimated occupancy rate is outlined in the social assessment report (Heather Nesbitt Planning, 2010). This report provides a breakdown of the occupancy rate for each dwelling type and an indicative age profile for the site. The expected number of residents and estimates of typical per capita water use enable the water streams to be determined for the post-development scenario.

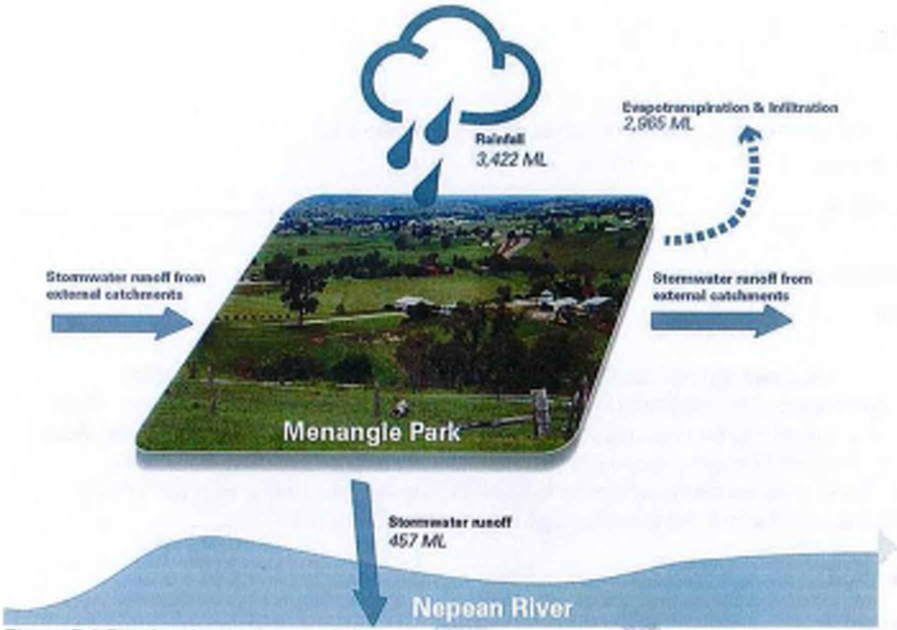


Figure 7.1 Pre-development water balance

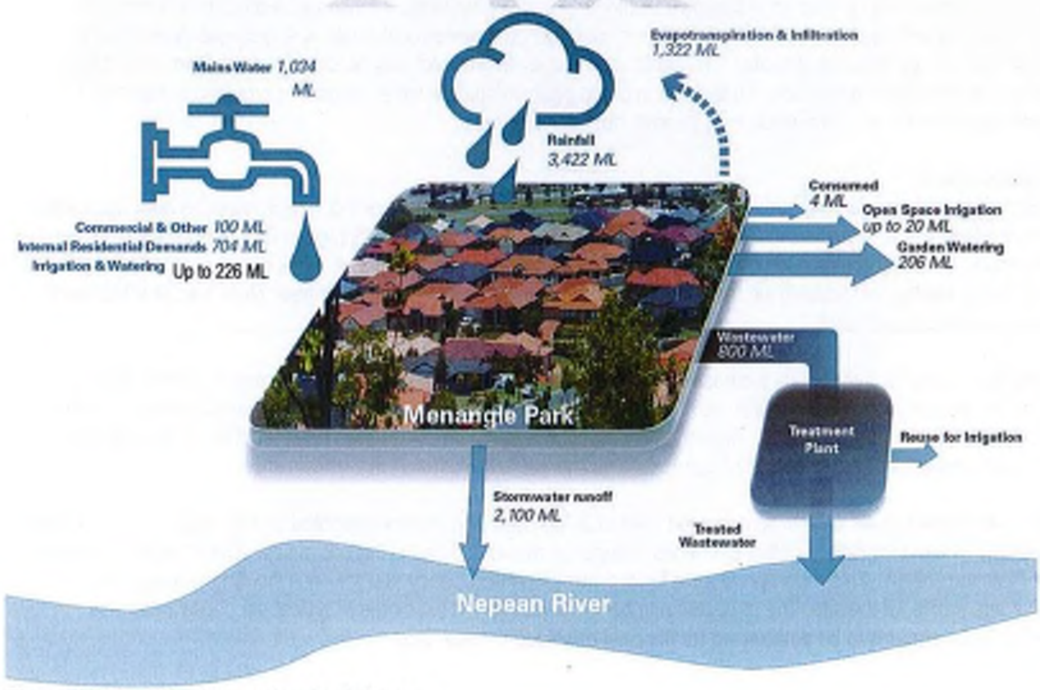


Figure 7.2 Post-development water balance

The estimated demand for water (assuming use of water efficient fixtures like dual flush toilets and efficient shower heads) is approximately 1034 ML/yr, with 704 ML associated with internal residential demand. The increase in stormwater runoff associated with urbanisation of the site (1,643ML/yr) is twice that of the internal residential water demand (457 ML/yr). A proportion (up to nearly 80%) of the water demand can be met with harvested rainwater or stormwater, (for example - hot water supply, irrigation, toilets and laundry). The remaining water demands would be met with potable water, supplied by Sydney Water, from the Macarthur Water Filtration Plant (drawing primarily on the Cataract Dam) – subject to confirmation of capacity and development of potable water servicing strategy.
The majority of household indoor water used would be disposed of via a sewerage network connecting to the West Camden Sewage Treatment Plant which discharges to Matahil Creek, a tributary of the Nepean River approximately 12km downstream of Menangle Park - subject to confirmation of capacity and development of wastewater servicing strategy. A proportion of the sewage treated at the West Camden STP is reused. Pipelines for irrigation of treated effluent from the West Camden STP were constructed in 2009 as the plant capacity was increased from 9 ML/d to 23 ML/d.

The demand for water for irrigation of private gardens is estimated at 206 ML/yr. There would be additional demand for irrigation of public open space areas, playing fields and for irrigation of the grounds of the adjoining Harness Racing Club. The addition of up to 5 ha of irrigated public open spaces would require approximately another 20 ML/yr of water. Stormwater harvesting can typically meet a significant proportion of the irrigation demand, however large storages are required as the demand is strongly seasonal.

Comparison of the predevelopment and post development water balance show that developing the site significantly increases average annual stormwater runoff volumes. There are also potential impacts on water quality and on the health of the receiving waterway. This WSUD strategy aims to mitigate the impacts associated with the changes to the water streams resulting from urban development.

7.2 WATER CONSERVATION

For Menangle Park section 5 of this WSUD strategy identified a water conservation target of a 45% reduction on the BASIS benchmarked water usage and stretch target of 60 – 70+% (consistent with Landcom's WSUD Policy). It is noted that compliance with BASIX is however the minimum legislated requirement, and thus the base case in this discussion on water conservation options.

All residential dwellings in NSW must meet the NSW State Environmental Planning Policy (SEPP) Building Sustainability Index (BASIX) target for a 40% reduction in potable water use compared to a base case scenario. The BASIX benchmark is 90,340 litres of water per person per year (247 L/p/d), based on the average of Sydney households prior to the BASIX scheme introduction. The BASIX assessment tool allows the benefits of specific water conservation measures to be compared based on the expected potable water demand of the household.

The current BASIX target (40% reduction in water use) typically requires the use of:

- water efficient showerheads, toilets and taps,
- a small rainwater tank (2 – 3 kL) connected to either toilets or laundry or hot water and
- garden areas with low water use planting or rainwater used for irrigation

The breakdown of the various internal demands is illustrated in Figure 7.3 and Table 7.1. The daily use per person (Litres per person per day) is tabulated using data from the Yarra Valley Water 2004 Residential End-Use Measurement Study with modifications for assumed uptake of dual flush toilets, showerheads, fixtures and clothes washing machines (MWH, 2006).

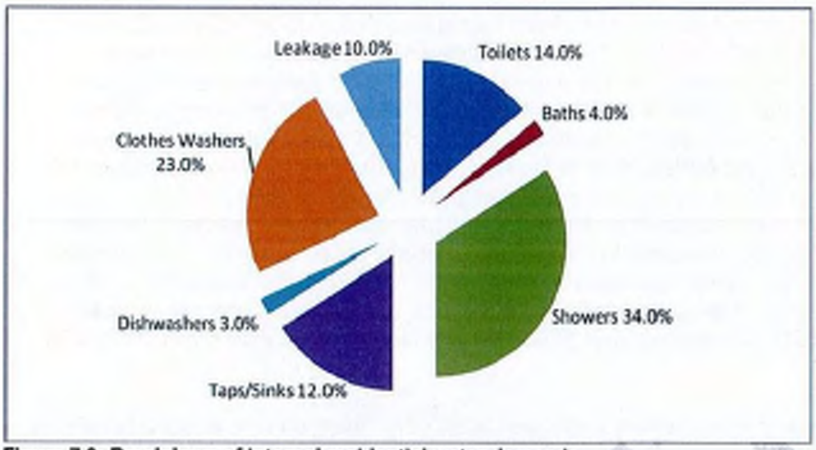


Figure 7.3: Breakdown of internal residential water demands

In Table 7.1, the total water use in L/p/d and equivalent ML/yr describes the internal residential water use for the development, based on 3,400 lots; 11,560 people. The internal water use breakdown for potable demands, hot water demands and non potable uses is provided, with leakage apportioned between the three streams. This breakdown assists in modelling opportunities to use alternative water sources to reduce potable water demand (e.g. rainwater harvesting or stormwater / treated wastewater reuse).

Irrigation of residential garden areas, estimated at up to 206 ML/yr across the development, represents an additional non potable demand (external).

Table 7.1: Breakdown of internal water demands

Usage	Total Water use		*Potable (cold)*	*Hot Water*	*Non-Potable*
	L/p/d	ML/yr	*ML/yr*	*ML/yr*	*ML/yr*
INTERNAL					
Toilets	22	90.7	-	-	*90.7*
Baths	3	13.0	*2.6*	*10.4*	-
Showers	52	220.3	*66.4*	*153.8*	-
Taps/Sinks	25	103.6	*27.6*	*76.0*	-
Dishwashers	3	13.0	*10.4*	*2.6*	-
Clothes Washers	37	155.5	-	-	*155.5*
Leakage	12	51.8	*9.3*	*21.1*	*21.4*
SUB-TOTAL INTERNAL	**154**	**647.8**	***116.3 (18%*)***	***263.9 (41%)***	***267.6 (41%)***

(18%*) – percentage of potable (cold) water demands as proportion of total internal water use for the development. Similarly for hot water and non potable demands, each 41% of total internal water demands.

Rainwater Tank Sizing

Rainwater tanks can reduce potable water demands by providing an alternative water supply to meet demands for toilet flushing, laundry use and irrigation. The reliability in meeting non potable demands for a given harvestable roof area was modelled using MUSIC. Rainwater tank sizing curves can guide the appropriate selection of rainwater tank sizes for individual dwellings by demonstrating the effectiveness of increasing the tank size on the 'reliability of supply' (percentage of the modelled demands that can be met with the available harvested water).

Figure 7.4 shows a sizing curve for a 250 m² roof area, assessing the reliability in supplying rainwater for toilet flushing, irrigation and laundry demands. A 2 - 3kL tank gives 45 - 53% reliability of supply. This correlates to a potable water saving of 60 - 71 kL/yr/dwelling or 202 - 239 ML/yr for the development. The rainwater tank sizing curves enable the point of diminishing returns to be identified and demonstrates that additional water savings can be realised with a slightly larger tank size (5kL) than that required to meet the minimum BASIX requirement of typically 2 – 3kL.

The cost for a rainwater tank is approximately $5,000 per dwelling. The total cost for the development is $16.8 million (based on 3,400 lots). This cost is typically borne by the householder.

As a ratio of capital cost to annual water reuse, small rainwater tanks results in a dollar value per ML of $21 - $25/ML. This is considerably higher than the cost for alternative strategies with greater water savings.

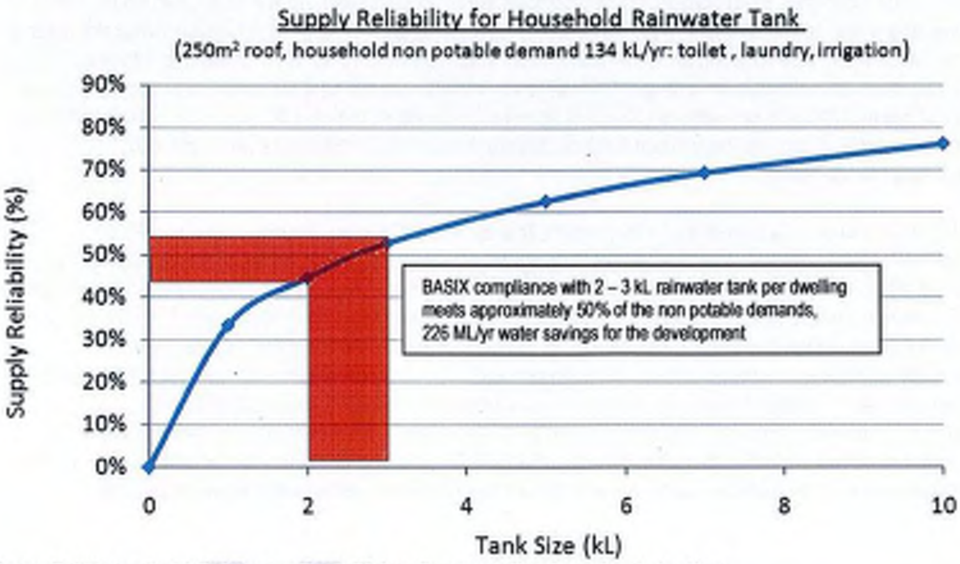


Figure 7.4 Household Rainwater Tank Sizing Curve - toilet, laundry, irrigation

Fit-for-purpose use of water

A significant proportion of the urban water demands do not require water of a quality suitable to drink. Alternative water sources may include treated wastewater, harvested stormwater and rainwater harvested from roof surfaces. Alternative water sources can be used to meet demands for water of a lower standard – for example treated wastewater can replace drinking quality water currently used for toilet flushing, laundry use and irrigation. Fit-for-purpose use of water enables a reduction in the quantity of potable water imported to the site (to meet water conservation targets) and reduced environmental impacts associated with water extraction from reservoirs, transfer and treatment.

Fit-for-purpose use of water matches water of an appropriate quality from the various urban water streams with water demands. This approach is an effective mechanism to reduce demand for scarce potable water resources and meet water conservation targets.

A matrix of fit-for-purpose domestic water use matches the water quality of various sources with suitable or preferred uses. This approach enables optimum water conservation outcomes to be achieved. The preferred uses for the various water sources are listed below:

Potable water: cold water demands in the kitchen, laundry and bathroom

Harvested Rainwater: hot water demands in the kitchen, laundry and bathroom

Treated Wastewater (or Harvested Stormwater): garden irrigation, and toilet flushing

A fit-for-purpose approach extends the use of rainwater tanks for BASIX compliance, resulting in significantly greater potable water savings and associated benefits. Additional 'dual reticulation' infrastructure is required to facilitate the use of treated wastewater or harvested stormwater to meet non potable demands. It should be noted that the cost for such infrastructure is typically less for a large development areas than the cost for individual rainwater tanks.

Rainwater can be used to meet hot water demands (for showers, hot water taps etc), as effective disinfection can be achieved through the hot water system. A high reliability of supply can be achieved with even a small rainwater tank due to the relatively high constant daily demand for hot water. This ensures rapid drawdown on the tank, and hence available storage volume for most rainfall events.

Dual Reticulation

There has been some significant advancement in technology for water recycling over recent years, leading to many innovative applications of small-scale water reuse schemes. There are already technologies for stormwater harvesting and reuse, greywater reuse, sewer mining and local wastewater treatment plant and it is anticipated that they will become more and more cost effective for a range of development scales over the next ten years. It is also anticipated that local and statewide standards for water recycling will be established within the next decade. The benefits of these technological advancements can only be realised if the necessary reticulation infrastructure are in place in developments being planned today.

In assessing the water conservation strategy for this project, it is apparent that there are significant benefits in providing a dual reticulation network. The construction of a dual reticulation network in a greenfield development is cost effective and allows the development to benefit from future advancements in water recycling technologies. Such a system can ultimately maximise water conservation, minimise the transport of water and wastewater from the site, and minimise treatment costs of water and sewerage, as well as possibly off-setting any costs associated with augmentation of the downstream sewage carrier. Through provision of a dual reticulation network and infrastructure for supplying an alternative source of water, the entire non potable demand for each house could be met, corresponding to potable water savings of approximately 450 ML each year. This would allow a stretch water conservation target to be met, with the site achieving more than a 60% reduction on benchmarked water use. The dual reticulation network would be plumbed to supply reuse water for toilet flushing, garden watering and cold water laundry.

The benefits of dual reticulation include:

- significantly greater potable water savings (and reduced impacts associated with supplying potable water)
- reduction in discharge of pollutants to the Nepean River (through reuse of stormwater or treated wastewater)
- cost effectively essential infrastructure for Greenfield sites
- allows for flexibility in the most cost effective water sources – as base pipe network can be the conduit for a any future non potable water source
- ensures residents of Menangle Park can access cheaper water for their non potable demands where a recycled water source is available (IPART stipulate charges for non potable water at 80% of those for potable water)
- resilience to the expected increasing variability in rainfall with climate change that is likely to make rainwater tanks less effective in terms of supply reliability

There are some risks with irrigation of treated waste water as it is typically higher in nutrient concentrations and in salt levels. The use of treated waste water for irrigation needs to be carefully managed to ensure there is not excess irrigation leading to surface runoff with high nutrient concentrations. Salts can build up in the soils and have negative impacts on soil structure and plant growth. Stormwater is preferable as the source for irrigation as these risks are able to be mitigated. Treated wastewater is the preferable source for toilet flushing and cold water laundry demands. The human health risks are managed with adequate disinfection of either treated wastewater or harvested stormwater.

The cost for the dual reticulation network is estimated at $5 - $8.4 million dollars, ($1,500 - $2,500 per lot). The water supply for the dual reticulation network can be obtained from a range of sources including treated stormwater, onsite wastewater or from sewer mining where wastewater is extracted from a nearby sewer carrier. Treatment of all these sources of water will be required to ensure appropriate public health and environmental standards are met. The treatment and supply of non-potable water using either an on-site treatment plant or through pipeline connection to West Camden STP is estimated at up to $10 million, bringing the total approximate cost per lot to $4.5 - $5.5k per lot. This is comparable to the cost associated with the use of rainwater tanks but has a superior potable water conservation outcome, i.e. 452 ML/yr compared with 226 ML/yr for the rainwater tank option).

As a ratio of capital cost to annual water savings, dual reticulation options (C and D in the follow section – and downstairs) result in a dollar value per ML of between $8 - $12 /ML. This is considerably competitive with a range of options, but enables s=higher than the cost for alternative strategies with greater water savings.

Existing Infrastructure
Figure 7.5 illustrates the proximity of a number of water assets in the vicinity of the site that have the potential to facilitate enhanced water conservation outcomes. It is acknowledged that this is the baseline infrastructure and may not have the capacity to service the Menangle Park site. Further investigation is required to ascertain the capacity constraints and identify if there is a case for augmentation of this infrastructure or preferable alternatives. Landcom has commissioned MWH to assess the optimum water servicing strategy in collaboration with Sydney Water. (Infrastructure Report, Lean & Hayward, Jan 2010)

An upgrade and amplification of the existing West Camden Sewage Treatment Plant (STP) was completed in late 2009. Improvement in the STP's treatment processes increased the capacity to cater for population growth in the region, provides opportunities for effluent re-use and reduces nutrient discharge to the Nepean River. The advanced tertiary sewage treatment level at the West Camden STP produces effluent of suitable quality for either reuse of discharge to the Nepean.

A reuse pipeline has been constructed to supply up to 5 million litres per day of high quality recycled water to the Elizabeth Macarthur Agricultural Institute, located 9km from the STP. The 300mm diameter pipeline cost approximately $3 million and transfers tertiary treated effluent to a 60 ML earth dam located on the Agricultural Institute. This dam is located approximately 3 km from the Menangle Park site.

Sugarloaf Dam is located adjacent to the eastern boundary of the site. The SCA (Sydney Catchment Authority - SCA), no longer use the 100 ML dam (originally intended to provide for sedimentation control). They propose to breach the dam wall. Council has discussed opportunities with the SCA on site, but the SCA does not want to retain the dam and consider their decision final on the partially breach the dam wall. There may be an opportunity to retain a smaller water storage volume (20 ML) or use the site for a small reservoir, connected by a harvesting pipeline to distributed water storages within detention basins.

Stormwater harvesting as part of an urban development at the nearby UWS site may provide an opportunity to expand the reuse network and facilitate investment in the sewer mining to provide treated wastewater to meet a greater proportion of non potable demands. There is potential for collaborative grant applications to the federal government for large scale stormwater harvesting initiatives.

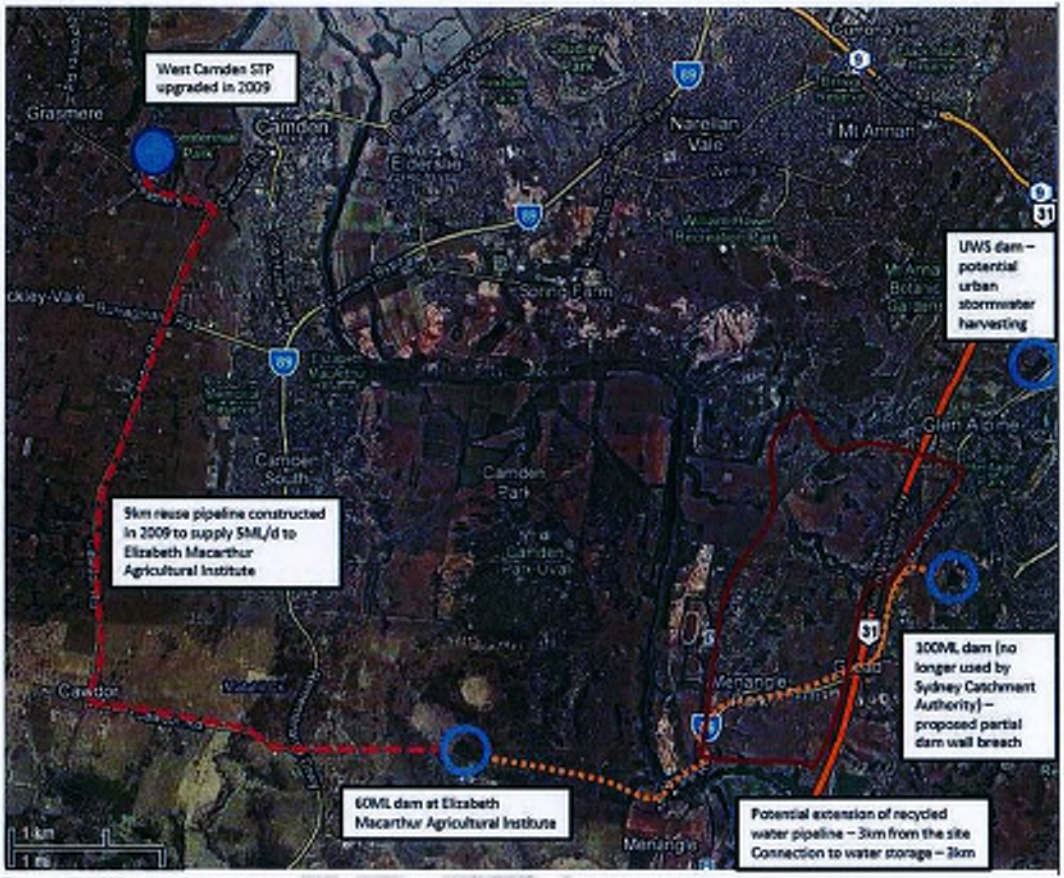


Figure 7.5 Water infrastructure assets near the Menangle Park site

Water Conservation Options
As the planning for the Menangle Park Development proceeds, the range of options available for water conservation should be understood and considered. The options outlined below range from (A) BASIX compliance to (E) an optimum strategy for fit-for-purpose use with dual reticulation, wastewater or stormwater reuse and roof water harvesting for hot water demands.

Figure 7.6 provide a comparison of three of the five options demonstrating the increasing storage volume required to increase potable water savings. Note that the 'Combined storage volume' represents the storage required to get the water savings – regardless of whether this is distributed storage in rainwater tanks for each lot or centralised storage(s) for larger scale stormwater harvesting. Table 7.2 has details and estimated costs for each option, with additional notes following the table.

Option A – BASIX COMPLIANCE
Standard BASIX scenario with 2-3 kL tanks installed on each lot, (equating to 7-10 ML total storage volume across site). This provides water savings of approximately 200-240 ML/yr, resulting in 45-53% non-potable demands being met. This option is the cheapest for developers, as rainwater tank costs are typically incurred by the dwellings residents after sale of the lot. The total cost for this option is high however and it provides the least water savings, and most limited future servicing potential.

This option does not meet the proposed potable water conservation target of a 45% reduction on benchmarked water use. Installing rainwater tanks that are 3.5kL or larger would enable the proposed potable water conservation target to be met, but would not enable stretch targets to be met.

Option B – LARGE RAINWATER TANKS
Large 10 kL rainwater tanks are installed on 90% of the lots, (equating to 30ML total storage vol). The remaining 10% of lots would be serviced by smaller 2-3kL tanks. The collected rainwater is used to supply toilets, laundry, irrigation and hot water demands, resulting in 55-61% of this total demand being met – which is equivalent to meeting 79 – 88% of the non potable demands. This option also has limited future servicing potential, and water savings are likely to reduce with increasing climate variability.

A potable water saving of approximately 58% of benchmark water usage can be achieved with large rainwater tanks. This enables the proposed potable water conservation target to be met – but falls just short of meeting stretch targets for potable water use.

Option C – DUAL RETICULATION AND HARVESTED STORMWATER
A centralised water storage strategy is adopted which results in savings of between 340-410 ML/yr for storage volumes of 20 – 50ML. No rainwater tanks are required on lot areas as a dual reticulation pipe network is provided connecting the central supply of reuse water to each dwelling and to stormwater harvesting basins. This option has excellent future servicing potential enabling a greater proportion of non potable demands to be met when a centralised reuse water supply becomes available. Stormwater harvesting provides a cost effective, interim non potable water supply with additional environmental benefits.

The water savings for these options (A – C) depend on the storage volume available (i.e. large rainwater tanks or central storage volumes result in increasing water saving).

A potable water saving of approximately 62% of benchmark water usage can be achieved with dual reticulation connected to a 50ML stormwater storage. This enables the proposed potable water conservation target to be met, and Landcom's target for areas where dual reticulation is provided – but falls short of meeting Landcom's stretch target of a 70% reduction for potable water use where dual reticulation is provide.

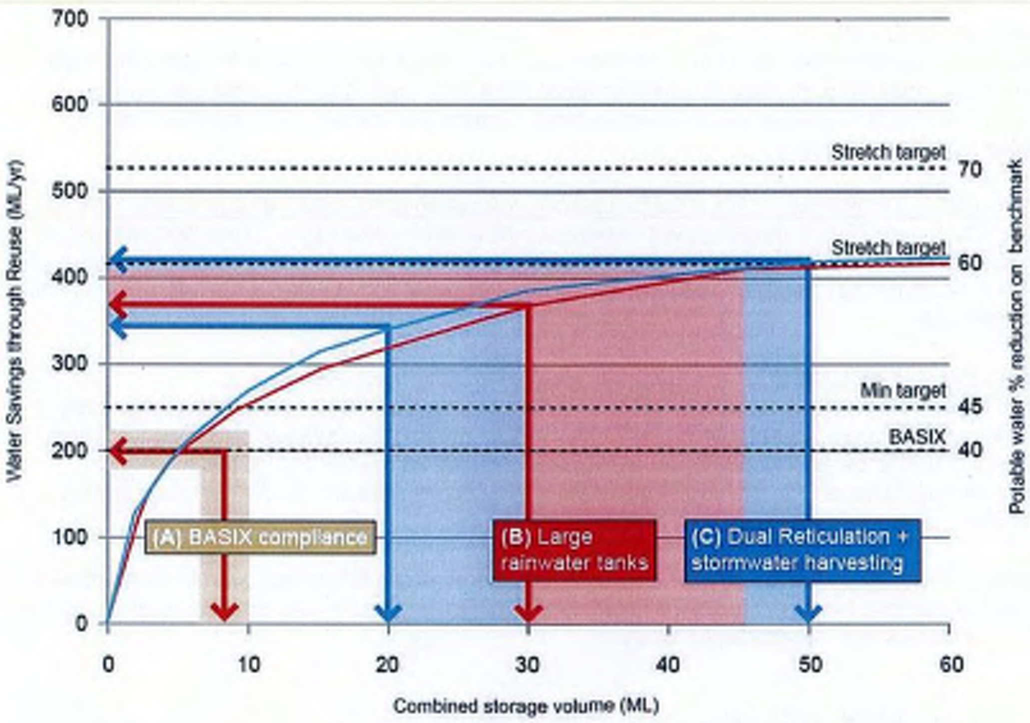


Figure 7.6: Water savings for water conservation options A, B and C

Figure 7.6 shows that

- Option A, BASIX compliance using 2 – 3 kL tanks to supply non potable demands enables water savings of approximately 200-240 ML/yr. Note that 2-3 kL storage per lot equates to a combined storage volume (X axis) for 3,360 dwellings of 7 – 10ML.
- Significantly greater water savings can be achieved with options that go beyond using small rainwater tanks for compliance with BASIX.
- The red shaded area represents option B which uses large rainwater tanks (10 – 15kL per large lot equating to 30 – 45 ML stoarage across the development). With the supply plumbed to both hot water and non potable demands) water savings of 360 ML/yr (10kL tanks) to 400ML/yr (15 kL tanks) are achieved. This is 1.5 to 2 times that achieved with option A - BASIX compliance.
- The blue shaded area representing option C (dual reticulation and stormater harvesting) enables water savings of between 340 and 410 ML/yr, with a central (or distributed) storage volume of 20 – 50 ML.
- For option C, if the available storage volume was 10 kL, water savings of 270 ML/yr are achieved (blue line). Note that this option provides the infrastructure to facilitate additional water savings where a future more reliable storage size is available (e.g. through connection to a treated waste water supply from a Sydney Water Sewage Treatment Plant or a local / nearby sewer mining plant).

There are options that provide even greater water savings, both building on option C, using a dual reticulation network to facilitate fit-for-purpose water use and conservation of potable water supplies. These options (D and E) are presented in Figure 7.7 below, with additional details in Table 7.2.

Option D – DUAL RETICULATION AND TREATED WASTEWATER NON POTABLE SUPPLY

Option D – (yellow label in figure below). A non-potable network with connection to a central supply of recycled water would enable almost all non potable demands to be met (450 ML/yr), without requiring large storage volumes. A non potable reservoir would be requried to buffer demands. There may be a small proportion of the peak irrigation demand in Summer that may not be met subject to design of the non potable supply and irrigation networks.

*** A potable water saving of approximately 66% of benchmark water usage can be achieved with dual reticulation connected to a treated wastewater supply. This enables the proposed potable water conservation target to be met, and Landcom's target for areas where dual reticulation is provided – but falls short of meeting Landcom's stretch target of a 70% reduction for potable water use where dual reticulation is provide.**

Option E – RAINWATER TANKS (HOT WATER SUPPLY) + DUAL RETICULATION (TREATED WASTEWATER)

Option E – (green label in figure below) builds on option D, adding small rainwater tanks to meet hot water demands, in addition to the dual reticulation network to meet non potable demands. This enables even greater water savings, reducing potable water import to just 22% of the total residential demand. This option is an optimum strategy for fit-for-purpose use with dual reticulation, wastewater reuse and roof water harvesting for hot water demands

*** A potable water saving of approximately 77% of benchmark water usage can be achieved with dual reticulation connected to a treated wastewater supply. This enables the proposed potable water conservation target to be met, and Landcom's target for areas where dual reticulation is provided and also meets Landcom's stretch target of a 70% reduction for potable water use where dual reticulation is provide.**

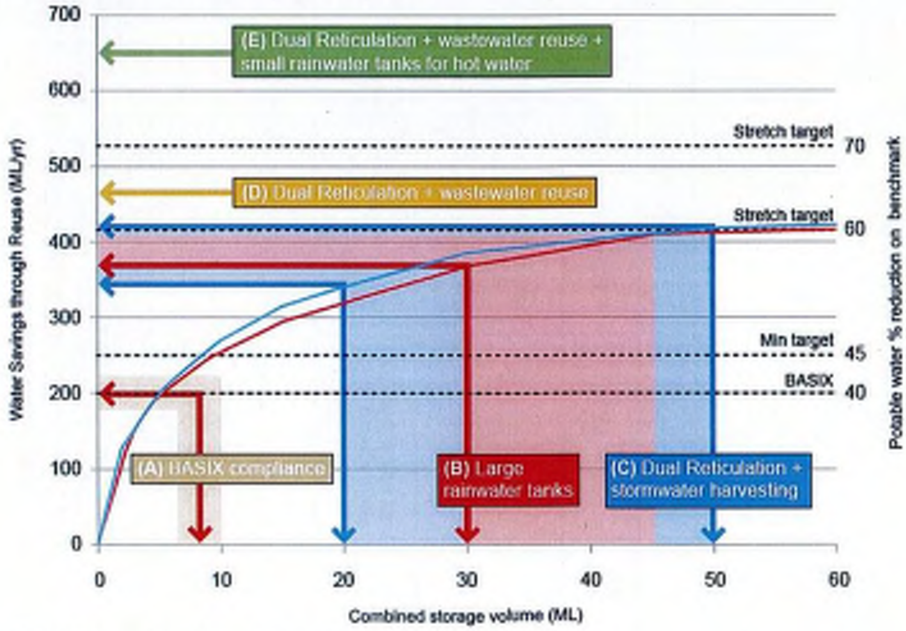


Figure 7.7: Water savings for water conservation options A - E

Figure 7.7 shows that

- Option D, enables water savings of 450 ML/yr, with almost all non potable demands met. This is more than double the savings with small rainwater tanks under the BASIX scenario and can be delivered at cheaper overall cost.
- Option E enables water savings of 620 - 650 ML/yr, with a significant proportion (38 – 66%) of hot water demand met (using rainwater tanks of 3 – 5kL) in addition to supply of treated wastewater to meet non potable demands.

Table 7.2 Water Conservation Options A - E

Option	**A**	**B**	**C**	**D**	**E**
	BASIX compliance	Large rainwater tanks on 90% of lots & small tanks on small lots	Dual reticulation & non potable water supply: harvested stormwater	Dual reticulation & non potable water supply: treated wastewater	Dual reticulation (non potable supply D) & rainwater tanks for hot water demands
Rainwater tank size per dwelling (T)	2 – 3 kL	10 – 15 kL	-	-	3 - 5 kL
Centralised water storage volume required (S)	-	-	20 – 50 ML	2 – 5 ML to buffer demands	2 – 5 ML to buffer demands
Equivalent combined total storage volume (T + S)	7 – 10 ML	20 – 30 ML	20 – 50 ML	2 – 5 ML	12 – 22 ML
Water savings	200 - 240 ML/yr	360 – 400 ML/yr	340 - 410 ML/yr	~ 450 ML/yr	620 - 650 ML/yr
Equivalent % reduction on benchmark water use	**41% - 44%**	**56% - 60%**	**54% - 62%**	**66%**	**74% - 81%**
Supply reliability to meet non potable demands	45% - 53%	Equivalent to 79 – 88%	75% - 91%	~100 %	137 - 144% (all non potable demand met, + 38-66% hot water demand)
Advantages	Cheapest option for developer	No dual retic. required. Rainwater supply to hot water, toilets, laundry and irrigation, meeting 55% - 61% of demand.	Facilitates optimum future water savings. No rainwater tanks required on lots. Environmental benefits from SW harvesting	Delivers maximum non potable water savings. No rainwater tanks required on lots. Environmental benefits from WW reuse Sydney Water mgt	Delivers optimum total water savings Environmental benefits from rainwater harvesting and WW reuse
Disadvantages	Least water savings, locks out cost-effective future non potable servicing	Large tanks are costly and difficult to fit on mid size lots (<1,000m²) Climate change likely to reduce water savings	Cost of central storage + pipe network (dual retic and SW harvesting) Need operator / mgt	Upfront cost for pipe network infrastructure: dual retic + reuse supply No SW harvesting	Cost of rainwater tanks and pipe network dual retic + reuse supply
Cost Assumptions	$5k per lot for small tank	$10k per lot for large tank, (some small tanks)	$2k per lot for dual retic, $5 million for storage & filtering/disinfection $1.8 million for pipelines	$2k per lot for dual retic, $2 million for reservoir $3.6 million for reuse supply connection	$6k per lot for small tank $2k per lot for dual retic, $2 million for reservoir $3.6 million for reuse supply connection
Estimated Cost	**$16.8 million**	**$31.9 million**	**$13.5 million**	**$12.3 million**	**$32.5 million**
Estimated Cost per lot	**$5,000 / lot**	**$9,500 / lot**	**$4,000 / lot**	**$3,700 / lot**	**$9,700 / lot**
Estimated Cost ($) per ML saved	**$21 - $25**	**$24 - $26**	**$10 - $12**	**~ $8**	**$15 - $16**
Operational Costs / Savings	For all options there are some cost savings in the unit supply cost of non potable water (pegged at 80% of potable) and rainwater (no unit supply cost) in comparison with use of potable water. The maintenance costs for tanks / pumps and service charges from operating utilities are likely to be comparable in magnitude with the identified savings – thus a more detailed study with sensitivity analysis on critical assumptions is required to provide life cycle costing.				

- **Notes for Table 7.2 are provided on the following page**

Notes for table 7.2

- **Option B:** About 10% of lots are small (390 – 450m²). Large tanks would be difficult to configure on small lots. Option B assumes these lots have small tanks for BASIX compliance. This would increase water savings for this option by 20 – 24 ML/yr more than the numbers in the table above. The estimated cost includes the cost for small tanks on 10% of lots.
- Supply reliability of 55 – 61% for both hot water and non potable demands and equates to water savings of 79 – 88% of the non potable demand. No dual reticulation network required, but water savings from rainwater tanks will reduce with increasing climate variability.
- **Option C:** Cost effective central storage is possible through reconfiguring Sydney Catchment Authority's 100ML Sugarloaf Dam - currently proposed to be partially breached – or by configuring distributed storage in detention basins or other locations. Only minor treatment required (filter and disinfection) for stormwater from bioretention systems. Harvesting pipework & pumping: estimated 6km @ $300/m: $1.8 million). Should this option be pursued an assessment of stormwater storage options would need to be undertaken. Note that large below ground storage costs may reduce within the coming decade through advances in technologies which make assist in feasibility for this option.
- Modelled reuse for water savings: 250 ML/yr for toilet flushing and laundry, 200 ML/yr of irrigation, impervious catchment of 150ha; harvesting from some of the large detention basins in the central part of the site: Basins 4, 2, 12, 7, 8 and 9 with combined impervious catchment 149 ha). A 6km harvesting network required to link basins
- **Option D:** Non potable supply from Sydney Water's reuse pipeline from West Camden STP. This option for non potable supply is the least complex management arrangement as Sydney Water would construct the required connections and supply the alternative water source with cost of water as set by IPART.
- **Option D2:** Alternative non potable supply from an onsite sewage treatment plant or sewer mining plant. Management and operator required. Costs likely to be approximately $5,000 per lot. Also possible to integrate stormwater harvesting with sewer mining and operate cost effectively and sell reuse water.
- **Option E:** Rainwater tanks plumbed to meet hot water demands can deliver an additional 170 – 200 ML/yr in water savings, using a 3 – 5 kL tank / dwelling.

Water Conservation in the public domain

In addition to initiatives to meet residential water demands there are also further opportunities to reduce potable water demands in the Menangle Park development:

- In areas of public open space, use vegetation that does not require irrigation, or where irrigation is necessary, install a drip irrigation system. A list of plant species indigenous to Campbelltown City Council and with low water use requirements can be found at: http://www.basix.nsw.gov.au/pdf/indigenous_species/29.pdf.
- If there are public open spaces requiring irrigation within the development, these could be supplied with treated stormwater collected from treatment systems.
- Sewer mining and wastewater treatment could be undertaken locally with a small treatment plant or plants, to provide a recycled water source for open space irrigation (and supply household non potable demands).

Conclusion

The 45% target can be met with any of options B – E. The stretch target of a 60% reduction in potable water use could be realised for the Menangle Park site with any of the strategies C – E. A stretch target of 70% can be met with option E. The most cost effective solutions are Options C and D which required the construction of a dual reticulation network and a supply of non potable water from either Sydney Water or from harvested stormwater.

7.3 STORMWATER TREATMENT

For Menangle Park section 5 of this WSUD strategy identified a water conservation target of a 45% reduction on the

The pollutant load reduction targets adopted for Menangle Park require an 85% reduction in the TSS load from the developed site, a 70% reduction in the TP load and a 55% reduction in the TN load, as outlined in section 5. The WSUD Strategy outlines how these stormwater quality targets can be met.

This section describes

- **WSUD elements** - the types of systems proposed to integrate water quality improvement within suitable landscaped areas,
- **Treatment area sizing** - the required size for these systems based on impervious catchment areas and
- **WSUD layout** - the design configuration proposed for the site to ensure that the water quality targets are met.

7.3.1 WSUD elements

A range of stormwater treatment elements are available and can be configured as part of the WSUD Strategy for the site to meet the pollution control targets. These systems can be integrated with landscape areas at a range of scales, distributed within the catchment or concentrated in centralised locations. The range of treatment configurations available include:

- In public open space at the downstream areas of the development, regional systems such as wetlands can be constructed. Bioretention systems or wetlands can be configured in the base of detention basins.
- In minor drainage lines, swales or vegetated channels can be used in place of concrete pipes or concrete lined channels.
- In the streetscapes, swales and/or bioretention systems can be incorporated into median strips, road edges, traffic calming features, etc.
- On lots / lot frontage and verge (particularly in the case of rural residential development where lot sizes are relatively large), treatment systems such as bioretention raingardens can be incorporated into the garden areas particularly within the lot frontage (house setback zone) where the ongoing systems functionality can be observed/monitored.

The range of WSUD elements are illustrated through the following images and general description of the design configuration for:

A. bioretention systems within in detention basins,
B. floodplain wetlands, and
C. streetscape bioretention pods
D. on lot / lot frontage bioretention rain gardens

A. Bioretention systems with Detention Basins

Saturated Zone (SZ) bioretention pods are proposed within detention basins for water quality improvement. The bioretention area would typically be less than half of the basin floor area, and be perched above the basin floor, separated from the vegetated open space area of the basin with an embankment. Small flows would enter the bioretention system via a swale or low flow pipe to a coarse sediment forebay (this will concentrate easily removed sediment in an accessible maintenance location). Flows that exceed the capacity of the bioretention system would be directed to the other part of the basin (vegetated open space area), separated from the bioretention system by a bund of 0.5m – 1m. Diversion of high flows from the swale can occur via a side casting weir. Ponding in the open space area will then result in backflow of water to inundate the bioretention system above the extended detention depth. Larger events will result in inundation of the full detention area.

There are design options available to ensure that there will be no impact on landtake for the basin as a result of bunding for the bioretention system. The details will be worked through in detailed design. The bunds separating the bioretention systems from the remaining flood detention area would have a very small volume in comparison with the total storage volume provided. The refinement of the basin design and operation through the detailed design phase would ensure that the configuration accommodates the required flow attenuation and also strategies for the protection of the water quality elements.

Figure 7.8 Vegetated bioretention system as part of a detention basin

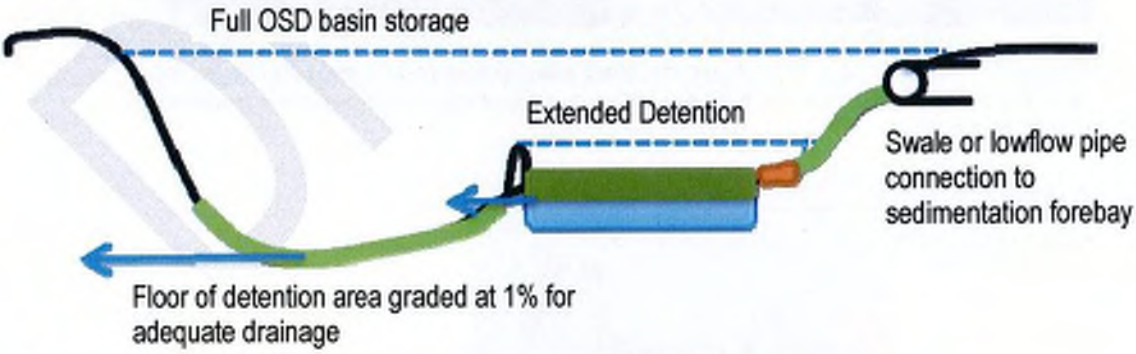


Figure 7.9 Plan (right) and section (above) of detention basin configuration ensuring pre-treatment sedimentation forebay and bypass configuration for high flows

Figure 7.10 Section through detention basin showing a saturated zone bioretention and bund (small) separating it from the larger basin footprint

Figure 7.11 Detention basins may include paths, board walks, wetland pools, varied batter slopes and basin floor elevations and other landscape elements and variety of vegetation types to create interesting public open spaces.

Figure 7.12 Section illustrating path within the detention basin

B. Floodplain Wetlands

Wetlands are proposed within floodplain areas for stormwater quality improvement. These systems are located between the riparian corridor and the development interface. The wetlands are sensitively integrated with existing high quality vegetation and existing topography (requiring limited earthworks primarily for the formation of bunds).

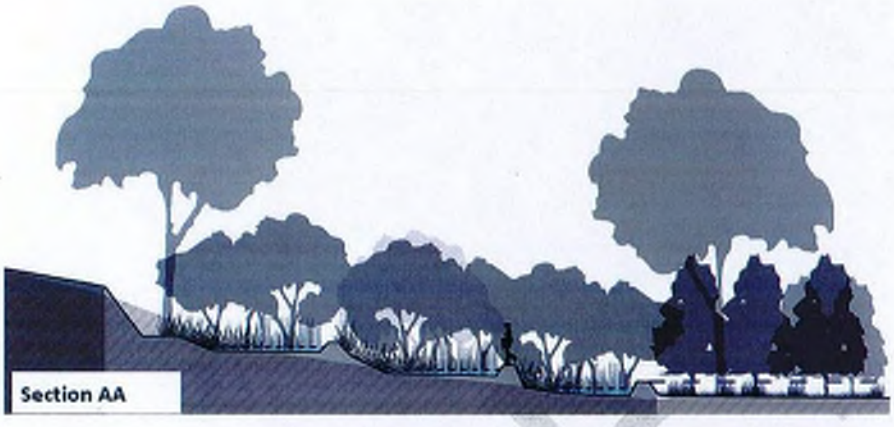


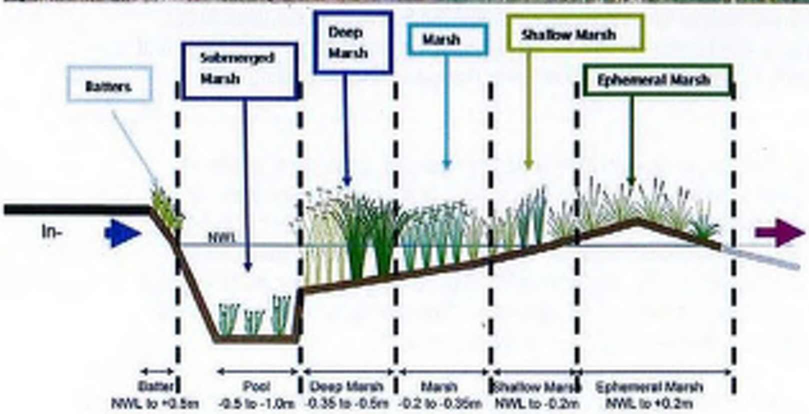
Figure 7.13: Floodplain wetlands (plan – right, section AA- above). Formed creating earth bunds within the floodplain which could be designed as shared paths for recreation opportunities and to control access to valuable vegetation area

Existing Vegetation: The stormwater treatment systems are located outside areas mapped as high quality vegetation to be retain, including areas of Endangered Ecological Communities (e.g. Sydney Freshwater Wetlands). Floodplain wetlands for stormwater treatment are a suitable landscape type adjacent to the Freshwater Wetlands. Establishing wetland areas across the floodplain will increase the habitat value and foraging range for fauna, and is complementary to the habitat types that occur naturally along the waterway in floodplain areas.

Hydrology & floodplain vegetation: Directing urban runoff to floodplain wetland areas (after sediment removal at development interface) will supports the proposed vegetation types (sedges and wetland species), converting pasture lands to floodplain vegetation and sustaining large areas of this vegetation type with runoff from the urban areas. The treatment volume / storage provided in the wetland areas attenuates flows significantly for small storm events. Multiple wetland areas provide distributed discharge of treated runoff to the waterway to minimise erosion of the waterway. Concentration of flows to a small number of drainage discharge locations is likely to impact on the waterway form.

Floodplain engagement: The floodplain wetlands will provide additional attenuation of flows and result in conveyance across a much wider corridor. This will provide protection for existing riparian vegetation and sections of natural geomorphic form. Controls are required to ensure the corridor is well vegetated with tufted grass species and that flows are spread and dispersed to reduce velocity and shear stress.

Bunds: Earthen bunds are proposed to enable attenuation of flow within the wetlands. The bunds would be approximately 7.5m in width including the embankments. There would be no impact on existing trees as the alignment of the bund is flexible. The bunds are best positioned along the contours, providing paths for controlled pedestrian access, reducing the disturbance to the adjacent wetter areas that support wetland species. The bunds can provide clear delineation of wetlands which may mitigate risk of inappropriate community / future land managers



Wetland Long Section (indicative only)

Figure 7.14: Floodplain wetland vegetation - ranging from terrestrial and ephemeral species on the bunded areas to aquatic species within wetland pools.

C. Streetscape Bioretention Systems

At the initial master planning level and rezoning of the site WSUD strategy for Menangle Park will ensure that adequate footprints are reserved for stormwater quality management centrally located bioretention or wetland systems. Streetscape systems do however provide a number of advantages over the larger treatment systems concentrated within the key public open spaces. Streetscape opportunities should be considered as the detail of the drainage and landscaping for the site is developed.

Streetscape systems can be designed to treat runoff from both road surfaces, and from lot areas (downpipe connection to rain garden). The size of streetscape raingardens can vary from small tree pits (2 – 5 m²) to larger bioretention pods (100 m²+) extending into large verge areas or adjoining open spaces.

Figure 7.15: Bioretention in the street verge within residential estate (Photo A.Cook, AECOM)

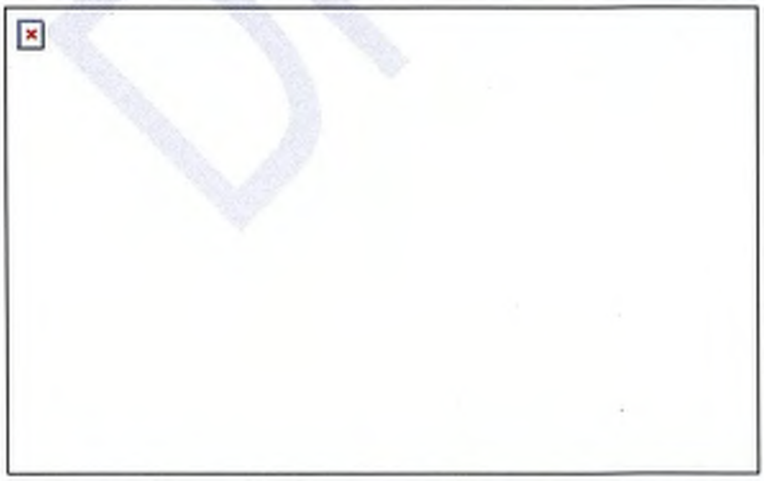


Figure 7.16: Bioretention in the street verge, clusteded at the entry to a local access street (Image from SEQ HWP, 2009, Concept Design Guidelines for WSUD)

A range of drainage configurations can be used to direct stormwater runoff to appropriate streetscape locations. The diagrams below illustrate options for a range of scenarios:

1. lot runoff from the high side of the street to verge area
2. road runoff to the verge on the low side of the street
3. back of lot drainage to end of block verge
4. street drainage to planted areas at intersections
5. street drainage to planted areas in the middle of the block
6. street trees for drainage on steeper slopes
7. street drainage to adjacent open space areas
8. street drainage to planter beds between car parking bays

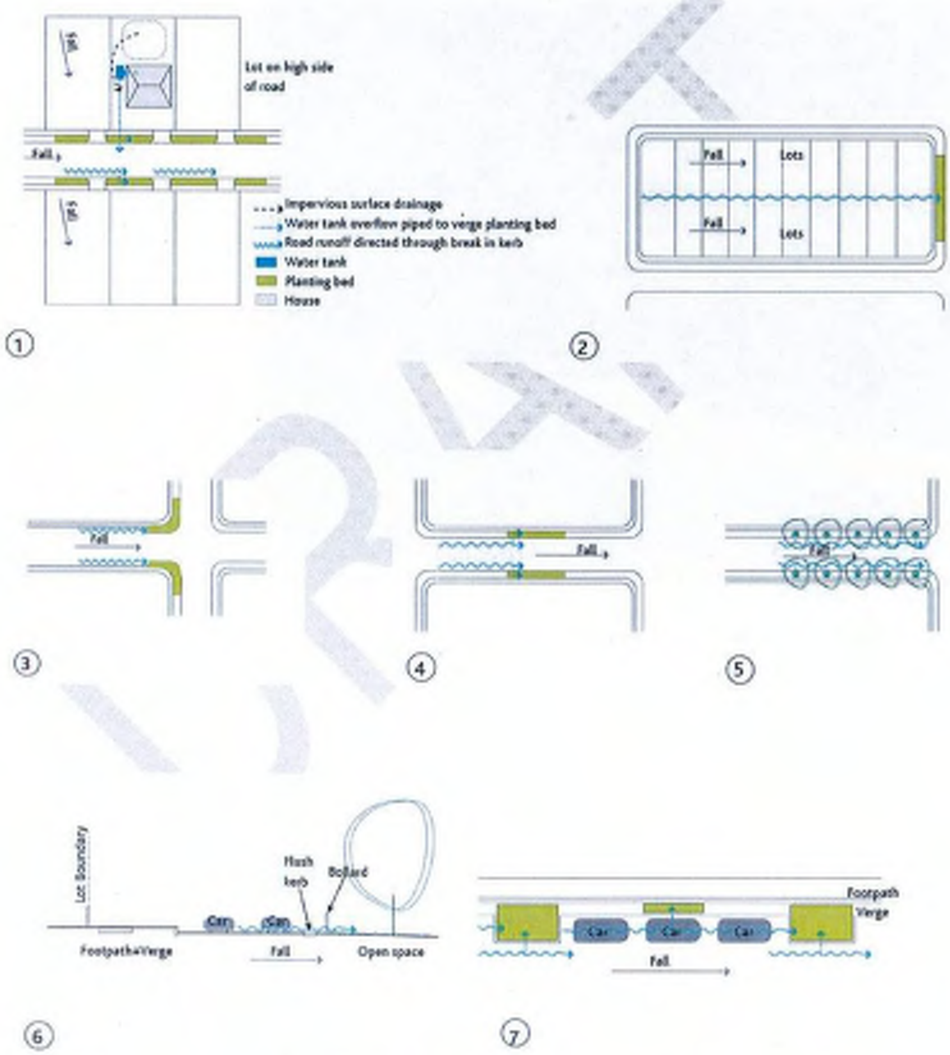


Figure 7.17: Options for integrating WSUD elements in streetscape areas – passive irrigation and/or bioretention pods

The indicative sections below show possible configurations of bioretention systems within the streetscape. Within the available road corridor widths, there are constraints on integrating footpaths, required set backs, service allocations and landscaped areas / WSUD treatment landscape areas. Joint trenching may be required to combine services to enable sufficient space for WSUD or other landscape elements.

The Guide to Codes and Practices for Streets Opening, (NSW Street Opening Conference) provides useful information on space allocations for foot paths, shared trenching, tree selection, and various construction issues. Landcom's Street Design Guidelines provide design principles and guidelines for good practice in street design to enhance urban design outcomes. The design principles for streets include the integration of WSUD.

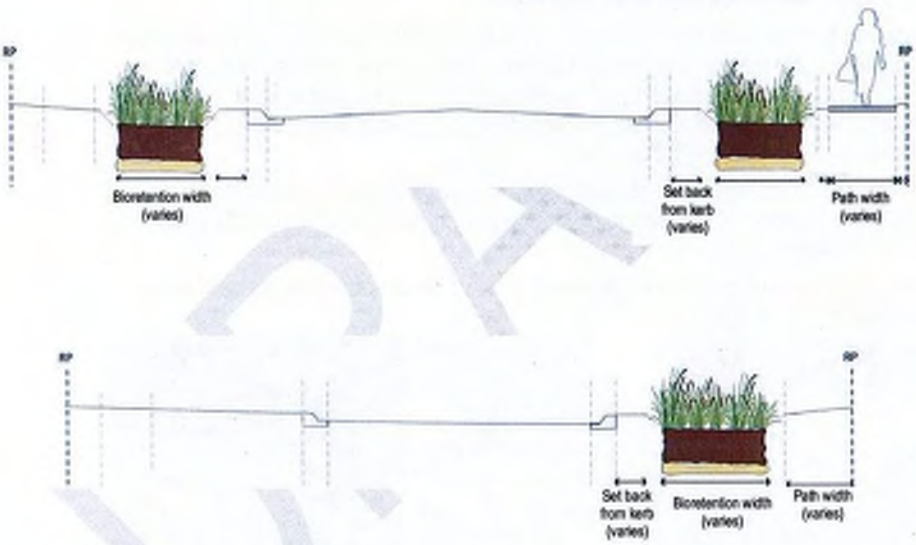


Figure 7.18: Indicative Streetscape Sections illustrating Bioretention Systems within Verge areas

D. Bioretention Systems within Lot Frontages

Bioretention systems can be integrated within lot areas. This area could be in the lot frontage (where observations could be made of these distributed systems to ensure their continuing effective operation as vegetated filtration systems). For a 1000 – 1500 m^2 lot and associated road area, with an assumed impervious area of 60%, a bioretention raingarden of approximately 20m^2 can provide the required water quality improvement (2% impervious area, normal bioretention system with 0.3m ponding depth)

Designing systems with a shallower ponding depth following rain may be desirable to reduce the need for noticeable batters to the set down bioretention surface. The footprint required will then increase to approximately 30m^2 (up to 3% of impervious catchment area). A saturated zone system could be used, requiring a slightly smaller footprint.

Bioretention systems within lots have many benefits:

- reduce the size of treatment systems needed downstream (this reduces the constraints on design of detention basins etc)
- reduce water use by residents for irrigation as bioretention systems are passively irrigated by stormwater runoff
- investment in visible and attractive garden areas that are sustained by appropriate hydrology, enhances aesthetic values and habitat with native , lush planting.
- Council or a developer could construct these systems in partnership with the community, providing an opportunity to engage with the community in awareness of stormwater issues, understanding of the local catchment and waterways and appreciation of native vegetation and material of local provenance. Opportunities to communicate about these issues may result in enhanced environmental outcomes and dialogue with Council.
- residents are likely to take on the ownership, management and maintenance of systems planted within or adjacent to their property. This may reduce the requirement for Council to maintain larger centralised systems downstream.

Council has noted concerns about the long term management of these systems which would need to be addressed for these systems to be adopted.

Figure 7.19a: Bioretention Systems within lots (front setback to house).Photos S.Boer (AECOM)

Figure 7.19b: Bioretention Systems within lots (front setback to house).Photos S.Boer (AECOM)

7.3.2 WSUD treatment area sizing

The impervious area within drainage catchments across the site has been estimated. MUSIC modelling has been used to determine the size of wetlands and bioretention systems required to reduce the pollutant loads. A strategy has been developed to integrate appropriately sized WSUD elements suitably within the site – responding to the constraints and opportunities discussed in section 6 of this report.

IMPERVIOUS AREAS

Campbelltown City Council has provided estimates of the average impervious area associated with particular land use categories (based on lot size) as tabulated below (Table 7.3). Road areas are included in these land use categories. These assumptions enable the likely impervious areas for each catchment to be calculated. The treatment area required is based on the impervious area for each catchment, as pervious runoff is likely to occur when the treatment capacity of a bio retention system or wetland is exceeded (ie bypass occurs).

Table 7.3 Impervious areas for various landuses (based on lot size) (Campbelltown Council)

Land use category based on lot size	Estimated impervious fraction (%)
350-390sqm lots	90%
540-700sqm lots	75%
1000-1500sqm lots	60%
2000+sqm lots	30%

The estimated impervious fraction for rural lands is highly variable. The required area for water quality treatment will be based on the impervious areas for a given rural site and is assumed to be able to be accommodated within the rural lands in association with drainage easements.

MUSIC MODELLING

The MUSIC modelling demonstrates that the following treatment areas are able to meet the water quality targets:

- Floodplain wetland areas corresponding to 6% of the impervious catchment area (including sedimentation control).
- Saturated zone bioretention filter media area corresponding to 1% of the impervious catchment area (with 0.3m extended detention).
- Streetscape bioretention systems (with as little as 0.1m extended detention) with a footprint of 2-3% of the impervious catchment area.

Note that sedimentation control is required upstream of the bioretention systems. This may include GPTs (in some areas), sediment forebays and pre-treatment swales. The footprint to provide for 0.3m extended detention is larger than the filter media area. The final footprint is dependent on the shape and configuration of the system.The documentation of the MUSIC modelling for the site is included as Appendix B to this report.

The SZ bioretention sizing through MUSIC is based on modelling using algorithms derived from the CRC for Catchments Hydrology and the Facility for Advancing Water Biofiltration. This technology represents current best practice with a significantly more efficient treatment foot print in comparison with that for constructed wetlands. Wetlands have been selected in floodplain areas due to the habitat, revegetation flow management and amenity values that are complementary with location within the riparian corridor.

As more research and monitoring of the SZ systems become available, the sizing and configuration can be refined. This would occur through the detailed design phase where drainage catchments will also be confirmed.

7.3.3 WSUD Layout

The strategy is illustrated in Figures 20 and 21 with the wetland and bioretention areas proposed. The expected drainage subcatchments are illustrated on Figure 20. The proposed elements are also overlaid on an aerial photo of the site (Figure 21) which shows areas of existing vegetation.

Where possible, wetlands have been used within floodplains to enhance the habitat value of the riparian corridors that will be revegetated as part of the development works.

Saturated zone bioretention systems are proposed within most of the detention basins as their efficient treatment footprint enables the stringent water quality targets to be met within the limited basin floor area available.

Streetscape systems are also recommended, and the use of these systems will reduce the constraints on design of the centralised treatment locations proposed. A range of streetscape opportunities exist (as presented Figure 7.17). The details of the optimum configuration for street trees and raingardens would need to be developed in the next phase of planning for the site – in association with the landscape masterplanning and detailed drainage design for the site. Streetscape systems would be particularly suitable:

- along the existing wide streets of the Menangle Park township (illustrated in Figure 7.21)
- in sub-catchments 18 and 19 (illustrated in Figure 7.20) which include areas that are likely to be difficult to drain to basins 7 and 8 respectively.
- along the drainage corridor between sub-catchments 24 and 26, where the sandy soils may be suitable to configure elements that allow infiltration of treated stormwater.

Tables 7.4 – 7.6 provide the details for each of the minor subcatchment areas:

- Catchment area
- Impervious area
- Proposed WSUD treatment element
- Notes, discussion and alternative WSUD options.

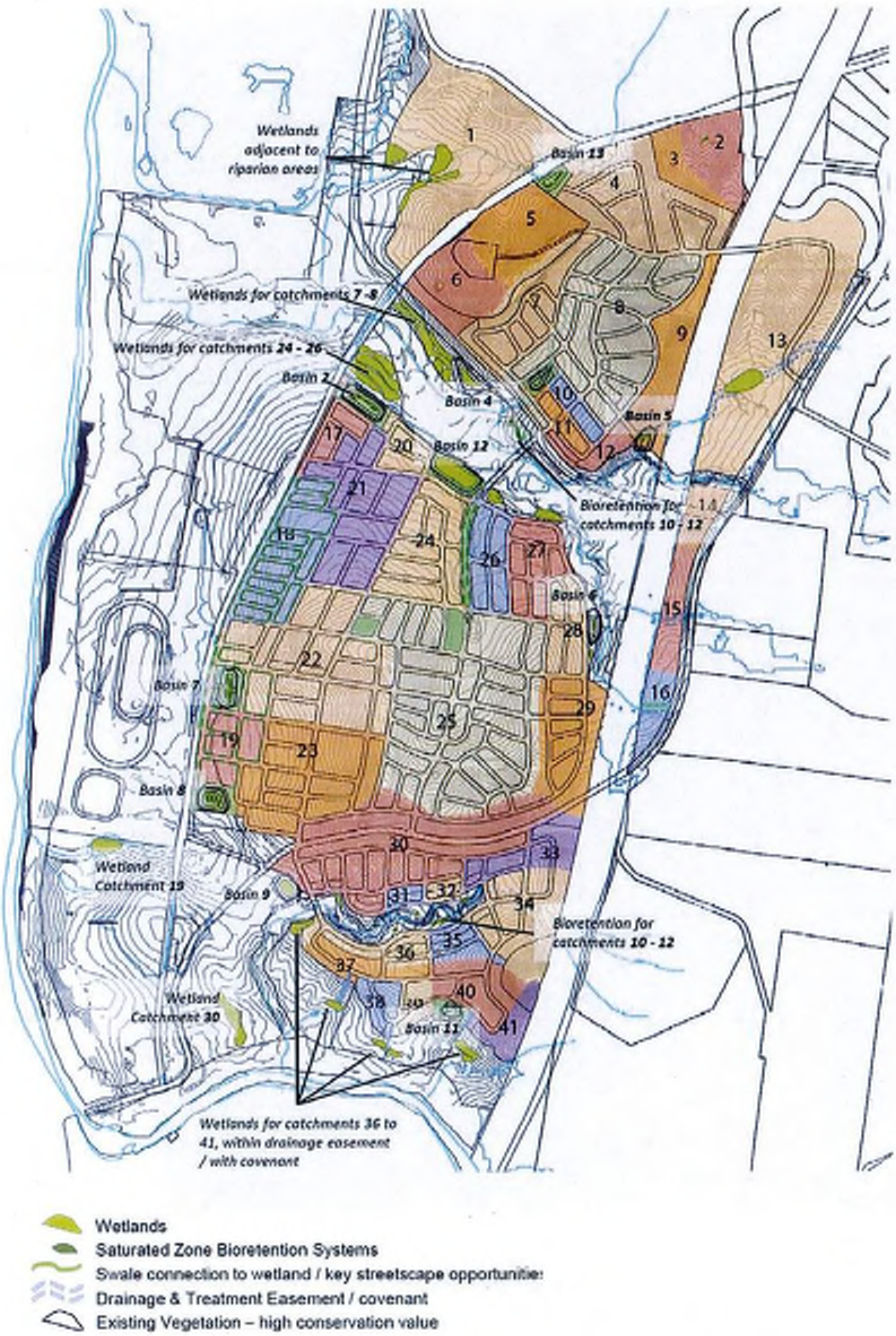


Figure 7.20: Drainage subcatchments and WSUD elements for managing stormwater quality

Wetlands
Saturated Zone Bioretention Systems
Swale connection to wetland / key streetscape opportunitie:
Drainage & Treatment Easement / covenant
Existing Vegetation – high conservation value

Figure 7.21: Wetland and Bioretention areas for managing stormwater quality

Table 7.4 - Northern and Eastern Catchments – WSUD elements

Ref no.	Catchment Area (m²)	Description	Impervious %	Impervious Area (m²)	WSUD treatment element	Notes / Alternatives
1	280,217	Employment lands	90%	252,195	Wetland cells for each minor catchment (total footprint 15,100m²): 2,700+2,200+6,150+4,050	To be integrated with future masterplanning. Where constrained, can use smaller footprint SZ bioretention (2,520m² filter area). Wetland provides a good buffer to the downstream riparian corridor
2 & 3	101,316	Transgrid site	20%	20,263	Water quality management on Transgrid site (bioretention 200 - 400m²)	
4	192,478	catchment to Basin 13	60%	115,487	2 x 575m² SZ bio in Basin 13 (44% of basin base area)	
5	99,740	Glenlee (northern side)	1%	997	Water quality management within Glenlee site	
6	84,470	Glenlee (southern side)	1%	845		
7 & 8	391,250	Full catchment including parks / large pervious areas (breakdown below for lot and road areas)				
	362,329	lot & road areas	68%	246,472	Wetland cells in Basin 4 and floodplain (total 14,800m²); Basin 2,500 + 6 floodplain cells each approx 2,000m²	SZ bioretention (2,470m² filter area) at edge of floodplain
9	90,322	large lot area adj freeway	60%	54,193	540m² SZ bio (2 x 270m²) in Basin 5	
10 - 12	79,750	lot & road areas	70%	55,703	560m² SZ bio (2 x 280m²) at riparian / development interface	
13	326,115	lot & road areas	39%	128,539	7,700m² wetland integrated with drainage easement/bypass	Streetscape / allotment SZ bio (1,235 – 2,570m²) Note: steep grades
14 - 16	101,172	rural land	~ 10%	10,117	On site water quality management, allotment systems	

Table 7.5 – Central Catchments – WSUD elements

Ref no.	Catchment Area (m^2)	Description	Impervious %	Impervious Area (m^2)	WSUD treatment element	Notes / Alternatives
19	69,900	To 'polishing wetland' West of rail line	75%	52,470	5,250m² wetland in existing pond along the drainage corridor at the southern boundary with the Harness racing track	Reduce size with streetscape WSUD, Note difficulty to drain to Basin 8
17, 20, 21	219,527	To basin 2	75%	164,645	1,640m² SZ bio (4 cells x 410m²), 40% Basin 2 floor area	Reduce size with streetscape WSUD
18 & 22	259,203	Catchment 22 and as much as possible of 18 to Basin 7	76%	306,616	3,000m² SZ bio (6 cells x 500m²), 80% Basin 7 floor area	Use streetscape elements (and potentially treatment within rail corridor / Harness Racing land) to reduce the catchment treated in Basin 7. Note difficulty to get some areas to Basin 7 and potential to direct some piped flow to Basin 8 – thus the Basin 7 catchment may be slightly reduced when drainage catchments are confirmed.
23	180,985	To basin 8	52%	145,214	1,500m² SZ bio (3 cells x 500m²), 35% Basin 8 floor area	Reduce size with streetscape WSUD
24,25, 26	652,828	To basin 12	Full catchment including parks / large pervious areas (breakdown below for lot and road areas)			
	626,662	lot & road areas	75%	469,997	Wetland in Basin 12 and floodplain wetlands: total 28,200m², (8,220 in basin + 4 floodplain cells (8,200+5,224+3,700+3,420))	Size may be reduced with streetscape WSUD (including in drainage channel)
27 & 28	129,240		75%	96,930	Floodplain wetland cells 5,800m² (3,100 + 2,700) as interface between road and riparian	SZ system where constrained
29	110,945		70%	77,539	775m² SZ Bio (2 cells: 400 in Basin 6 and 375 cell to the south)	

Table 7.6 – Southern Catchments – WSUD elements

Ref no.	Catchment Area (m^2)	Description	Impervious %	Impervious Area (m^2)	Preferred WSUD treatment element	Notes / Alternatives
30	271,450	Full catchment including parks / large pervious areas (breakdown below for lot and road areas)				
	261,098	lot & road areas	68%	177,828	10,700 m^2 wetland (2,700m^2 in Basin 9 and swale connection to 8,000m^2 in floodplain)	
31	11,813		83%	9,746	600m^2 perched wetland	Small catchments 31 - 35 treated in bioretention or wetlands in landscape buffer to riparian corridor. Bioretention systems preferred where more dense planting / screening is desired and where space constraints arise due to road batter.
32	20,119		78%	15,625	160m^2 SZ bio	
33	45,578		65%	29,521	300m^2 SZ bio	
34	112,927		70%	78,884	790m^2 SZ bio (2 x 400m^2 cells)	
35	29,105		79%	23,102	230m^2 SZ bio	
36	40,485		83%	33,696	2,020m^2 wetland, southern side of watercourse	340m^2 SZ bio
37	37,210		75%	27,908	1,670m^2 wetland, draining to minor watercourse	280m^2 SZ bio
38	26,719		67%	17,923	1,080 m^2 wetland	180m^2 SZ bio
39	24,681		68%	16,880	1,010 m^2 wetland	170m^2 SZ bio
40	66,378	Full catchment including parks / large pervious areas (breakdown below for lot and road areas)				
	59,738	lot & road areas	64%	42,497	2,550m^2 wetland downstream of Basin 11 as protective buffer to stand of existing high quality vegetation	420m^2 SZ bio in Basin11, 70% of the basin floor area
41	30,782	Full catchment including parks / large pervious areas (breakdown below for lot and road areas)				
	24,751	1000 – 1500m^2 lots	60%	14,851	900 m^2 wetland associated with drainage pathway for external catchment / waterway corridor (not classified riparian zone)	Bioretention within allotments or within drainage corridor.

7.4 FLOW MANAGEMENT

Detention basins are used to meet the flood management targets for the site. The basin locations and sizing is summarised in Figure 7.22. Further details are provided in GHD's Flood Study for the site (GHD, 2010).

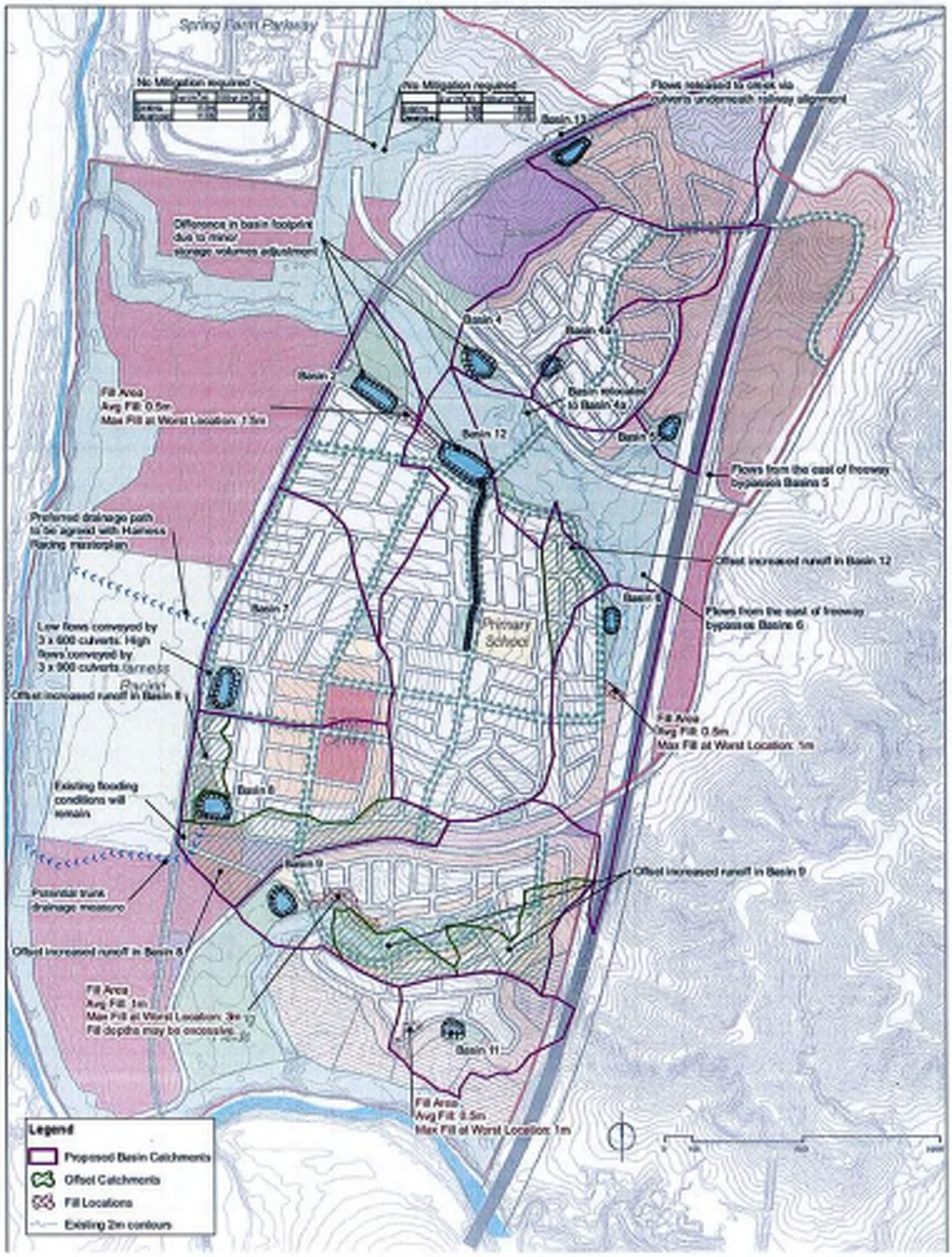


Figure 7.22: Detention Basin locations and sizing (GHD).

GHD has commented that Council's DCP parameters (including Mannings coefficient) result in higher than usual predevelopment flows and smaller than expected detention requirements. Council has noted the catchment time of concentration characteristics as a possible reason for the small detention requirements.

The assumptions and outcomes of the flood study are supported by Council's own flood studies, and the flood models have been endorsed by Council.

As a result of the small detention basin footprints saturated zone bioretention systems rather than wetlands have been configured within most of the detention basins as they have a more efficient treatment footprint.

Along Howells Creek (Waterway M), floodplain wetlands have been proposed which can be configured to provide additional attenuation and protection of the remaining geomorphic attributes of the waterway (Figure 7.23). These wetlands can be configured to enable more distributed discharge of flow to the waterway, rather than concentrated point source discharge locations from a small number of detention basins. The resulting engagement of the floodplain will provide enhanced waterway protection.

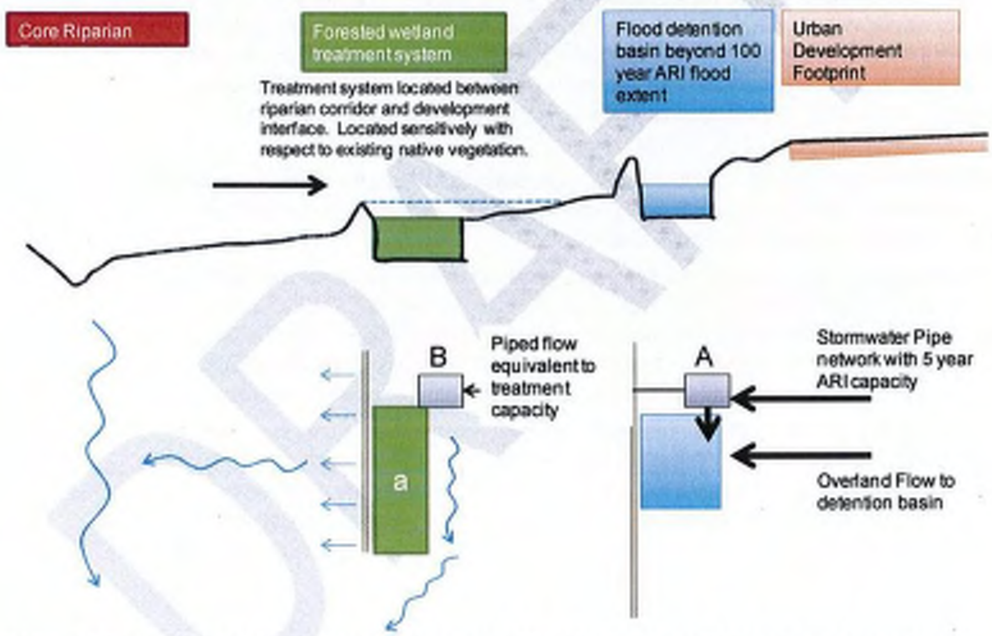


Figure 7.23 Schematic (section and plan) of the operation of the floodplain wetland treatment system

7.5 RIPARIAN CORRIDOR MANAGEMENT

The rehabilitation of the riparian corridors within the Menangle Park site presents a significant opportunity for an enhanced ecological outcome. Most of the waterways are in a degraded condition with little or no riparian vegetation and significant erosion of the bed and banks due to impacts from agricultural land use.

The riparian corridor categorisation outlines the environmental objectives for the waterways on the site. The aesthetic, recreational and microclimate benefits for the development associated with rehabilitation of the riparian corridors provides additional drivers for planning the rehabilitation of waterways and investing in the revegetation of these corridors and in the water management elements that protect and can sustain the riparian vegetation.

The key areas to be address include:

- Waterway stability – works will be required to address existing erosion of the watercourses prior to the urbanisation of the catchment and resulting increase in stormwater runoff. Detention basin configurations should ensure optimum flow control to maintain pre-development storm discharges for the 1.5 year ARI event (objective for waterway protection).
- There are a number of large headcuts along the southern watercourses – particularly in the lower reaches as the tributaries meet the Nepean River. A waterway rehabilitation approach is required that addresses the need for any bed and bank control structures as a priority. Revegetation of the waterway corridor can be strategically planned, with early establishment of canopy vegetation to shade out weeds and a longer term, staged and adaptive approach to in channel works and increasing the diversity in ground cover planting.
- Water quality – the construction of the WSUD elements proposed will ensure the water quality targets for the site can be met. Through construction, it is critical that adequate sedimentation control is provided and monitored to ensure its effective function.
- Habitat – the revegetation works within the corridor and within the waterway channel will result in a significant enhancement of the terrestrial and aquatic habitat value on the site. The floodplain wetlands proposed for water quality improvement will create important refugia for flora and fauna. There are significant areas of pastoral land supporting mostly exotic species. Once these areas are replaced with native vegetation, they will substantially augment the provision of riparian habitat.
- Environmental corridors – A substantial corridor width has been provided for the category 1 water courses in the northern part of the site. These corridors provide biodiversity linkages by maintaining connectivity for aquatic and terrestrial fauna and flora. Where effective works are delivered for waterway rehabilitation, flow control, revegetation and water quality management, enhanced outcomes will be realised; with less erosion in healthy and functioning streams, corridors of habitat supporting a diverse range of species and improved water quality.

The Biodiversity offset strategy (GHD, 2010) requires revegetation of large areas of pastoral land, particularly along the waterway corridors. This will enhance the ecology of the site considerably.

7.6 WASTEWWATER POLLUTION CONTROL

Given the sensitive receiving environment, limiting sewage discharge to the Nepean River is important.

SEWERAGE NETWORK DESIGN

To minimise leakage from the sewage network in dry weather, small bore sewers and other advanced sewerage design options should be considered. This will also assist in minimising infiltration during wet weather and subsequent wet weather overflows. Design of sewage pumping stations should accommodate adequate storage volumes to ensure that back up pumps could be brought in following a breakdown or power failure without discharge of sewage to the environment.

Overflow points from the sewage system should be configured to discharge into WSUD elements (bioretention or wetland areas via the stormwater network) rather than directly to waterways to provide some treatment in the event of an overflow, particularly those that may occur in dry weather due to blockages etc.

Whilst a dry weather overflow directed to a WSUD element may result in significant odour, resident complaints and some mess that is inconvenient for Council, it is likely that the problem would be identified, reported and resolved. Discharges directly to the Nepean may not be noticed, reported, and resolved for extended periods.

WSUD elements would typically be operating above designed capacity during wet weather flow conditions where wet weather sewer overflows may occur. However, without establishing dedicated sewer overflow detention structure, it is recommended that stormwater treatment systems remains the 'first line of defence' against discharge of sewage to the receiving water.

SEWAGE TREATMENT

At present there is no centralised sewage infrastructure servicing the Menangle Park site.

The most likely option for sewage treatment is construction of a pipeline connecting to the recently upgraded West Camden sewage treatment plant located about 10 km from the site. With suitable sewerage network design, centralised wastewater treatment provides economic and effective wastewater management, with all operational issues managed by Sydney Water.
Wastewater reuse pipelines have been constructed from this plant (to within 3km of the Menangle Park site), allowing for some beneficial reuse for agricultural irrigation. The remainder of sewage treated at the plant is discharged to the Nepean River. An extension of the reuse pipeline to the site could provide a non potable water source.

Onsite sewage treatment is feasible, and should be considered as planning for the site proceeds. It is acknowledged that a suitable location would need to be identified for an onsite sewage plant and options resolved for management and operations. There is a significant upfront cost for the design, construction and coordination of onsite sewage treatment plants.
An onsite sewage treatment plant would also provide a source of non potable water for reuse. It may be possible for an effective water manager to provide a comparable service to Sydney Water, with the potential for cost savings if the operational costs for a localised scheme are less than Sydney Water's increasing operational costs for regional scale systems.

8 MAINTENANCE CONSIDERATIONS

8.1 INSPECTION AND MAINTENANCE

WSUD infrastructure such as sedimentation basins, constructed wetlands and bioretention systems, require ongoing inspection and maintenance to ensure that they establish and operate in accordance with the design intent. Potential problems associated with WSUD infrastructure as a result of poor maintenance include:

- Decreased aesthetic amenity;
- Reduced functional performance;
- Public health and safety risks; and
- Decreased habitat diversity (dominance of exotic weeds).

Importantly, the most intensive period of maintenance is during the plant establishment period (initial one to two years) when weed removal and some replanting may be required. The designs of the WSUD elements seek to minimise maintenance requirements during this period by incorporating a provision to isolate the majority of the 'vegetated' areas of the WSUD systems from inflows during the 'Allotment Building' phases. This greatly reduces the risk of plants becoming smothered by sediments resulting from construction activity (a common cause of early plant mortality and filter media clogging for bioretention systems) and importantly also reduces the seed load being deposited during the period when the plants are establishing and least able to compete with (shade out) weed species. Therefore, it is expected that the vegetation in the WSUD systems will become well established prior to bringing them online – which will occur at the end of 'on maintenance' period (2 years after construction).

After establishment, WSUD elements should be inspected every three months, with particular reference to:

- Structures, such as overflow weirs, bypass and inlets
- Erosion
- Sediment build-up
- Weeds
- Algal blooms
- Litter (anthropogenic and non-anthropogenic)
- Oil slicks

Inspections are also recommended following large storm events to check for flow distribution, ponding, scour and any other damage.

It is recommended that the personnel who are to undertake the operation and maintenance of the stormwater treatment elements be briefed and trained on procedures and protocols prior to commencement. Vegetated WSUD elements should be monitored by personnel with bush regeneration qualifications (as approved by Australian Association of Bush Regenerators). Bush regenerators are well equipped at identifying evasive species within a native landscape typical of vegetated WSUD systems. Keeping and maintaining records on the condition of the systems and all maintenance works required will be important to inform and schedule future maintenance works.

The following sections provide details of the maintenance requirements of the sedimentation basins, constructed wetlands and bioretention basins, during both the 'on maintenance' period and 'operational' phase. Additionally, construction/establishment and asset handover checklists can be found in Landcom (2009) to assist in 'on maintenance' period and 'off maintenance' period inspections.

8.2 SEDIMENTATION BASINS AND GROSS POLLUTANT TRAPS (GPTS)

Sedimentation basins are stormwater detention systems that promote the settling of coarse sediment (defined as particles greater than 125 microns in diameter). GPTs are effective in the removal of litter, gross pollutants and (to varying degrees depending on GPT design) will also remove sediment.

Due to the operation of a sedimentation basin, regular clean out and removal of accumulated sediment is required. Sedimentation basins are generally designed for a clean out frequency of five years, which equates to a volume half that of the permanent pool (defined by the invert of the outlet structure). Accumulated sediments must also be removed when sediment accumulates to half the sediment basin depth to ensure that the sediment trapping performance of this system is sustained.

The majority of maintenance associated with sedimentation basins concerns the inlet zone (and GPT if installed). Inlets can be prone to scour and build up of litter. Litter removal and potential replanting may be required as part of maintaining an inlet zone. Inspections should be undertaken monthly and after storm events as the frequency of litter and debris removal may be high. Debris, if not removed, can block inlets or outlets, and can be unsightly if located in a visible location. Inspection for accumulated sediments and debris should be done regularly and debris should be removed whenever it is observed. Weed removal and replanting of edge vegetation will also be required intermittently.

More details on the monitoring requirements for sediment basins can be found in Table 5 of Landcom's *DRAFT Water Sensitive Urban Design, Book 4: Maintenance.*

8.3 CONSTRUCTED WETLANDS

Constructed wetlands use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from stormwater. The wetland processes are engaged by slowly passing runoff through heavily vegetated areas where plants filter sediments and pollutants from the water. Biofilms that grow on the plants can absorb nutrients and other associated contaminants.

Maintenance requirements

To ensure the functionality of the system, routine monitoring and maintenance of constructed wetlands will require:

- Checking flow paths in and out of the system are unobstructed
- Ensuring vegetation is healthy and is sufficiently dense
- Preventing undesired vegetation from taking over the desirable vegetation
- Removal of noxious plants or weeds
- Re-establishment of plants that die
- Removal of accumulated sediments
- Litter and debris removal

More details on the monitoring requirements for constructed wetlands can be found in Table 4 of Landcom's *DRAFT Water Sensitive Urban Design, Book 4: Maintenance.*

Of the above items, debris removal should be the only action requiring ongoing attention. Debris, if not removed, can block inlets or outlets, and can be unsightly if located in a visible location. Inspection and removal of debris should be done regularly, but debris should be removed whenever it is observed.

8.4 BIORETENTION SYSTEMS

Bioretention systems are vegetated filter systems designed to allow water to pool temporarily before percolating through the filter media. Critical to the performance of a bioretention system is maintaining the permeability of the filter media and the health of the vegetation. In comparison with a sedimentation basin or wetland inlet zone, the maintenance requirements for a bioretention system are perhaps more frequent but involve less heavy machinery for removal of sediment and for access. Maintenance of bioretention systems will involve:

- Routine monthly inspection of the bioretention system profile to identify any areas of obvious increased sediment deposition, scouring from storm flows, rill erosion of the batters from lateral inflows, damage to the profile from vehicles and clogging of the bioretention system (evident by a 'boggy' filter media surface).
- Routine monthly inspection of inflows systems, overflow pits and under-drains to identify and clean any areas of scour, litter build up and blockages.
- Removal of sediment where it is smothering the bioretention system vegetation.
- Removal of accumulated sediment from the coarse sediment forebay.
- Repairing any damage to the profile resulting from scour, rill erosion or vehicle damage by replacement of appropriate fill (to match onsite soils) and revegetating.
- Tilling of the bioretention system surface, or removal of the surface layer, if there is evidence of clogging.
- Regular watering / irrigation of vegetation until plants are established and actively growing.
- Removal and management of invasive weeds (herbicides should not be used).
- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule.
- Pruning to remove dead or diseased vegetation material and to stimulate growth.
- Vegetation pest monitoring and control.

Maintenance should only occur after a reasonably rain free period when the soil in the bioretention system is dry. Inspections are also recommended following large storm events to check for scour and other damage.

Resetting (i.e. complete reconstruction) of bioretention elements will be required if the available flow area of the overlying basin is reduced by 25 percent (due to accumulation of sediment) or if the bioretention trench fails to drain adequately after tilling of the surface. Current experience with systems operating for approximately 10 years (Victoria Park) and modelling suggests that this would only be required after 20 - 25 years.

More details on the monitoring requirements for bioretention basins can be found in Table 3 of Landcom's *DRAFT Water Sensitive Urban Design, Book 4: Maintenance.*

8.5 MINIMISING MAINTENANCE THROUGH DESIGN

Good design can reduce maintenance costs, and poor design can result in systems that are a significant cost burden for Council. There are a number of recommended strategies that assist in designing for low maintenance, for example

- Using landscape edge treatments to define a management edge
- Plant selection to reduce areas requiring mowing
- Plant selection appropriate to the hydrology to ensure self sustaining and healthy landscapes
- Designing for ease of access for sediment removal
- Designing sedimentation areas that are screened visually and can assimilate some sediment

9 COSTING

9.1 MENANGLE PARK WSUD – PRELIMINARY CAPITAL COST ESTIMATES

A preliminary costing has been completed for the proposed water sensitive elements (bioretention basins and constructed wetlands). The costing is based on previous experience in the construction and establishment of these systems in similar greenfield developments. The costing includes only those items that are unique to the construction of either bioretention basin or constructed wetlands. Infrastructure costs and site specific costs have not been included as these items have been addressed in the GHD preliminary schedule of costs for the basins in which these systems will be constructed.

A summary of the cost for each water sensitive urban design element proposed is given in Table 9.1.

The items included in the costing are described in Table 9.2 (a 500 m^2 saturated zone bioretention cell) and Table 9.3 (a 1000 m^2 constructed wetland cell).

The itemised costing includes the following assumptions:

<u>**Bioretention basin**</u>

- Plant density 12/m^2
- Filter depth 400mm
- Sandy transition layer = 150 mm
- Saturated zone depth (coarse sand - gravel) = 440 mm
- Drainage layer (gravel) = 200 mm
- Flow distribution = 150 mm half pipe with an equivalent length equal to the perimeter of the basin
- Costs associated with basin construction, inlet and outlet structures and site preliminaries and management excluded (these costs have been included in the GHD costing).
- GPT's have also been costed by GHD ($30,000 per basin). Note – it is recommended that consideration be given to the use of sedimentation basins rather than GPT's in residential areas as the majority of material collected is leaf litter which can more cost effectively be managed in a well designed sedimentation basin that is suitably integrated with basin design and meets Council requirements for maintenance / access. The capital cost of a sedimentation basin/inlet zone would be similar to that of a GPT.
- NO contingency has been allowed for as the GHD contingency is considered high at 30 percent

ITEMISED COST FOR A 500m^2 BIORETENTION CELL IS APPROXIMAETLY $190 / m^2 (see table 9.2)

<u>**Constructed wetland within floodplain areas**</u>

- The cost of earthworks is assumes bund length of 100m for a 1000m^2 cell (approximate 15 x 60m dimensions, bunding on the low side only, the high side bunded by adjoining cells).
- The bund configuration (0.5m height, 2m top width/path, 1 in 6 side slope)
- Topsoil and a clay/soil layer may be required to ensure the wetlands operate effectively in floodplain areas
- A simple inlet and outlet structure is required – estimated at up to $10,000 each. This may include swale inlets, side casting weirs, small pits with riser outlet pipes, leaky rocky weir outlets. All systems should be designed to sit naturally and unobtrusively within the floodplain and be simple and cost effective.

ITEMISED COST FOR A 1,000m^2 CONSTRUCTED WETLAND CELLS IS APPROXIMAETLY $50 / m^2
(see table 9.3)

Table 9.1: Summary of costs for proposed WSUD elements

Catchment	Basin no.	Catchment no.	WSUD treatment	Wetland Area (m²)	Bioretention Area (m²)	Cost $50/m² for wetlands, $190/m² for bioretention
Employment Zone		1	Wetland cells integrated into each minor catchment	15,100		$755,000
		2&3	Trans grid - on site mgt - not included			-
Northern	13	4	Bioretention		1,150	$218,500
		5&6	Glenlee - not included			-
Central	4	7&8	Wetland (within basin and floodplain)	14,800		$740,000
	5	9	Bioretention		540	$102,600
		10-Dec	Bioretention adjacent to riparian		560	$106,400
		13	Wetland on drainage easement	7,700		$385,000
		14 - 16	Rural - on site mgt - not included			-
		27, 28	Wetland floodplain	5,800		$290,000
	6	29	Bioretention (partly in basin)		775	$147,250
	12	24 -26	Wetland (within basin and floodplain)	28,200		$1,410,000
	2	17,20,21	Bioretention		1,640	$311,600
Village	7	18, 22	Bioretention		3,000	$570,000
		19	Wetland near S3 waterway	5,250		$262,500
	8	23	Bioretention		1,500	$285,000
Southern	9	30	Wetland downstream of basin	10,700		$535,000
		31	Wetland	600		$30,000
		32 - 35	Bioretention along riparian		1,480	$281,200
		36 - 39	Wetland floodplain	5,960		$298,000
		41	Wetland floodplain	900		$45,000
	11	40	Wetland downstream of basin	2,550		$127,500
Sub total constructed wetlands – including substantial revegetation within the floodplain / riparian corridor				**97,560**		**$4,878,000**
Sub total bioretention					**10,645**	**$2,022,550**
TOTAL						**$6,900,550**

NOTE: Waterway rehabilitation strategy required to assess the rehabilitation approach, extent of works and stabilisation structures required. A costing cannot be given until this strategy is developed.

Table 9.2: Itemised costing for a typical 500m² saturated zone bioretention cell

500m² BIORETENTION CELL COSTING					
Pay Item	**Brief Description**	**Unit**	**Qty**	**Unit Rate ($ excl GST)**	**Price ($ excl GST)**
1.01	Slotted under-drainage pipes (a) 100 mm diameter, supply and install	m	150	$20.00	$3,000
	(b) 150 mm diameter, supply and install	m	25	$40.00	$1,000
1.02	Cleanout points for slotted pipes (a) 100 mm diameter	No.	10	$41.00	$410
	(b) 150 mm diameter	No.	1	$76.00	$76
1.03	Geofabric to base and walls	m²	500	$2.25	$1,125
1.04	200 mm gravel drainage + 400mm saturated zone (a) Supply and delivery	m³	300	$60.00	$18,000
	(b) Install	m³	300	$15.00	$4,500
1.05	Hardwood woodchips (a) Supply and delivery	m³	70	$28.60	$2,002
	(b) Install to transition sand layer as directed	m³	70	$15.00	$1,050
1.06	150 mm sand transition layer (a) Supply and delivery	m³	75	$115.60	$8,670
	(b) Install	m³	75	$15.00	$1,125
1.07	Filter material 400 mm deep (a) Supply and delivery	m³	180	$120.50	$21,690
	(b) Install	m³	180	$15.00	$2,700
1.08	Rock energy dissipation (a) rock placed at inlet	m	25	$35.00	$875
1.09	Inflow distribution (150 mm half pipe)	M	45	$40.00	$1,800
1.10	Planting area including 150 mm subsoil cultivation, 200 mm topsoil, 75 mm mulch	m²	500	$12.00	$6,000
1.11	Planting (mix tube stock - pot size) 12/m²	no.	6,000	$2.00	$12,000
1.12	Water truck hire - excluding cost of water	hour	80	$100.00	$8,000
Sub-total Amount for bioretention cell including planting (excl GST)					**$ 94,023 (~$190/m²)**

Table 9.3: Itemised cost for constructed floodplain wetlands

WETLAND COSTING (1,000m² cell)					
Pay Item	Brief Description	Unit	Unit Rate ($ excl GST)	Qty	Price ($ excl GST)
4.01	Earthworks	m^3	$5.00	150	$750
4.02	Bunding (including placement of removed soil)	m^3	$10.00	400	$4,000
4.03	Minor preparation of planting area	m^2	$5.00	1000	$5,000
4.04	Planting	m^2	$20.00	1000	$20,000
4.05	Inlet structures	item	$10,000	1	$10,000
4.06	Outlet structures	item	$10,000	1	$10,000
Sub-total amount for wetland (excl GST)					$ 49,750 (~$50/m²)

Annualised maintenance costs

Annualised maintenance costs for these treatment systems have also been calculated. Like construction costs, maintenance also becomes less costly as the size of the system increases.

The range of maintenance costs for bioretention basins and constructed wetlands given in the Landcom WSUD maintenance booklet (Book 4) is:

- Bioretention systems = $2 to $4 per m²
- Constructed wetland systems = $3 to $5 per m²

Maintenance costs will typically include general maintenance of public areas, litter control, weed control (especially during establishment phase) and inspection (with occasional repairs) of hydraulic structures (pipes/pits/weirs etc).

Waterway rehabilitation works

The total cost of the proposed WSUD measures given below DOES NOT include site wide waterway rehabilitation work. A cost for this work cannot be determined until a waterway rehabilitation strategy is developed for the site.

10 CONCLUSIONS

The WSUD Strategy Report documents preliminary WSUD Options for the Menangle Park release area.

The report describes the nature of the site (Section 4); identifies opportunities and constraints (Section 6); outlines WSUD strategy targets (Section 5); presents components of the WSUD strategy (Section 7); and provides discussion of costing (Sections 8 & 9).

The site is largely degraded as a result of historical clearing and grazing practices. The catchments and waterways are illustrated in Figure 4.2. The development of Menangle Park release area and associated waterway rehabilitation and revegetation works has the potential to enhance the habitat and amenity of the waterway and riparian areas.

WSUD Strategy objectives are listed in Table 5.1. These include:

- **Water conservation target**
  - 45% reduction on base case water consumption (exceeding minimum BASIX target for a 40% reduction on base case)
  - Stretch target of 60% if a reticulated non-potable (recycled) water supply is not available
  - Further stretch target of a 70+% reduction on the benchmarked water use is proposed if a reticulated non-potable (recycled) water supply is available for the site.
- **Stormwater pollution control targets** for
  - 55% reduction in mean annual load of Total Nitrogen,
  - 70% reduction in mean annual load of Total Phosphorus and
  - 85% reduction in mean annual load of Total Suspended Solids
- **Flow management targets**
  - Maintain 1.5 year ARI peak discharge to pre-development magnitude.
  - Stream Erosion Index [4] (SEI) of 2.
  - *Stretch target:* Stream Erosion Index target of 1 (limit the erosion potential of urban waterways to the pre-development erosion potential).

Flood Protection target

- Maintain 5 and 100 year ARI peak discharge to pre-development magnitude.

Riparian Corridor Management

- Provision of riparian corridors to meet the NSW Office of Water's requirements.

Wastewater Pollution Control Targets

- No dry weather sewer overflows
- Restrict wet weather sewer overflows to a maximum of 10 overflows each 10 years

Section 6 provides a detailed description of the site and outlines the proposed treatment elements and approach for both the WSUD strategy and waterway rehabilitation.

Section 7 outlines the components of the WSUD Strategy needed to meet the identified objectives. Potable water conservation options are discussed and their ability to meet the proposed potable water conservation targets and stretch targets is described. The provision of large rainwater tanks or a dual reticulation network (supplied with either treated waste water or harvested stormwater) can ensure the potable water target is met. The stretch target for potable water conservation where a dual reticulation network is provided can be achieved with the use of rainwater tanks for hot water demands – in addition to a non potable supply for toile flushing, irrigation and cold water for clothes washing.

The WSUD Strategy integrates stormwater treatment elements with the opportunities identified on the site, particularly in response to topography, catchment and waterway condition and existing vegetation. Rehabilitation works along the central Category 1 watercourse ('M') are to incorporate floodplain wetlands, improving stormwater quality, while providing riparian restoration. Bioretention areas are integrated with the stormwater detention basin design for multi-functional open spaces. The design of these basins can ensure that stormwater quality and flood mitigation targets are met in addition to creating interesting open spaces with high amenity value for the community.
Options for streetscape bioretention systems are described. These systems can be configured further improve water quality or to reduce the size of the treatment elements proposed in central basins and floodplain locations.

The flow management targets are achieved through the use of detention basins to maintain predevelopment peak flows for the 1 in 2 year – 1 in 100 year ARI storm events in addition to the use of WSUD elements that ensure post development peak flows are attenuated for smaller storm events (wetlands and bioretention systems with a capacity for approximately the 1 in 3 month ARI).

A separate flood study (GHD, May 2010) provides detail of the detention basin configuration to mitigate flooding risks.

The Menangle Park: Offsetting Strategy (GHD, May 2010) provides details of the NSW Office of Water's requirements in relation to riparian corridors for the site. The opportunities to enhance waterway condition are identified for each watercourse in Section 6. The WSUD strategy has aimed to integrate opportunities for stormwater management using vegetated systems with the objectives for revegetating the riparian corridors and enhancing the ecological and social values of these areas.

A discussion of maintenance costs and preliminary capital cost estimates for the WSUD elements proposed are discussed in Sections 8 & 9. These costs are intended to inform this phase of the development process and ensure that adequate funds are reserved for the implementation of the elements proposed in this strategy.

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Review of Drainage Options

GHD

November 2011

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Report for Menangle Park

Review of Drainage Options

November 2011

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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GHD has prepared the preliminary cost estimates set out in section Appendix B using information reasonably available to the GHD employee(s) who prepared this Report; and

- *based on assumptions and judgments made by GHD*

The Cost Estimate has been prepared for the purpose of preliminary information *and must not be used for any other purpose.*

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1. Introduction

1.1 Background

GHD was appointed to assist with the surface water management for the Menangle Park Release Area and in the formulation of a Water Sensitive Urban Design strategy.

This drainage review forms an update to aspects of the drainage strategy, previously documented in the Menangle Park Local Environmental Study (LES), and aims to investigate the effectiveness and feasibility of an alternative strategy without provision of some of the basins.

This study builds on prior work carried out towards development of the detention strategy and should be read in conjunction with the May 2010 report by GHD: "*Local Flooding and Stormwater Quality Management (Detention)"* which was included as a chapter of the Menangle Park LES.

1.2 Objectives

The objectives of the drainage review were to:

- Review efficacy of various proposed detention basins;
- Assess potential for works to upgrade or stabilise existing open channels as an alternative to provision of a number of basins;
- Investigate routes for release of flow to the Nepean over land belonging to Harness Racing; and
- Provide preliminary cost estimates for stream stabilisation works.

1.3 Information Used in the Study

Information used in carrying out the drainage review includes:

- *Local Flooding and Stormwater Quality Management (Detention) Report*, GHD (May 2010);
- RAFTS models for developed catchment case, both with and without basins, GHD;
- Ground data and survey information previously provided for Menangle Park;
- Information gathered during a site visit (September 2011), and
- *Campbelltown (Sustainable City) Development Control Plan 2009, Volume 2, Engineering Design for Development*, June 2009 (hereafter referred to as the Campbelltown DCP).

1.4 Assumptions and Limitations

The following assumptions were made in carrying out this study:

- Survey data was assumed to be current, except where visual inspection identified otherwise;
- Existing hydrology models were assumed to be correct, except where specific review and checking of the models formed part of the brief; and
- It is noted that the study is limited by the existing survey data, which does not include detailed channel survey or bathymetry. Such information could have an impact on the findings of the study.
- Costing is based on preliminary estimates. No concept or detailed design has been carried out.

2. Basin Review

2.1 Overview

Basins 2, 4, 4a, 5, 6, 9, 11 and 12 were selected for review, with the aim of removing these basins and then compensating the loss of the basins with stream stabilisation works. In the case of Basin 8, the option of relocating the basin to a lot south of the current proposed location was reviewed. The proposed location and configuration of these basins is shown in GHD's Stormwater Quantity Management Strategy Drawing (June 2010), updated in this report and included as Appendix A.

A review of channel capacities of proposed overland flowpaths was carried out for the drainage from Basins 7 and 8 discharging to the Harness Racing Land.

The delineation of the hydrologic catchments have been included in previous reports but are also reproduced here in Appendix A.

2.2 Howes Creek

2.2.1 Basins 5 and 6

West of the Hume Highway, two streams converge to form Howes Creek. The proposed Basins 5 and 6 are located such that they discharge to each of these streams.

It was therefore necessary to consider both the outflows from Basins 5 and 6 into the individual creeks, as well as the combined flows into Howes Creek further downstream.

RAFTS models were run to assess the combined downstream flows for proposed Basins 5 and 6, discharging to Howes Creek with both basins removed.

Outflows at each of the proposed basin locations were also determined for the 1-year Annual Recurrance Interval (ARI) and 5-year ARI events and checked for the 2-year ARI events.

The individual peak basin outflows from Basin 5 and from Basin 6 in the 100- year ARI and 2-year ARI event as reported in Table 9 of the Flooding and Stormwater Quality Management Report (hereafter referred to as the Detention Report) were found to be consistent.

2.2.2 Basins 2, 4, 4a and 12

The proposed basins 2, 4, 4a and 12 are located downstream of Basins 5 and 6 but upstream of the railway.

No existing channels between the basins and Howes Creek currently exist.

Flows along this reach were assessed at two locations:

- Immediately downstream of the discharge from Basins 4a and 12, and;

- Downstream of the discharge from all Basins, including Basins 4 and 2 (immediately upstream of the railway).

2.2.3 Modelled Flow Results, Howes Creek

Flows predicted from the RAFTS modelling for various ARI's are included in **Error! Reference source not found.** to Table 2.

The location of the outflow is given with respect to a node from RAFTS (refer to drawings in Appendix A) and are described as follows:

- Node T9 is downstream of Basins 5 and 6, but upstream of proposed Basins 4a and 12;
- Node T12 is downstream of Basins 5, 6, 4a and 12; and,
- Node T16 is downstream of Basins 5, 6, 4a, 12, 4 and 2.

The flows quoted for the individual basins are at locations immediately downstream of each basin. It is noted that all flows quoted are either with all upstream basins in place or with no upstream basins in place. No permutations were modelled considering some basins in place and some not in place.

Table 1 Howes Creek Flows, 2-year ARI

Location	Existing Flow (where previously reported)	Developed Flow (without mitigation)	Developed Flow (with mitigation)
Outflow from Basins, 5 and 6 - Howes Creek Upstream Reach			
Basin 5 outflow	2	3.3	1.9
Basin 6 outflow	3.3	5	3.2
Upstream Catchments Outflow (node T9)	-	34.7	33.4
Outflow from Basins 2, 4, 4a and 12 - Howes Creek Downstream Reach			
Basin 2 outflow	2.7	6.7	2.1
Basin 4 outflow	3.7	6.7	3.1
Basin 4a outflow	1.9	3.7	1.8
Basin 12 outflow	6	11.7	5.7
Downstream catchments outflow (node T12)	-	39.3	43.1
Outflow from Basins 2, 4, 4a, 5, 6 - Upstream of Railway			

Location	Existing Flow (where previously reported)	Developed Flow (without mitigation)	Developed Flow (with mitigation)
Node T16	46	44	46

Table 2 Howes Creek Flows, 100-year ARI

Location	Existing Flow (where previously reported)	Developed Flow (without mitigation)	Developed Flow (with mitigation)
Outflow from Basins, 5 and 6 - Howes Creek Upstream Reach			
Basin 5 outflow	6.6	8.5	6
Basin 6 outflow	10.2	11.9	9.9
Upstream Catchments Outflow (node T9)	-	111	106
Outflow from Basins 2, 4, 4a and 12 - Howes Creek Downstream Reach			
Basin 2 outflow	10.5	14.3	8.5
Basin 4 outflow	11.2	14.9	10.4
Basin 4a outflow	6.2	8.3	6
Basin 12 outflow	19	25.7	18.2
Downstream catchments outflow (node T12)	-	129.4	131.8
Outflow from Basins 2, 4, 4a, 5, 6 - Upstream of Railway			
Node T16	142*	136	139

The results demonstrate that flows in the lower reaches of Howes Creek are slightly lower when no basins are in place. In the upstream catchments however (node T9), flows are slightly higher when basins are removed; approximately 5% higher in a 100-year ARI event and between 1% and 3% higher in the smaller ARI's.

Although the basins mitigate the developed flows, the results do not preclude assessment of an alternative drainage strategy, given that the difference in flows is relatively small. These flow results were used to assess existing channel capacities and required size of low flow channels (refer to section 3)

2.3 Basins 7 and 8

2.3.1 Review of Catchment Areas and Design Flows

The outflows from Basin 8 as tabulated in the Detention Report were reviewed.

Shortly before the Detention Report was finalised, it was proposed to relocate Basin 7 to the current proposed location.

A review of the catchments specified in the report identified that these were correct for the old configuration of Basins 7 and 8 and as included in the RAFTS model reviewed by council. The fall of the existing ground levels tended towards the catchments identified with the original location of Basin 7.

However, with the relocation of Basin 7, the preferred catchment strategy is as indicated on the map identified in Appendix A. It is noted that the catchments will be subject to final development levels and should be taken into account as the site grading is progressed.

On the basis of the preferred strategy therefore, the catchments have been reassessed.

Table 3 updates the catchment list provided in Table 10 of the detention report to reflect the new strategy.

Table 3 Catchments Contributing to Basins 7 and 8

Basin	Contributing Catchments	Offset Catchments	Area, ha
7	V11, V12, V13, $V14_a$, V17, V18, V19, V20, V21	None	41.5
8	V1, V7, V8, V9, V10, $V14_b$	V2, V3	31.5 (41.9)

(includes offset catchments)

The RAFTS model was adjusted to account for the revised catchment configuration. The volume of Basin 7 was reassessed to accommodate the additional flows.

Preliminary sizing for Basin 7 was carried out to allow for over-throttling of the flows to discharge to the 3 x 600 and 3 x 900 culverts beneath the railway.

The revised estimated catchment flows used for design are included in Table 4.

Table 4 Revised 100-year ARI Flows (m^3/s), Basin 7 and 8

Basin	Area	Existing Flows	Developed Flows (no mitigation)	Developed Flows (with mitigation)	Developed No Mitigation Flows, Specific Flow Rate
7	41.5	14.3	18.2	4.8	0.44
8	41.9	15.1	19.5*	13.8*	0.47*

**Includes offset catchments*

Table 4 indicates the need for the basins to mitigate the developed flows.

2.3.2 Relocation of Basin 8 to south lot

Council expressed a desire to review the location of Basin 8 and assess the possibility of moving it to the lot south of its existing location.

A visual assessment of the lot was carried out during a site visit. Photographs of the lot show the gently sloping ground including stockpiled fill falling away steeply to the south.

Figure 1 South lot, taken from the south-west corner

Figure 2 South Lot, taken from the west

Relocating Basin 8 to the south lot would require an increased embankment height to batter to existing levels on Racecourse Avenue.

Maintaining basin capacity and appropriate levels, a basin embankment of up to 5m high would be required, as compared to that of up to approximately 2.6m in the current proposed location.

The new invert of the basin would be at approximately 74.5 mAHD with top level at 76.5m AHD and total volume of approximately 12,000 m^3 as per the previously proposed basin.

It is noted that the south lot is shown to be within the 100-year ARI event floodplain. The Nepean flood level downstream of the railway is 76.07 mAHD. Flow through the railway culverts relies on head from the basins for flow through the culverts.

If the downstream is flooded to a higher level, then flow through the culvert will not occur.

Ground levels at the existing basin location range from 75.9 mAHD to 76.8 mAHD. At the south lot they fall steeply from 79 mAHD in the north east corner to 70.5, with the majority of the lot being located below 74.5 mAHD.

At its current location, some flow would be expected (amount depending on the water level in the pond) to occur from Basin 8 even during backwater flooding.

If moved to the south lot, the Basin cannot be raised substantially without impacting on the potential for catchment V8 to drain into the basin.

However, in the event that flow through the culverts did not occur due to tailwater levels, there is no predicted increase in flood levels over existing and hence this may be considered acceptable.

The presence of the Basin in the floodplain would displace an estimated 7,200 m^3 in volume from the floodplain, with a subsequent increase in expected flood levels in the roads. On the above basis, it is considered that the preferred location is as originally proposed. However, the alternative location of Basin 8 is also shown on the plan in Appendix A. Costing of this option is also included in Appendix B.

2.4 Basin 9

The proposed Basin 9 discharges into a Category 3 riparian corridor. The potential for retaining the existing flow characteristics rather than introducing a basin was assessed.

2.4.1 Modelled Flow Results, Basin 9

Table 5 summarises the modelled outflows for Basin 9. Two locations are assessed, that immediately downstream of the proposed basin, as well as at the downstream outflow into the Nepean (node T20 in the RAFTS model).

Table 5 Downstream Flow (m^3/s), with and without Basin 9

ARI	Location	Existing Flow (where previously reported)	Developed Flow (without mitigation)	Developed Flow (with mitigation)
100y	At outflow to Nepean (node T20)	-	54.1	49.6
1y	At outflow to Nepean (node T20)	-	10.7	9.8
2y	At outflow to Nepean (node T20)	-	18.6	16.2
5y	At outflow to Nepean (node T20)	-	27.9	25.5
100y	Basin Outflow	15.0*	16.3*	15*
1y	At Basin Outflow	-	4.9	3.8
2y	At Basin Outflow	5.1*	5.6*	4.9*
5y	At Basin Outflow	-	9.6	7.4

Previously reported in Table 9 of the Detention Report

As in the case of Basins 5 and 6, the differences in flows suggest that an alternative strategy to basin implementation can be considered. The flow results were used in determining the adequacy of the existing channel and for sizing of a low flow channel.

2.5 Basin 11

The proposed Basin 11 also discharges into a Category 3 riparian corridor. As with Basin 9, the potential for retaining the existing flow characteristics rather than introducing a basin was assessed.

2.5.1 Modelled Flow Results, Basin 11

Table 6 summarises the modelled outflows for Basin 11. Two locations are assessed, that immediately downstream of the proposed basin, as well as at the downstream outflow into the Nepean (node O8 in the RAFTS model).

Table 6 Downstream Flow (m^3/s), with and without Basin 11

ARI	Location	Existing Flow (where previously reported)	Developed Flow (without mitigation)	Developed Flow (with mitigation)
100y	At outflow to Nepean (node O8)	-	21.9	20.3
1y	At outflow to Nepean (node O8)	-	3.4	3.0
2y	At outflow to Nepean (node O8)	-	6.7	5.9
5y	At outflow to Nepean (node O8)	-	11.8	9.6
100y	At Basin Outflow	7.9*	9.6*	7.9*
1y	At Basin Outflow	-	2.1	1.7
2y	At Basin Outflow	2.6*	3.6*	2.4*
5y	At Basin Outflow	-	5.7	3.8

***** *Previously reported in Table 9 of the Detention Report*

As in the case of Basins 5, 6 and 9, the flow results from Table 6 were used to estimate the adequacy of the existing channel and also for sizing of a low-flow channel.

3. Channels

3.1 Overview

It was desired to review existing conditions of the watercourses on site to determine their condition. The creeks are referred to with the nomenclature used in the Detention Report, that is:

- Basin 9 discharges to Creek S1
- Basin 11 discharges to Creek S2
- Basins 5, 6, 2, 4, 4a and 12 discharge to Creek M (Howes Creek)

Creek M is further divided into various reaches for the purposes of this study.

The channels providing drainage for low flows from Basin 7 over Harness Racing Land is referred to as HR-1. HR-2 downstream is proposed to take flows from Basin 8 as well as the low flows from Basin 7. It is proposed that a third flow path (HR-3) will be provided to take high flows from Basin 7 over a route yet to be agreed.

Channels are shown on the plan in Appendix A. Existing channel estimates are based on available DEM data and limited site visit information and are therefore preliminary.

It is further noted that the existing survey does not include detailed channel survey. Cross-sections are approximate and may not pick up inverts, bank levels or any existing low flow channels.

Velocity limits for estimation of low flow channels and costing of stabilisation works assumed a limiting velocity of 2m/s.

The limiting velocities for erosion resistance of grass vegetation is generally dependent on the flow duration as well as the quality of the cover. For normal cover and flow durations of between 6 to 12 hours, limiting velocities of between 2.1 to 2.5 m/s may be expected (Table 7).

Table 7 Limiting Velocities for Erosion Resistance of Grasses

Flow Duration (hours)	Velocities for Quality of cover (m/s)		
	Good	**Normal**	**Poor**
2	5.0	3.9	2.8
4	3.7	2.9	2.1
6	3.3	2.5	1.8
9	3.0	2.3	1.6
12	2.8	2.1	1.5
18	2.7	2.0	1.3

Flow Duration (hours)	Velocities for Quality of cover (m/s)		
24	2.6	1.9	1.2
48	2.5	1.7	1.0
72	2.4	1.6	0.9

Source: AR&R (1987)

For Menangle Park, this may vary depending on the types of native vegetation selected as part of the creek stabilisation works. It is recommended that this be reviewed during detailed design.

3.2 Existing Channels

Typical cross-sections of the existing channels were determined from survey, as well as existing longitudinal profiles. From this information, approximate 100-year, 5-year, 2-year and 1-year ARI levels within each creek were approximated using Mannings equation.

The channels identified by the survey typically have wide overbanks with shallow side slopes, resulting in relatively shallow flow depths in the 100-year ARI event (excluding backwater effects from the Nepean).

Approximate existing in-channel and overbank dimensions are included in Table 8.

The in-channel top width refers to the dimensions of the "low flow" channel, as estimated from aerial photography. The overbank channel refers to the wider floodplain cross-section as estimated from the survey.

For longer channels, where possible, existing cross sections were examined both downstream of the proposed Basin and also at the outflow to the Nepean. Where survey and access did not permit, this is in some cases limited to a single location.

Several separate existing reaches of Howes Creek (Creek M1) were assessed. The locations can be seen on the drawing in Appendix A and were as follows:

- The tributary channel immediately downstream of Basin 5 (M1_5);
- The tributary channel immediately downstream of Basin 6 (M1_6);
- The existing main channel immediately downstream of both basins 5 and 6 (M1_U);
- The channel downstream stream of Basins 4a and 12 (M1_D1); and,
- The channel downstream of all basins including basins 2 and 4 (M1_D2)

No existing channels immediately downstream of proposed basins 4, 4a, 2 and 12 have been identified.

Creek S1 (Basin 9) was assessed both at the location of the proposed basin outflow, as well as at the downstream outflow to the Nepean.

Creek S2 (Basin 11) was assessed at a location towards the downstream outflow into the Nepean.

The flow channels over Harness Racing Land were assessed at location HR-1 (Basin 7 low flows) and HR-2 (Basins 7 low flows and Basin 8).

Table 8 Existing Channel Geometry*

Chnl	Location	Basin	Top Width, In-channel (m)	Overbank Flow Width (m)	Base Width (m)	In-channel depth (m)	Longitu-dinal Slope (%)
M1_5	Stream immediately DS of 5	5	7.5	43	0.3	1.2	1.2
M1_6	Stream immediately DS of 6	6	5	45	0.3	0.5	1.2
M1_U	Howes Creek DS of Basin 5 & 6	5 & 6	14	260	5	0.9	1.2
M1_D1	Howes Creek DS of Basins 12 & 4a,	4a, 12	17.5	270	12	0.4	1
M1_D2	Howes Creek DS of all Basins	5, 6, 4q, 12, 2, 4	17.5	310	12	0.4	1
S1	Downstream near Nepean Outflow	9	22	143	2	0.7	1.2**
S1	Downstream of Basin 9	9	8.5	143	0.5	0.4	1
S2	Downstream near Nepean outflow	11	8.5	52	0.5	0.5	1.2**
HR1	Near entrance to Harness Racing	7	4.5	12	0.3	0.6	1.2
HR2	Downstream of existing pond	7 & 8	4.6	107	1	0.4	1.2

***** *Approximate, from aerial and representative survey cross-sections*

***Average over several hundred metres upstream of outlet*

The predicted 100-year ARI event velocities and depths of flow are included for scenarios with and without basins at comparative locations in Table 9. These consider the larger surveyed cross-section. As Basins 7 and 8 are not considered for removal, these channels are considered for the “with basins” case only.

Council noted that Creeks S1 and S2 are steep and deeply incised towards the Nepean Outlet. At the Nepean outlet, the area is heavily vegetated and the survey does not identify the channel.

The slopes of Table 8 are an average for the area downstream of the development outflows (i.e. downstream of the locations of Basins 9 and 11).

The estimated slope of Basin 9 is approximately 0.5% for approximately 200m, after which the channel bed appears to drop sharply and steepen to a slope of 1.4%. This has been considered further when identifying potential stabilisation options.

Creek S2 is poorly reflected in the survey, making it difficult to refine slope estimates along its length. On the basis that it does steepen towards the downstream area, provisional allowances are made for stabilisation works.

Table 9 Existing Channel Flow Depths and Velocities, 100-year ARI

Drainage System	Location	Basin	Depth (m)		Velocity (m/s)	
			With Basin	Without Basin	With Basin	Without Basin
M1_5	Stream immediately DS of 5	5	1.5	1.7	1.5	1.4
M1_6	Stream immediately DS of 6	6	1.4	1.4	1.8	1.8
M1_U	Howes Creek DS of Basin 5 & 6	5 & 6	1.2	1.2	2	2
M1_D1	Howes Creek DS of Basins 12 & 4a,	4a, 12	0.95	0.95	1.8	1.8
M1_D2	Howes Creek DS of all Basins	5, 6, 4a, 12, 2, 4	0.96	0.96	1.8	1.8
S1	Downstream near Nepean Outflow	9	1	1	1.7	1.7
S1	Downstream of Basin 9	9	1.2	1.2	1.8	1.8
S2	Downstream near Nepean outflow	11	0.7	0.7	1.7	1.7
HR1	Near entrance to Harness Racing	7	0.5	N/A	1.1	N/A
HR2	Downstream of existing pond	7 & 8	0.56	N/A	1.43	N/A

Table 9 indicates that the overbank channels have capacity to pass the 100-year ARI events for the developed case, both with and without basins, at velocities not predicted to exceed 2 m/s.

Table 10 shows the predicted channel flow for the 2-year ARI. Where flow is anticipated to pass beyond the existing channel banks into the overbank floodplain, results are underlined for information. However, wide corridors are available for the conveyance of overbank flows.

Table 10 Existing Channel Flow Depths and Velocities, 2-year ARI

Drainage System	Location	Basin	Depth (m)		Velocity (m/s)	
			With Basin	Without Basin	With Basin	Without Basin
M1_5	Stream immediately DS of 5	5	0.7	0.9	1.8	2.0
M1_6	Stream immediately DS of 6	*6*	*0.9*	*1.5*	*0.9*	*1.5*
M1_U	Howes Creek DS of Basin 5 & 6	5 & 6	0.8	0.8	1.6	1.6
M1_D1	Howes Creek DS of Basins 12 & 4a,	4a, 12	*0.6*	*0.6*	*1.2*	*1.2*
M1_D2	Howes Creek DS of all Basins	5, 6, 4a, 12, 2, 4	*0.7*	*0.7*	*1.3*	*1.3*
S1	Downstream near Nepean Outflow	*9*	*0.8*	*0.9*	*1.3*	*1.5*
S1	Downstream of Basin 9	*9*	0.7	1.2	0.7	1.2
S2	Downstream near Nepean outflow	11	0.5	0.5	1.3	1.3
HR1	Near entrance to Harness Racing	*7*	0.42	N/A	1.0	N/A
HR2	Downstream of existing pond	7 & 8	0.41	N/A	1.1	N/A

**Underlined italics indicates flow passes into overbank corridor*

3.2.1 Flood Modelling Assessment, 100-year ARI

The Howes Creek TUFLOW model was run for the 100-year developed flow (without Basins 2, 4, 4a, 12, 5 and 6) case. A flood map is included in the Appendix.

The flood line indicates limited changes from that issued in the Flooding and Detention Report. The flood line considers flooding from rivers only and the drainage will need to be designed to manage flood risk from development flows.

As compared to the approximate hydraulic estimates of Table 9, the TUFLOW results generally indicated velocities of up to 1.1 m/s in the floodplain, and 1.8 m/s in channel.

Modelled velocity-depth products were below 1 in the floodplain and up to 1.5 in the channel. However, as the high hazard areas are mostly confined within the main channel and are buffered with low hazard areas within the overall floodplain which is typical of most natural creeks, it is not considered to be an issue.

3.3 Low Flow Channels

For those channels found to exceed the capacity of the existing low flow channel in the 2-year ARI event, or where existing velocities were estimated at greater than 2m/s, approximate required dimensions of low flow channels at the locations previously identified were assessed for the 2-year ARI event.

On the basis that the catchments concerned are downstream of the development areas with a substantial riparian zone available for overland flow of larger ARI events, the 2-year ARI event was not considered unreasonable, although overbank velocities and flood impacts have not been assessed through hydraulic modelling.

The difference in the with-basin and without-basin scenarios was minor in many cases. The level of detail in the preliminary estimates therefore did not in all cases identify differences in required channel geometry.

Although sizing of these channels has been investigated, it is suggested that the flows may be better managed through allowing overbank flow to occur and carrying out stabilisation works.

3.3.1 Creek M, upstream catchments

Howes Creek drains a substantial catchment, with the 2-year ARI combined flows downstream of Basins 5 and 6 being in excess of 30 m^3/s.

Table 11 Howes Creek Channels Required Channel Geometry for 2-year ARI, Upstream Reaches

Event	Q* (m^3/s)	Top Width (m)	Base Width (m)	Longitudinal Slope (%)	Side Slope, 1 in x	Average Velocity (m/s)	Depth (m)
M1_5							
Existing channel sufficient for all development conditions							

Event	Q* (m^3/s)	Top Width (m)	Base Width (m)	Longitudinal Slope (%)	Side Slope, 1 in x	Average Velocity (m/s)	Depth (m)
M1_6							
With Basins	3.2	7.4*	0.5	1.2	6	1.4	0.58
Without Basins	5	8.9*	1.3	1.2	6	1.6	0.63
Howes Creek_U							
Existing channel sufficient for all development conditions							

***** *Indicates top width required for flow. Channel geometry could be extended to provide minimum width of 15m as per Council's DCP requirement.*

3.3.2 Creek M, downstream catchments

The required flows for the channel reaches downstream of proposed basins 4a and 2, as well as downstream of basins 12 and 4a are included in Table 12.

Table 12 Howes Creek Channels Required Low-Flow Channel Geometry for 2-year ARI, Downstream Reaches

M1_D1 (Downstream of Basins 4a and 12)							
With Basins	43	27.4	10	1.2	8	2.1	1.1
Without Basins	39	26.7	10	1.2	8	2.1	1.0
M1_D2 (Downstream of all Howes Creek Basins, upstream of railway)							
With Basins	46	28.1	10	1.2	8	2.2	1.13
Without Basins	44	27.6	10	1.2	8	2.1	1.10

A substantial channel would be required in these lower reaches of Howes Creek for a 2-year ARI event. Predicted velocities and velocity products are high and stabilisation works or channel flattening would be required in order to reduce the velocities to acceptable levels (2m/s).

The required size of channel for the 2-year ARI would indicate that provision of a low flow channel may not be practical. Management of flows by improvement to the existing channel was examined as an alternative. For Howes Creek, the assessment of the existing flow regime indicates velocities are more favourable.

3.3.3 Creek S1, Basin 9

Table 13 Creek S1, Required Channel Geometry for 2-year-ARI

Event	Q* (m^3/s)	Top Width (m)	Base Width (m)	Longitudinal Slope (%)	Side Slope, 1 in x	Average Velocity (m/s)	Depth (m)
S1, Downstream of Basin 9							
Existing channel sufficient for all development conditions, stabilisation considered							
S1, at outflow to Nepean							
With Basins	16.2	22.1	12	1	9	1.73	0.56
Without Basins	18.6	24.1	14	1	9	1.76	0.56

It is noted that the existing channel slopes at this downstream location are estimated to be steeper than indicated on the survey. Stabilisation works to the existing channel have been considered.

3.3.4 Creek S2, Basin 11

Creek S2, into which Basin 11 is proposed to drain, was found to have sufficient existing in-capacity for the 2-year ARI event for both development scenarios.

3.3.5 Harness Racing Land

A heavily vegetated existing drainage ditch (referred to as HR1 in this report) flows in a southerly direction on the harness racing land to the west of the railway embankment Appendix A.

At the entrance to the racecourse, the ditch appears to pass under the roadway, although it was not possible to view the culvert.

From there, it is assumed that the ditch passes beneath the flood embankment into the existing culvert which joins HR-2 downstream before discharging into the Nepean.

Figure 3 Drainage Ditch, looking towards the south-east, railway embankment in the background

Channel requirements are assessed in Table 14.

Table 14 Harness Racing, Channel HR-1, Required Channel Geometry for 2-year ARI

Event	Q* (m^3/s)	Top Width (m)	Base Width (m)	Longitudinal Slope (%)	Side Slope, 1 in x	Average Velocity (m/s)	Depth (m)
With Basins	0.86	4.5	1	1.2	6	1.14	0.29

***** *Peak Low Flow from Basin 7*

The channel referred to as HR-2 is an existing Creek as identified on the plan in Appendix A.

Table 15 Harness Racing, Channel HR-2, Required Channel Geometry for 2-year ARI

Event	Q* (m^3/s)	Top Width (m)	Base Width (m)	Longitudinal Slope (%)	Side Slope, 1 in x	Average Velocity (m/s)	Depth (m)
With Basins	6.7	10.3	3.5	1.2	6	1.73	0.57

***** *Simplified estimate – sum of peak low flow for Basin 7 and peak total flow for Basin 8*

3.4 Harness Racing Easement

For the existing channel HR-1, the flow width in the 100-year ARI event is estimated at 4.5m. Allowing for 0.5m freeboard and an additional 1m (council DCP Volume 2, Table 14.8), the easement width required would be 8.5m. If council's minimum floodway width of 15m is required then the freeboard allowance would already be included and the minimum easement required would be 16m.

Channel HR-1 flows between the railway embankment and a cut-off wall (Figure 3). The total width between the railway embankment and cut-off wall is approximately 20m.

Because of the proximity of HR-1 to the existing railway embankment (distance estimated from visual inspection to be approximately 3m from top of channel), the easement width would be primarily on the western side of the channel with a limited width between the channel and railway.

If necessary, realignment of the channel to meet with the easement width requirements could take place.

Figure 4 HR-1 looking north: railway embankment at right of picture and cut-off wall to the left

For the existing channel HR-2, the flow width in the 100-year ARI event is estimated at 38 m. This takes account of the peak flow from Basin 8, peak low flow from Basin 7 and excludes backwater effects from the Nepean.

Council has noted that this land is flood affected in the 100-year ARI event and a width of easement allowing for the full extent may not be beneficial.

If the 2-year ARI is considered instead, the width required when 0.5m freeboard allowance is taken into consideration is still greater than the predicted 100-year ARI flow width.

The following alternatives are considered:

1. Construct new channel to take 100-year flows with steeper side slopes than existing and narrower easement requirements;
2. Adopt a nominal easement width of the minimum floodway width plus an additional 1m i.e. 16m.

Given that the channel capacity and existing velocity-depth products are estimated to be acceptable and that the channel lies within the Nepean flood extent, the benefits of option 1 above are considered minimal.

It is suggested that a nominal easement width be adopted as suggested in 2.

3.5 Stabilisation

There are a number of options available for stabilisation and erosion prevention of existing channels.

3.5.1 Stabilisation Matting

Bank stabilisation could be considered through introduction of channel lining in problem areas. Because of the shallow side slopes identified from survey (1 in 3 or flatter), it was assumed that general purpose polyethylene matting would be suitable for stabilisation.

Although the matting deteriorates with time and would not be expected to have a design life of the required 100 years, it allows for establishment of a well vegetated and more stable channel which should endure beyond the life of the matting.

Indicative costs for stabilisation works have been provided assuming introduction over an assumed width.

3.5.2 Grade Control Structures

The predicted channel velocities have generally been estimated to be 2m/s or below; however, the channel slopes are relatively high for natural creeks at 1 to 1.2%.

Drop structures can be used to control velocities and manage sudden changes in slope (as identified at a location along Channel S2).

A variety of options are available, including straight drop concrete drops, rock-lined chutes or a series of smaller drops using logs.

Straight concrete drop structures tend to have a lower chance of failure and longer design life, but may not be preferred for flora and fauna habitat.

As an alternative to implementing lining mats, costs for construction have been provided for implementing drop structures to reduce effective longitudinal stream slopes to 0.5%. Various options have been considered in the cost estimates (Appendix B).

3.5.3 Preferred Stabilisation Options

It is expected that channel stabilisation works for each creek may necessitate a combination of options. In order to assess and design these in detail, it is recommended that:

- Detailed cross-sectional survey of channels is carried out;
- Complete longitudinal profile of channel is surveyed;
- Monitoring of channel flows and velocities;
- Mapping of key channel features based on survey and further site work

4. Costing

4.1 General

For costing of channel works at this initial stage, estimates were made for construction of low flow channels in those cases where the 2-year flow was found to flow into the overbank. Estimates both with and without basins were only made where appreciable differences in channel geometry were identified (please see section 3.3). Otherwise, a single cost estimate was provided.

Where low flow channels have been sized, these are intended to provide suitable flow velocities within channel and thus stabilisation works required would be limited.

Separate cost estimates have been provided for stabilisation works only (no low-flow channel).

Cost estimates are included in Appendix B. The following limitations and assumptions are noted in regard to these estimates:

- No allowance has been made for temporary works or design (construction costs only);
- Costing assumes cut and fill of low flow channels will be balanced;
- Road inlet drainage has not been costed in detail;
- Existing channel side slopes have been assumed to be 1 in 3 or shallower (based on survey);
- The channel width over which stabilisation works have been costed is that determined for the existing low flow cross-section where channel side slopes are steepest, plus a nominal additional 30% width;
- The scenario considered for stabilisation works is “with-basins” for HR-1 and HR-2 and “without basins” for the other channels;
- No allowance has been made for requirements of the water quality strategy as it is understood that allowances have been made in a separate study; and

Cost estimates are provided in Appendix B for the following:

- Construction of low-flow channels for the estimated formed channel;
- Construction of stabilisation works for two options; and,
- Updated Basin 7 and 8 costs and costs for relocated Basin 8.

4.2 Findings

4.2.1 Howes Creek Basins

Cost estimates for low-flow channels and stabilisation works have been provided for two reaches of Howes Creek, M1_U (catchments of Basins 5 and 6) and M1_D (downstream reach including flows from all basins).

The preliminary hydraulic estimates showed little difference in flow between the with-basins and without-basins approach for Basins 5 and 6. For this reason, there was no difference in costing for the upper reaches of Howes Creek between the two scenarios.

For the lower reach, minor differences were noted downstream near the railway and separate cost estimates were provided for the with basins and without basins scenarios.

The existing channel from Basin 5 (upstream of the confluence of the channels which combine to form Howes Creek) was sufficient for passing the 2-year ARI flow and no low-flow channel works were included. Costs for estimated stabilisation of the existing channel were estimated.

A comparison of costs estimated for Basin Construction (July 2011) against channel stabilisation are included in Table 16.

Table 16 Comparison of Estimated Basin Construction Costs against Channel Stabilisation Works

Basins	Basin Construction Cost Estimate	Stabilisation Works Estimate
5 & 6	$1.85 million	$975,000
2, 4, 4a & 12	$5.4 million	$1.6 million
TOTAL	$7.25 million	$2.575 million

Note that the channel stabilisation includes works to the existing channel only over a limited width and excludes all works associated with water quality aspects and costs of constructing a low flow channel.

4.2.2 Basin 9

Estimated costs for construction of Basin 9 were $1.2 million (July 2010). Stabilisation works are estimated at a cost of $1.07 million. Basin 9 may therefore be identified for removal depending on the outcome of detailed assessment.

4.2.3 Basin 11

Construction of Basin 11 was estimated at a cost of approximately $1 million (July 2010).

In this study, the estimated costs of stabilisation works were found to be approximately $400,000.

4.2.4 Harness Racing Land (Basins 7 and 8)

Estimated costs of stabilisation works for these channels (HR-1 and HR-2) are estimated at approximately $400,000 each.

4.2.5 Basin 8

It is estimated that the cost of constructing Basin 8 in its current location is approximately $1.975 million. The value is higher than estimated in July 2011 due to a more conservative value assumed for reinforced turf (used in construction of the high flow spillway).

A comparative cost for a Basin south of the current proposed location is estimated to cost approximately $2.6 million with a reduction to $2.2 million if a retaining wall is constructed instead of an earth embankment.

The primary difference in cost is due to expected additional fill import requirements associated with building the basin with a larger embankment over steeper ground on the south lot.

4.2.6 Basin 7

Basin 7 construction estimates have been updated based on allowance for additional capacity to take the flows of the southern catchments, originally proposed to drain to Basin 8.

Costs are now estimated at $1,500,000.

5. Conclusions and Recommendations

From the preliminary cost estimates, it appears that there may be some merit in considering channel upgrade works rather than implementing basins on Howes Creek (Basins 2, 4, 4a, 5, 6, and 12) and in Creek S1 (Basin 9) and Creek S2 (Basin 11). The estimated cost of stabilisation works for these basins is approximately $3 million whilst the costs of constructing the basins were estimated in July 2011 at approximately $8.2 million.

This report has not considered water quality requirements as it is understood these are considered in a separate study.

Approximate easement widths on the Harness Racing Land have been identified.

The existing channels were found sufficient to manage the flows up to the 100-year ARI event if overbank flow portions are permitted and it may therefore not be necessary to engineer low flow channels for the purposes of keeping the low ARI events within channel.

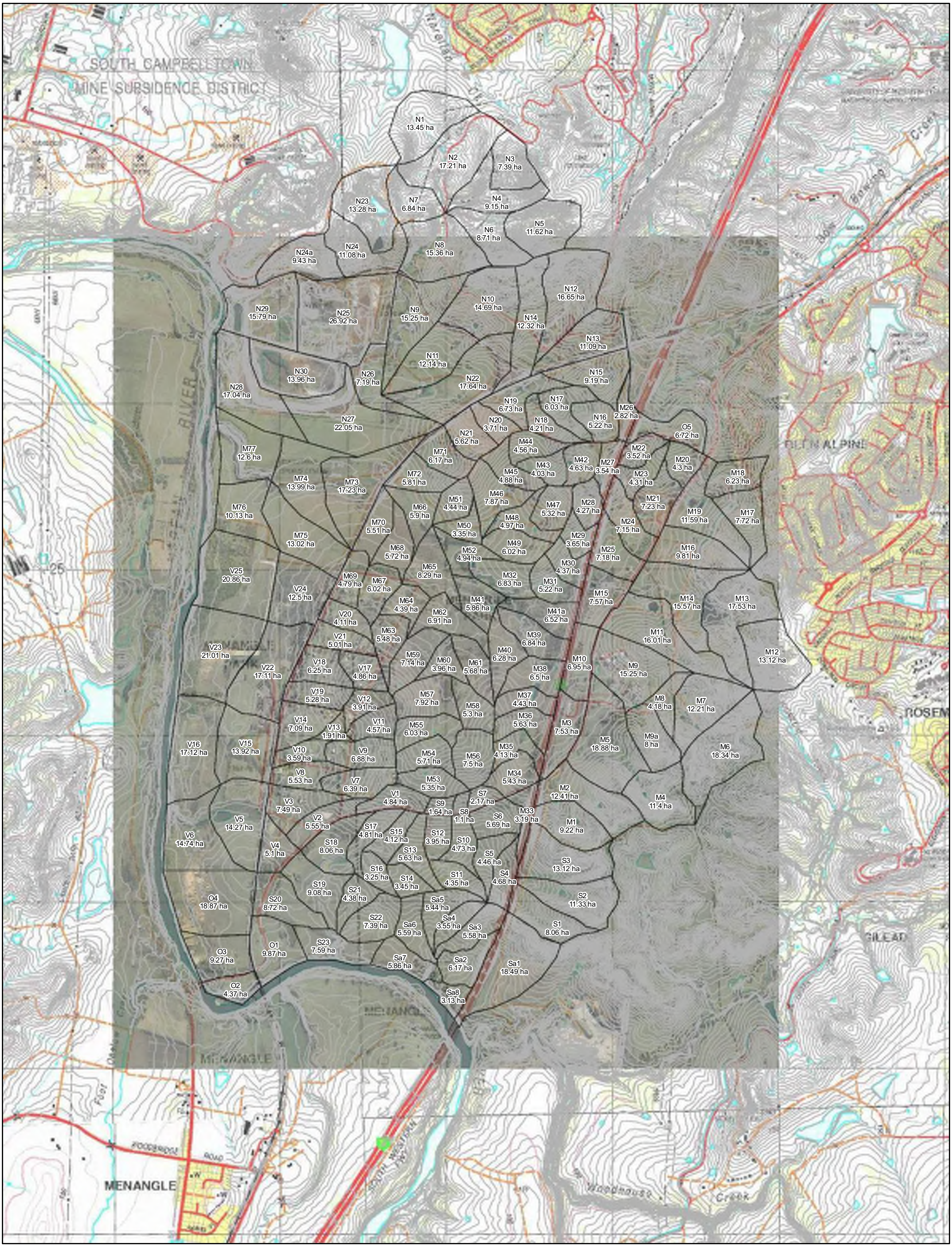
It is concluded that there may be merit in removing some of the basins from the scheme and reconsidering the need for low flow channels up to the 2 year event; however these findings would need to be confirmed through detailed site investigation, survey and possibly hydraulic modelling of overland flow paths (where not already undertaken).

Before carrying out any stabilisation works, it is recommended that monitoring of the creek condition should be carried out

The findings indicate a revised drainage strategy is possible where basins Basins 2, 4, 4a, 5, 6, 9 and 11 are removed for water quantity management while retaining water quantity management in accordance with the Menangle Park WSUD report. It is proposed that Basins 7 and 8 be retained for water quantity management

Appendix A

Drawings



1:20,000 at A3

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Campbelltown City Council/Landcom
Menangle Park Local Flooding and Detention

RAFTS Catchments

Job Number	21-15581
Revision	A
Date	20th Jan 2010

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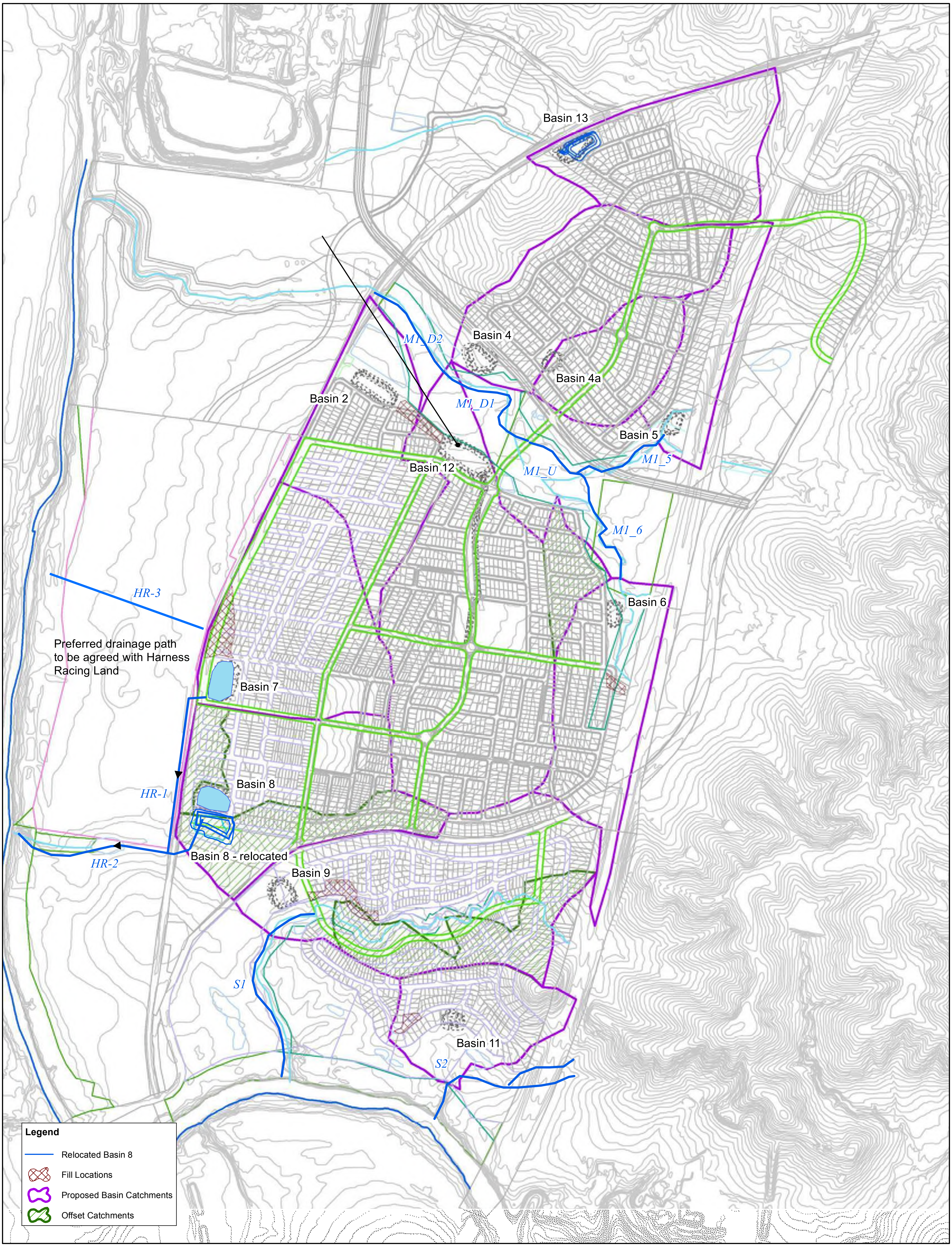
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: C Pappin



1:12,000 at A3

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Campbelltown City Council/Landcom
Menangle Park Local Flooding and Detention

Job Number	21-20952
Revision	A
Date	November 2011

Drainage Review

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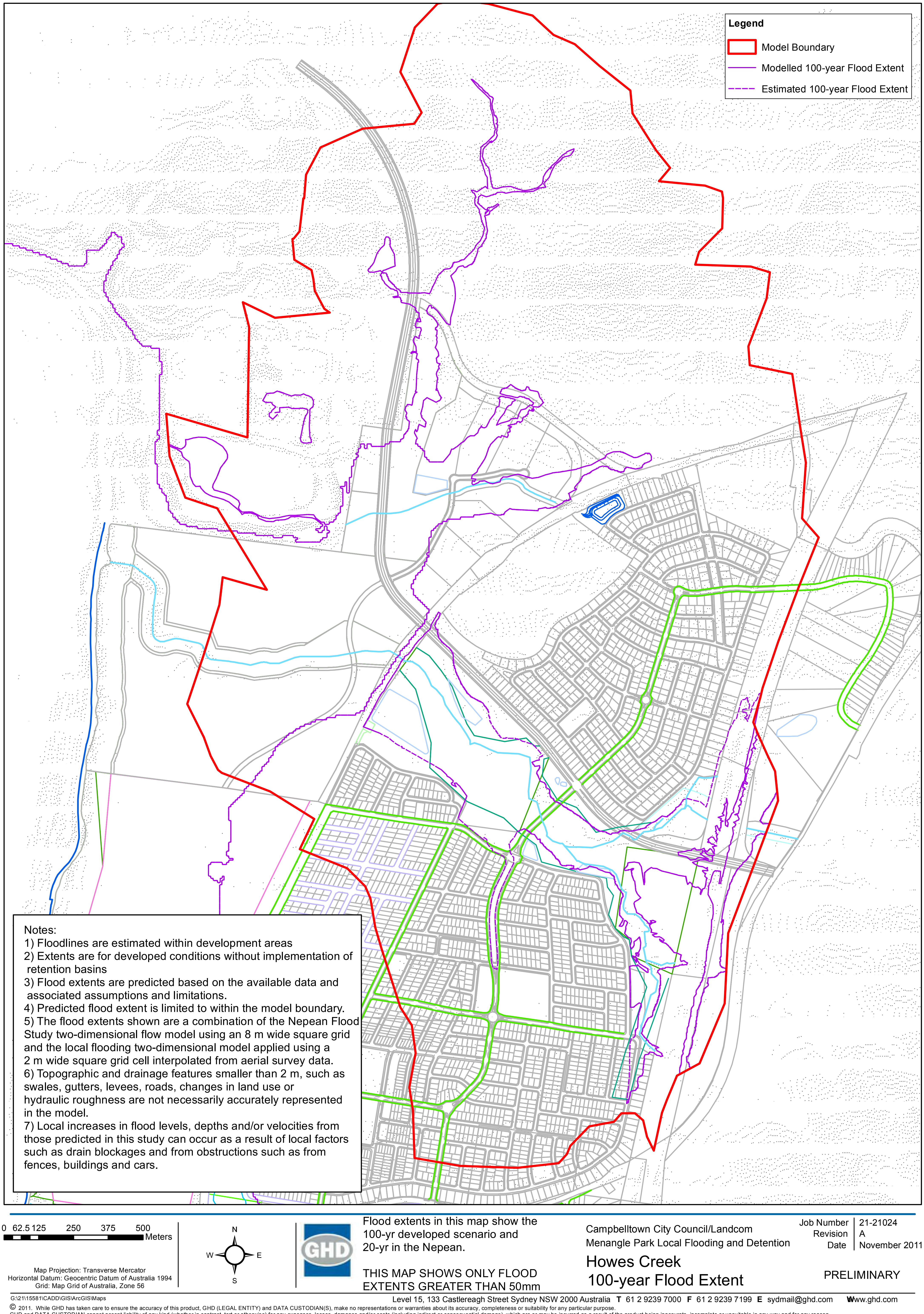

Notes:
1) Floodlines are estimated within development areas
2) Extents are for developed conditions without implementation of retention basins
3) Flood extents are predicted based on the available data and associated assumptions and limitations.
4) Predicted flood extent is limited to within the model boundary.
5) The flood extents shown are a combination of the Nepean Flood Study two-dimensional flow model using an 8 m wide square grid and the local flooding two-dimensional model applied using a 2 m wide square grid cell interpolated from aerial survey data.
6) Topographic and drainage features smaller than 2 m, such as swales, gutters, levees, roads, changes in land use or hydraulic roughness are not necessarily accurately represented in the model.
7) Local increases in flood levels, depths and/or velocities from those predicted in this study can occur as a result of local factors such as drain blockages and from obstructions such as from fences, buildings and cars.

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

Flood extents in this map show the 100-yr developed scenario and 20-yr in the Nepean.

THIS MAP SHOWS ONLY FLOOD EXTENTS GREATER THAN 50mm

Campbelltown City Council/Landcom
Menangle Park Local Flooding and Detention

Howes Creek
100-year Flood Extent

Job Number	21-21024
Revision	A
Date	November 2011

PRELIMINARY

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Appendix B

Cost Estimates

Appendix B1 – Basin 7 and 8 cost estimates

Appendix B2 – Low Flow Channel Cost Estimates

Appendix B3 – Stabilisation Works Cost Estimates, 1

Appendix B 4 – Stabilisation Works Cost Estimates, 2

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APPENDIX B1, PRELIMINARY COST ESTIMATE SUMMARY

ITEM	DESCRIPTION	AMOUNT
1	**Basin 8**	
1.1	Preliminaries	$ 20,000
1.2	Earthworks	$ 179,839
1.3	High Flow Spillway	$ 82,413
1.4	High Flow Box Culvert	$ 617,400
1.5	Low Flow Outlet Pipe	$ 72,690
1.6	Inlet from Road Drainage (to be advised)	$ 112,980
1.7	Landscaping and Planting	$ 113,715
1.8	Bioretention Area Not Costed	$ -
1.9	Supervision, Project Management & Contractor On-Costs	$ 359,711
2.0	Contingencies	$ 359,711
		$ 1,918,000
2	**Basin 8 Relocated - Earth Embankment**	
2.1	Preliminaries	$ 20,000
2.2	Earthworks	$ 579,849
2.3	High Flow Spillway	$ 66,776
2.4	High Flow Box Culvert	$ 617,400
2.5	Low Flow Outlet Pipe	$ 72,690
2.6	Inlet from Road Drainage (to be advised)	$ 112,980
2.7	Landscaping and Planting	$ 151,039
2.8	Bioretention Area Not Costed	$ -
2.9	Supervision, Project Management & Contractor On-Costs	$ 486,220
3.0	Contingencies	$ 486,220
		$ 2,593,000
3	**Basin 8 Relocated - Retaining Wall**	
3.1	Preliminaries	$ 20,000
3.2	Earthworks	$ 380,649
3.3	High Flow Spillway	$ 1,538
3.4	High Flow Box Culvert	$ 617,400
3.5	Low Flow Outlet Pipe	$ 72,690
3.6	Inlet from Road Drainage (to be advised)	$ 112,980
3.7	Landscaping and Planting	$ 151,039
3.8	Bioretention Area Not Costed	$ -
3.9	Supervision, Project Management & Contractor On-Costs	$ 406,889
4.0	Contingencies	$ 406,889
		$ 2,170,000
3	**Basin 7 Updated**	
3.1	Preliminaries	$ 20,000
3.2	Earthworks	$ 255,862
3.3	High Flow Spillway	$ 71,174
3.4	High Flow Box Culvert	$ 161,100
3.5	Low Flow Outlet Pipe	$ 24,930
3.6	Inlet from Road Drainage (to be advised)	$ 112,980
3.7	Landscaping and Planting	$ 298,479
3.8	Bioretention Area Not Costed	$ -
3.9	Supervision, Project Management & Contractor On-Costs	$ 283,358
4.0	Contingencies	$ 283,358
		$ 1,511,000

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Menangle Park
Detention Basin 8
SCHEDULE OF ESTIMATED QUANTITIES

Revision: 03

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE		AMOUNT	NOTES
1	**Preliminaries**						
1.1	Establishment	1	item	10000	$	10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$	10,000	Allowance only
	SUBTOTAL				$	20,000	
2	**Earthworks**						
2.1	Clearing and grubbing	1.3	ha	2900	$	3,713	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	50.0	m2	50	$	2,500	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	-	m2	63	$	-	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	-	m2	13	$	-	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	1,921	m3	5	$	9,412	Assuming light soil (not clay)
2.6	Excavate to reduce levels and deposit surplus cut in spoil heaps within 10km, in Light Soil	5,104	m3	9	$	45,936	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	2,765	m3	12	$	33,177	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	232	m3	10	$	2,319	
2.9	Access Road: place and compact imported fill	232	m3	12	$	2,782	
2.10	Allowance: Over excavation to restore soil profile				$	10,000	
2.11	Allowance: Treatment of dispersive soils with gypsum (or similar)				$	50,000	
2.12	Allowance: Separate and place select clay in embankment core				$	20,000	
	SUBTOTAL				$	179,839	
3	**High Flow Spillway**						
3.1	Form spillway crest in embankment	38	m3	21	$	788	-
3.2	Geotextile Fabric - non woven polypropylene/ polyethylene 2.8mm thick (310g/sqm)	150	m2	5	$	750	-
3.3	Reinforced Turf - supply, deliver, lay turf, roll and water	578	m2	140	$	80,875	0
	SUBTOTAL				$	82,413	
4	**High Flow Outlet Box Culvert**						
	Box Culvert - Supply and deliver 4.2m (span) x 0.9m (height) box culvert	120	m	4500	$	540,000	
	Headwall - Supply, deliver, lay and join precast unit; including toe excavation to suit 4.2m (span) x 0.9m (height) box culvert: 1 cell	4	each	5700	$	22,800	
	Concrete - reinforced, cast in-situ 25MPa to form cut-off wall	2	m3	300	$	600	
	Excavate 2000mm wide trench by machine, backfill with same material and compact, up to 3.0m deep	120	m	380	$	45,600	
	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	60	m2	140	$	8,400	
	SUBTOTAL				$	617,400	
5	**Low Flow Outlet Pipe**						
4.1	Pit - Supply, deliver, lay and join 900mm square pit with grated inlet	3	item	3700	$	11,100	-
4.2	Pipe - Supply, deliver, lay and join 600mm RCP (Class 2)	30	m	270	$	8,100	Rubber ring joint; excavation excluded
	Pipe - Supply, deliver, lay and join 525mm RCP (Class 2)	60	m	230	$	13,800	
4.3	Headwall - Supply, deliver, lay and join precast unit; including toe excavation - to suit 600mm pipe	3	each	590	$	1,770	-
4.4	Concrete - reinforced, cast in-situ 25MPa to form cut-off wall	4	m3	300	$	1,200	Approximate only
4.5	Excavate 2000mm wide trench by machine, backfill with same material and compact, up to 3.0m deep	90	m	380	$	34,200	Assuming clay soil
4.6	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	18	m2	140	$	2,520	0
	SUBTOTAL				$	72,690	
6	**Inlet from Road Drainage**						
5.1	Pipe - Supply, deliver, lay and join 375mm RCP (Class 2)	90	m	130	$	11,700	Rubber ring joint; excavation excluded
5.2	Excavate 1200mm wide trench by machine, backfill with same material and compact, up to 2.0m deep	90	m	140	$	12,600	Assuming clay soil
5.3	GPT - Supply, deliver and install CDS 2018	1	each	87000	$	87,000	Subject to final design
5.4	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	12	m2	140	$	1,680	0
	SUBTOTAL				$	112,980	
7	**Landscaping and Planting**						
6.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	1,921	m3	6	$	11,524	
6.2	Lawn turf - spread and grade 50mm topsoil, lay turf, roll and water	8,586	m2	10	$	85,862	-
6.3	Landscaping - supply, deliver and plant approved plants	419	m2	39	$	16,329	-
	SUBTOTAL				$	113,715	
8	**Bioretention Area**						
7.1	Construct bioretention system, complete with geofabric liner, drainage pipe, drainage layer, filter media, top-soil and vegetation		m2		$	-	NOT COSTED
7.2	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia		m2		$	-	NOT COSTED
7.3	Allowance: Placement and removal of sacrificial layer for staged development. 150mm thick layer, woven textile and temporary turf.						NOT COSTED
	SUBTOTAL				$	-	
	SUBTOTAL ITEMS 1-7				$	1,199,037	
9	**Supervision, Project Management & Contractor On-Costs**						
8.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$	359,711.14	-
	SUBTOTAL				$	359,711	
10	**Contingencies**						
9.1	Contingencies - General	30	%	-	$	359,711	-
	SUBTOTAL				$	359,711	
	TOTAL				**$**	**1,918,000**	

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Menangle Park
Detention Basin 8, Relocated - Earth Embankment
SCHEDULE OF ESTIMATED QUANTITIES

Revision: 03

SCHEDULE OF ESTIMATED QUANTITIES							
PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE		AMOUNT	NOTES
1	**Preliminaries**						
1.1	Establishment	1	item	10000	$	10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$	10,000	Allowance only
	SUBTOTAL				$	20,000	
2	**Earthworks**						
2.1	Clearing and grubbing	1.6	ha	2900	$	4,758	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	50.0	m2	50	$	2,500	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	-	m2	63	$	-	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	-	m2	13	$	-	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	2,461	m3	5	$	12,059	Assuming light soil (not clay)
2.6	Fill - place and compact imported fill	7,192	m3	60	$	431,520	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	3,615	m3	12	$	43,380	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	285	m3	10	$	2,850	
2.9	Access Road: place and compact imported fill	232	m3	12	$	2,782	
2.10	Allowance: Over excavation to restore soil profile				$	10,000	
2.11	Allowance: Treatment of dispersive soils with gypsum (or similar)				$	50,000	
2.12	Allowance: Separate and place select clay in embankment core				$	20,000	
	SUBTOTAL				$	579,849	
3	**High Flow Spillway**						
3.1	Form spillway crest in embankment	38	m3	21	$	788	-
3.2	Geotextile Fabric - non woven polypropylene/ polyethylene 2.8mm thick (310g/sqm)	150	m2	5	$	750	-
3.3	Reinforced Turf - supply, deliver, lay turf, roll and water	466	m2	140	$	65,239	0
	SUBTOTAL				$	66,776	
4	**High Flow Outlet Box Culvert**						
	Box Culvert - Supply and deliver 4.2m (span) x 0.9m (height) box culvert	120	m	4500	$	540,000	
	Headwall - Supply, deliver, lay and join precast unit; including toe excavation to suit 4.2m (span) x 0.9m (height) box culvert: 1 cell	4	each	5700	$	22,800	
	Concrete - reinforced, cast in-situ 25MPa to form cut-off wall	2	m3	300	$	600	
	Excavate 2000mm wide trench by machine, backfill with same material and compact, up to 3.0m deep	120	m	380	$	45,600	
	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	60	m2	140	$	8,400	
	SUBTOTAL				$	617,400	
5	**Low Flow Outlet Pipe**						
4.1	Pit - Supply, deliver, lay and join 900mm square pit with grated inlet	3	item	3700	$	11,100	-
4.2	Pipe - Supply, deliver, lay and join 600mm RCP (Class 2)	30	m	270	$	8,100	Rubber ring joint; excavation excluded
	Pipe - Supply, deliver, lay and join 525mm RCP (Class 2)	60	m	230	$	13,800	
4.3	Headwall - Supply, deliver, lay and join precast unit; including toe excavation - to suit 600mm pipe	3	each	590	$	1,770	-
4.4	Concrete - reinforced, cast in-situ 25MPa to form cut-off wall	4	m3	300	$	1,200	Approximate only
4.5	Excavate 2000mm wide trench by machine, backfill with same material and compact, up to 3.0m deep	90	m	380	$	34,200	Assuming clay soil
4.6	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	18	m2	140	$	2,520	0
	SUBTOTAL				$	72,690	
6	**Inlet from Road Drainage**						
5.1	Pipe - Supply, deliver, lay and join 375mm RCP (Class 2)	90	m	130	$	11,700	Rubber ring joint; excavation excluded
5.2	Excavate 1200mm wide trench by machine, backfill with same material and compact, up to 2.0m deep	90	m	140	$	12,600	Assuming clay soil
5.3	GPT - Supply, deliver and install CDS 2018	1	each	87000	$	87,000	Subject to final design
5.4	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	12	m2	140	$	1,680	0
	SUBTOTAL				$	112,980	
7	**Landscaping and Planting**						
6.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	2,461	m3	6	$	14,766	
6.2	Lawn turf - spread and grade 50mm topsoil, lay turf, roll and water	12,255	m2	10	$	122,545	-
6.3	Landscaping - supply, deliver and plant approved plants	352	m2	39	$	13,728	-
	SUBTOTAL				$	151,039	
8	**Bioretention Area**						
7.1	Construct bioretention system, complete with geofabric liner, drainage pipe, drainage layer, filter media, top-soil and vegetation		m2		$	-	NOT COSTED
7.2	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia		m2		$	-	NOT COSTED
7.3	Allowance: Placement and removal of sacrificial layer for staged development. 150mm thick layer, woven textile and temporary turf.						NOT COSTED
	SUBTOTAL				$	-	
	SUBTOTAL ITEMS 1-7				$	1,620,734	
9	**Supervision, Project Management & Contractor On-Costs**						
8.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$	486,220.25	-
	SUBTOTAL				$	486,220	
10	**Contingencies**						
9.1	Contingencies - General	30	%	-	$	486,220	-
	SUBTOTAL				$	486,220	
	TOTAL				**$**	**2,593,000**	

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Menangle Park
Detention Basin 8, Relocated - Retaining Wall
SCHEDULE OF ESTIMATED QUANTITIES

Revision: 03

SCHEDULE OF ESTIMATED QUANTITIES

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
2	**Earthworks**					
2.1	Clearing and grubbing	1.6	ha	2900	$ 4,758	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	50.0	m2	50	$ 2,500	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	-	m2	63	$ -	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	-	m2	13	$ -	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	2,461	m3	5	$ 12,059	Assuming light soil (not clay)
2.6	Fill - place and compact imported fill	1,312	m3	60	$ 78,720	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	3,615	m3	12	$ 43,380	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	285	m3	10	$ 2,850	
2.9	Access Road: place and compact imported fill	232	m3	12	$ 2,782	
2.10	Allowance: Over excavation to restore soil profile				$ 10,000	
2.11	Allowance: Treatment of dispersive soils with gypsum (or similar)				$ 50,000	
2.12	Allowance: Separate and place select clay in embankment core				$ 20,000	
2.13	Retaining wall - Keystone system blockwork including levelling base, joint pins, and 3.0m crushed rock backfill - 3.0 - 5.0m high	320	m2	480	$ 153,600	
	SUBTOTAL				**$ 380,649**	
3	**High Flow Spillway**					
3.1	Form spillway crest in embankment	38	m3	21	$ 788	-
3.2	Geotextile Fabric - non woven polypropylene/ polyethylene 2.8mm thick (310g/sqm)	150	m2	5	$ 750	-
3.3	Reinforced Turf - supply, deliver, lay turf, roll and water	-	m2	140	$ -	0
	SUBTOTAL				**$ 1,538**	
4	**High Flow Outlet Box Culvert**					
	Box Culvert - Supply and deliver 4.2m (span) x 0.9m (height) box culvert	120	m	4500	$ 540,000	
	Headwall - Supply, deliver, lay and join precast unit; including toe excavation to suit 4.2m (span) x 0.9m (height) box culvert: 1 cell	4	each	5700	$ 22,800	
	Concrete - reinforced, cast in-situ 25MPa to form cut-off wall	2	m3	300	$ 600	
	Excavate 2000mm wide trench by machine, backfill with same material and compact, up to 3.0m deep	120	m	380	$ 45,600	
	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	60	m2	140	$ 8,400	
	SUBTOTAL				**$ 617,400**	
5	**Low Flow Outlet Pipe**					
4.1	Pit - Supply, deliver, lay and join 900mm square pit with grated inlet	3	item	3700	$ 11,100	-
4.2	Pipe - Supply, deliver, lay and join 600mm RCP (Class 2)	30	m	270	$ 8,100	Rubber ring joint; excavation excluded
	Pipe - Supply, deliver, lay and join 525mm RCP (Class 2)	60	m	230	$ 13,800	
4.3	Headwall - Supply, deliver, lay and join precast unit; including toe excavation - to suit 600mm pipe	3	each	590	$ 1,770	-
4.4	Concrete - reinforced, cast in-situ 25MPa to form cut-off wall	4	m3	300	$ 1,200	Approximate only
4.5	Excavate 2000mm wide trench by machine, backfill with same material and compact, up to 3.0m deep	90	m	380	$ 34,200	Assuming clay soil
4.6	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	18	m2	140	$ 2,520	0
	SUBTOTAL				**$ 72,690**	
6	**Inlet from Road Drainage**					
5.1	Pipe - Supply, deliver, lay and join 375mm RCP (Class 2)	90	m	130	$ 11,700	Rubber ring joint; excavation excluded
5.2	Excavate 1200mm wide trench by machine, backfill with same material and compact, up to 2.0m deep	90	m	140	$ 12,600	Assuming clay soil
5.3	GPT - Supply, deliver and install CDS 2018	1	each	87000	$ 87,000	Subject to final design
5.4	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	12	m2	140	$ 1,680	0
	SUBTOTAL				**$ 112,980**	
7	**Landscaping and Planting**					
6.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	2,461	m3	6	$ 14,766	
6.2	Lawn turf - spread and grade 50mm topsoil, lay turf, roll and water	12,255	m2	10	$ 122,545	-
6.3	Landscaping - supply, deliver and plant approved plants	352	m2	39	$ 13,728	-
	SUBTOTAL				**$ 151,039**	
8	**Bioretention Area**					
7.1	Construct bioretention system, complete with geofabric liner, drainage pipe, drainage layer, filter media, top-soil and vegetation		m2		$ -	NOT COSTED
7.2	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia		m2		$ -	NOT COSTED
7.3	Allowance: Placement and removal of sacrificial layer for staged development. 150mm thick layer, woven textile and temporary turf.					NOT COSTED
	SUBTOTAL				**$ -**	
	SUBTOTAL ITEMS 1-7				**$ 1,356,295**	
9	**Supervision, Project Management & Contractor On-Costs**					
8.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 406,888.62	-
	SUBTOTAL				**$ 406,889**	
10	**Contingencies**					
9.1	Contingencies - General	30	%	-	$ 406,889	-
	SUBTOTAL				**$ 406,889**	
	TOTAL				**$ 2,170,000**	

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Menangle Park
Detention Basin 7
SCHEDULE OF ESTIMATED QUANTITIES

Revision: 03

SCHEDULE OF ESTIMATED QUANTITIES						
PAY ITEM	**DESCRIPTION OF WORK**	**QTY**	**UNIT**	**RATE**	**AMOUNT**	**NOTES**
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				$ 20,000	
2	**Earthworks**					
2.1	Clearing and grubbing	1.7	ha	2900	$ 4,974	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	50.0	m2	50	$ 2,500	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	-	m2	63	$ -	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	-	m2	13	$ -	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	2,573	m3	5	$ 12,607	Assuming light soil (not clay)
2.6	Excavate to reduce levels and deposit surplus cut in spoil heaps within 10km, in Light Soil	6,307	m3	9	$ 56,763	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	7,762	m3	12	$ 93,144	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	267	m3	10	$ 2,670	
2.9	Access Road: place and compact imported fill	267	m3	12	$ 3,204	
2.10	Allowance: Over excavation to restore soil profile				$ 10,000	
2.11	Allowance: Treatment of dispersive soils with gypsum (or similar)				$ 50,000	
2.12	Allowance: Separate and place select clay in embankment core				$ 20,000	
	SUBTOTAL				$ 255,862	
3	**High Flow Spillway**					
3.1	Form spillway crest in embankment	38	m3	21	$ 788	-
3.2	Geotextile Fabric - non woven polypropylene/ polyethylene 2.8mm thick (310g/sqm)	150	m2	5	$ 750	-
3.3	Reinforced Turf - supply, deliver, lay turf, roll and water	497	m2	140	$ 69,637	0
	SUBTOTAL				$ 71,174	
4	**High Flow Outlet Box Culvert**					
	Box Culvert - Supply and deliver 4.2m (span) x 0.9m (height) box culvert	30	m	4500	$ 135,000	
	Headwall - Supply, deliver, lay and join precast unit; including toe excavation to suit 4.2m (span) x 0.9m (height) box culvert: 1 cell	1	each	5700	$ 5,700	
	Concrete - reinforced, cast in-situ 25MPa to form cut-off wall	2	m3	300	$ 600	
	Excavate 2000mm wide trench by machine, backfill with same material and compact, up to 3.0m deep	30	m	380	$ 11,400	
	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	60	m2	140	$ 8,400	
	SUBTOTAL				$ 161,100	
5	**Low Flow Outlet Pipe**					
4.1	Pit - Supply, deliver, lay and join 900mm square pit with grated inlet	1	item	3700	$ 3,700	-
4.2	Pipe - Supply, deliver, lay and join 600mm RCP (Class 2)	30	m	270	$ 8,100	Rubber ring joint; excavation excluded
	Pipe - Supply, deliver, lay and join 525mm RCP (Class 2)	-	m	230	$ -	
4.3	Headwall - Supply, deliver, lay and join precast unit; including toe excavation - to suit 600mm pipe	1	each	590	$ 590	-
4.4	Concrete - reinforced, cast in-situ 25MPa to form cut-off wall	1	m3	300	$ 300	Approximate only
4.5	Excavate 2000mm wide trench by machine, backfill with same material and compact, up to 3.0m deep	30	m	380	$ 11,400	Assuming clay soil
4.6	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	6	m2	140	$ 840	0
	SUBTOTAL				$ 24,930	
6	**Inlet from Road Drainage**					
5.1	Pipe - Supply, deliver, lay and join 375mm RCP (Class 2)	90	m	130	$ 11,700	Rubber ring joint; excavation excluded
5.2	Excavate 1200mm wide trench by machine, backfill with same material and compact, up to 2.0m deep	90	m	140	$ 12,600	Assuming clay soil
5.3	GPT - Supply, deliver and install CDS 2018	1	each	87000	$ 87,000	Subject to final design
5.4	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia	12	m2	140	$ 1,680	0
	SUBTOTAL				$ 112,980	
7	**Landscaping and Planting**					
6.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	2,573	m3	6	$ 15,437	
6.2	Lawn turf - spread and grade 50mm topsoil, lay turf, roll and water	8,513	m2	10	$ 85,133	-
6.3	Landscaping - supply, deliver and plant approved plants	5,075	m2	39	$ 197,909	-
	SUBTOTAL				$ 298,479	
8	**Bioretention Area**					
7.1	Construct bioretention system, complete with geofabric liner, drainage pipe, drainage layer, filter media, top-soil and vegetation		m2		$ -	NOT COSTED
7.2	Rip Rap - supply, deliver and place rip rap scour protection, 250mm dia		m2		$ -	NOT COSTED
7.3	Allowance: Placement and removal of sacrificial layer for staged development. 150mm thick layer, woven textile and temporary turf.					NOT COSTED
	SUBTOTAL				$ -	
	SUBTOTAL ITEMS 1-7				$ 944,525	
9	**Supervision, Project Management & Contractor On-Costs**					
8.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 283,357.61	-
	SUBTOTAL				$ 283,358	
10	**Contingencies**					
9.1	Contingencies - General	30	%	-	$ 283,358	-
	SUBTOTAL				$ 283,358	
	TOTAL				**$ 1,511,000**	

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APPENDIX B2, PRELIM COST ESTIMATE - LOW FLOW CHANNELS SUMMARY

ITEM	DESCRIPTION		AMOUNT
1	**Channel S1 With Basins**		
1.1	Preliminaries	$	20,000
1.2	Earthworks	$	220,172
1.3	Inlet from Road Drainage	$	32,000
1.4	Landscaping and Planting	$	590,799
1.5	Supervision, Project Management & Contractor On-Costs	$	258,891
1.6	Contingencies	$	258,891
		$	**1,381,000**
2	**Channel S1 Without Basins**		
2.1	Preliminaries	$	20,000
2.2	Earthworks	$	227,757
2.3	Inlet from Road Drainage	$	32,000
2.4	Landscaping and Planting	$	644,265
2.5	Supervision, Project Management & Contractor On-Costs	$	277,207
2.6	Contingencies	$	277,207
		$	**1,478,000**
3	**Channel HR1 With Basins**		
3.1	Preliminaries	$	20,000
3.2	Earthworks	$	87,951
3.3	Inlet from Road Drainage	$	32,000
3.4	Landscaping and Planting	$	123,890
3.5	Supervision, Project Management & Contractor On-Costs	$	79,152
3.6	Contingencies	$	79,152
		$	**422,000**
5	**Channel HR2 With Basins**		
5.1	Preliminaries	$	20,000
5.2	Earthworks	$	118,701
5.3	Inlet from Road Drainage	$	32,000
5.4	Landscaping and Planting	$	269,596
5.5	Supervision, Project Management & Contractor On-Costs	$	132,089
5.6	Contingencies	$	132,089
		$	**704,000**
6	**Channel HR3 With Basins**		
6.1	Preliminaries	$	20,000
6.2	Earthworks	$	88,050
6.3	Inlet from Road Drainage	$	32,000
6.4	Landscaping and Planting	$	125,637
6.5	Supervision, Project Management & Contractor On-Costs	$	79,706
6.6	Contingencies	$	79,706
		$	**425,000**
7	**Howes Creek Upstream, With/Without Basins**		
7.1	Preliminaries	$	20,000
7.2	Earthworks	$	134,333
7.3	Inlet from Road Drainage	$	32,000
7.4	Landscaping and Planting	$	426,374
7.5	Supervision, Project Management & Contractor On-Costs	$	183,812
7.6	Contingencies	$	183,812
		$	**980,000**
8	**Howes Creek Downstream, With Basins**		
8.1	Preliminaries	$	20,000
8.2	Earthworks	$	297,586
8.3	Inlet from Road Drainage	$	128,000
8.4	Landscaping and Planting	$	885,505
8.5	Supervision, Project Management & Contractor On-Costs	$	399,327
8.6	Contingencies	$	399,327
		$	**2,130,000**
9	**Howes Creek Downstream, Without Basins**		
9.1	Preliminaries	$	20,000
9.2	Earthworks	$	296,107
9.3	Inlet from Road Drainage	$	128,000
9.4	Landscaping and Planting	$	878,502
9.5	Supervision, Project Management & Contractor On-Costs	$	396,783
9.6	Contingencies	$	396,783
		$	**2,116,000**
	TOTAL LOW FLOW, WITH BASIN OPTION (Exl-GST)	**$**	**6,042,000**
	TOTAL LOW FLOW, WITHOUT BASIN OPTION (Exl-GST)	**$**	**6,125,000**

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Menangle Park
Low Flow Channel Channel S1 With Basins
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES						
PAY ITEM	**DESCRIPTION OF WORK**	**QTY**	**UNIT**	**RATE**	**AMOUNT**	**NOTES**
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
2	**Earthworks**					
2.1	Clearing and grubbing	1.5	ha	2900	$ 4,294	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	-	m2	50	$ -	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	740	m2	63	$ 46,642	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	740	m2	13	$ 9,625	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	2,221	m3	5	$ 10,883	Assuming light soil (not clay)
2.6	Excavate to reduce levels and deposit surplus cut in spoil heaps within 10km, in Light Soil	-	m3	9	$ -	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	6,097	m3	12	$ 73,164	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	402	m3	10	$ 4,020	-
2.9	Access Road: place and compact imported fill	402	m3	12	$ 4,824	-
2.10	Rip Rap - supply, deliver and place rip rap scour protection at channel inlet, 250mm dia	48	m2	140	$ 6,720	0
2.11	Allowance: Over excavation to restore soil profile				$ 10,000	
2.12	Allowance: Treatment of dispersive soils with gypsum (or similar)				$ 50,000	
	SUBTOTAL				**$ 220,172**	
3	**Inlet From Road Drainage**					
3.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
4	**Landscaping and Planting**					
4.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	2,221	m3	6	$ 13,326	
4.2	Landscaping - supply, deliver and plant approved plants	14,807	m2	39	$ 577,473	-
	SUBTOTAL				**$ 590,799**	
	SUBTOTAL ITEMS 1-7				**$ 862,971**	
5	**Supervision, Project Management & Contractor On-Costs**					
5.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 258,891	-
	SUBTOTAL				**$ 258,891**	
6	**Contingencies**					
6.1	Contingencies - General	30	%	-	$ 258,891	-
	SUBTOTAL				**$ 258,891**	
	TOTAL				**$ 1,381,000**	

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Menangle Park
Low Flow Channel S1 Without Basin
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
2	**Earthworks**					
2.1	Clearing and grubbing	1.6	ha	2900	$ 4,683	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	-	m2	50	$ -	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	807	m2	63	$ 50,863	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	807	m2	13	$ 10,496	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	2,422	m3	5	$ 11,868	Assuming light soil (not clay)
2.6	Excavate to reduce levels and deposit surplus cut in spoil heaps within 10km, in Light Soil	-	m3	9	$ -	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	6,097	m3	12	$ 73,164	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	402	m3	10	$ 4,020	-
2.9	Access Road: place and compact imported fill	402	m3	12	$ 4,824	-
2.10	Rip Rap - supply, deliver and place rip rap scour protection at channel inlet, 250mm dia	56	m2	140	$ 7,840	
2.11	Allowance: Over excavation to restore soil profile				$ 10,000	
2.12	Allowance: Treatment of dispersive soils with gypsum (or similar)				$ 50,000	
	SUBTOTAL				**$ 227,757**	
3	**Inlet From Road Drainage**					
3.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
4	**Landscaping and Planting**					
4.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	2,422	m3	6	$ 14,532	
4.2	Landscaping - supply, deliver and plant approved plants	16,147	m2	39	$ 629,733	-
	SUBTOTAL				**$ 644,265**	
	SUBTOTAL ITEMS 1-7				**$ 924,023**	
5	**Supervision, Project Management & Contractor On-Costs**					
5.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 277,207	-
	SUBTOTAL				**$ 277,207**	
6	**Contingencies**					
6.1	Contingencies - General	30	%	-	$ 277,207	-
	SUBTOTAL				**$ 277,207**	
	TOTAL				**$ 1,478,000**	

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Menangle Park
Low Flow Channel Channel HR1 With Basin
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
2	**Earthworks**					
2.1	Clearing and grubbing	0.3	ha	2900	$ 900	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	-	m2	50	$ -	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	155	m2	63	$ 9,781	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	155	m2	13	$ 2,018	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	466	m3	5	$ 2,282	Assuming light soil (not clay)
2.6	Excavate to reduce levels and deposit surplus cut in spoil heaps within 10km, in Light Soil	-	m3	9	$ -	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	275	m3	12	$ 3,302	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	414	m3	10	$ 4,140	-
2.9	Access Road: place and compact imported fill	414	m3	12	$ 4,968	-
2.10	Rip Rap - supply, deliver and place rip rap scour protection at channel inlet, 250mm dia	4	m2	140	$ 560	0
2.11	Allowance: Over excavation to restore soil profile				$ 10,000	
2.12	Allowance: Treatment of dispersive soils with gypsum (or similar)				$ 50,000	
	SUBTOTAL				**$ 87,951**	
3	**Inlet From Road Drainage**					
3.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
4	**Landscaping and Planting**					
4.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	466	m3	6	$ 2,795	
4.2	Landscaping - supply, deliver and plant approved plants	3,105	m2	39	$ 121,095	-
	SUBTOTAL				**$ 123,890**	
	SUBTOTAL ITEMS 1-7				**$ 263,841**	
5	**Supervision, Project Management & Contractor On-Costs**					
5.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 79,152	-
	SUBTOTAL				**$ 79,152**	
6	**Contingencies**					
6.1	Contingencies - General	30	%	-	$ 79,152	-
	SUBTOTAL				**$ 79,152**	
	TOTAL				**$ 422,000**	

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Menangle Park
Low Flow Channel HR2 With Basin
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE		AMOUNT	NOTES
1	**Preliminaries**						
1.1	Establishment	1	item	10000	$	10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$	10,000	Allowance only
	SUBTOTAL				**$**	**20,000**	
2	**Earthworks**						
2.1	Clearing and grubbing	0.7	ha	2900	$	1,959	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	-	m2	50	$	-	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	338	m2	63	$	21,284	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	338	m2	13	$	4,392	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	1,014	m3	5	$	4,966	Assuming light soil (not clay)
2.6	Excavate to reduce levels and deposit surplus cut in spoil heaps within 10km, in Light Soil	-	m3	9	$	-	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	1,290	m3	12	$	15,480	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	394	m3	10	$	3,936	-
2.9	Access Road: place and compact imported fill	394	m3	12	$	4,723	-
2.10	Rip Rap - supply, deliver and place rip rap scour protection at channel inlet, 250mm dia	14	m2	140	$	1,960	0
2.11	Allowance: Over excavation to restore soil profile				$	10,000	
2.12	Allowance: Treatment of dispersive soils with gypsum (or similar)				$	50,000	
	SUBTOTAL				**$**	**118,701**	
3	**Inlet From Road Drainage**						
3.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$	32,000	
	SUBTOTAL				**$**	**32,000**	
4	**Landscaping and Planting**						
4.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	1,014	m3	6	$	6,081	
4.2	Landscaping - supply, deliver and plant approved plants	6,757	m2	39	$	263,515	-
	SUBTOTAL				**$**	**269,596**	
	SUBTOTAL ITEMS 1-7				**$**	**440,297**	
5	**Supervision, Project Management & Contractor On-Costs**						
5.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$	132,089	-
	SUBTOTAL				**$**	**132,089**	
6	**Contingencies**						
6.1	Contingencies - General	30	%	-	$	132,089	-
	SUBTOTAL				**$**	**132,089**	
	TOTAL				**$**	**704,000**	

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Menangle Park
Low Flow Channel HR3 With Basins
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES							
PAY ITEM	**DESCRIPTION OF WORK**	**QTY**	**UNIT**	**RATE**		**AMOUNT**	**NOTES**
1	**Preliminaries**						
1.1	Establishment	1	item	10000	$	10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$	10,000	Allowance only
	SUBTOTAL				**$**	**20,000**	
2	**Earthworks**						
2.1	Clearing and grubbing	0.3	ha	2900	$	913	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	-	m2	50	$	-	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	157	m2	63	$	9,919	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	157	m2	13	$	2,047	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	472	m3	5	$	2,314	Assuming light soil (not clay)
2.6	Excavate to reduce levels and deposit surplus cut in spoil heaps within 10km, in Light Soil	-	m3	9	$	-	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	256	m3	12	$	3,078	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	394	m3	10	$	3,936	-
2.9	Access Road: place and compact imported fill	394	m3	12	$	4,723	-
2.10	Rip Rap - supply, deliver and place rip rap scour protection at channel inlet, 250mm dia	8	m2	140	$	1,120	0
2.11	Allowance: Over excavation to restore soil profile				$	10,000	
2.12	Allowance: Treatment of dispersive soils with gypsum (or similar)				$	50,000	
	SUBTOTAL				**$**	**88,050**	
3	**Inlet From Road Drainage**						
3.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$	32,000	
	SUBTOTAL				**$**	**32,000**	
4	**Landscaping and Planting**						
4.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	472	m3	6	$	2,834	
4.2	Landscaping - supply, deliver and plant approved plants	3,149	m2	39	$	122,803	-
	SUBTOTAL				**$**	**125,637**	
	SUBTOTAL ITEMS 1-7				**$**	**265,687**	
5	**Supervision, Project Management & Contractor On-Costs**						
5.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$	79,706	-
	SUBTOTAL				**$**	**79,706**	
6	**Contingencies**						
6.1	Contingencies - General	30	%	-	$	79,706	-
	SUBTOTAL				**$**	**79,706**	
	TOTAL				**$**	**425,000**	

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Menangle Park
Low Flow Channel Howes Creek Upstream
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES						
PAY ITEM	**DESCRIPTION OF WORK**	**QTY**	**UNIT**	**RATE**	**AMOUNT**	**NOTES**
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
2	**Earthworks**					
2.1	Clearing and grubbing	0.8	ha	2900	$ 2,259	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	-	m2	50	$ -	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	390	m2	63	$ 24,540	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	390	m2	13	$ 5,064	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	1,169	m3	5	$ 5,726	Assuming light soil (not clay)
2.6	Excavate to reduce levels and deposit surplus cut in spoil heaps within 10km, in Light Soil	-	m3	9	$ -	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	2,028	m3	12	$ 24,342	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	431	m3	10	$ 4,314	-
2.9	Access Road: place and compact imported fill	431	m3	12	$ 5,177	-
2.10	Rip Rap - supply, deliver and place rip rap scour protection at channel inlet, 250mm dia	21	m2	140	$ 2,912	0
2.11	Allowance: Over excavation to restore soil profile				$ 10,000	
2.12	Allowance: Treatment of dispersive soils with gypsum (or similar)				$ 50,000	
	SUBTOTAL				**$ 134,333**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	1,169	m3	6	$ 7,011	
5.2	Landscaping - supply, deliver and plant approved plants	10,753	m2	39	$ 419,363	-
	SUBTOTAL				**$ 426,374**	
	SUBTOTAL ITEMS 1-7				**$ 612,708**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 183,812	-
	SUBTOTAL				**$ 183,812**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 183,812	-
	SUBTOTAL				**$ 183,812**	
	TOTAL				**$ 980,000**	

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SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
2	**Earthworks**					
2.1	Clearing and grubbing	2.2	ha	2900	$ 6,436	Assuming medium density bushland
2.2	Demolition - break up and remove existing works on site	-	m2	50	$ -	Disposal extra
2.3	Dewatering - system to reduce water level by 1.0m	1,110	m2	63	$ 69,908	Approximate only
2.4	Desilting - strip soil to 0.5m deep and dispose of excavated material to tip within 10km	1,110	m2	13	$ 14,426	Approximate only
2.5	Topsoil - excavate to average 150mm deep and deposit in spoil heaps within 500m for later use: light soil	3,329	m3	5	$ 16,312	Assuming light soil (not clay)
2.6	Excavate to reduce levels and deposit surplus cut in spoil heaps within 10km, in Light Soil	-	m3	9	$ -	-
2.7	Excavate to reduce levels and deposit, spread, level and compact to 90% within 1km, in Light Soil	9,061	m3	12	$ 108,731	-
2.8	Access Road: excavate to reduce levels and deposit in spoil heaps within 10km, in Light Soil	481	m3	10	$ 4,806	-
2.9	Access Road: place and compact imported fill	481	m3	12	$ 5,767	-
2.10	Rip Rap - supply, deliver and place rip rap scour protection at channel inlet, 250mm dia	80	m2	140	$ 11,200	0
2.11	Allowance: Over excavation to restore soil profile				$ 10,000	
2.12	Allowance: Treatment of dispersive soils with gypsum (or similar)				$ 50,000	
	SUBTOTAL				**$ 297,586**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	4	item	32000	$ 128,000	
	SUBTOTAL				**$ 128,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	3,329	m3	6	$ 19,974	
5.2	Landscaping - supply, deliver and plant approved plants	22,193	m2	39	$ 865,531	-
	SUBTOTAL				**$ 885,505**	
	SUBTOTAL ITEMS 1-7				**$ 1,331,091**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 399,327	-
	SUBTOTAL				**$ 399,327**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 399,327	-
	SUBTOTAL				**$ 399,327**	
	TOTAL				**$ 2,130,000**	

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APPENDIX B3, PRELIM COST ESTIMATE - STABILISATION 1 SUMMARY

ITEM	DESCRIPTION	AMOUNT	
1	**Channel S1**		
1.1	Preliminaries	$	20,000
1.2	Stabilisation	$	126,630
1.3	Inlet from Road Drainage	$	32,000
1.4	Landscaping and Planting	$	489,214
1.5	Supervision, Project Management & Contractor On-Costs	$	200,353
1.6	Contingencies	$	200,353
		$	**1,069,000**
2	**Channel S2**		
2.1	Preliminaries	$	20,000
2.2	Earthworks	$	36,720
2.3	Inlet from Road Drainage	$	32,000
2.4	Landscaping and Planting	$	138,373
2.5	Supervision, Project Management & Contractor On-Costs	$	68,128
2.6	Contingencies	$	68,128
		$	**363,000**
3	**Channel HR1**		
3.1	Preliminaries	$	20,000
3.2	Earthworks	$	41,400
3.3	Inlet from Road Drainage	$	32,000
3.4	Landscaping and Planting	$	148,667
3.5	Supervision, Project Management & Contractor On-Costs	$	72,620
3.6	Contingencies	$	72,620
		$	**387,000**
4	**Channel HR2**		
4.1	Preliminaries	$	20,000
4.2	Earthworks	$	40,147
4.3	Inlet from Road Drainage	$	32,000
4.4	Landscaping and Planting	$	144,483
4.5	Supervision, Project Management & Contractor On-Costs	$	70,989
4.6	Contingencies	$	70,989
		$	**379,000**
5	**Howes Creek Upstream**		
5.1	Preliminaries	$	20,000
5.2	Earthworks	$	110,538
5.3	Inlet from Road Drainage	$	64,000
5.4	Landscaping and Planting	$	414,377
5.5	Supervision, Project Management & Contractor On-Costs	$	182,675
5.6	Contingencies	$	182,675
		$	**974,000**
6	**Howes Creek Downstream**		
6.1	Preliminaries	$	20,000
6.2	Earthworks	$	173,016
6.3	Inlet from Road Drainage	$	128,000
6.4	Landscaping and Planting	$	671,158
6.5	Supervision, Project Management & Contractor On-Costs	$	297,652
6.6	Contingencies	$	297,652
		$	**1,587,000**
	TOTAL, WITHOUT BASIN OPTION (Exl-GST)	**$**	**4,759,000**

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Menangle Park
Stabilisation Channel S1
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES							
PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE		AMOUNT	NOTES
1	**Preliminaries**						
1.1	Establishment	1	item	10000	$	10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$	10,000	Allowance only
	SUBTOTAL				**$**	**20,000**	
3	**Stabilisation - Nominal**						
3.1	General purpose mat, high density polethylene, laid on embankment, mesh size 40 x 60mm	12,261	m2	10	$	122,610	
3.2	Anchor trench 300m wide x 250mm deep, including excavation, backfilling and pinning edge of matting	804	m	5	$	4,020	
	S2				**$**	**126,630**	
4	**Inlet From Road Drainage**						
4.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$	32,000	
	SUBTOTAL				**$**	**32,000**	
5	**Landscaping and Planting**						
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	1,839	m3	6	$	11,035	
5.2	Landscaping - supply, deliver and plant approved plants	12,261	m2	39	$	478,179	-
	SUBTOTAL				**$**	**489,214**	
	SUBTOTAL ITEMS 1-7				**$**	**667,844**	
6	**Supervision, Project Management & Contractor On-Costs**						
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$	200,353	-
	SUBTOTAL				**$**	**200,353**	
7	**Contingencies**						
7.1	Contingencies - General	30	%	-	$	200,353	-
	SUBTOTAL				**$**	**200,353**	
	TOTAL				**$**	**1,069,000**	

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Menangle Park
Stabilisation Channel S2
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
3	**Stabilisation - Nominal Allowance for works to existing Channel S2**					
3.1	General purpose mat, high density polethylene, laid on embankment, mesh size 40 x 60mm	3,468	m2	10	$ 34,680	
3.2	Anchor trench 300m wide x 250mm deep, including excavation, backfilling and pinning edge of matting	408	m	5	$ 2,040	
	SUBTOTAL				**$ 36,720**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	520	m3	6	$ 3,121	
5.2	Landscaping - supply, deliver and plant approved plants	3,468	m2	39	$ 135,252	-
	SUBTOTAL				**$ 138,373**	
	SUBTOTAL ITEMS 1-7				**$ 227,093**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 68,128	-
	SUBTOTAL				**$ 68,128**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 68,128	-
	SUBTOTAL				**$ 68,128**	
	TOTAL				**$ 363,000**	

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Menangle Park
Stabilisation Channel HR1
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES						
PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
3	**Stabilisation - Nominal Allowance for works to existing Channel S2**					
3.1	General purpose mat, high density polethylene, laid on embankment, mesh size 40 x 60mm	3,726	m2	10	$ 37,260	
3.2	Anchor trench 300m wide x 250mm deep, including excavation, backfilling and pinning edge of matting	828	m	5	$ 4,140	
	SUBTOTAL				**$ 41,400**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	559	m3	6	$ 3,353	
5.2	Landscaping - supply, deliver and plant approved plants	3,726	m2	39	$ 145,314	-
	SUBTOTAL				**$ 148,667**	
	SUBTOTAL ITEMS 1-7				**$ 242,067**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 72,620	-
	SUBTOTAL				**$ 72,620**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 72,620	-
	SUBTOTAL				**$ 72,620**	
	TOTAL				**$ 387,000**	

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Menangle Park
Stabilisation Channel HR2
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES						
PAY ITEM	**DESCRIPTION OF WORK**	**QTY**	**UNIT**	**RATE**	**AMOUNT**	**NOTES**
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
3	**Stabilisation - Nominal Allowance for works to existing Channel S2**					
3.1	General purpose mat, high density polethylene, laid on embankment, mesh size 40 x 60mm	3,621	m2	10	$ 36,211	
3.2	Anchor trench 300m wide x 250mm deep, including excavation, backfilling and pinning edge of matting	787	m	5	$ 3,936	
	SUBTOTAL				**$ 40,147**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	543	m3	6	$ 3,259	
5.2	Landscaping - supply, deliver and plant approved plants	3,621	m2	39	$ 141,224	-
	SUBTOTAL				**$ 144,483**	
	SUBTOTAL ITEMS 1-7				**$ 236,630**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 70,989	-
	SUBTOTAL				**$ 70,989**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 70,989	-
	SUBTOTAL				**$ 70,989**	
	TOTAL				**$ 379,000**	

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Menangle Park
Stabilisation Channel M1, Upstream
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES						
PAY ITEM	**DESCRIPTION OF WORK**	**QTY**	**UNIT**	**RATE**	**AMOUNT**	**NOTES**
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
3	**Stabilisation - Nominal Allowance for works to existing Channel S2**					
3.1	General purpose mat, high density polethylene, laid on embankment, mesh size 40 x 60mm	10,385	m2	10	$ 103,854	
3.2	Anchor trench 300m wide x 250mm deep, including excavation, backfilling and pinning edge of matting	1,337	m	5	$ 6,684	
	SUBTOTAL				**$ 110,538**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	2	item	32000	$ 64,000	
	SUBTOTAL				**$ 64,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	1,558	m3	6	$ 9,347	
5.2	Landscaping - supply, deliver and plant approved plants	10,385	m2	39	$ 405,031	-
	SUBTOTAL				**$ 414,377**	
	SUBTOTAL ITEMS 1-7				**$ 608,915**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 182,675	-
	SUBTOTAL				**$ 182,675**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 182,675	-
	SUBTOTAL				**$ 182,675**	
	TOTAL				**$ 974,000**	

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Menangle Park
Stabilisation Channel M1, Downstream
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES						
PAY ITEM	**DESCRIPTION OF WORK**	**QTY**	**UNIT**	**RATE**	**AMOUNT**	**NOTES**
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
3	**Stabilisation - Nominal Allowance for works to existing Channel S2**					
3.1	General purpose mat, high density polethylene, laid on embankment, mesh size 40 x 60mm	16,821	m2	10	$ 168,210	
3.2	Anchor trench 300m wide x 250mm deep, including excavation, backfilling and pinning edge of matting	961	m	5	$ 4,806	
	SUBTOTAL				**$ 173,016**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	4	item	32000	$ 128,000	
	SUBTOTAL				**$ 128,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	2,523	m3	6	$ 15,139	
5.2	Landscaping - supply, deliver and plant approved plants	16,821	m2	39	$ 656,019	-
	SUBTOTAL				**$ 671,158**	
	SUBTOTAL ITEMS 1-7				**$ 992,174**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 297,652	-
	SUBTOTAL				**$ 297,652**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 297,652	-
	SUBTOTAL				**$ 297,652**	
	TOTAL				**$ 1,587,000**	

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APPENDIX B4, PRELIM COST ESTIMATE - STABILISATION 2 SUMMARY

ITEM	DESCRIPTION	AMOUNT
1	**Channel S1**	
1.1	Preliminaries	$ 20,000
1.2	Stabilisation - Drop Structure	$ 81,000
1.3	Inlet from Road Drainage	$ 32,000
1.4	Landscaping and Planting	$ 489,214
1.5	Supervision, Project Management & Contractor On-Costs	$ 186,664
1.6	Contingencies	$ 186,664
		$ 996,000
2	**Channel S2**	
2.1	Preliminaries	$ 20,000
2.2	Stabilisation - Drop Structure	$ 27,000
2.3	Inlet from Road Drainage	$ 32,000
2.4	Landscaping and Planting	$ 138,373
2.5	Supervision, Project Management & Contractor On-Costs	$ 65,212
2.6	Contingencies	$ 65,212
		$ 348,000
3	**Channel HR1**	
3.1	Preliminaries	$ 20,000
3.2	Stabilisation - Drop Structure	$ 54,000
3.3	Inlet from Road Drainage	$ 32,000
3.4	Landscaping and Planting	$ 148,667
3.5	Supervision, Project Management & Contractor On-Costs	$ 76,400
3.6	Contingencies	$ 76,400
		$ 407,000
4	**Channel HR2**	
4.1	Preliminaries	$ 20,000
4.2	Stabilisation - Drop Structure	$ 54,000
4.3	Inlet from Road Drainage	$ 32,000
4.4	Landscaping and Planting	$ 144,483
4.5	Supervision, Project Management & Contractor On-Costs	$ 75,145
4.6	Contingencies	$ 75,145
		$ 401,000
5	**Howes Creek Upstream**	
5.1	Preliminaries	$ 20,000
5.2	Stabilisation - Drop Structure	$ 54,000
5.3	Inlet from Road Drainage	$ 64,000
5.4	Landscaping and Planting	$ 141,845
5.5	Supervision, Project Management & Contractor On-Costs	$ 83,953
5.6	Contingencies	$ 83,953
		$ 448,000
6	**Howes Creek Downstream**	
6.1	Preliminaries	$ 20,000
6.2	Stabilisation - Drop Structure	$ 81,000
6.3	Inlet from Road Drainage	$ 128,000
6.4	Landscaping and Planting	$ 671,158
6.5	Supervision, Project Management & Contractor On-Costs	$ 270,047
6.6	Contingencies	$ 270,047
		$ 1,440,000
	TOTAL, (Exl-GST)	**$ 4,040,000**

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Menangle Park
Stabilisation Channel S1
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES						
PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
2	**Stabilisation - Drop Structure***					
	Concrete Drop Structure - Construction Estimate	3	each	27000	$ 81,000	
	SUBTOTAL				**$ 81,000**	
3	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
4	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	1,839	m3	6	$ 11,035	
5	Landscaping - supply, deliver and plant approved plants	12,261	m2	39	$ 478,179	-
	SUBTOTAL				**$ 489,214**	
	SUBTOTAL ITEMS 1-7				**$ 622,214**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 186,664	-
	SUBTOTAL				**$ 186,664**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 186,664	-
	SUBTOTAL				**$ 186,664**	
	TOTAL				**$ 996,000**	

	***Alternative Stabilisation - Rock Chute**					
	Rock Chute - Construction Estimate	5	item	7100	$ 35,500	
	Alternate TOTAL 1				**$ 922,742**	
	***Alternative Stabilisation - Pool-Riffle**					
	Pool - Riffle Construction Estimate	9	item	3700	$ 33,300	
	Alternate TOTAL 2				**$ 919,222**	

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Menangle Park
Stabilisation Channel S2
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES						
PAY ITEM	**DESCRIPTION OF WORK**	**QTY**	**UNIT**	**RATE**	**AMOUNT**	**NOTES**
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
3	**Stabilisation - Drop Structure***					
3.1	Concrete Drop Structure - Construction Estimate	1	each	27000	$ 27,000	
	SUBTOTAL				**$ 27,000**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	520	m3	6	$ 3,121	
5.2	Landscaping - supply, deliver and plant approved plants	3,468	m2	39	$ 135,252	-
	SUBTOTAL				**$ 138,373**	
	SUBTOTAL ITEMS 1-7				**$ 217,373**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 65,212	-
	SUBTOTAL				**$ 65,212**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 65,212	-
	SUBTOTAL				**$ 65,212**	
	TOTAL				**$ 348,000**	

	***Alternative Stabilisation - Rock Chute**					
	Rock Chute - Construction Estimate	2	item	7100	$ 14,200	
	Alternate TOTAL 1				**$ 327,317**	
	***Alternative Stabilisation - Pool-Riffle**					
	Pool - Riffle Construction Estimate	3	item	3700	$ 11,100	
	Alternate TOTAL 2				**$ 322,357**	

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Menangle Park
Stabilisation Channel HR1
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES						
PAY ITEM	**DESCRIPTION OF WORK**	**QTY**	**UNIT**	**RATE**	**AMOUNT**	**NOTES**
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
3	**Stabilisation - Drop Structure***					
3.1	Concrete Drop Structure - Construction Estimate	2	each	27000	$ 54,000	
	SUBTOTAL				**$ 54,000**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	559	m3	6	$ 3,353	
5.2	Landscaping - supply, deliver and plant approved plants	3,726	m2	39	$ 145,314	-
	SUBTOTAL				**$ 148,667**	
	SUBTOTAL ITEMS 1-7				**$ 254,667**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 76,400	-
	SUBTOTAL				**$ 76,400**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 76,400	-
	SUBTOTAL				**$ 76,400**	
	TOTAL				**$ 407,000**	

	***Alternative Stabilisation - Rock Chute**					
	Rock Chute - Construction Estimate	4	item	7100	$ 28,400	
	Alternate TOTAL 1				**$ 350,508**	
	***Alternative Stabilisation - Pool-Riffle**					
	Pool - Riffle Construction Estimate	8	item	3700	$ 29,600	
	Alternate TOTAL 2				**$ 352,428**	

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Menangle Park
Stabilisation Channel HR2
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
3	**Stabilisation - Drop Structure***					
3.1	Concrete Drop Structure - Construction Estimate	2	each	27000	$ 54,000	
	SUBTOTAL				**$ 54,000**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	1	item	32000	$ 32,000	
	SUBTOTAL				**$ 32,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	543	m3	6	$ 3,259	
5.2	Landscaping - supply, deliver and plant approved plants	3,621	m2	39	$ 141,224	-
	SUBTOTAL				**$ 144,483**	
	SUBTOTAL ITEMS 1-7				**$ 250,483**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 75,145	-
	SUBTOTAL				**$ 75,145**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 75,145	-
	SUBTOTAL				**$ 75,145**	
	TOTAL				**$ 401,000**	

	***Alternative Stabilisation - Rock Chute**					
	Rock Chute - Construction Estimate	4	item	7100	$ 28,400	
	Alternate TOTAL 1				**$ 359,812**	
	***Alternative Stabilisation - Pool-Riffle**					
	Pool - Riffle Construction Estimate	8	item	3700	$ 29,600	
	Alternate TOTAL 2				**$ 361,732**	

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Menangle Park
Stabilisation Channel M1, Upstream Tributaries 5 and 6
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

SCHEDULE OF ESTIMATED QUANTITIES

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
3	**Stabilisation - Drop Structure***					
3.1	Concrete Drop Structure - Construction Estimate	2	each	27000	$ 54,000	
	SUBTOTAL				**$ 54,000**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	2	item	32000	$ 64,000	
	SUBTOTAL				**$ 64,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	533	m3	6	$ 3,200	
5.2	Landscaping - supply, deliver and plant approved plants	3,555	m2	39	$ 138,645	-
	SUBTOTAL				**$ 141,845**	
	SUBTOTAL ITEMS 1-7				**$ 279,845**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 83,953	-
	SUBTOTAL				**$ 83,953**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 83,953	-
	SUBTOTAL				**$ 83,953**	
	TOTAL				**$ 448,000**	

	***Alternative Stabilisation - Rock Chute**					
	Rock Chute - Construction Estimate	2	item	7100	$ 14,200	
	Alternate TOTAL 1				**$ 384,071**	
	***Alternative Stabilisation - Pool-Riffle**					
	Pool - Riffle Construction Estimate	4	item	3700	$ 14,800	
	Alternate TOTAL 2				**$ 385,031**	

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Menangle Park
Stabilisation Channel M1, Downstream
SCHEDULE OF ESTIMATED QUANTITIES

Revision: Draft

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				**$ 20,000**	
3	**Stabilisation - Drop Structure***					
3.1	Concrete Drop Structure - Construction Estimate	3	each	27000	$ 81,000	
	SUBTOTAL				**$ 81,000**	
4	**Inlet From Road Drainage**					
4.1	GPT - Supply, deliver and install CDS 1009	4	item	32000	$ 128,000	
	SUBTOTAL				**$ 128,000**	
5	**Landscaping and Planting**					
5.1	Topsoil - excavate from spoil heap, cart not exceeding 500m and spread and level average 150mm thick: light soil - battered areas	2,523	m3	6	$ 15,139	
5.2	Landscaping - supply, deliver and plant approved plants	16,821	m2	39	$ 656,019	-
	SUBTOTAL				**$ 671,158**	
	SUBTOTAL ITEMS 1-7				**$ 900,158**	
6	**Supervision, Project Management & Contractor On-Costs**					
6.1	Supervision, Project Management & Contractor On-Costs	30	%	-	$ 270,047	-
	SUBTOTAL				**$ 270,047**	
7	**Contingencies**					
7.1	Contingencies - General	30	%	-	$ 270,047	-
	SUBTOTAL				**$ 270,047**	
	TOTAL				**$ 1,440,000**	

	***Alternative Stabilisation - Rock Chute**					
	Rock Chute - Construction Estimate	6	item	7100	$ 42,600	
	Alternate TOTAL 1				**$ 1,378,813**	
	***Alternative Stabilisation - Pool-Riffle**					
	Pool - Riffle Construction Estimate	11	item	3700	$ 40,700	
	Alternate TOTAL 2				**$ 1,375,773**	

GHD

133 Castlereagh St Sydney NSW 2000

-

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
01	N Bailey	R. Kwan		R. Kwan		2011-09-29
02	N Bailey	R Kwan		R. Kwan		2011-10-17
03	N Bailey	R Kwan		R. Kwan		2011-11-18
04	N Bailey	R Kwan		R. Kwan		2011-11-25

Office of Environment & Heritage letter

22 September 2011

Office of Environment & Heritage

NSW GOVERNMENT

Our reference: DOC11/42534
Contact Fran Kelly

26 SEP 2011
LANDCOM
PARRAMATTA

James Bedford
Development Coordinator
Landcom
PO Box 237
Parramatta NSW 2127

Dear Mr Bedford

Thank you for your email dated 13 September 2011, regarding an alternate stormwater strategy for the Menangle Park urban release area.

In general the Office of Environment and Heritage is supportive of the overall aim of the alternate strategy and has no specific concerns. However it is recommended that in view of the good Aboriginal archaeological potential and actual and potential cultural significance within the riparian corridors, as detailed in the May 2010 *Archaeological Assessment of Indigenous Heritage Issues* report, an assessment of where any proposed new works would impact is undertaken.

The assessment should be done in conjunction with any conservation management plan for the site.

It is recommended that any known or uncovered sites are avoided, but where this is not possible appropriate mitigation is undertaken.

If you have any queries regarding the above please contact Fran Kelly on 9995 6820.

Yours sincerely

SUSAN HARRISON
A/Manager Planning & Aboriginal Heritage
Environment Protection and Regulation
Office of Environment and Heritage
Department of Premier and Cabinet

The Department of Environment, Climate Change and Water is now known as the Office of Environment and Heritage, Department of Premier and Cabinet

menanglepark

NSW Office of Water letter

31 August 2011

NSW GOVERNMENT | Office of Water

Contact: Greg Brady
Phone: 02 47298 134
Fax: 02 4729 8141
Email: greg.brady@ohn.nsw.gov.au

Our ref: 10 ERM2011/0911
File No: 9011814
Your Ref:

James Belford
Development Coordinator
Landcom
PO Box 237
PARRAMATTA NSW 2124

Attention: James Belford

31 August 2011

Dear Sir

Re: Menangle Park Urban Release Area – Stormwater Management Strategy-alternative basin strategy-Landcom

Thank you for your letter dated 25 August 2011 in relation to our meeting of 18 August 2011 where Landcom presented to NSW Office of Water (NOW) alternatives to the current basin strategy for the Menangle Park Urban Release Area.

Due to the unusual circumstances in relation to runoff characteristics of the site, the NOW understands that Council and OEH are to be also consulted on the alternate strategy. NOW gives qualified support to the alternative proposal as presented, except for basin 11, subject to there being no significant environmental issues raised by Council and OEH.

It would be expected by NOW that the alternative strategy should result in lower establishment costs to Landcom and much lower future maintenance costs to Council for achieving a similar or better environmental outcome.

Howes Creek Catchment Considerations

It is NOW's understanding that it is due to the constriction/detention effects of the current railway culvert that post development peak discharges below the railway culvert will be similar to the current peak discharges from between the 1:2 year to 1:100 year flood events, with or without the proposed basins 2, 4, 4a, 5, 6, and 12. The conclusion is that there appears to be little environmental benefit below the railway culvert for having these basins.

For this alternative to the stormwater management strategy to succeed in the Howe Creek catchment, a high quality *Creek and Riparian Stabilisation Management Plan* will be required taking into consideration the unique natural attributes of the site. Details of possible environmental issues are discussed below.

(1). Landcom needs to ensure that the environmental benefit is not lost upstream of the railway culvert. The removal of the basins will cause an increase in low and medium flows, and while these flows do not cause the full detention effect of the railway culvert they will cause significant destabilisation of Howe Creek's bed and banks and the adjacent natural wetlands. The plan, for the same reason also needs to address the current Howe Creek instability issues below the railway culvert, otherwise it will accelerate the current instability issues below the railway culvert.

(2). It is noted that with this alternative proposal the basins will be replaced by having a GPT (which it is assumed would also be required under the original proposal) with a bioretention or wetland system. As part of the original concept there are also 2 large constructed wetlands and a bioretention basin being proposed above the railway culvert. These are separate to the basins, acting as stand-alone water quality structures, with the low flows from the basins being diverted into them.

It is the NOW's view that with the removal of the basins that the footprint of these removed basins can then be used for the water quality treatment structures, as some form of structure is still required to enable dissipation of water energy and spreading of flows from the urban pipe system, and address the water quality aspects at the same time.

(3). Above the railway culvert, the riparian area and open space components of Howes Creek has a very large area of significant natural ephemeral wetlands. These wetlands are themselves reasonably unusual to many other wetlands in the Hawkesbury Nepean catchment and are important to protect and conserve.

Therefore it is important to minimise adverse impacts due to the removal of the proposed basins, such as channelisation through the natural wetlands caused by the increase in frequency, speed and quantity of flows, and the subsequent permanent lowering of the shallow groundwater table that supports these wetlands. This is particularly important for the consideration of the location of the current Basin 12 discharge point/s.

(4). Similarly, above the railway culvert, the issue of increasing channel width and bed instability of the existing Howes Creek channel needs to be addressed, otherwise this too will lower the local shallow groundwater watertable and threaten the existing good riparian vegetation. The plan should investigate continuing the same size piping from the urban area from the wetland/bioretention basins to a constructed naturally armoured structure adjacent to the railway culvert. This may minimise many of the potential adverse impacts for at least 4 (and largest) of the 6 basins proposed to be removed.

(4). Below the railway culvert, the same channel instability issues with Howes Creek need to be closely investigated. This is particularly important if the Howe Creek stabilisation component of the consented development proposal between the railway line and the Hawkesbury Nepean River **has not been completed before the Menangle Park urban subdivision works commence**. It is considered prudent to do this planning and costing as part of this alternative, as it will need to be done either way as it will otherwise potentially lead to significant erosion and sediment issues and threaten the eventual stability of the railway culvert.

Basin 9.

It is noted that there is an increase in peak discharge of 9% to 10% for the range of flows presented (from Table 1) if Basin 9 is removed. It is reasonable to expect that an adequate Creek and Riparian Stabilisation Management Plan can be successfully implemented to address the higher energy water issues caused by the urbanisation of this catchment area. Therefore the option to remove Basin 9 is supported, if an adequate Creek and Riparian Stabilisation Management Plan is presented.

Basin 11.

It is noted that there is an increase in peak discharge of 22% to 38% for the range of flows presented (from Table 1) if Basin 11 is removed. This is regarded as a significant increase in potential energy within the creek. It will need to be demonstrated that with suitable stabilisation works the watercourse can, and will remain stable before NOW can endorse the removal of this basin.

Other unrelated Issues.

The NOW is concerned the Structural Plan as presented in Landcom's letter, does not show all negotiated watercourses (M3b, M4 or S3). The NOW has previously raised this as an issue in its submission of 15 September 2010 to Council on the draft LEP study and LEP. These watercourses need to be shown on the Structural Plan. By not showing these watercourses it does not enable transparency of natural resource issues for those particular locations for existing and future landholders.

Please direct any questions or correspondence to Greg Brady. Please note that Greg Brady is again within Office of Water and these matters need to be addressed to him at Office of Water.

Yours sincerely

Greg Brady
Licensing Officer
NSW Office of Water - Licensing Operations South

menanglepark

Landcom letter to NSW Office of Water

Landcom

25 August 2011

LANDCOM

www.landcom.com.au

25 August 2011

Greg Brady
In Stream Development Officer
NSW Office of Water – Office of Hawkesbury Nepean
PO Box 3720
PARRAMATTA NSW 2124

Dear Greg

Menangle Park Urban Release Area – Stormwater Management Strategy

Further to our meeting on Friday 18 August 2011 please find attached for your consideration and concurrence an alternate proposal for the management of post development stormwater runoff for the above urban release area.

The alternate proposal follows a general review of a more traditional strategy that has been prepared and documented in the May 2010 GHD Local Flooding and Stormwater Quantity Management (detention) report which accompanied the Section 62 consultation documents for the draft LES.

A review of the GHD report identified that an opportunity exists, due to the unique location of the urban release area within the catchment, coupled with existing site characteristics, to redirect the required stormwater management investment away from basin construction and into naturalised stream stabilisation and improvement works. It is anticipated this redirection will result in an improved environmental outcome without compromising the stormwater quantity or quality management objectives for the release area.

Details of the alternate strategy framework are outlined in Attachment A for your consideration and concurrence.

The framework is being prepared to support the establishment of the development contributions regime for the release area. Detailed design and planning will occur with relevant development applications and associated Controlled Activity Approval applications once the release area has been rezoned.

Your consideration of the alternate proposal and in principle agreement would be appreciated.

If you have any queries please call to discuss.

Yours sincerely

James Belford
Development Coordinator

Certified Environmental Management

Level 2, 330 Church Street
Parramatta NSW 2150
PO Box 237 Parramatta NSW 2124
DX 28448 Parramatta
ABN 79 268 260 688
Telephone 61 2 9841 8600
Facsimile 61 2 9841 8688
enquiry@landcom.nsw.gov.au

Attachment A

Alternate Stormwater Quantity Management Strategy

Contents

LANDCOM

A. Background

Campbelltown City Council and Landcom undertook studies of the existing riparian framework at Menangle Park in consultation with the NSW Office of Water. These studies were concluded in December 2007 with GHD preparing a Riparian Corridor Assessment, refer Annexure A. The Department of Energy and Water provided in principle agreement with the assessment subject to resolution of the drainage strategy by letter dated 24 January 2008, refer Annexure B. Figure 1 shows the initial assessment, with the resultant preferred riparian network shown in Figure 2.

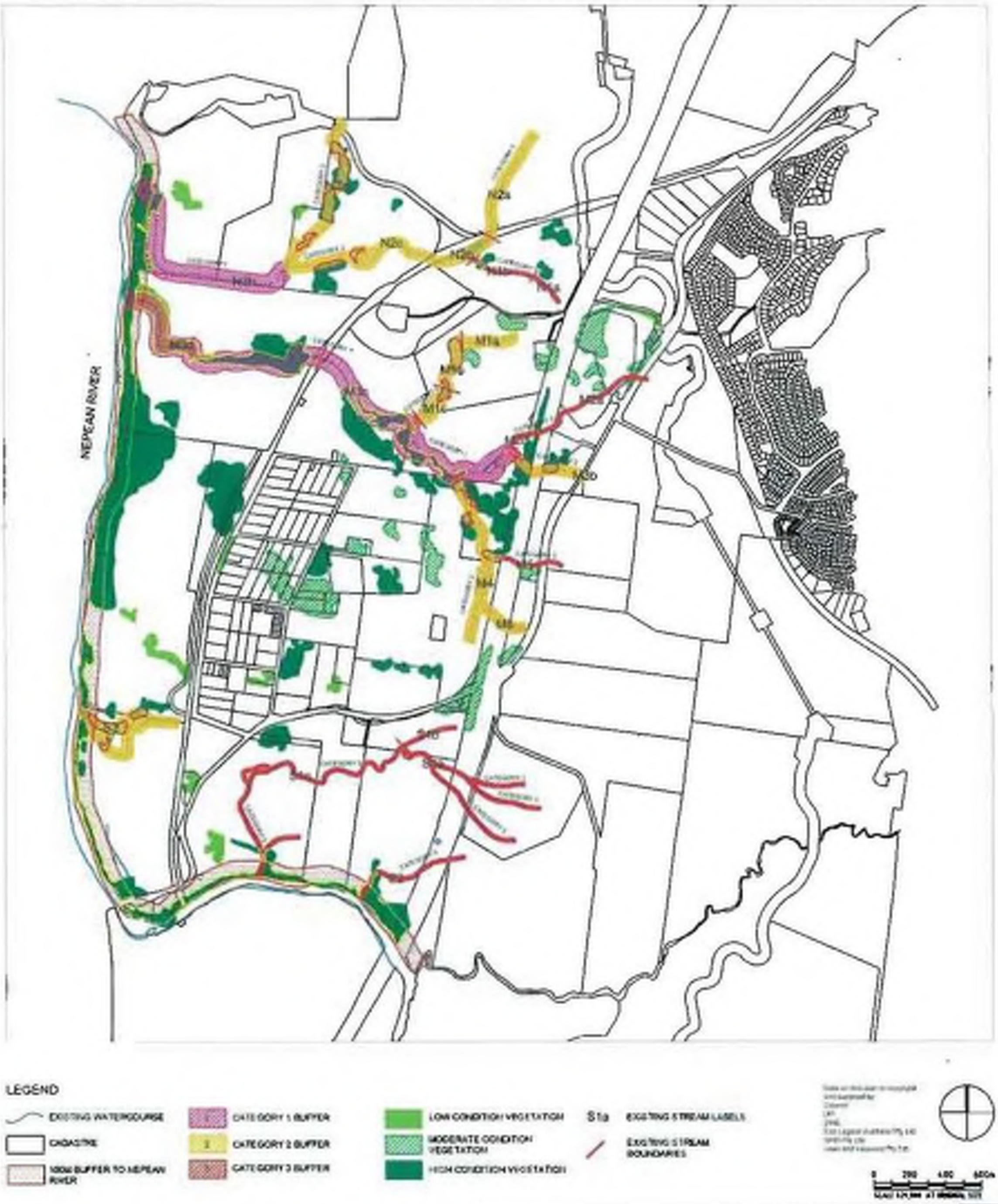
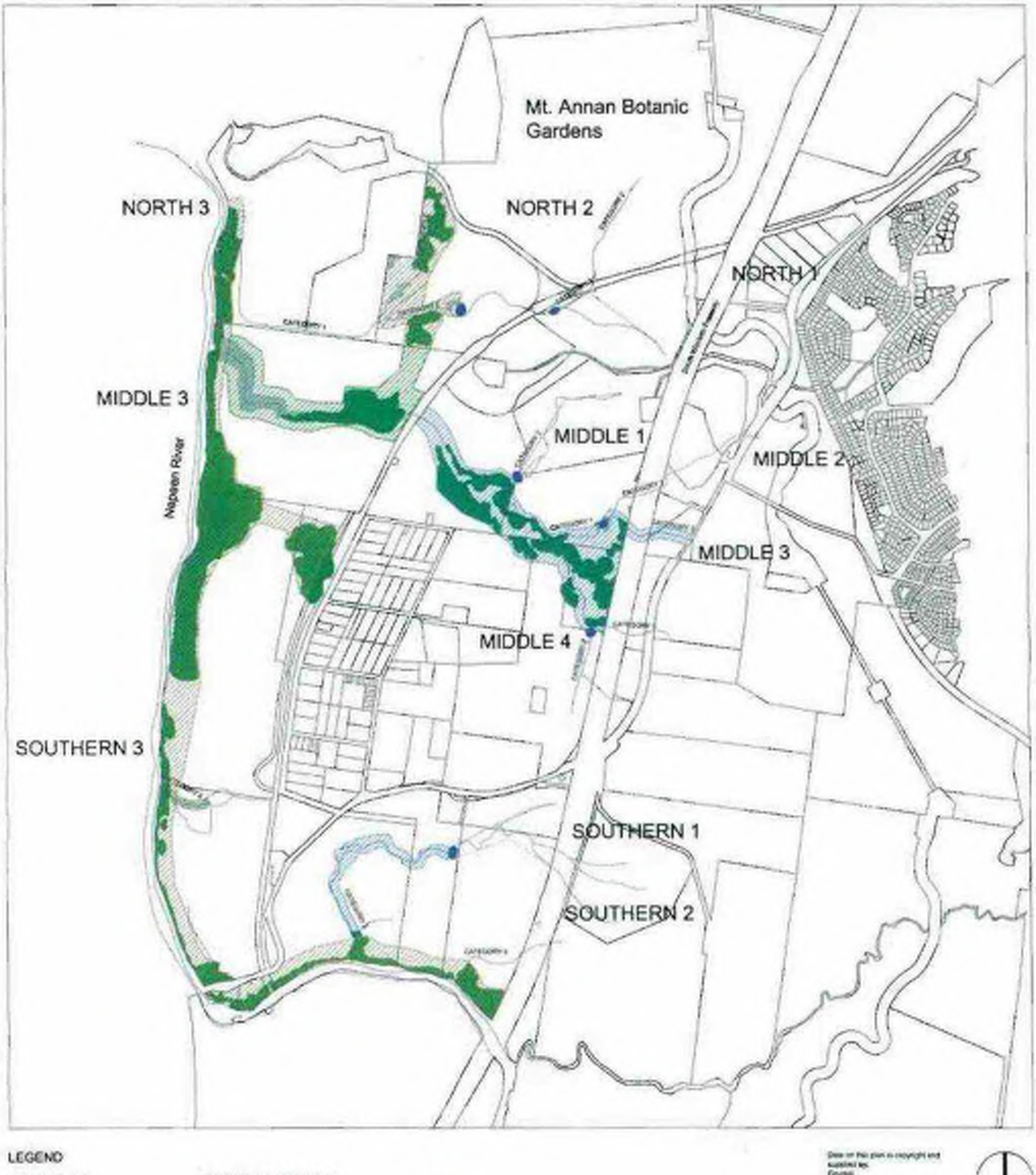


Figure 1
Riparian Corridor Initial Assessment

LANDCOM



menanglepark	SCALE 1:20 000@A3	PROJECT Menangle Park Project
	FILE NAME 22-13346-PRCN.pdf	DATE & ISSUE 19/12/07 ISSUE 2
	DESCRIPTION PREFERRED RIPARIAN CORRIDOR NETWORK	PROJECT PARTNERS LANDCOM

Figure 2
Preferred Riparian Corridor Network

LANDCOM

The preferred riparian corridor networks was used as the basis for the preparation of the urban release area master plan prepared by URBIS in 2010 and updated by SMEC Urban in 2011, refer Figure 3. The master plan forms the basis of both the AECOM 2010 Water Sensitive Urban Design report and GHD 2010 Local Flooding and Stormwater Quantity Management (Detention) report that formed part of the draft LES. The draft LES Section 62 consultation was completed in late 2010.

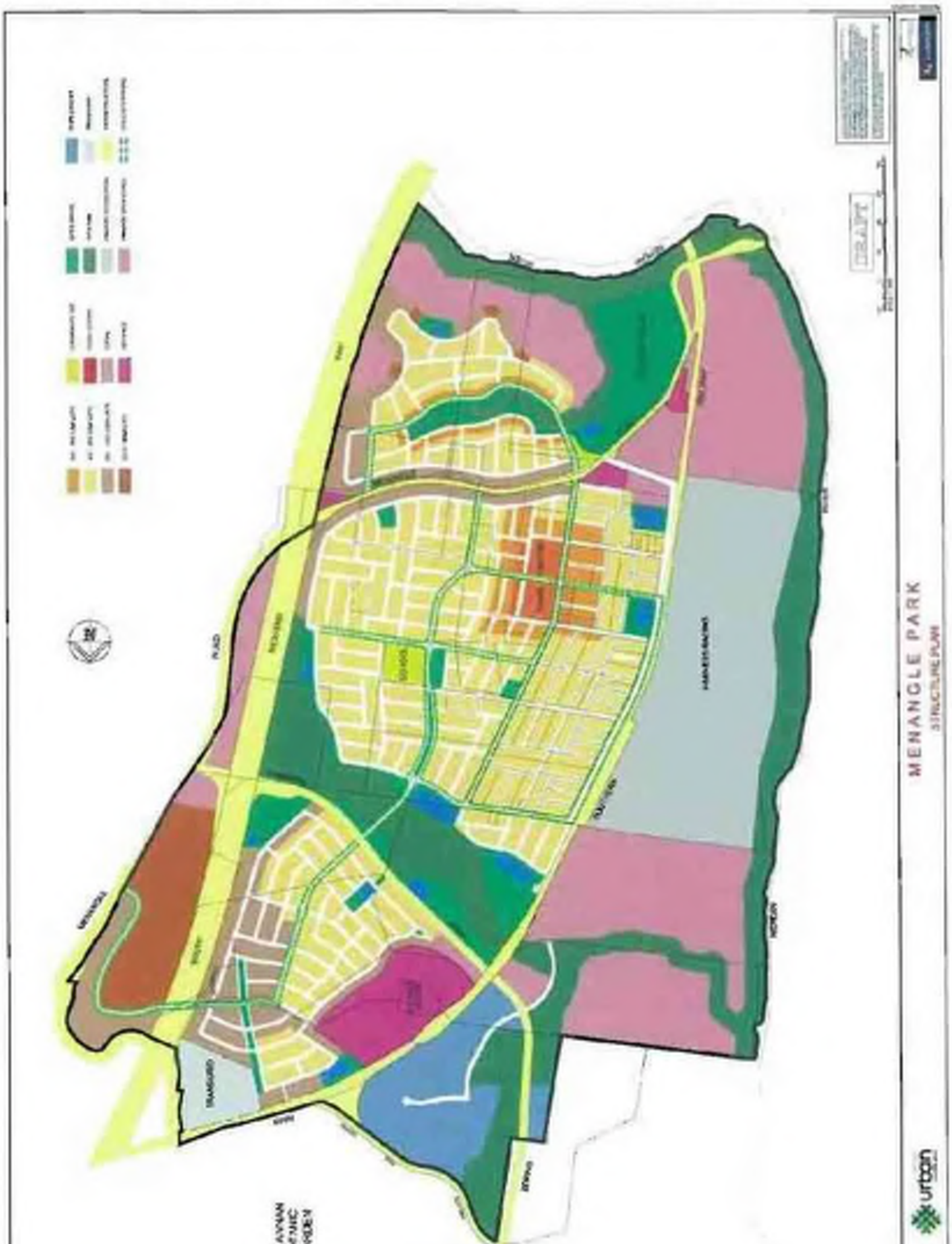


Figure 3
Draft Structure Plan

B. Current Proposal

B.1 Stormwater Quality

The current Water Sensitive Urban Design strategy recognises the presence of the detention basins and the channelling of runoff through these. Hence for a number of catchments the proposed water quality measures are integrated in these basins, refer Figure 4. The strategy requires:

(a) water quality treatment of stormwater runoff for the 3 month ARI storm, targeting
   - (i.) 55% reduction in the mean annual load of Total Nitrogen (TN);
   - (ii.) 70% reduction in the mean annual load of Total Phosphorous (TP);
   - (iii.) 85% reduction in the mean annual load of Total suspended solids (TSS);

(b) Management of flows in the natural creek lines to achieve a Stream Erosion Index (SEI) of between 1 and 2 by managing the 1 in 1.5 year ARI peak discharge.

Figure 7.20: Drainage subcatchments and WSUD

Figure 4
AECOM 2010 Water Quality Strategy

LANDCOM

B.2 Stormwater Quantity

The current stormwater quantity management strategy seeks to manage stormwater runoff for individual subcatchments by restricting post development peak flows to pre development peak flows for all storms between the 2 year to 100 year ARI events (section 3.2 GHD 2010). This is in accordance with the provisions of Campbelltown City Council's Sustainable Cities Development Control Plan provisions and is common practice for new urban developments of this type.

Stormwater detention strategies are designed to recognise the need for new developments to mitigate their potential impacts upon people, property and the environment with regards to increased stormwater runoff.

The peak discharge analysis on a catchment by catchment basis as determined by GHD in their report are summarised in Table 1. The resultant stormwater quantity management strategy is as shown in Figure 5.

Drainage System	100-year Flood Peak (m^3/s) for critical duration			
	Location	Existing	Developed (no mitigation)	Developed with mitigation
Creek M – Howes Creek	Basin 2 outflow	10.5	14.3	8.5
	Basin 4 outflow	11.2	14.9	10.4
	Basin 4a	6.2	8.3	6.0
	Basin 5 outflow	6.6	8.5	6.0
	Basin 6 outflow	10.2	11.9	9.9
	Basin 12 outflow	19.0	25.7	18.2
	D/S of Basins 2, 4, 4a, 5, 6, 12 at the railway	142	138	139
Creek S1	Basin 9 outflow	15.0	16.3	15.0
Creek S2	Basin 11 outflow	7.9	9.6	7.9
Creek N	Basin 13 outflow	10.5	14.2	10.5
Tributaries west of Menangle Park	Basin 7 outflow	8.9	12.4	4.5
	Basin 8 outflow	20.6	26.5	.20.4
Drainage System	**2-year Flood Peak (m^3/s) for critical duration**			
	Location	Existing	Developed (no mitigation)	Developed with mitigation
Creek M – Howes Creek	Basin 2 outflow	2.7	6.7	2.1
	Basin 4 outflow	3.7	6.7	3.1
	Basin 4a	1.9	3.7	1.8
	Basin 5 outflow	2.0	3.3	1.9
	Basin 6 outflow	3.3	5.0	3.2
	Basin 12 outflow	6.0	11.7	5.7
	D/S of Basins 2, 4, 4a, 5, 6, 12 at the railway	46	44	46
Creek S1	Basin 9 outflow	5.1	5.6	4.9
Creek S2	Basin 11 outflow	2.6	3.6	2.4
Creek N	Basin 13 outflow	3.3	6.3	3.2
Tributaries west of Menangle Park	Basin 7 outflow	3.8	5.9	2.6
	Basin 8 outflow	6.1	12.5	6.1

Greater flow reduction benefit gained by not detaining post development flows

Marginal peak flow improvement in category 3 stream, suggests focus on stream stabilisation may be better outcome

Table 1
GHD 2010 Water Quantity Management Strategy

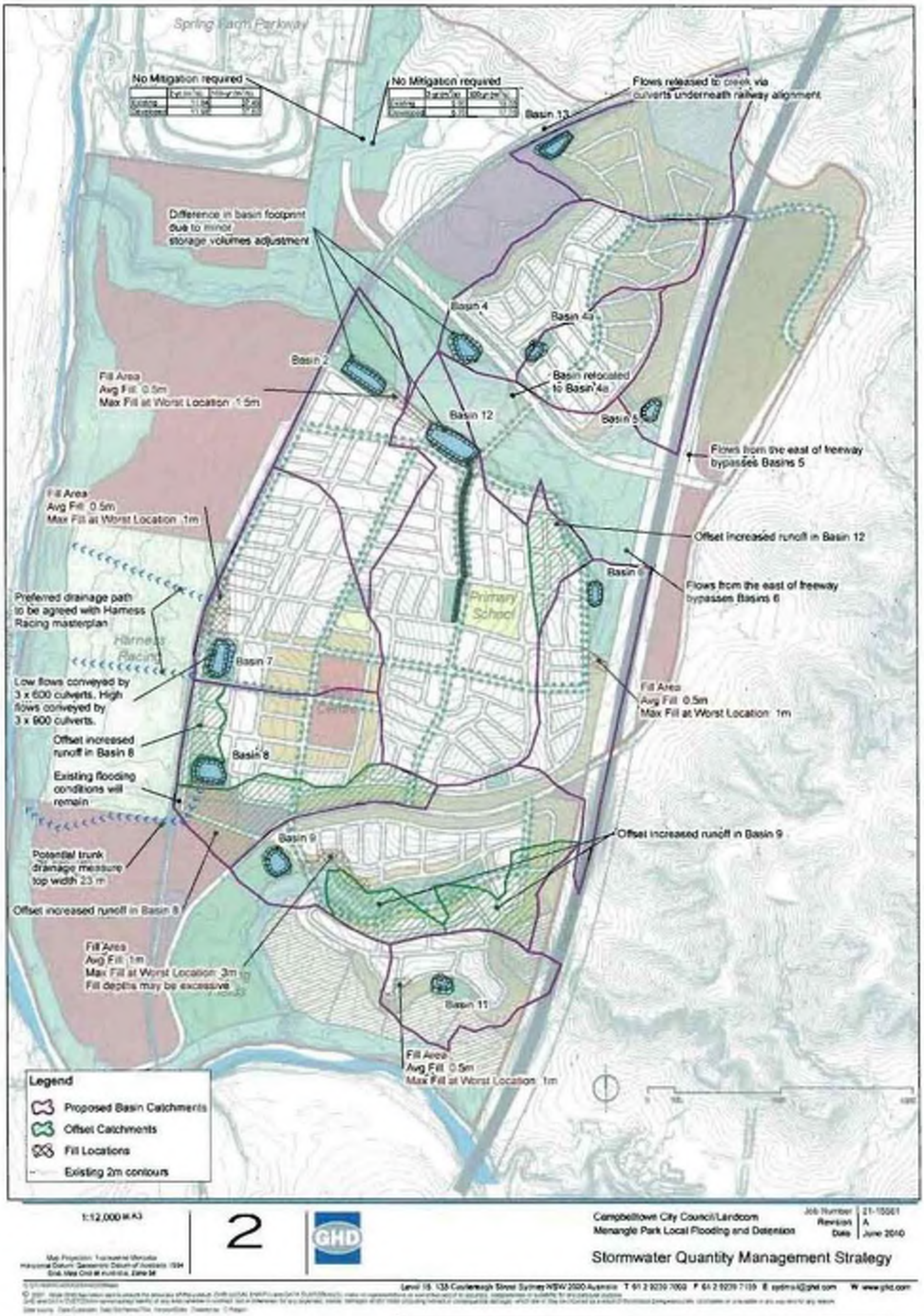


Figure 5
GHD 2010 Water Quantity Management Strategy

C. Alternate Framework

C.1 Stormwater Quality

The water quality management strategy for the alternate framework will remain essentially the same as the current proposal. That is, the strategy will address the:

(a) water quality treatment of stormwater runoff for the 3 month ARI storm, targeting
  - (i.) 55% reduction in the mean annual load of Total Nitrogen (TN);
  - (ii.) 70% reduction in the mean annual load of Total Phosphorous (TP);
  - (iii.) 85% reduction in the mean annual load of Total suspended solids (TSS);

(b) management of flows in the natural creek lines to achieve a Stream Erosion Index (SEI) of between 1 and 2 by managing the 1 in 1.5 year ARI peak discharge.

C.2 Stormwater Quantity

The basis of the current proposal is the implementation of detention storage to either protect people, property or the environment (or a combination of these). Table 2 sets out which criteria are governing the requirement for each of the basins. The table identifies that a number of the basins are being implemented primarily for environmental management reasons. This, in itself, is highly appropriate given the category of the receiving water, being Howes Creek (Category 1) or the Nepean River (Category P). In reviewing the outcome of the hydrological analysis as presented in Table 1 it becomes clear that the net benefit of the investment being made in implementing the basins may not be as great as that achievable if the investment was being made directly in the protection and rehabilitation of the creek lines within the catchment. This redirection of funds is the basis for the alternate framework, table 3 provides the general justification on a basin by basin basis.

Table 2 – Basin Design Controlling Criteria

Basin	**Controlling Criteria** (protection of . . .)		
	People	**Property**	**Environment**
Basin 2	x	x	✓
Basin 4a	x	x	✓
Basin 4	x	x	✓
Basin 5	x	x	✓
Basin 6	x	x	✓
Basin 7	✓	✓	✓
Basin 8	✓	✓	✓
Basin 9	x	x	✓
Basin 11	x	x	✓
Basin 12	x	x	✓
Basin 13	✓	✓	✓

For the basins in isolated catchments where the basins are meeting the multiple criteria of people, property and/or environment, the strategy cannot be readily modified as the cost impact of the alternative measures is likely to be higher then the cost of providing the basin. On this basis it is proposed that Basins 7, 8 and 13 still be constructed generally as proposed.

For those basins where the controlling criteria is primarily environmental there is the potential to consider the redirection of funds away from hard infrastructure provision and into environmental works that will provide a greatly improved outcome for both the environment (in terms of stability and quality of riparian corridors) and the community (in terms of environmental quality and reduced ongoing maintenance costs). The basins where this refocus of the strategy may be beneficial include Basins 2, 4, 4a, 5, 6, 9, 11 and 12.

Basin 9 and 11 discharge into the Nepean River via two category 3 creek lines that are in poor condition. The quantum of works required to stabilise and rehabilitate these category 3 streams to cater for the undetained post developed flow conditions relative to that required for pre development conditions is not expected to be significant. By contrast the cost of implementing the detention basins is quite significant and results in ongoing maintenance obligations on Council. The benefit of implementing basins rather than increasing the investment in the rehabilitation of the creek lines is anticipated to be negligible.

Basins 2, 4, 4a, 5, 6 and 12 all manage storm flows from sub catchments that discharge into the mid reach of Howes Creek. They each constrain post development discharges to pre development discharges from their respective subcatchments but collectively they increase the post development discharge through the rail corridor drainage culvert. This effectively reduces the benefit of development works in reducing the discharge to the lower reach of Howes Creek. It is anticipated that this outcome is related to the localised configuration of the catchment and the impact this has on the discharge hydrographs for each of these subcatchments. In this instance it would appear more beneficial to not detain the subcatchment flows but rather invest in 'natural' stream stabilisation works and rehabilitation to mitigate any potential damage to the creekline and utilise the floodplain created behind the rail corridor drainage culvert as the detention storage basin, this is consistent with what currently occurs in this location. This approach will optimise the reduction in peak flows into the lower reach of the Howes Creek post development, refer table 1.

The alternate framework for the water quantity management strategy is shown schematically in Figure 6 for reference.

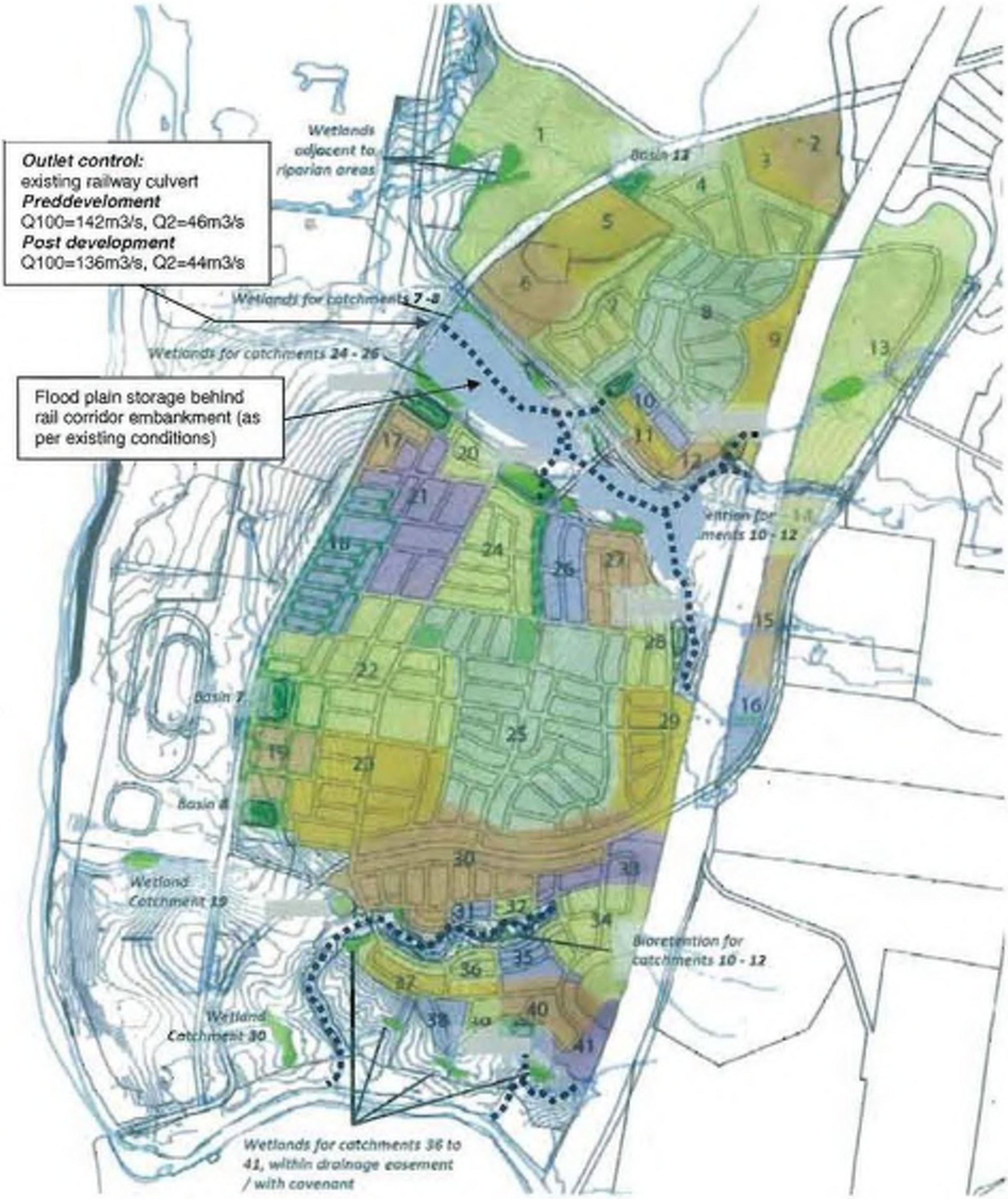
Table 3 – Basin by Basin Review

Basin	Location & receiving water	Key Flow Parameters	Proposed alternate	Reason for change
2	Mid catchment upstream of rail corridor; Howes Creek	1 in 100 yr ARI: Qu= 10.5m3/s Qdu= 14.3m3/s Qb = 8.5m3/s I in 2 yr ARI: Qu= 2.7m3/s Qdu= 6.7m3/s Qb = 2.1m3/s No existing defined channel or discharge point	GPT to outlet into bioretention or wetland system (low flow); level spreader and dispersed flow into Howes Creek; Howes Creek low flow channel 'natural' stabilisation works and overbank flow area native regeneration works as stabilisation	Culvert through Rail corridor creates a natural detention basin in creekline; installing basin reduces the net reduction in discharge to lower reach of Howes Creek; stabilisation and rehabilitation works achieve better environmental outcome

Basin	Location & receiving water	Key Flow Parameters	Proposed alternate	Reason for change
4	Mid catchment upstream of rail corridor; Howes Creek	1 in 100 yr ARI: Qu= 11.2m3/s Qdu= 14.9m3/s Qb = 10.4m3/s I in 2 yr ARI: Qu= 3.7m3/s Qdu= 6.1m3/s Qb = 3.1m3/s Category 2 poor condition	GPT to outlet into bioretention or wetland system (low flow); level spreader and dispersed flow into Howes Creek; Howes Creek low flow channel 'natural' stabilisation works and overbank flow area native regeneration works as stabilisation	Culvert through Rail corridor creates a natural detention basin in creekline; installing basin reduces the net reduction in discharge to lower reach of Howes Creek; stabilisation and rehabilitation works achieve better environmental outcome
4a	Mid catchment upstream of rail corridor and Spring Farm Parkway; Howes Creek	1 in 100 yr ARI: Qu= 6.2m3/s Qdu= 8.3m3/s Qb = 6.0m3/s I in 2 yr ARI: Qu= 1.9m3/s Qdu= 3.7m3/s Qb = 1.8m3/s Category 2 poor condition	GPT to outlet into bioretention or wetland system (low flow); level spreader and dispersed flow into Howes Creek via floodway under Spring Farm Parkway; Howes Creek low flow channel 'natural' stabilisation works and overbank flow area native regeneration works as stabilisation	Culvert through Rail corridor creates a natural detention basin in creekline; installing basin reduces the net reduction in discharge to lower reach of Howes Creek; stabilisation and rehabilitation works achieve better environmental outcome
5	Upper mid catchment upstream of Spring Farm Parkway; Howes Creek	1 in 100 yr ARI: Qu= 6.6m3/s Qdu= 8.5m3/s Qb = 6.0m3/s I in 2 yr ARI: Qu= 2.0m3/s Qdu= 3.3m3/s Qb = 1.9m3/s Category 2 poor condition	GPT to outlet into bioretention or wetland system (low flow); level spreader and dispersed flow into Howes Creek via floodway under Spring Farm Parkway; Howes Creek low flow channel 'natural' stabilisation works and overbank flow area native regeneration works as stabilisation	Culvert through Rail corridor creates a natural detention basin in creekline; installing basin reduces the net reduction in discharge to lower reach of Howes Creek; stabilisation and rehabilitation works achieve better environmental outcome

Basin	Location & receiving water	Key Flow Parameters	Proposed alternate	Reason for change
6	Upper mid catchment upstream of collector road crossing; Howes Creek	1 in 100 yr ARI: Qu= 10.2m3/s Qdu= 11.9m3/s Qb = 9.9m3/s I in 2 yr ARI: Qu= 3.3m3/s Qdu= 5.0m3/s Qb = 3.2m3/s Category 2 poor condition	GPT to outlet into bioretention or wetland system (low flow); level spreader and dispersed flow into Howes Creek; Howes Creek low flow channel 'natural' stabilisation works and overbank flow area native regeneration works as stabilisation	Culvert through Rail corridor creates a natural detention basin in creekline; installing basin reduces the net reduction in discharge to lower reach of Howes Creek; stabilisation and rehabilitation works achieve better environmental outcome
9	Lower south catchment downstream of collector road crossing; Category 3 creekline	1 in 100 yr ARI: Qu= 15m3/s Qdu= 16.3m3/s Qb = 15m3/s I in 2 yr ARI: Qu= 5.1m3/s Qdu= 5.6m3/s Qb = 4.9m3/s Category 3 poor condition	GPT to outlet into bioretention or wetland system (low flow); level spreader and dispersed flow into Category 3 creek line; Category 3 creek line low flow channel 'natural' stabilisation works and overbank flow area native regeneration works as stabilisation	Pre and post development peak flow differences are marginal; stabilisation and rehabilitation works achieve better environmental outcome
11	Lower south catchment near M5; Category 3 creekline	1 in 100 yr ARI: Qu= 7.9m3/s Qdu= 9.6m3/s Qb = 7.9m3/s I in 2 yr ARI: Qu= 2.6m3/s Qdu= 3.6m3/s Qb = 2.4m3/s Category 3 poor condition	GPT to outlet into bioretention or wetland system (low flow); level spreader and dispersed flow into Category 3 creek line; Category 3 creek line low flow channel 'natural' stabilisation works and overbank flow area native regeneration works as stabilisation	Pre and post development peak flow differences are marginal; stabilisation and rehabilitation works achieve better environmental outcome
12	Mid catchment upstream of rail corridor; Howes Creek	1 in 100 yr ARI: Qu= 19m3/s Qdu= 25.7m3/s Qb = 18.2m3/s	GPT to outlet into bioretention or wetland system (low flow); level	Culvert through Rail corridor creates a natural detention basin

Basin	Location & receiving water	Key Flow Parameters	Proposed alternate	Reason for change
		I in 2 yr ARI: Qu= 6.0m3/s Qdu= 11.7m3/s Qb = 5.7m3/s Category 1 Howes Creek	spreader and dispersed flow into Howes Creek via floodway under Spring Farm Parkway; Howes Creek low flow channel 'natural' stabilisation works and overbank flow area native regeneration works as stabilisation	in creekline; installing basin reduces the net reduction in discharge to lower reach of Howes Creek; stabilisation and rehabilitation works achieve better environmental outcome



Wetlands
Saturated Zone Bioretention Systems
Swale connection to wetland / key streetscape opportunitie
Drainage & Treatment Easement / covenant
Existing Vegetation – high conservation value
Proposed stream stabilisation works and overbank natural revegetation

Drainage subcatchments and WSUD elements for managing stormwater quality and quantity

Figure 6
Water Quantity Management Alternate Framework

LANDCOM

menanglepark

Local Flooding and Stormwater Quantity Management (Detention)

GHD

May 2010

menanglepark

Local Flooding and Stormwater Quantity Management (Detention)

Document prepared by

Dr Rainer Berg
Principal Hydrology and Stormwater Engineer

GHD

26th May 2010

campbelltown city council

LANDCOM

CONTENTS

1 INTRODUCTION

1.1 PLANNING AT MENANGLE PARK

Campbelltown City Council undertook a Local Environmental Study (LES) for the Menangle Park in 1990 but ceased work, as the area was subject to an air and water quality moratorium under the South-Western Sydney Strategy.

In light of concerns regarding pressures on the Sydney housing market and housing affordability, the State Government announced in December 2001 that land in Western Sydney would be investigated for future residential release. Menangle Park was one of the key sites identified as part of this program. It was subsequently included in the Metropolitan Development Program.

Council recommenced preparation of an LES in 2003. The aim was to investigate the environmental, social and economic opportunities and constraints of the Menangle Park Study Area. It was intended to identify the capability of the area to accommodate urban development and recommend appropriate land use zones for incorporation into a subsequent draft LEP for the area. The owners of the two largest land holdings (Campbelltown City Council and Landcom) commissioned various studies to assist the preparation of the LES and concept Master Plan.

The LES was substantially completed when the project was put on hold in July 2004 to allow implications of land subsidence due to coal mining to be assessed. A Cabinet-requested Working Group reached an agreed position on this issue in 2005 and completion of the LES is now possible.

To this end, Campbelltown City Council and Landcom have asked APP to review and update the 2003/04 LES work before the LEP and DCP is completed.

1.2 OBJECTIVES OF THIS STUDY

GHD were appointed, by Campbelltown City Council and Landcom, to assist with the surface water management for the Menangle Park Release Area and in the formulation of a Water Sensitive Urban Design strategy. The Water Sensitive Urban Design strategy was to be compiled by two separate consultancies, who liaised to ensure maximised outcomes in managing surface water and flooding. The consultancies were:

- GHD – Nepean flooding, local flooding and stormwater quantity management (detention); and
- Aecom – Stormwater quality management

The objectives of this study are to report on local flooding and stormwater quantity management (detention) strategies. The Nepean flooding has been reported on in a separate report (GHD, 2008). The objectives of this study are to:

- Define and report on local flooding at the site;
- Define the impact of the development footprint as provided in the Masterplan, and propose a stormwater quantity management (detention) strategy that interfaces with the stormwater quality management strategy;
- Provide input and contribute to the integrated planning team on matters related to flooding and water cycle management; and
- Ensure efficient use of land for water cycle management facilities through co-location with other land-use elements, to maximise developable land and in consideration of other site constraints/opportunities (eg riparian corridors, climate, existing infrastructure).

1.3 WATER SENSITIVE URBAN DESIGN (WSUD)

WSUD encompasses all aspects of urban water cycle management including water supply, wastewater and stormwater management. WSUD is a multi-disciplinary approach that promotes opportunities for linking water infrastructure, landscape design and the urban built form to minimize the impacts of development upon the water cycle and achieve more sustainable forms of urban development.

The principles of WSUD are incorporated in the Campbelltown City Council Sustainable City DCP and the Growth Centres Commission Development Code. The intent of Councils' requirements in relation to stormwater management is to ensure systems are carefully planned, designed and located to prevent the disturbance, redirection, reshaping or modification of watercourses and associated vegetation and to protect the quality of receiving waters. If adequate WSUD measures are not adopted, the proposed development may have the following impacts:

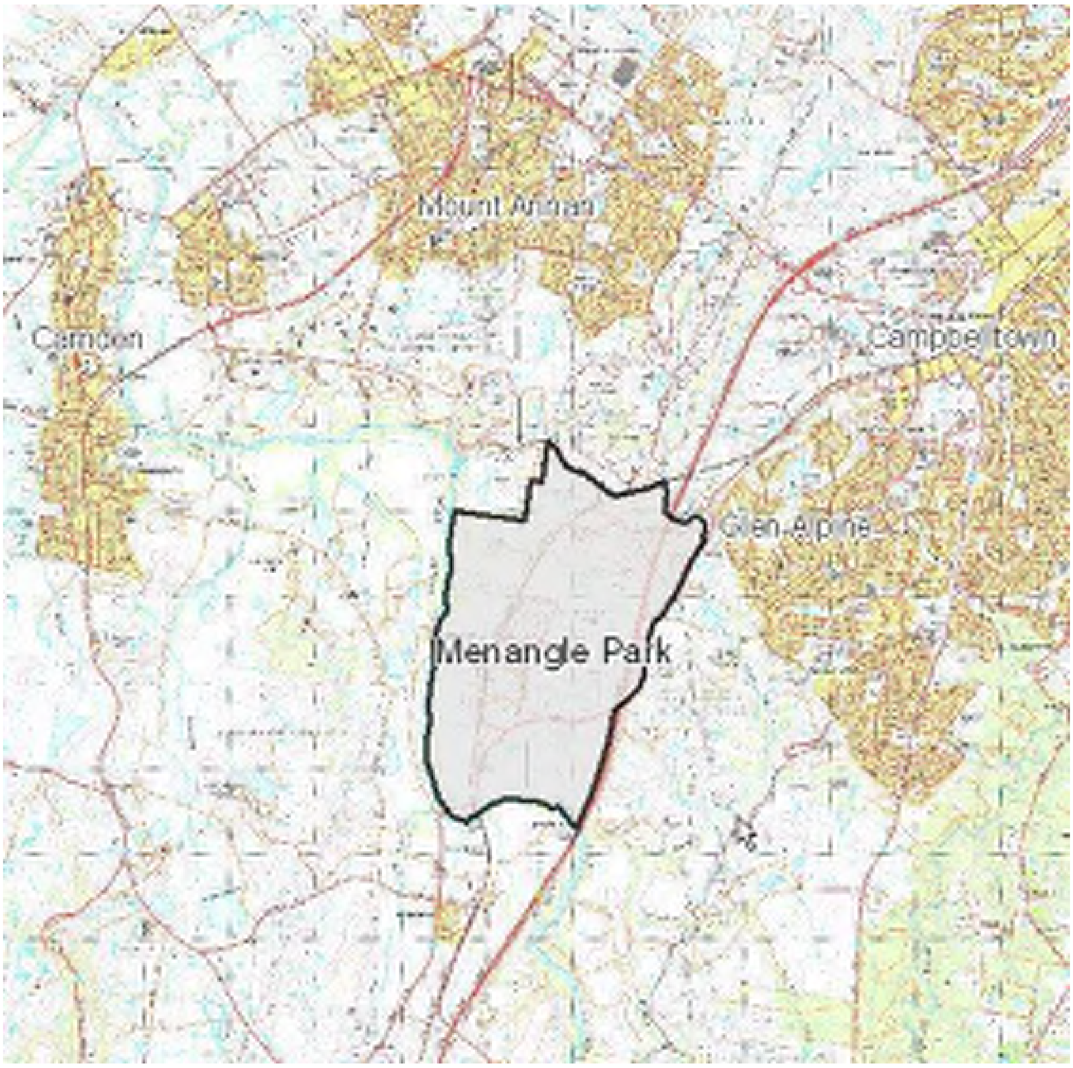
- Increased stormwater runoff, which could impact sensitive downstream habitats in terms of flushing regimes (frequency, volume and rate), water quality and wetting cycles;
- Reduction in rainfall infiltration and decreased groundwater recharge; and
- Disturbance of groundwater flow due to site compaction, fill, landform reshaping and underground structures.

The suitability of WSUD solutions to any proposed development depends upon a number of factors, including climate and rainfall, site topography, geology and available land.

1.4 MASTER PLAN

This report responds to the Master Plan dated 2/12/2009 ISSUE 4 (DRAFT Revised Structure Plan), which is included in Appendix A.

Figure 1 Menangle Park Site



2 SITE DESCRIPTION AND DERIVED CONSTRAINTS

2.1 CLIMATE AND RAINFALL

Referring to Figure 1, the site is located some approximately 25 km inland and is buffered from the typical Sydney coastal climatic conditions by intermediate terrain, such as the Royal National Park. The area experiences greater variations in temperature and is generally dryer than Sydney.

The nearest pluviograph stations in proximity of the site are located at Waterfall, Lucas Heights and Liverpool, all of which are considered too distant to provide representative data for the study area. A number of daily rainfall stations are located in close proximity to the study area. Table 1 summarises the stations located closest to the study site, providing station number, name and recording start and end years.

Table 1 Daily Rainfall Data

Station Number	Station Name	Start Date	End Date
068041	Menangle	1895	1952
068216	Menangle Bridge (Nepean River)	2000	ongoing
068013	Menangle (Elizabeth Macarthur Agricultural Institute)	1861	1992
068227	Ambarvale Clennam Ave	1961	1988
068014	Campbelltown 1	1845	ongoing
068081	Campbelltown Swimming Centre	1959	1984

Daily rainfall data was obtained from the Bureau of Meteorology (BOM) for the Menangle Elizabeth Macarthur Agricultural Institute station (Station No. 068013). An analysis undertaken on this data indicated that there is significant annual variability in the rainfall with the maximum annual rainfall of 1560 mm while the minimum annual rainfall recorded was 280 mm. The average annual rainfall at the gauge is 722 mm with the median being 710 mm. Figure 2 provides a plot of the annual rainfall to indicate the variability.

A frequency analysis (
Figure 3) was undertaken to determine the likely range of annual rainfalls. It was found that the 1 percentile annual rainfall was approximately 1300 mm a year while the 99 percentile of rainfall was likely to be in the order of 295 mm a year.

An analysis was undertaken of the monthly rainfall records between 1878 and 1992 to determine seasonal trends in the rainfall. As indicated in Figure 4 there is the possibility of a relatively high month of rainfall, at any period during the year. A mild seasonal pattern was evident in the average and median rainfalls for the month, with generally the average being higher in late summer and early autumn, dropping to a low towards the end of winter and early spring, rising again towards summertime. Based on

that historical period of record there is the possibility of no rainfall, or minimal rainfall, in any month of the year.
Mean daily evaporation data for the site, listed in Table 2, was sourced from BOM from the 068013 pluviograph site (Elizabeth Macarthur), which also measured evaporation.

The high likelihood of rainfall occurring in any month throughout the year would support utilisation of vegetated systems such as swales and wetlands to manage stormwater. Furthermore, the mild seasonal variability would indicate that rainwater collection via rainwater tanks might be viable for domestic uses.

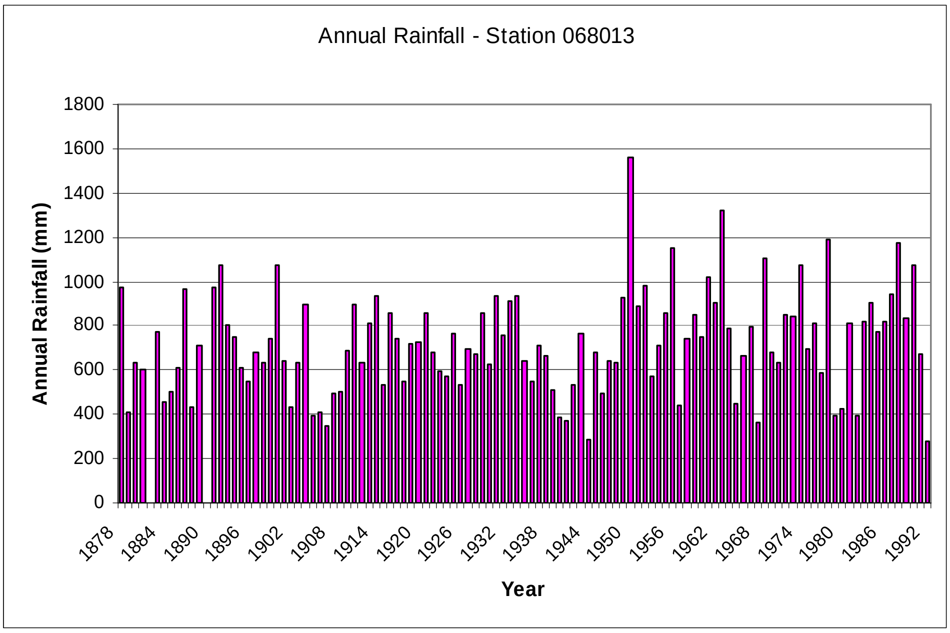


Figure 2 Annual Rainfall

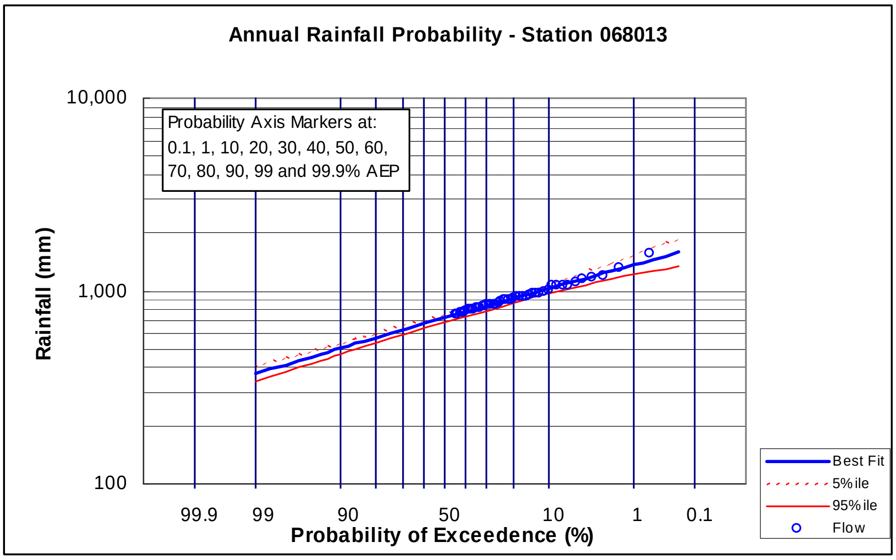


Figure 3 Annual Rainfall Frequency Analysis

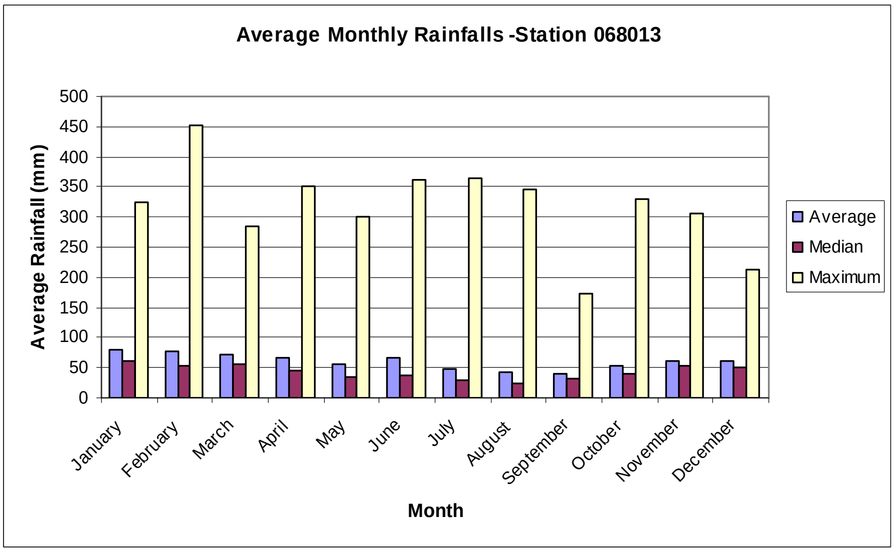


Figure 4 Monthly Rainfall Distribution

Table 2 Mean Daily Evaporation

Month	Mean Daily Evaporation (mm)
January	5.6
February	5.2
March	4.5
April	3.9
May	2.4
June	2.1
July	2.1
August	2.9
September	4.2
October	4.9
November	5.8
December	6.3

2.2 TOPOGRAPHY

The broader catchment area in which the site is located is characterised by higher relief rolling hills to the east and north, most noteworthy are Menangle, Sugarloaf and Mount Annan, sloping toward a flatter alluvial terrace in the centre, namely the Nepean River floodplain. There are three distinct drainage creek valleys draining roughly east to west and discharging into the Nepean River.

Referring to Table 3 approximately 60 to 70% of the site is located in reasonably steep terrain with slopes in excess of 2 to 3%.

The hydrological catchment is 43% larger than the study area and the highest relief areas (slopes in excess of 5%) are generally located to the east and north of the study area boundary. The Main Southern Railway line generally traverses the edge of the Nepean flood plain demarcating the eastern edge of the low relief areas.

Table 3 Site Slope Analysis

Slope Range	Percentage of the Study Site
0.0% to 2.0%	18%
2.0% to 5.0%	37%
5.0% to 10.0%	32%
Above 10.0%	13%

Steeper slopes (generally greater than 4%) generally make construction of large regional wetlands and detention basins more difficult, particularly when located off-channel. Steeper slopes (greater than 5 to 10%) generally make construction of flow attenuation via vegetated swales and bio-retention systems less desirable due to excessive flow velocities, reduced detention times and potential scouring.

2.3 WATERWAYS AND CREEKS

The Nepean River bounds the study site in the west and south, and receives discharge from all drainage systems on the Menangle Park site. A large portion of the site area includes the Nepean River and it's floodplain. The Nepean has its headwaters in the Illawarra Range to the west of Wollongong some 60 km to the south of Camden. Upstream of Camden the catchment area of the Nepean River is some 1380 km^2. The 13.5 km^2 Menangle Park catchment only contributes a small percentage of the total runoff arriving at Bergins Weir (located in the Nepean River, adjacent to the Glenlee Washery).

The Nepean River and its floodplain has been subject to a separate study (GHD, 2008), which provides 20-, 50-, 100-year and PMF flooding information.

The site is drained by a number of smaller onsite creeks. All creeks generally drain in a westward direction towards the Nepean River. It is customary to identify significant creeks and drainage channels as those identified as 'blue lines' on the 1 in 25 000 topographic series, subject to site investigation with DECCW representatives and confirmation of extent. Referring to Figure 1, there are five such creeks that are located within the study area. With exception of one creek, the creeks are not named, and for the sake of this report, Table 4 lists a naming convention adopted in previous studies. Also listed are general flooding implications of each creek.

The main catchment draining the site (Creek M – Howes Creek) discharges from the east of the South Western Freeway, through the site to the Nepean River north of Menangle Park Village. This catchment drains approximately 43% of the total site catchment. There are a number of smaller drainage systems, one to the north (Creek N) draining approximately 27% of the northern part of the main study area and two to the south (Creek S1 and S2). Smaller drainage channels discharge local runoff from Menangle Park Village north of the Menangle Park Raceway, and south of the Menangle Park Paceway.

Table 4 Significant Creeks in the Study Area

Name	Approximate Catchment (ha)	Catchment Area within Study Area (ha)	Description
Creek N	370	110	Flooding in upper reaches could affect urban footprint, lower reaches affected by Nepean flooding backwaters
Creek M – Howes Creek	590	380	Flooding in upper reaches could affect urban footprint, lower reaches affected by Nepean flooding backwater
Creek S1	130	95	Flooding in upper reaches could affect urban footprint, lower reaches affected by Nepean flooding backwater
Creek S2	55	30	Entire creek likely to be affected by Nepean flooding backwater
Village Creeks	220	220	Entire creek likely to be affected by Nepean flooding backwater
TOTAL	1365	835	

Along the drainage paths, some creeks discharge under the South Western Freeway, Main Southern Railway and/or Menangle Road. These crossings are achieved via culverts, which could potentially attenuate floods and affect local flood levels on the upstream side of the structure.

Some of the creeks have existing farm dams located along their reaches. These dams generally have small basins. In one instance, a tributary of Creek M, appears to have been diverted to allow discharge to enter an off-channel dam.

Creek slopes are flat (less than 1%) in the Nepean River floodplain, generally to the west of the Main Southern Railway, and Nepean River flood levels and backwater effects dominate flooding in this area.

2.5 RIPARIAN CORRIDORS

The GHD Riparian Areas Assessment for Menangle Park (September 2008) categorised streams (please see Appendix B) in accordance with the Water Management Act. In broad terms, the management objectives of each category were:

- 3rd Order (Category 1) - Environmental Corridor – minimum Core Riparian Zone (CRZ) of 20-40 m from the top of each bank, with a further 10m vegetated buffer to counter edge effects. The entire riparian zone is to consist of local provenance native vegetation with the CRZ including full structural floristics of the endemic vegetation community. Utility services, bushfire asset protection, recreational activities and stormwater treatment facilities etc to be located outside the CRZ;
- 2nd Order (Category 2)- Terrestrial and Aquatic Habitat – minimum CRZ of 20 m from the top of each bank, with a further 10m vegetated buffer to counter edge effects. The entire riparian zone is to consist of local provenance native vegetation, with the CRZ including full structural floristics of the endemic vegetation community. Utility services, recreational activities and stormwater treatment facilities etc to be located outside the CRZ; and
- 1st Order (Category 3) - Bank Stability and Water Quality – CRZ minimum width of 10m from top of each bank on each side of the drainage line and generally no vegetated buffer. Vegetation used in restoration will be of local provenance. Previous planning decisions have, on occasions, enabled 1st order streams to be ‘managed’ like a vegetated buffer and/or incorporated into WSUD initiatives.

2.6 COUNCIL CONSIDERATIONS

Council, over the course of the study, has expressed a range of preferences in terms of formulating the Water Sensitive Urban Design strategy for the precincts. In particular, Council has:

- Reviewed and requested revisions to the sub-catchment break-up;
- Provided preferred parameters for use in hydrological and other models;
- Provided preferred design parameters for water management facilities, such as depths, side slopes and configuration of filter media in bio-retention systems; and
- Provided preferences for co-located precinct scale basins over on-lot treatment.

3 DESIGN CRITERIA

3.1 SUPPORTING DOCUMENTS

Campbelltown (Sustainable City) Development Control Plan 2009 (CCC, 2009), and the NSW Floodplain Development Manual, 2005 define the requirements for management of stormwater quantity, quality and flooding at the precincts.

3.2 LOCAL FLOODING AND STORMWATER QUANTITY MANAGEMENT (DETENTION)

The Campbelltown (Sustainable City) Development Control Plan (CCC, 2009) requires developed flood peaks to match the undeveloped natural peak flow rates for all storm events up to and including the critical duration 100-year ARI event.

Development and land-use in flood prone areas should be in accordance with the Campbelltown (Sustainable City) Development Control Plan and the NSW Floodplain Development Manual. In assessing the flood risk, consideration needs to be given to the full range of risks to people and property, for a full range of flood events up to and including the PMF. Development guidelines specify, amongst others:

- Habitable floor levels of new residences, commercial and industrial developments, together with normally occupied floors of special use developments should either be at or above the Flood Planning Level or be flood proofed to this level. For habitable floor levels, the Flood Planning Level is defined as 300mm above the 100-year ARI level where the flood depth is less than 300mm, and 500mm above the 100-year ARI level where the flood depth is greater than 300mm. The 100-year ARI level is associated with the creeks across the site and any precinct basins or local flood routes, as well as levels defined by flooding in the Nepean River;
- For development in flood storage areas and flood ways, development must not lead to a significant increase in flood levels, flood damages, flood behaviour or flood hazard at the site or elsewhere. Provision of adequate and acceptable compensating works to offset must be provided; and
- Effective evacuation procedures must be provided for all flood prone lands (i.e up to the PMF)

For flooding associated with discharges on internal roads and other areas of concentrated flow, overland flows should be limited to lower flow velocities and depths, thereby reducing the flood hazard. This could be achieved through a detailed design of the subsurface stormwater infrastructure. In addition, areas of elevated velocity (for example in riparian corridors) may require energy dissipation using environmentally acceptable strategies (for example rock protection).

Most of the precinct site area is generally located above PMF levels. Areas that are inundated by the PMF require a flood evacuation strategy. Elevated areas would provide suitable evacuation muster areas.

4 SUPPORTING SIMULATIONS

Numerical modelling was used to assess the local flooding and stormwater quantity management (detention) strategy, which:

- Defined existing condition flood peaks and flood levels for the creeks within the precinct, for a range of design storm events (using RAFTS and TUFLOW); and
- Determined appropriate volumes of detention throughout the precinct, that responded as best possible to the Masterplan, and which throttled post development flood peaks to existing condition flood peaks in accordance with the design criteria (using RAFTS).

4.1 SIMULATING STORMWATER FLOOD HYDROGRAPHS

The Menangle Park area is partially developed and is considered as a rural catchment. Flood peaks and detention requirements were simulated using the RAFTS hydrological model. The RAFTS model was simulated for the 2-year and 100-year ARI events and durations ranging from 25 minutes to 12 hours. For each event the critical duration was reported.

Three RAFTS models were prepared, namely:

- For flood modelling, an existing conditions RAFTS model for the catchments draining to the creeks in Table 4 and associated tributaries discharging through the site (2-year and 100-yr ARI events);
- For sizing of detention basins, an existing conditions RAFTS model for the on site catchments (2-yr, 100-yr and the PMF); and
- For sizing of detention basins, a developed conditions RAFTS model in response to the Masterplan. For the developed condition a number of assumptions in regard to impervious percentages were made. This model was also used to size detention storage requirements to manage the increase in impervious area on account of the development (2-yr and 100-yr ARI events).

Compilation of the RAFTS model included:

- Catchment delineation;
- Hydrological parameter determination; and
- Intensity-Duration-Frequency determination for generating storm rainfall events

Lag times were based on average slopes and flow velocities, ranging between 1 m/s and 2 m/s depending on slope.

Percentages of impervious areas, used in the hydrology model, were as follows:

- Commercial 100%
- Town Centre 95%
- Employment 90%
- 350 to 390 sqm lots 90%
- 540 to 700 sqm lots 80%
- 1000 to 1500 sqm lots 60%
- 2000+ sqm lots 30%
- Heritage 25%
- Open spaces 10%
- Playing Fields 10%

For existing conditions areas, percent of impervious areas were determined from the topographic maps and aerial photography. The modelling parameters are consistent with Appendix B of Council's DCP, Volume 2 (2009). Key parameters for the RAFTS modelling are provided in Table 5, in accordance with Council's DCP. Detailed listings of the RAFTS models are provided in Appendix C.

Table 5 Key Rafts Parameters

Catchment Conditions	Pern n	Initial loss	Continuous loss
Pervious area	0.025	15 mm	2.5 mm/hr
Impervious area	0.015	1.5 mm	0 mm/hr

4.2 SIMULATING FLOOD RISK

Flood levels were simulated for existing conditions using the TUFLOW software. For the hydrological analysis, it was assumed that any future development upstream of the precinct would be required to provide management strategies, which ensure that flood peaks discharging the precincts are maintained at existing conditions, by provision of detention storage within these areas.

The model extent is shown in Appendix D, which includes catchments draining to the creeks in Table 4 and associated tributaries discharging through the site. The TUFLOW model compilation, with key parameters shown in Table 6, was undertaken as follows:

- Available survey data for the local area was imported into a digital terrain-modelling program and triangulated to represent the ground surface;
- A TUFLOW grid was generated with a cell size of 2 m^2. Each point in the grid was given an elevation based on its location in the DTM. The grid size was chosen because this is a compromise between the accuracy of the DTM data, simulation run time, model stability, and the accuracy of the results;
- Supplied cadastral information was imported into GIS and the aerial photography geo-referenced;
- Using aerial photography and surveyed data, the locations of hydraulic structures in the catchment were digitised into strings to form the one-dimensional part of the network;
- The sub-catchments used in the RAFTS hydrologic modelling were applied as "rainfall inflows" over the 2-D model, with inflows distributed and divided over the model grid points; and
- Based on aerial photography and site inspections, hydraulic roughness coefficients for the floodplain were input to the model. These coefficients were digitised into MapInfo as polygons to represent the various surfaces. Table 6 lists the roughness categories used in this model.
- RAFTS storm event hydrographs were used as upstream boundary conditions. Downstream boundary conditions were adopted as per Table 7.
- Coincidental flooding of the Nepean and the local drainage lines are expected and through discussions with Council, it was decided to adopt the 20-yr ARI backwater level of the Nepean for the 100-yr ARI discharge of the on-site creeks. For the 2-yr ARI case, the 5-yr backwater level of the Nepean was adopted. These levels were extracted from the 2008 GHD flood study for the Nepean, and shown in Table 7.

In the absence of corresponding rainfall (hyetograph) and runoff data, calibration of the TUFLOW model was not possible. Furthermore no historic flood markers were available for calibrating of overland flood depths. Calibration of the model was thus limited to checking the sensibility of the overland flow routes and depths, and qualitative comparisons.

Table 6 Key TUFLOW Parameters

Feature	Value
Time step	0.5 seconds
Grid size	2m x 2m
Manning's "n" – sealed roads	0.017
Manning's "n" – unsealed roads or exposed soil/ sand	0.022
Manning's "n" – floodplain short grass	0.03
Manning's "n" – floodplain high grass	0.035
Manning's "n" – light vegetation	0.05
Manning's "n" – private open space	0.06
Manning's "n" – medium vegetation	0.08
Manning's "n" – dense vegetation	0.1
Manning's "n" – houses or fenced areas (zero conveyance)	4

Table 7 Downstream Boundary Conditions for the 2-yr and 100-yr ARI Scenarios

ARI	Village Creeks *	Creek M – Howes Creek *	Creek S1 *
5-yr Nepean Flood Level	73.02 – 73.43 m AHD	72.80 m AHD	73.97 m AHD
20-yr Nepean Flood Level	74.837 – 75.45 m AHD	74.30 m AHD	76.60 m AHD

* These levels were extracted from the 2008 GHD Menangle Flood Study for the Nepean

The flood extents are provided in Appendix D for the 2- and 100-year ARI events and the PMF. It is important to note that the accuracy of the flood maps depends highly on the quality of digital terrain data. The results show that:

- A significant portion of the site is affected by backwater from the Nepean. This Nepean flooding would discharge through the railway culverts and the railway underpass and inundate portions of the site;
- In Creek M – Howes Creek, the 100-yr ARI event is mostly contained within its floodplain, with the flood extending into the precinct boundary during the larger events. The railway culverts attenuate the flood discharge. Should the Nepean River be in flood, backwater could back up through the culverts and define the local flooding;
- The South Western Freeway embankment height is approximately 5 m, resulting in considerable attenuation of the flood peaks from eastern tributaries of Creek M – Howes Creek. During large to extreme events, it is likely that a number of these creeks will combine upstream of the freeway embankment, with potential overflow of the freeway;
- In the 100-yr ARI event, overflow occurs at the South Western Freeway at the location of the 2 x 450 mm and the 2 x 1800 mm diameter culverts. Flows attenuated upstream of the freeway embankment are redistributed to the location of the 2 x 1800 diameter culverts and the freeway overtops by a depth of 1.9 m at its lowest point;

- The northern and southern tributaries of Creek M – Howes Creek convey significant flood flows from the adjacent catchments and these will need to be managed within the stormwater network of the development area with in-ground stormwater pipes and overland flow routes;
- A number of catchments drain through the existing Menangle Park village toward the railway embankment. Most of this flow is expected to be contained on the roads by the kerb and gutter however where there are no kerbs or depths are excessive the flood may discharge through the properties. At the railway embankment, the flood flows combine resulting in some local flooding. While it would appear that the Menangle Park village area is flood affected, flood depths are often shallow (< 50 mm) across a large portion of the village. Flood depths less than 50 mm have been eliminated from the flood extents shown in Appendix D;
- Creek N is mostly contained within its floodplain for the 100-yr ARI event until it discharges onto the Nepean floodplain where its channel capacity will likely be surpassed, resulting in a wide floodplain. Should the Nepean River be in flood, backwater would inundate this part of the floodplain and dominate the flooding;
- Flooding of Creek S1 is contained in the wide channel profile. Should the Nepean River be in flood, backwater would inundate the lower part of the Creek S1 floodplain and dominate the flooding. In addition the possibility of Menangle Road overflow exists with a portion of the Nepean flooding diverting over the road via a low saddle and through the railway underpass at Racecourse Avenue; and
- Some of the lower laying areas of the development would be subject to inundation in a PMF, however the undulating topography and proposed orientation of roads would be expected to provide evacuation routes.

5 WSUD MANAGEMENT STRATEGY

5.1 PRINCIPLES

In general, the principles for stormwater management at the site should aim to retain as much stormwater as possible, treat pollutant entrained in the stormwater, transport as little stormwater as possible to receiving waters, 'lose' as much stormwater as possible along the treatment train and slow the transmission of stormwater to receiving waters. In addition, water usage and water conservation along with maintaining the health of the surrounding environment are important considerations of any proposed development.

5.2 OBJECTIVES

In applying the above principles, the key Water Sensitive Urban design planning and design objectives are:

- To protect and enhance natural water systems in urban developments;
- To integrate stormwater treatment into the landscape by incorporating multiple-use corridors that maximise the visual and recreational amenity of the development;
- To manage water quality from the development;
- To reduce runoff and peak flows from developments by employing local detention measures, minimising impervious areas and maximising re-use; and
- To add value while minimising drainage infrastructure development and ongoing maintenance costs.

The development of a management plan to achieve the above must consider flood management, flow management, water quality management and flow attenuation.

For this project, as stated before, the Water Sensitive Urban Design strategy was to be compiled as two separate consultancies, who liaised to ensure maximised outcomes in managing surface water and flooding. The consultancies were:

- GHD – Nepean flooding, local flooding and stormwater quantity management (detention); and
- Aecom – Stormwater quality management

5.3 SITE OPPORTUNITIES

General opportunities for WSUD at the Menangle Park Site include:

- Maximise source control measures in preference to end of line treatment measures. Manage the quality of stormwater at or near the source, which will involve a significant component of education;
- Orientate roads to traverse contours, providing slopes with grades of 4% or less to promote the provision of above ground conveyance mechanisms such as vegetated swales into the streetscape;
- Maintain and re-establish vegetation along waterways and provide public open space along drainage lines to develop multi-use corridors linking public and private areas;
- Preserve and restore existing valuable elements of the stormwater drainage system such as wetlands, natural channels and riparian vegetation;
- Treatment practices such as precinct scale detention basins co-located with bio-retention in the basin invert, to manage water quality and quantity. These could be provided downstream or close to the point of discharge from development areas, before discharge to key riparian and waterway areas. Furthermore detention basins should be located off-line to riparian corridors; and

- Provide ‘structural’ stormwater quantity and quality management practices that provide flood management, flow attenuation and volume reduction, along with water quality management. Typical structures include detention basins, bioretention facilities, rehabilitated waterways, trunk drainage channels and water re-use schemes.

5.4 MENANGLE PARK WSUD STRATEGY (FLOODING AND STORMWATER QUANTITY MANAGEMENT (DETENTION))

The local flooding and stormwater quantity management (detention) components, of the proposed WSUD strategy for the Menangle Park site are provided in Appendix E. A number of specific “drivers” were identified, which have guided the flooding and stormwater quantity management (detention) strategy development:

- The undulating site topography:
- Requires management of stormwater at a number of discharge points corresponding to existing drainage lines;
- The flatter site topography in the lower reaches:
- Favours larger (precinct scale) co-located bio-retention and detention basins located offline before discharge to riparian corridors;
- Favours opportunistic provision of swales in the street;
- Favours co-located open space and stormwater treatment measures;
- The residential nature of the proposed development:
- Favours opportunistic landscape and bio-retention systems for treating road runoff at a local scale.
- The high likelihood of rainfall occurring in any month throughout the year and the mild seasonal variability:
- Supports utilisation of WSUD vegetated systems such as swales, bio-retention and wetlands to manage stormwater;
- Favours rainwater collection via rainwater tanks depending on roof areas and demands for the captured water;
- The presence of riparian corridors; and
- The potential for lined infiltration based treatment facilities, to manage the groundwater recharge.

5.5 STORMWATER QUANTITY MANAGEMENT (DETENTION)

Referring to Appendix E:

- Environmentally sympathetic drainage channels will be provided along the identified main flow routes. These channels will convey flows up to 100-year ARI storm event and will be vegetated swales;
- Precinct scale co-located detention/ bio-retention systems will be provided at discharge locations to riparian corridors. These systems would comprise a dry basin (to provide detention function) combined with bio-retention (to provide water quality treatment function) situated in the invert of the basin; and
- Rainwater tanks are recommended throughout. The size of the tanks will be decided as part of the lot development. Even though, the purpose of rainwater tanks is for roof water harvesting, they also detain the stormwater flows to a certain extent. However this function was not included in the assessment of detention requirements for the precinct. Installation of rainwater tanks in residential areas in conjunction with recycled water should be further explored. Rainwater would be utilised first with recycled water used to supplement the supply when necessary.

To test the effectiveness of the strategy, detention storage basins were configured in the RAFTS model at key locations and simulated. The results for the entire precinct showed the approximate detention storage requirements presented in Table 8.

Table 9 shows the effectiveness of the detention strategy at a number of locations during the 2- and 100-year ARI event, which are typical events that govern the land take in regards to precinct scale stormwater management facilities. The table shows that the developed flood peaks are suitably throttled.

Table 8 Stormwater Quantity Management (Detention)

Drainage System	Basin (see Appendix E)	Active Detention storage (m^3) * [A]	Upstream + offset treatment area** (ha) [B]	[A] / [B] (m^3/ha)
Creek M – Howes Creek	2	7400	31.9	232
	4	5100	33.7	151
	4a	2100	16.4	128
	5	2900	15.9	182
	6	2800	29.3	95
	12	12700	76.1	167
Creek S1	9	5300	57.3	92
Creek S2	11	1600	20.1	80
Creek N	13	4800	31.4	153
Tributaries west of Menangle Park	7	6200	25.5	243
	8	6900	44.7	154

*Active detention storage is equal to the storage in the basin between the top of the water quality zone and the maximum 100-year ARI event flood level

** offset treatment areas do not drain directly to the basin, however, the basin has been designed to over attenuate so that flows downstream are no greater than pre development levels.

Table 9 Effectiveness of Detention Strategy

Drainage System	100-year Flood Peak (m^3/s) for critical duration			
	Location	Existing	Developed (no mitigation)	Developed with mitigation
Creek M – Howes Creek	Basin 2 outflow	10.5	14.3	8.5
	Basin 4 outflow	11.2	14.9	10.4
	Basin 4a	6.2	8.3	6.0
	Basin 5 outflow	6.6	8.5	6.0
	Basin 6 outflow	10.2	11.9	9.9
	Basin 12 outflow	19.0	25.7	18.2
	D/S of Basins 2, 4, 4a, 5, 6, 12 at the railway	142	136	139
Creek S1	Basin 9 outflow	15.0	16.3	15.0
Creek S2	Basin 11 outflow	7.9	9.6	7.9
Creek N	Basin 13 outflow	10.5	14.2	10.5
Tributaries west of Menangle Park	Basin 7 outflow	8.9	12.4	4.5
	Basin 8 outflow	20.6	26.5	20.4
Drainage System	2-year Flood Peak (m^3/s) for critical duration			
	Location	Existing	Developed (no mitigation)	Developed with mitigation
Creek M – Howes Creek	Basin 2 outflow	2.7	6.7	2.1
	Basin 4 outflow	3.7	6.7	3.1
	Basin 4a	1.9	3.7	1.8
	Basin 5 outflow	2.0	3.3	1.9
	Basin 6 outflow	3.3	5.0	3.2
	Basin 12 outflow	6.0	11.7	5.7
	D/S of Basins 2, 4, 4a, 5, 6, 12 at the railway	46	44	46
Creek S1	Basin 9 outflow	5.1	5.6	4.9
Creek S2	Basin 11 outflow	2.6	3.6	2.4
Creek N	Basin 13 outflow	3.3	6.3	3.2
Tributaries west of Menangle Park	Basin 7 outflow	3.8	5.9	2.6
	Basin 8 outflow	6.1	12.5	6.1

5.6 FLOODING AND FLOOD RISK

Development and land-use in flood prone areas must be in accordance with Campbelltown (Sustainable City) Development Control Plan 2009 (CCC, 2009), and the NSW Floodplain Development Manual.

- All buildings would be located above the Flood Planning Level associated with the creeks across the site and any precinct basins or local flood routes. It is proposed that Flood Planning Levels be adopted that locate floor levels of buildings as defined by the design criteria (Section 3);
- For flooding associated with discharges on internal roads and other areas of concentrated flow, it is proposed to limit the overland flows and lowering flow velocities and depths to reduce the flood hazard. Campbelltown City Council DCP Volume 2 requires a velocity depth product of v x d <0.4. This could be achieved through a detailed design of the subsurface stormwater infrastructure including provision of a larger pipe system. In addition, areas of high velocity (for example in riparian corridors) may require energy dissipation using environmentally acceptable strategies (for example rock protection); and
- Areas that are inundated by the PMF would be provided with a flood evacuation strategy. Elevated areas would provide suitable evacuation muster areas. As shown in Appendix D, some of the lower laying areas of the development would be subject to inundation in a PMF, however the undulating topography and proposed orientation of roads would be expected to provide adequate evacuation routes.

The management of floods and floodplains are the responsibility of Campbelltown City Council. SES is mainly responsible for dealing with floods. Flood planning and land management rest with Council. The main considerations for the evacuation strategy are:

- The areas to be evacuated, which include areas within 500 year ARI flood extents;
- Numbers of people to be evacuated and the time available;
- Muster areas and evacuation routes; and
- Resources and transport means necessary to meet these needs.

Given the timing of flood peaks, the evacuation will be required at short notice. The strategy and operations must be pre-planned during design stages. It is considered, the site has sufficient space and locations to assemble and evacuate during flood events.

5.7 DETAILED DESCRIPTION OF STORMWATER MANAGEMENT STRATEGY

Referring to Appendix E the table below discusses the stormwater strategy on a basin by basin and catchment by catchment basis.

Table 10 Stormwater Quantity Management (detention) (see Appendix E for basin locations)

Basin	Contributing Catchments	Offset Catchments	Inflow source	Outflow
2	M63, M64, M67, M68, M69, M70		Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed to the basin from the south and south-east via the pipe drainage network and overland flows in the road network. Fill will be required directly to the east of the basin to direct overland flows to the basin. The road network adjacent to Basin 12 will be graded such that runoff from catchments M63 and M64 is directed past Basin 12 towards Basin 2.	Flow released to Creek M – Howes Creek
4	M42, M43, M44, M45, M46, M50,		Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed from the north via the pipe drainage network and	Flow released to Creek M – Howes Creek

Basin	Contributing Catchments	Offset Catchments	Inflow source	Outflow
	M51		overland flows in the road network before passing under the proposed Spring Farm Parkway via a culvert/culverts and discharging into the basin.	
4a	M47, M48, M49		Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed to the basin from the east and north-east via the pipe drainage network and overland flows in the road network.	Outflow released to Creek M – Howes Creek via a culvert/culverts under the proposed Spring Farm Parkway
5	M26, M27, M28, M29, M30		Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed to the basin from the North.Runoff from the east of the freeway passing under the culvert adjacent to the basin will bypass the basin via a 10 m wide 0.6 m deep open channel.	Flow released to Creek M – Howes Creek
6	M33, M34, M35, M36, M37, M38		Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed to the basin from the south via the pipe drainage network and overland flows in the road network. The basin will be placed off-line from upstream flows from east of the freeway such that these flows bypass the basin via a riparian corridor.	Flow released to the riparian corridor that bypasses the basin
7	V17, V18, V19, V20, V21		Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed to the basin from the north and east via the pipe drainage network and overland flows in the road network. Racecourse Avenue will be regraded to ensure that the 100-year ARI event can be conveyed from the north via overland flow in the road network.	Flow released to the Nepean floodplain via the 3x600 and 3x900 culverts underneath the railway corridor. The basin is designed to meet the capacities of these culverts. The discharge from the 3x900 culverts could be conveyed using a channel (with dimensions 12.5 m top width, 4 m base width, 0.55 flow depth with a 0.5 m freeboard) to the Nepean River. the location of this swale would need to be incorporated in any future Harness Racing Park masterplan
8	V1, V7, V8, V9, V10, V11, V12, V13, V14	V2. V3	Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed to the basin from the east and north-east via the pipe drainage network and overland flows in the road network. Racecourse Avenue will be regraded to ensure that the 100-year ARI event can be conveyed from the north via overland flow in the road network. The Culverts underneath the railway corridor to the north of the basin will be closed such that runoff is directed southwards towards the basin rather than passing under the railway.	Flow released to the Nepean floodplain via a trunk drainage channel to the existing channel under the railway In discussion with Council (21/04/2010) it has been agreed that the access road to Harness Racing Park need not conform to Councils DCP in terms of drainage serviceability.

Basin	Contributing Catchments	Offset Catchments	Inflow source	Outflow
			In discussion with Council (21/04/2010) it was noted that a portion of Racecourse Avenue and adjacent lots could potentially be offset, should it not be desirable to grade these areas to Basin 8 using fill. This would be achieved by overcompensating in Basin 8 and allowing the small Racecourse Avenue catchment to bypass the basin. While this has not been simulated, it is expected to have a minor effect on the basin footprint.	
9	S6, S7, S8, S9, S10, S12, S13, S15, S17, S18	S5, S11, S14, S16	The basin will be located offline from Creek S1 on the north side of the creek. The basin will collect runoff from the north of the creek and offset runoff flows from the south of the creek rather than directing these flows to the basin. Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed to the basin from the east via the pipe drainage network and overland flows in the road network. Fill will be required to the east of the basin to remove the natural low point in the topography and direct flows to the basin.	Basin outflow released directly to Creek S1. Offset flows to drain to the creek without any water quantity treatment.
11	Sa3, Sa4, Sa5, Sa6		Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed to the basin from the north-west and north-east via the pipe drainage network and overland flows in the road network. Fill will be required to the west of the basin to direct overland flows to the basin.	Flow released to Creek S2
12	M53, M54, M55, M56, M57, M58, M59, M60, M61, M62, M65	M40	Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed to the basin via a trunk drainage channel. The pipe drainage network and overland flows in the road network will be directed to discharge to the channel or directly to the basin. Runoff from Catchment M40 will not be directed to the basin but will be offset for water quantity through over-treating of flows entering the basin.	Flow released to Creek M – Howes Creek. Offset flows to drain to the creek without any water quantity treatment
13	N15, N16,N17, N18, N19		Runoff from contributing catchments for flows up to the 100-year ARI Event will be conveyed to the basin from the east and north-east via the pipe drainage network and overland flows in the road network.	Flow released to Creek N via a culvert/culverts underneath the railway alignment.

5.7.1 Railway Culverts

There are a number of existing railway culverts that are proposed to convey the outflow from the basins located immediately east of the railway (Basin 13, 7, and 8). The capacity to convey the outflows from these basins are predominantly governed by the tailwater level from the 20-yr ARI Nepean River flooding. Table 11 shows the capacities of the culverts and the tailwater levels used. The locations of these culverts are shown in Appendix E.

Culvert capacities are summarised below:

- The 3650 x 3930 culvert is able to adequately convey the outflow from Basin 13.
- The outflow from Basin 7 is over throttled to meet the capacities of the 3 x 600 and 3 x 900 culverts. Low flows are piped to the 3 x 600 culverts, whilst higher flows are conveyed by the 3 x 900 culverts.
- The 1500 diameter culvert has a depth of approximately 7 m at the tailwater, as a result of the Nepean flooding; consequently, this culvert has no capacity for conveying outflows from the basins.

Table 11 Culvert Information

Culvert Dimensions (mm)	Conveying outflow from	Tailwater level (mAHD) – 20-yr ARI flood level from Nepean River	Capacity (m^3/s)
3650 x 3930	Basin 13	80.9	13.26
3 x 900	Basin 7	77.6	3.86
3 x 600	Basin 7	76.3	0.47
1500 diameter	Basin 8	76.07	n/a

5.8 CONSIDERATION OF TOTAL LIFE CYCLE COSTS

GHD has proposed precinct scale co-located bio-retention/detention basins to manage stormwater water quantity and quality. These systems achieve the following common goals:

- The treatment area is optimised. Total land acquisition cost is minimised;
- The area could be landscaped without hindering its function; and
- Annual maintenance cost would be less compared to open water bodies such as wetland.

GHD has proposed trunk drainage channels at a number of locations. These are open channels system, which could be designed to treat water quality with low capital and maintenance costs. At this stage, any water quality treatments along arterial and local roads and at individual lots are not considered.

6 WSUD CONCEPT DESIGN AND COSTING

6.1 BACKGROUND

To assist in better determining the Section 94 contributions for the trunk stormwater infrastructure and water sensitive design facilities, concept design was undertaken. These concept designs were prepared for:

- Sizing of detention basins; and
- Consideration of diversions and/or other engineered trunk drainage creeks.

The level of detail for the concept designs was discussed and approved by Council.

6.2 CONCEPT DESIGN METHODOLOGY

The methodology for the basin concept designs was the following:

- First-cut estimate of basin designs was undertaken to check volumes, using 3D ground modelling software (12D);
- Revised estimate of basin designs was undertaken to check volumes, using 3D ground modelling software (12D);
- Workshop were held with the planners, to finalise basin positions in the context of the master planning;
- Final estimate of basin design was undertaken to confirm position and balance cut versus fill, plus confirmation of volume. In some instances this required adjustment of existing ground terrain to remove existing dams;
- Hydraulic concept design of outlet structures and spillways, using spreadsheets and RAFTS modelling. Multi-staged outlet dimensions were confirmed where required; and
- The concept design civil elements were transferred to CAD.

The methodology for the engineered trunk drainage creeks was the following:

- Creek vertical alignment to correspond with upstream and downstream inverts determined;
- The engineered trunk drainage channel was configured within 3D ground modelling software (12D); and
- The concept design civil elements were transferred to CAD.

6.3 CONCEPT DESIGN PARAMETERS

Key design parameters for the basins and drainage channels were determined in consultation with Council. These included:

- Embankment side slopes of 1:6;
- Active storage depths in basins of 1.2m;
- Extended storage depths over bio-retention media in basin inverts of 0.3m;
- Freeboard above 100-year ARI basin level of 0.5m;
- Basin low flow outlets to consist of pit and pipe configuration, and in some instances dual pit and pipe. When high flow required larger capacity, a box culvert configuration (or multiples of) were used;
- Minimum channel slope of 0.5%;
- Minimum channel side slopes of 1:4 as agreed with Council (21/04/2010); and
- Channels designed for 1 in 100yr ARI flow containment, with 0.5m freeboard allowance.

6.4 CONCEPT COSTING

A note on costs

The preliminary cost estimates presented in this section have been developed for the purposes of comparing options and may be used for preliminary budgeting. They are not to be used for any other purpose. The scope and quality of the works has not been fully defined and therefore the estimates are not warranted by GHD. These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. A functional design is recommended for budget setting purposes.

The concept designs were used to undertake the costing for Section 94 contribution purposes. The typical line items used for the costing were confirmed and approved by Council. GHD were not required to assess any existing utilities in terms of design and costing. Unit rates used in this costing was taken from Rawlinsons Australian Construction Handbook, Edition 26, 2008 and engineer's estimates.

Table 12 Concept Costing

DESCRIPTION		AMOUNT	
Detention Basins			
Basin 2		$	1,188,000
Basin 4		$	1,227,000
Basin 4a		$	738,000
Basin 5		$	736,000
Basin 6		$	866,000
Basin 7		$	1,115,000
Basin 8		$	1,582,000
Basin 9		$	1,027,000
Basin 11		$	861,000
Basin 12		$	1,720,000
Basin 13		$	1,261,000
	Subtotal for Detention Basins	$	12,221,000
Trunk Drainage			
Trunk Drainage leading into Basin 12		$	1,398,000
	Subtotal for Trunk Drainage	$	1,398,000
	TOTAL (Excl-GST)	$	13,619,000

7 SUMMARY AND CONCLUSIONS

- A number of opportunities for management of stormwater quality, quantity and flooding exist at the Menangle Park site. This management would benefit from the implementation of Water Sensitive Urban Design (WSUD) practices. WSUD encompasses all aspects of urban water cycle management including water supply, wastewater and stormwater management, that promotes opportunities for linking water infrastructure, landscape design and the urban built form to minimize the impacts of development upon the water cycle and achieve sustainable outcomes;
- The Water Sensitive Urban Design strategy was to be compiled as two separate consultancies, who liaised to ensure maximised outcomes in managing surface water and flooding. The consultancies were GHD for the Nepean flooding, local flooding and stormwater quantity management (detention); and Aecom for stormwater quality management;
- The objectives of this study are to report on local flooding and stormwater quantity management (detention) strategies. The Nepean flooding has been reported on in a separate report (GHD, 2008).
- A WSUD strategy for management of flooding and stormwater quantity (detention) has been developed for the site that nominates:
    - Environmentally sympathetic drainage channels along the identified main flow routes. The required width of the vegetated swales varies, according to the conveyed flows. These channels will convey flows up to 100-year ARI storm event and will be vegetated swales;
    - Precinct scale co-located detention/ bio-retention basins at key locations to treat the quantity and quality of stormwater flows. These systems would essentially comprise a dry basin (to provide detention function) combined with bio-retention (to provide water quality treatment function) situated in the invert of the basin.
    - Rainwater tanks throughout, as required and as appropriate.
- Development and land-use in flood prone areas management in accordance with the Campbelltown (Sustainable City) Development Control Plan and the NSW Floodplain Development Manual. Generally this would require:
    - All buildings would be located above the Flood Planning Level associated with the creeks across the site and any precinct basins or local flood routes. It is proposed that Flood Planning Levels be adopted that locate floor levels of buildings with a freeboard of 300 mm to 500 mm (depending on flow depth) above 100-year ARI flood levels; and
    - Flood evacuation planning for all areas designated flood prone land.
- To test the effectiveness of the WSUD strategy, numerical modelling was used as follows:
    - Flood peaks and flood levels for the creeks within the precinct were determined using RAFTS and TUFLOW;
    - Volumes of detention that responded as best possible to the Masterplan and which throttled flood peaks were determined using RAFTS; and
- The results of the numerical modelling have shown that the proposed flooding and stormwater quantity management (detention) strategy together with the flood plain management adequately satisfies the requirements of the Campbelltown (Sustainable City) Development Control Plan and the NSW Floodplain Development Manual for management of stormwater quantity and flooding at the site.

8 REFERENCES

- Campbelltown City Council 2009, Campbelltown (Sustainable City) Development Control Plan 2009 Volume 2 Engineering Design For Development, June 2009
- Department of Environment and Climate Change (DECC) 2006, Western Sydney Growth Centres – Stormwater Guidance for Precinct Planning, November 2006
- GHD 2008 Menangle Park Flood Study September 2008 Rev 4
- Institution of Engineers Australia 2001, Australian Rainfall and Runoff
- Landcom 2004, Soils and Construction, Managing Urban Stormwater, March 2004
- NSW Government, Floodplain Development Manual, 2005
- Rawlinsons 2008, Australian Construction Handbook Edition 26, Rawlinsons Publishing
- BMT WBM, 2008, TUFLOW User Manual 2008 (Build 2008-08-AA)
- XP Software 1994, XP-RAFTS User Manual

Appendix A – Master Plan

- 350 - 390 sqm lots
- 540 - 700 sqm lots
- 1000 - 1500 sqm lots
- 2000+ sqm lots
- Private Open Space
- Town Centre
- Community Use
- Open Space
- Riparian
- Private Recreation
- Rural
- Heritage
- Employment
- Transgrid
- Collector Roads

menanglepark	See Visual Scale	Urbis	Menangle Park
	10 03 04 Structure Plan.indd	24/05/2010 ISSUE 11	DRAFT Revised Structure Plan

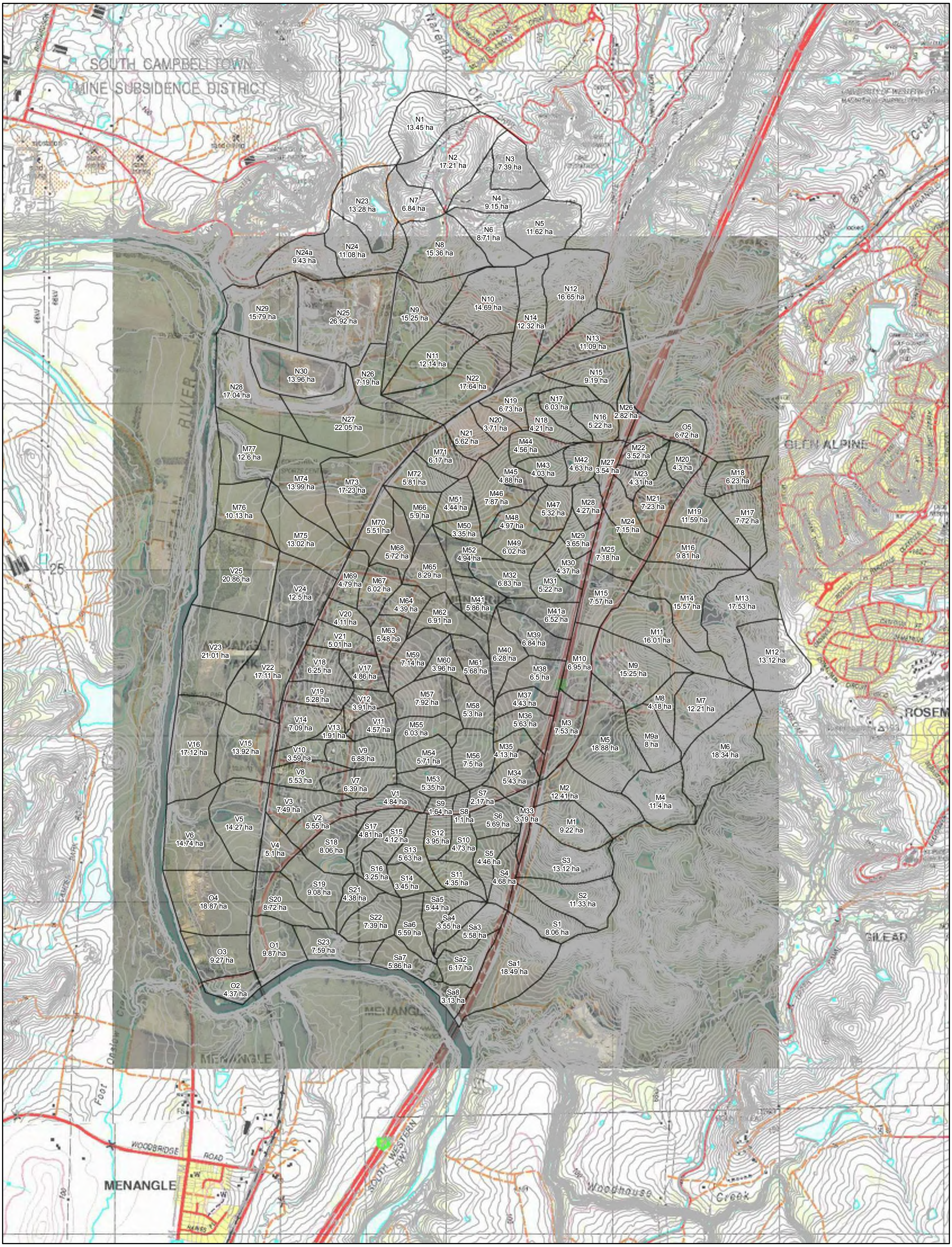
PROJECT PARTNERS campbelltown city council LANDCOM

DRAFT

Appendix B – Riparian Corridors


Mt. Annan Botanic Gardens
NORTH 3
NORTH 2
NORTH 1
CATEGORY 2
CATEGORY 3
South Western Freeway
MIDDLE 3
MIDDLE 1
MIDDLE 2
MIDDLE 4
CATEGORY 1
Nepean River
SOUTHERN 3
SOUTHERN 1
SOUTHERN 2

Appendix C – RAFTS Modelling



1:20,000 at A3

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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GHD

Campbelltown City Council/Landcom
Menangle Park Local Flooding and Detention

RAFTS Catchments

Job Number	21-15581
Revision	A
Date	20th Jan 2010

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Existing Case - Subcatchments for Flood Study

South Creek

Subcatchment	Area (ha)	Impervious Catchment (ha)	Pervious Catchment (ha)	Slope (%)	Impervious Mannings n	Pervious Mannings n
S1	8.06	0.40	7.66	7.4	0.015	0.025
S2	11.33	0.57	10.76	11.4	0.015	0.025
S3	13.12	0.66	12.46	7.6	0.015	0.025
S4	4.68	0.47	4.21	12.1	0.015	0.025
S5	4.47	0.00	4.47	7.2	0.015	0.025
S6	5.69	0.00	5.69	7.5	0.015	0.025
S7	2.17	0.00	2.17	13.1	0.015	0.025
S8	1.10	0.00	1.10	12.9	0.015	0.025
S9	1.64	0.00	1.64	6.8	0.015	0.025
S10	4.73	0.00	4.73	8.8	0.015	0.025
S11	4.34	0.00	4.34	10.5	0.015	0.025
S12	3.95	0.00	3.95	7.6	0.015	0.025
S13	5.65	0.00	5.65	8.0	0.015	0.025
S14	3.45	0.00	3.45	4.9	0.015	0.025
S15	4.12	0.00	4.12	6.5	0.015	0.025
S16	3.25	0.00	3.25	7.7	0.015	0.025
S17	4.73	0.00	4.73	5.9	0.015	0.025
S18	8.14	0.00	8.14	4.9	0.015	0.025
S19	9.08	0.09	8.99	2.3	0.015	0.025
S20	8.72	0.87	7.85	1.8	0.015	0.025
S21	4.38	0.04	4.34	6.0	0.015	0.025
S22	7.39	0.00	7.39	6.5	0.015	0.025
S23	7.59	0.00	7.59	3.0	0.015	0.025
Sa1	18.49	1.85	16.64	9.4	0.015	0.025
Sa2	6.17	0.31	5.86	6.2	0.015	0.025
Sa3	5.58	0.28	5.30	8.9	0.015	0.025
Sa4	3.55	0.00	3.55	14.0	0.015	0.025
Sa5	5.44	0.00	5.44	7.5	0.015	0.025
Sa6	5.59	0.00	5.59	4.9	0.015	0.025
Sa7	5.86	0.00	5.86	3.0	0.015	0.025
Sa8	3.13	0.00	3.13	6.8	0.015	0.025

Howes Creek

Subcatchment	Area (ha)	Impervious Catchment (ha)	Pervious Catchment (ha)	Slope (%)	Impervious Mannings n	Pervious Mannings n
M1	9.22	0.46	8.76	14.8	0.015	0.025
M2	12.41	0.62	11.79	9.7	0.015	0.025
M3	7.50	0.75	6.75	2.5	0.015	0.025
M4	11.40	0.00	11.40	13.2	0.015	0.025
M5	18.88	0.94	17.94	4.0	0.015	0.025
M6	18.34	0.00	18.34	11.6	0.015	0.025
M7	12.21	0.00	12.21	23.1	0.015	0.025
M8	4.18	0.00	4.18	12.8	0.015	0.025
M9	15.25	6.10	9.15	4.4	0.015	0.025
M9a	8.00	0.00	8.00	14.0	0.015	0.025
M10	6.95	0.35	6.60	2.1	0.015	0.025
M11	16.01	0.00	16.01	7.0	0.015	0.025
M12	13.12	0.00	13.12	8.0	0.015	0.025

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Subcatchment	Area (ha)	Impervious Catchment (ha)	Pervious Catchment (ha)	Slope (%)	Impervious Mannings n	Pervious Mannings n
M13	17.53	0.88	16.65	11.9	0.015	0.025
M14	15.57	0.00	15.57	2.9	0.015	0.025
M15	7.57	0.38	7.19	1.7	0.015	0.025
M16	9.81	1.47	8.34	12.7	0.015	0.025
M17	7.72	1.54	6.18	11.8	0.015	0.025
M18	6.23	2.49	3.74	7.5	0.015	0.025
M19	11.59	1.16	10.43	11.8	0.015	0.025
M20	4.30	0.00	4.30	6.6	0.015	0.025
M21	7.23	0.72	6.51	3.4	0.015	0.025
M22	3.52	0.18	3.34	8.6	0.015	0.025
M23	4.31	0.65	3.66	8.0	0.015	0.025
M24	7.15	0.36	6.79	4.8	0.015	0.025
M25	7.18	0.36	6.82	2.5	0.015	0.025
M26	2.82	0.14	2.68	3.1	0.015	0.025
M27	3.54	0.53	3.01	5.0	0.015	0.025
M28	4.27	0.21	4.06	11.0	0.015	0.025
M29	3.65	0.18	3.47	3.6	0.015	0.025
M30	4.37	0.22	4.15	6.4	0.015	0.025
M31	5.22	0.26	4.96	5.6	0.015	0.025
M32	6.83	0.00	6.83	4.2	0.015	0.025
M33	3.19	0.96	2.23	10.2	0.015	0.025
M34	5.43	0.27	5.16	6.9	0.015	0.025
M35	4.13	0.21	3.92	8.1	0.015	0.025
M36	5.63	0.28	5.35	6.9	0.015	0.025
M37	4.43	0.22	4.21	5.2	0.015	0.025
M38	6.50	0.33	6.18	4.5	0.015	0.025
M39	6.84	0.34	6.50	2.3	0.015	0.025
M40	6.28	0.00	6.28	3.6	0.015	0.025
M41	5.86	0.00	5.86	2.5	0.015	0.025
M41a	6.52	0.33	6.19	3.0	0.015	0.025
M42	4.63	0.46	4.17	11.7	0.015	0.025
M43	4.03	0.00	4.03	5.0	0.015	0.025
M44	4.56	0.00	4.56	6.4	0.015	0.025
M45	4.88	0.00	4.88	7.7	0.015	0.025
M46	7.87	0.00	7.87	5.9	0.015	0.025
M47	5.32	0.27	5.05	10.2	0.015	0.025
M48	4.97	0.25	4.72	5.6	0.015	0.025
M49	6.02	0.00	6.02	4.4	0.015	0.025
M50	3.35	0.00	3.35	7.0	0.015	0.025
M51	4.44	0.00	4.44	11.4	0.015	0.025
M52	4.94	0.00	4.94	3.1	0.015	0.025
M53	5.35	0.00	5.35	7.2	0.015	0.025
M54	5.71	0.00	5.71	5.4	0.015	0.025
M55	6.03	0.00	6.03	4.9	0.015	0.025
M56	7.50	0.00	7.50	7.9	0.015	0.025
M57	7.92	0.00	7.92	8.2	0.015	0.025
M58	5.30	0.00	5.30	5.8	0.015	0.025
M59	7.14	0.00	7.14	4.8	0.015	0.025
M60	3.96	0.00	3.96	3.8	0.015	0.025
M61	5.68	0.00	5.68	3.0	0.015	0.025
M62	6.91	0.00	6.91	3.0	0.015	0.025

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Subcatchment	Area (ha)	Impervious Catchment (ha)	Pervious Catchment (ha)	Slope (%)	Impervious Mannings n	Pervious Mannings n
M63	5.48	1.10	4.38	5.0	0.015	0.025
M64	4.39	0.66	3.73	3.0	0.015	0.025
M65	8.29	0.00	8.29	2.3	0.015	0.025
M66	5.90	0.00	5.90	1.0	0.015	0.025
M67	6.02	0.90	5.12	3.8	0.015	0.025
M68	5.72	0.00	5.72	2.6	0.015	0.025
M69	4.79	0.72	4.07	2.6	0.015	0.025
M70	5.51	0.55	4.96	2.5	0.015	0.025
M71	6.17	0.62	5.55	7.9	0.015	0.025
M72	5.81	0.58	5.23	8.4	0.015	0.025
M73	17.23	1.72	15.51	1.5	0.015	0.025
M74	13.99	0.00	13.99	2.7	0.015	0.025
M75	13.02	0.65	12.37	2.4	0.015	0.025
M76	10.13	0.00	10.13	1.5	0.015	0.025
M77	12.60	0.00	12.60	1.0	0.015	0.025
North Creek						
Subcatchment	**Area (ha)**	**Impervious Catchment (ha)**	**Pervious Catchment (ha)**	**Slope (%)**	**Impervious Mannings n**	**Pervious Mannings n**
N1	13.45	0.00	13.45	4.6	0.015	0.025
N2	17.21	0.00	17.21	7.7	0.015	0.025
N3	7.39	0.00	7.39	10.3	0.015	0.025
N4	9.15	0.00	9.15	4.2	0.015	0.025
N5	11.62	0.00	11.62	8.5	0.015	0.025
N6	8.71	0.00	8.71	21.3	0.015	0.025
N7	6.84	0.00	6.84	13.0	0.015	0.025
N8	15.36	1.54	13.82	23.1	0.015	0.025
N9	15.25	0.76	14.49	9.4	0.015	0.025
N10	14.69	0.00	14.69	19.1	0.015	0.025
N11	12.14	0.61	11.53	4.2	0.015	0.025
N12	16.65	0.83	15.82	11.2	0.015	0.025
N13	11.09	0.56	10.54	8.8	0.015	0.025
N14	12.32	0.62	11.70	14.0	0.015	0.025
N15	9.19	0.00	9.19	5.1	0.015	0.025
N16	5.22	0.00	5.22	7.4	0.015	0.025
N17	6.03	0.00	6.03	10.4	0.015	0.025
N18	4.21	0.00	4.21	9.2	0.015	0.025
N19	6.73	0.00	6.73	10.3	0.015	0.025
N20	3.71	0.00	3.71	9.7	0.015	0.025
N21	5.62	0.00	5.62	9.4	0.015	0.025
N22	17.64	0.88	16.76	5.0	0.015	0.025
N23	13.28	0.00	13.28	10.5	0.015	0.025
N24	11.08	1.11	9.97	14.5	0.015	0.025
N24a	9.79	0.94	8.85	14.5	0.015	0.025
N25	26.93	17.51	9.43	2.7	0.015	0.025
N26	7.19	0.36	6.83	2.0	0.015	0.025
N27	22.05	1.10	20.95	3.7	0.015	0.025
N28	17.04	5.11	11.93	3.5	0.015	0.025
N29	15.79	10.26	5.53	3.5	0.015	0.025
N30	13.96	9.07	4.89	0.1	0.015	0.025

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Subcatchment	Area (ha)	Impervious Catchment (ha)	Pervious Catchment (ha)	Slope (%)	Impervious Mannings n	Pervious Mannings n
Village Creeks						
Subcatchment	**Area (ha)**	**Impervious Catchment (ha)**	**Pervious Catchment (ha)**	**Slope (%)**	**Impervious Mannings n**	**Pervious Mannings n**
v1	4.84	0.73	4.11	4.7	0.015	0.025
v2	5.55	1.67	3.89	5.6	0.015	0.025
v3	7.49	0.75	6.74	5.3	0.015	0.025
v4	5.10	1.02	4.08	4.3	0.015	0.025
v5	14.27	1.43	12.84	4.8	0.015	0.025
v6	14.74	1.47	13.27	5.0	0.015	0.025
v7	6.39	1.28	5.11	7.5	0.015	0.025
v8	5.53	1.94	3.60	3.5	0.015	0.025
v9	6.88	0.69	6.19	6.6	0.015	0.025
v10	3.59	1.08	2.51	2.2	0.015	0.025
v11	4.57	0.69	3.89	8.3	0.015	0.025
v12	3.91	0.78	3.13	5.8	0.015	0.025
v13	1.91	0.38	1.53	4.5	0.015	0.025
v14	7.09	1.77	5.32	6.0	0.015	0.025
v15	13.92	1.39	12.53	1.0	0.015	0.025
v16	17.12	1.71	15.41	2.7	0.015	0.025
v17	4.86	1.46	3.40	5.1	0.015	0.025
v18	6.25	1.88	4.38	7.6	0.015	0.025
v19	5.28	1.58	3.70	7.7	0.015	0.025
v20	4.11	0.62	3.49	2.6	0.015	0.025
v21	5.01	1.50	3.51	3.8	0.015	0.025
v22	17.11	3.42	13.69	2.8	0.015	0.025
v23	21.01	4.20	16.81	1.4	0.015	0.025
v24	12.50	0.63	11.88	3.3	0.015	0.025
v25	20.86	2.09	18.77	1.3	0.015	0.025
O1	9.87	0.99	8.88	2.0	0.015	0.025
O2	4.37	0.44	3.93	3.0	0.015	0.025
O3	9.27	1.85	7.42	2.4	0.015	0.025
O4	18.87	5.66	13.21	2.7	0.015	0.025
O5	6.72	0.34	6.38	8.0	0.015	0.025

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Developed Case - Subcatchments for Flood Study

South Creek

Subcatchment	Area (ha)	Impervious Catchment (ha)	Pervious Catchment (ha)	Slope (%)	Impervious Mannings n	Pervious Mannings n
S1	8.06	0.40	7.66	7.4	0.015	0.025
S2	11.33	0.57	10.76	11.4	0.015	0.025
S3	13.12	0.66	12.46	7.6	0.015	0.025
S4	4.68	3.30	1.38	12.1	0.015	0.025
S5	4.47	2.41	2.06	7.2	0.015	0.025
S6	5.69	3.66	2.03	7.5	0.015	0.025
S7	2.17	1.37	0.80	13.1	0.015	0.025
S8	1.10	0.74	0.36	12.9	0.015	0.025
S9	1.64	0.98	0.66	6.8	0.015	0.025
S10	4.73	3.29	1.44	8.8	0.015	0.025
S11	4.36	2.92	1.44	10.5	0.015	0.025
S12	3.95	2.86	1.09	7.6	0.015	0.025
S13	5.63	3.83	1.80	8.0	0.015	0.025
S14	3.45	2.17	1.28	4.9	0.015	0.025
S15	4.12	3.32	0.80	6.5	0.015	0.025
S16	3.25	1.37	1.89	7.7	0.015	0.025
S17	4.73	3.03	1.70	5.9	0.015	0.025
S18	8.14	3.99	4.15	4.9	0.015	0.025
S19	9.08	0.91	8.17	2.3	0.015	0.025
S20	8.72	0.87	7.85	1.8	0.015	0.025
S21	4.38	1.14	3.24	6.0	0.015	0.025
S22	7.39	1.89	5.50	6.5	0.015	0.025
S23	7.59	0.76	6.83	3.0	0.015	0.025
Sa1	18.49	1.85	16.64	9.4	0.015	0.025
Sa2	6.17	1.42	4.75	6.2	0.015	0.025
Sa3	5.58	1.73	3.85	8.9	0.015	0.025
Sa4	3.55	1.46	2.09	14.0	0.015	0.025
Sa5	5.44	3.37	2.07	7.5	0.015	0.025
Sa6	5.59	2.68	2.91	4.9	0.015	0.025
Sa7	5.86	0.59	5.27	3.0	0.015	0.025
Sa8	3.13	0.44	2.69	6.8	0.015	0.025

Village Creeks

Subcatchment	Area (ha)	Impervious Catchment (ha)	Pervious Catchment (ha)	Slope (%)	Impervious Mannings n	Pervious Mannings n
M1	9.22	0.46	8.76	14.8	0.015	0.025
M2	12.41	0.62	11.79	9.7	0.015	0.025
M3	7.50	2.48	5.03	2.5	0.015	0.025
M4	11.40	0.00	11.40	13.2	0.015	0.025
M5	18.88	0.94	17.94	4.0	0.015	0.025
M6	18.34	0.00	18.34	11.6	0.015	0.025
M7	12.21	0.00	12.21	23.1	0.015	0.025
M8	4.18	0.00	4.18	12.8	0.015	0.025
M9	15.25	6.10	9.15	4.4	0.015	0.025
M9a	8.00	0.00	8.00	14.0	0.015	0.025
M10	6.95	2.29	4.66	2.1	0.015	0.025
M11	16.01	0.00	16.01	7.0	0.015	0.025
M12	13.12	0.00	13.12	8.0	0.015	0.025

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Subcatchment	Area (ha)	Impervious Catchment (ha)	Pervious Catchment (ha)	Slope (%)	Impervious Mannings n	Pervious Mannings n
M13	17.53	0.88	16.65	11.9	0.015	0.025
M14	15.57	0.00	15.57	2.9	0.015	0.025
M15	7.57	2.50	5.07	1.7	0.015	0.025
M16	9.81	1.47	8.34	12.7	0.015	0.025
M17	7.72	1.54	6.18	11.8	0.015	0.025
M18	6.23	2.49	3.74	7.5	0.015	0.025
M19	11.59	1.16	10.43	11.8	0.015	0.025
M20	4.30	1.42	2.88	6.6	0.015	0.025
M21	7.23	2.39	4.84	3.4	0.015	0.025
M22	3.52	1.16	2.36	8.6	0.015	0.025
M23	4.31	0.65	3.66	8.0	0.015	0.025
M24	7.15	2.36	4.79	4.8	0.015	0.025
M25	7.18	2.37	4.81	2.5	0.015	0.025
M26	2.82	2.41	0.41	3.1	0.015	0.025
M27	3.54	2.23	1.31	5.0	0.015	0.025
M28	4.27	2.69	1.58	11.0	0.015	0.025
M29	3.65	2.30	1.35	3.6	0.015	0.025
M30	4.37	2.08	2.29	6.4	0.015	0.025
M31	5.22	2.30	2.92	5.6	0.015	0.025
M32	6.83	3.11	3.72	4.2	0.015	0.025
M33	3.19	1.91	1.28	10.2	0.015	0.025
M34	5.43	3.42	2.01	6.9	0.015	0.025
M35	4.13	2.73	1.40	8.1	0.015	0.025
M36	5.63	3.83	1.80	6.9	0.015	0.025
M37	4.43	3.46	0.97	5.2	0.015	0.025
M38	6.50	3.61	2.89	4.5	0.015	0.025
M39	6.84	1.20	5.64	2.3	0.015	0.025
M40	6.28	5.12	1.16	3.6	0.015	0.025
M41	5.86	2.31	3.55	2.5	0.015	0.025
M41a	6.52	1.17	5.35	3.0	0.015	0.025
M42	4.63	2.92	1.71	11.7	0.015	0.025
M43	4.03	2.80	1.23	5.0	0.015	0.025
M44	4.56	3.15	1.41	6.4	0.015	0.025
M45	4.88	3.68	1.20	7.7	0.015	0.025
M46	7.87	6.12	1.76	5.9	0.015	0.025
M47	5.32	3.83	1.49	10.2	0.015	0.025
M48	4.97	3.68	1.29	5.6	0.015	0.025
M49	6.02	5.09	0.93	4.4	0.015	0.025
M50	3.35	2.18	1.17	7.0	0.015	0.025
M51	4.44	3.55	0.89	11.4	0.015	0.025
M52	4.94	1.38	3.56	3.1	0.015	0.025
M53	5.35	4.20	1.15	7.2	0.015	0.025
M54	5.71	4.68	1.03	5.4	0.015	0.025
M55	6.03	5.07	0.96	4.9	0.015	0.025
M56	7.50	5.66	1.84	7.9	0.015	0.025
M57	7.92	6.61	1.31	8.2	0.015	0.025
M58	5.30	4.32	0.98	5.8	0.015	0.025
M59	7.14	5.82	1.32	4.8	0.015	0.025
M60	3.96	2.53	1.43	3.8	0.015	0.025
M61	5.68	4.46	1.22	3.0	0.015	0.025
M62	6.91	4.46	2.45	3.0	0.015	0.025

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Subcatchment	Area (ha)	Impervious Catchment (ha)	Pervious Catchment (ha)	Slope (%)	Impervious Mannings n	Pervious Mannings n
M63	5.48	4.47	1.01	5.0	0.015	0.025
M64	4.39	3.58	0.81	3.0	0.015	0.025
M65	8.29	3.56	4.73	2.3	0.015	0.025
M66	5.90	1.18	4.72	1.0	0.015	0.025
M67	6.02	4.91	1.11	3.8	0.015	0.025
M68	5.72	3.66	2.06	2.6	0.015	0.025
M69	4.79	3.90	0.89	2.6	0.015	0.025
M70	5.51	3.91	1.60	2.5	0.015	0.025
M71	6.17	1.94	4.23	7.9	0.015	0.025
M72	5.81	3.43	2.38	8.4	0.015	0.025
M73	17.23	1.72	15.51	1.5	0.015	0.025
M74	13.99	0.00	13.99	2.7	0.015	0.025
M75	13.02	0.65	12.37	2.4	0.015	0.025
M76	10.13	0.00	10.13	1.5	0.015	0.025
M77	12.60	0.00	12.60	1.0	0.015	0.025
Village Creeks						
Subcatchment	**Area (ha)**	**Impervious Catchment (ha)**	**Pervious Catchment (ha)**	**Slope (%)**	**Impervious Mannings n**	**Pervious Mannings n**
N1	13.45	0.00	13.45	4.6	0.015	0.025
N2	17.21	0.00	17.21	7.7	0.015	0.025
N3	7.39	0.00	7.39	10.3	0.015	0.025
N4	9.15	0.00	9.15	4.2	0.015	0.025
N5	11.62	0.00	11.62	8.5	0.015	0.025
N6	8.71	0.00	8.71	21.3	0.015	0.025
N7	6.84	0.00	6.84	13.0	0.015	0.025
N8	15.36	1.54	13.82	23.1	0.015	0.025
N9	15.25	0.76	14.49	9.4	0.015	0.025
N10	14.69	0.00	14.69	19.1	0.015	0.025
N11	12.14	11.05	1.09	4.2	0.015	0.025
N12	16.65	0.83	15.82	11.2	0.015	0.025
N13	11.09	0.55	10.54	8.8	0.015	0.025
N14	12.32	0.62	11.70	14.0	0.015	0.025
N15	9.19	8.00	1.20	5.1	0.015	0.025
N16	5.22	3.45	1.78	7.4	0.015	0.025
N17	6.03	3.98	2.05	10.4	0.015	0.025
N18	4.21	2.65	1.56	9.2	0.015	0.025
N19	6.73	3.33	3.40	10.3	0.015	0.025
N20	3.71	1.17	2.54	9.7	0.015	0.025
N21	5.62	1.77	3.85	9.4	0.015	0.025
N22	17.64	16.85	0.79	5.0	0.015	0.025
N23	13.28	0.00	13.28	10.5	0.015	0.025
N24	11.08	1.11	9.97	14.5	0.015	0.025
N24a	9.43	0.94	8.49	14.5	0.015	0.025
N25	26.93	17.51	9.43	2.7	0.015	0.025
N26	7.19	0.36	6.83	2.0	0.015	0.025
N27	22.05	1.10	20.95	3.7	0.015	0.025
N28	17.04	5.11	11.93	3.5	0.015	0.025
N29	15.79	10.26	5.53	3.5	0.015	0.025
N30	13.96	9.07	4.89	0.1	0.015	0.025

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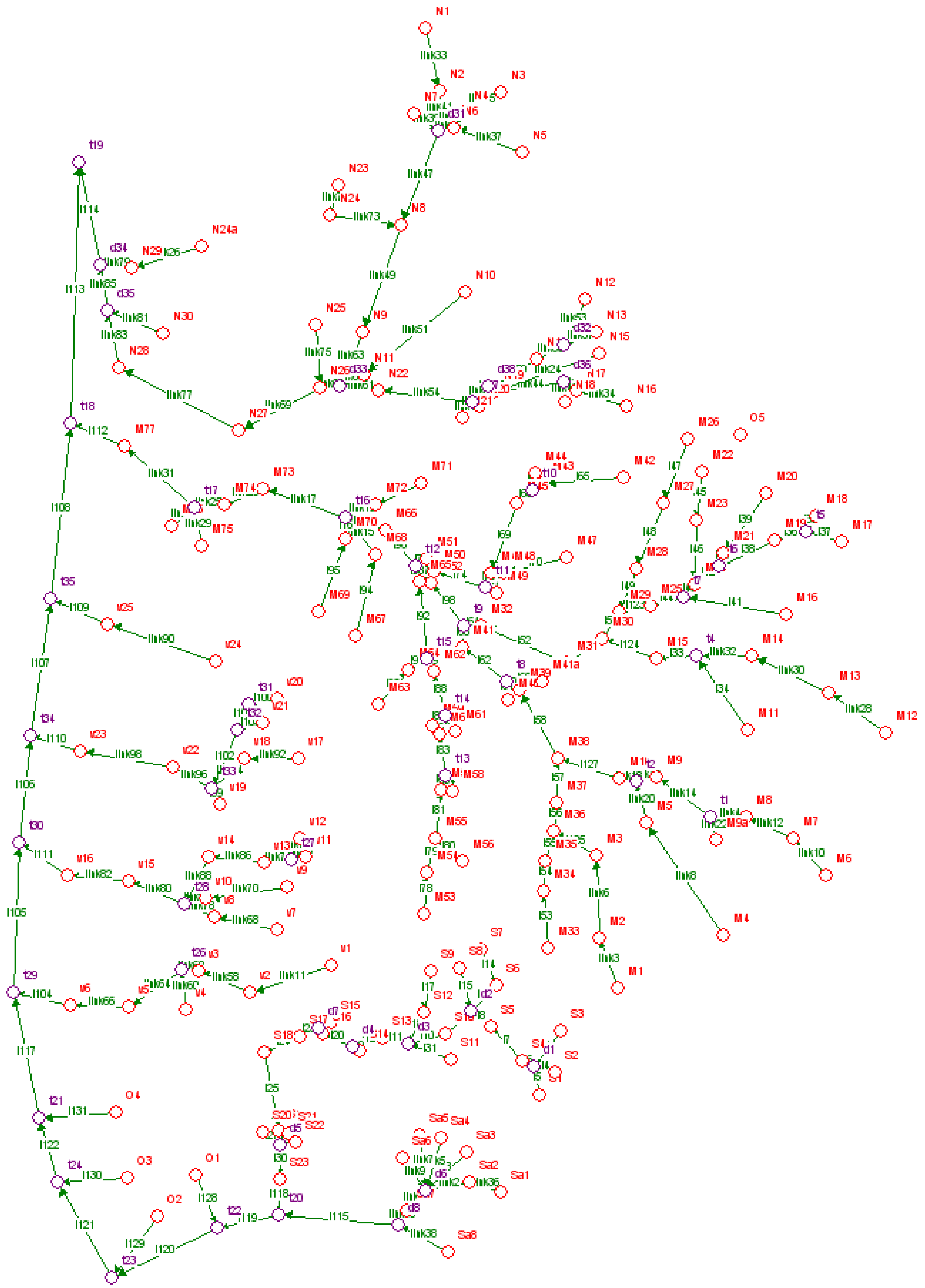
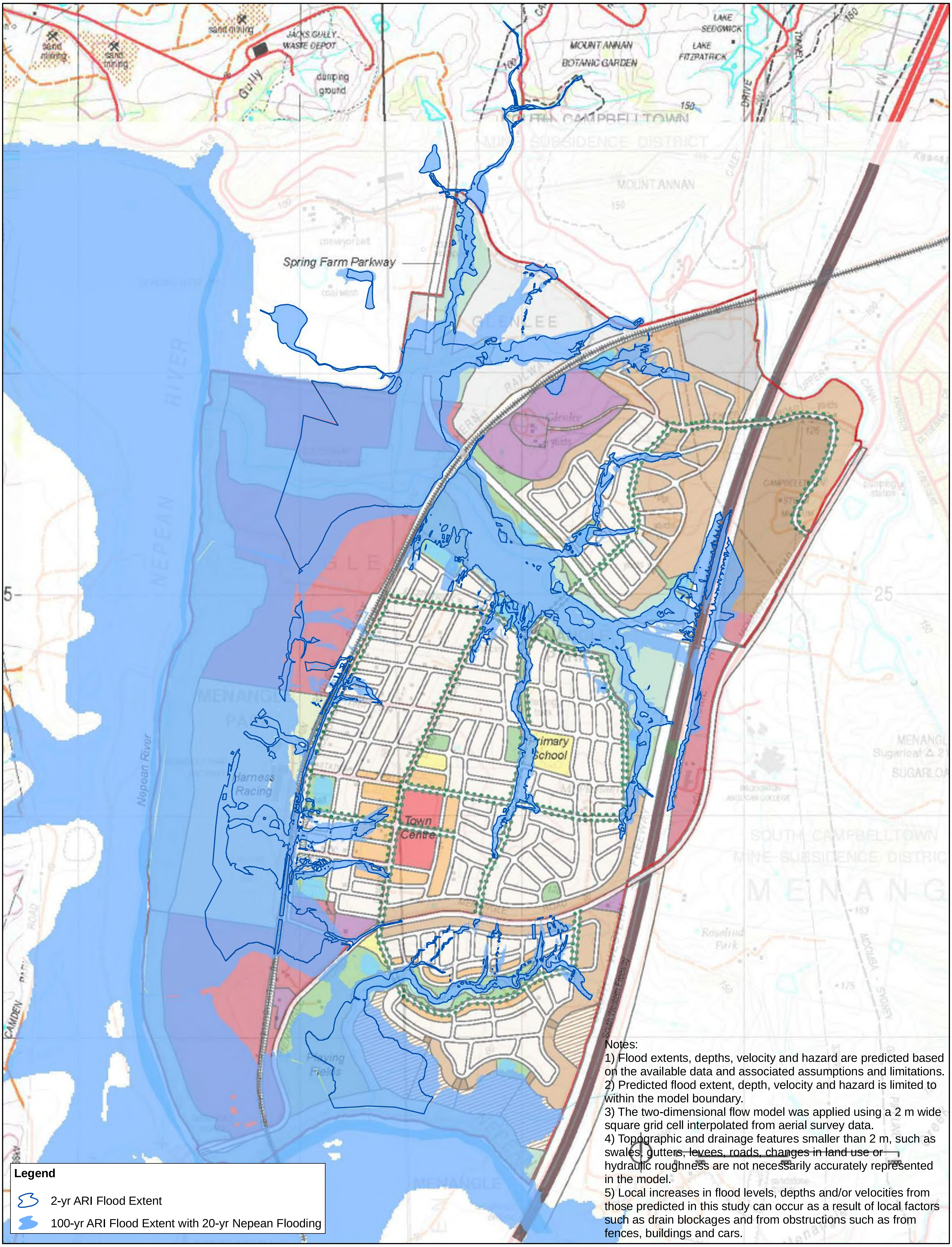
Subcatchment	Area (ha)	Impervious Catchment (ha)	Pervious Catchment (ha)	Slope (%)	Impervious Mannings n	Pervious Mannings n
Village Creeks						
Subcatchment	**Area (ha)**	**Impervious Catchment (ha)**	**Pervious Catchment (ha)**	**Slope (%)**	**Impervious Mannings n**	**Pervious Mannings n**
v1	4.84	3.19	1.65	4.7	0.015	0.025
v2	5.55	3.41	2.14	5.6	0.015	0.025
v3	7.49	5.95	1.54	5.3	0.015	0.025
v4	5.10	1.02	4.08	4.3	0.015	0.025
v5	14.27	1.43	12.84	4.8	0.015	0.025
v6	14.74	1.47	13.27	5.0	0.015	0.025
v7	6.39	5.38	1.01	7.5	0.015	0.025
v8	5.53	4.20	1.33	3.5	0.015	0.025
v9	6.88	6.36	0.52	6.6	0.015	0.025
v10	3.59	2.98	0.61	2.2	0.015	0.025
v11	4.57	4.26	0.31	8.3	0.015	0.025
v12	3.91	2.56	1.35	5.8	0.015	0.025
v13	1.91	1.72	0.19	4.5	0.015	0.025
v14	7.09	5.74	1.35	6.0	0.015	0.025
v15	13.92	1.39	12.53	1.0	0.015	0.025
v16	17.12	1.71	15.41	2.7	0.015	0.025
v17	4.86	3.79	1.07	5.1	0.015	0.025
v18	6.25	5.13	1.13	7.6	0.015	0.025
v19	5.28	4.30	0.98	7.7	0.015	0.025
v20	4.11	3.35	0.76	2.6	0.015	0.025
v21	5.01	4.08	0.93	3.8	0.015	0.025
v22	17.11	3.42	13.69	2.8	0.015	0.025
v23	21.01	4.20	16.81	1.4	0.015	0.025
v24	12.50	0.63	11.88	3.3	0.015	0.025
v25	20.86	2.09	18.77	1.3	0.015	0.025
O1	9.87	0.99	8.88	2.0	0.015	0.025
O2	4.37	0.44	3.93	3.0	0.015	0.025
O3	9.27	1.85	7.42	2.4	0.015	0.025
O4	18.87	5.66	13.21	2.7	0.015	0.025
O5	6.72	2.02	4.70	8.0	0.015	0.025

RAFTS Model Graphical Setup



Appendix D – Flood Maps



Notes:

1) Flood extents, depths, velocity and hazard are predicted based on the available data and associated assumptions and limitations.

2) Predicted flood extent, depth, velocity and hazard is limited to within the model boundary.

3) The two-dimensional flow model was applied using a 2 m wide square grid cell interpolated from aerial survey data.

4) Topographic and drainage features smaller than 2 m, such as swales, gutters, levees, roads, changes in land use or hydraulic roughness are not necessarily accurately represented in the model.

5) Local increases in flood levels, depths and/or velocities from those predicted in this study can occur as a result of local factors such as drain blockages and from obstructions such as from fences, buildings and cars.

Legend

- 2-yr ARI Flood Extent
- 100-yr ARI Flood Extent with 20-yr Nepean Flooding

1:15,000 at A3

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

THIS MAP SHOWS ONLY FLOOD EXTENTS GREATER THAN 50mm

Campbelltown City Council/Landcom
Menangle Park Local Flooding and Detention

Job Number	21-15581
Revision	A
Date	May 2010

Flood Modelling (TUFLOW) Results Developed Conditions

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: C Pappin