ECOLOGICAL ENGINEERING

Integrated Water Cycle Management Study

Water Sensitive Urban Design Component

March 2007

Report by: *Ecological Engineering Pty Ltd*

Lv 7, 249 Pitt St

Sydney NSW 2000

Report for: *Growth Centres Commission*

Document Control Sheet	
Report title:	Oran Park Integrated Water Cycle Management Study Water Sensitive Urban Design Component
Suggested Reference:	Ecological Engineering (2007). Oran Park Integrated Water Cycle Management Study. Water Sensitive Urban Design Component. Report by Ecological Engineering, to GCC. Ecological Engineering, Sydney.
Version:	Report
Author(s):	Peter Gillam, Kerrie Burge, Tony Wong and Richard McManus
Approved by:	Tony Wong
Signed:	
Date:	March 2007
Distribution:	APP

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Executive Summary

Ecological Engineering has been engaged by the Growth Centres Commission to develop the Water Sensitive Urban Design (WSUD) component of an Integrated Water Cycle Management strategy for the Oran Park Precinct. This Precinct includes lands bounded by a natural ridge line to the east of the Northern Road, Cobbitty Road, South Creek and a band of Rural land to the north. The site is within the Oran Park Growth Centre, as defined by the NSW Governments Growth Centres Commission.

The site is subject to a Development Code under the SEPP Growth Centres, and must be complied with for the development to attain approval. This Code prescribes WSUD stormwater management targets that supersedes Council requirements.

A WSUD strategy has been developed for the precinct based on the objectives outlined in the Code, and has been developed taking into consideration salinity, erodible soils and the ephemeral nature of the creeks that cross the site and recognises the potential to rehabilitate and enhance the values of the local creek systems. The strategy has also been developed in consultation with the masterplanners for the site to ensure that it is consistent with the development approach and layout. The elements of the strategy include:

- Stormwater quantity control so as to mitigate the flooding impacts of the development on South Creek and erosive flows within creeks across the site. This is to be achieved through a two-pronged approach of minor and major OSD basins including –
  - minor flows up to the 5 year ARI will be detained in minor OSD basins adjacent to the creeks, and potentially lot scale OSD within the town centre and employment zones
  - flows up to the 1 in 100year ARI event will be detained in major OSD basins.
- Stormwater quality control – stormwater treatment through a combination of regional wetlands and bioretention facilities where required to meet the stormwater quality reduction load targets, and
- Riparian zone and creek management –
  - Flows that meet the stream erosion index objectives established by DEC will flow into the creek
  - Flows beyond this level and up to the two year ARI event will bypass the creek via intercepting stormwater pipes to downstream storage for reuse or further attenuation. These elements will utilise and complement the minor OSD basins and ornamental water body storages.
  - erosion control and bank stabilisation measures within the waterway.

The strategy for potable mains water conservation and reducing wastewater discharge from the site includes:

- potable water demand management through the use of water efficient fittings
- utilisation of alternative water sources on a fit-for-purpose basis including treated stormwater harvested on site and recycled waster water either treated on site or supplied by a dual pipeline

The Oran Park development has the opportunity to be a flagship for sustainable and water sensitive development in the growth centres of western Sydney underpinned by strong principles of environmental protection and the conservation of our precious water resources.

1 Introduction

Ecological Engineering has been engaged by the Growth Centres Commission to develop the Water Sensitive Urban Design (WSUD) component of an Integrated Water Cycle Management strategy for their lands within the Oran Park Precinct (Figure 1-1). This Precinct includes lands bounded by bounded Cobbitty Road, South Creek and a band of Rural land to the north and a heritage farming property to the west. The site is within the Oran Park Growth Centre, as defined by the NSW Governments Growth Centres Commission.

WSUD is the integration of a holistic approach to the management of the urban water cycle into the urban design of a project. The WSUD strategy has been developed in partnership with the masterplanning process, so as to ensure that development does not encroach on sensitive water areas, ie floodplains and riparian zones and, more importantly, to ensure that appropriate WSUD options can be selected to complement the urban design and landscape objectives.

The WSUD Strategy for Oran Park, is guided by the key principles of WSUD. These principles are aimed at achieving integrated water cycle management of the three urban water streams potable water, wastewater and stormwater by:

- reducing potable mains water consumption through demand management and substitution with treated reclaimed water, stormwater and / or roofwater.
- treating urban stormwater to meet water quality objectives for reuse and/or discharge to waterways.
- using stormwater in the urban landscape to maximise visual and recreational amenity of developments, and where appropriate influence the micro-climate of the area

Opportunities exist to treat urban stormwater to meet water quality objectives for reuse and/or discharge to downstream environments as well as use stormwater in the urban landscape to maximise visual and recreational amenity of developments, and where appropriate influence the micro-climate of the area.

There are a number of ephemeral creeks and drainage lines throughout the site that warrant protection and enhancement as riparian corridors. The opportunity exists to restore the pre-settlement hydrology of the creek lines to suit the existing vegetation communities that are currently drought affected and provide greener spaces (than the current arid nature of the site) while minimising erosion risk.

This report outlines the opportunities to protect and enhance the ecological values of the site through the implementation of WSUD element within the Oran Park development.

2 WATER MANAGEMENT PRINCIPLES AND OBJECTIVES FOR ORAN PARK

There are a range of State and Local Government objectives which inform and direct water management for a given development. These objectives are outlined below, with the key targets identified which will guide the Oran Park WSUD Strategy.

2.1 State Government Targets

The Department of Environment and Conservation (DEC) has established stormwater management targets for Oran Park as part of the Development Code under the State Environmental Planning Policy "Growth Centres". The targets are outlined in Table 2-1 and are slightly different to those commonly that have been adopted throughout NSW. These targets are inline with current best practice nutrient reduction level reductions currently adopted in South East Queensland and Perth.

Table 2-1: Environmental Stormwater Objectives for Oran Park

Units	WATER QUALITY % reduction in pollutant loads				ENVIRONMENTAL FLOWS – Stream erosion control
	Gross Pollutants (> 5mm)	Total suspended solids	Total phosphorus	Total nitrogen	Post-development duration of above 'stream-forming flow' Natural duration of above 'stream forming flow'[1]
Stormwater management objective	90	85	65	45	3.5 – 5.0[2]
'Ideal' stormwater outcome	100	95	95	85	1

1. For the purposes of these objectives, the 'stream forming flow' is defined as 50% of the 2-year flow rate estimated for the catchment under natural conditions.
2. This ratio should be minimised to limit stream erosion to the minimum practicable. Development proposals should be designed to achieve a value as close to one as practicable, and values within the nominated range should not be exceeded. A specific target cannot be defined at this time.

The BASIX scheme requires new residential developments to use 40 per cent less mains water than average current housing of the same type. BASIX only considers those measures that can be incorporated into the construction of the dwelling, and does not consider water efficient appliances, such as washing machines and dishwashers. While BASIX provides flexibility in the manner in which water consumption (and other) targets are met, residential developments will typically be able to achieve the 40% reduction in potable mains water consumption by including:

- **water conservation** – AAA or better water efficient fixtures, such as showerheads, tap fittings and dual-flush toilets, and
- **water reuse** – a rainwater tank or equivalent communal system of a minimum specified volume, or connection to an appropriate recycled water supply, for toilet flushing and outdoor uses.

2.2 Local Government Targets

Camden Council Engineering Design Specification manual states that WSUD measures be designed to achieve the water quality and water quantity targets outlined in the 'Water Sensitive Urban Design Technical Guidelines for Western Sydney (2004)'. These targets establish pollution reductions of 80% reduction of the average annual load of TSS, and 45% reduction of the average annual load of TN and TP.

Where On Site Detention is required to mitigate post development flows, Council require the maximum discharge from the developed site shall not exceed the pre-development flows for all storms up to and including the 100-year ARI storm and shall not be concentrated

2.3 Appropriate Water Management Targets

The Development Code under the SEPP Growth Centres, must be complied with for the development to attain approval. This Code supersedes Council requirements, and is consistent with Landcom targets. The BASIX Scheme takes precedent over all local government water related planning provisions. The State Government targets outlined in section 4.1, are the water management targets to be adopted for Oran Park.

3 SITE DESCRIPTION

The Oran Park Precinct is situated within the Western Sydney Groewth Centre some 70 km south west of Sydney CBD, within the Camden Local Government Area. The precinct is one of the first to be developed under the Growth Centres Commission which will guide development in the surrounding areas over the next 25 years.

The development site is owned by two major land holders and 10 small landholdings.

3.1 Site hydrology

With the exception of South Creek, waterways across the precinct are typically ephemeral. The precinct lies within the Wianamatta Shales group which is typified by heavy clays with low rates of infiltration and high incidence of surface flow. Infiltration of catchment runoff is likely to be more prominent on the lower sections of the catchment. The site hydrology will be impacted by urban development due to an increase in the impervious areas and increasing the frequency and intensity of runoff events to the ephemeral creeks.

3.2 South Creek catchment

South Creek has a catchment area of 620km^2, and is a major tributary of the Hawkesbury-Nepean River System (Figure 3-1). The Oran Park Precinct is immediately downstream of the headwaters of the creek. Most of the original vegetation cover within the catchment has been cleared, with agriculture prominent in the southern and northern sections of the creek, and a band of urban development, including St Marys and Blacktown occurring in the centre of the catchment. South Creek has been identified as one of the most polluted streams in New South Wales, with urbanisation having a significant impact on the pollution loads and sediments within the creek. A significant goal of any development within the catchment should therefore be to minimise further impacts of the development on the creek, especially developments at the headwaters of the creek. There are often opportunities to improve stormwater quality through the adoption of WSUD from current stormwater quality generated from the existing landuse.

3.3 Waterway geomorphic characteristics

The Oran Park Precinct includes several defined waterways and a number of large farm dams. The north-western portion of the site contains two shallow ephemeral watercourses that form the headwaters of Lowes Creek which flows to South Creek.

The south and south-western portions of the site contain a short length of Cobbitty Creek and several shallow ephemeral tributaries that drain west to the Nepean River. These creeks retain some of the pre-settlement geomorphic form and some remnant vegetation. The Cobbitty Creek tributaries are already impacted from increased runoff and a large farm dam near the confluence with Cobbitty Creek.

The central and eastern potions of the site features a short reach of South Creek and three ephemeral tributaries that form its headwaters. The upper reaches of these creeks are minor drainage gullies that become defined creeks as they cross the site. Two tributaries meet to the north east of the precinct boundary at the location of a large farm dam. The confluence of the most significant tributary and South Creek coincides with South Creek becoming the eastern boundary of the site. The ephemeral creeks have little riparian vegetation except for a series of trees immediately adjacent to the banks. These trees are mostly 10- 20 years old.

The waterways are mostly modified with a series of on-line and off-line farms dams through the site, with the largest storages occurring at the north-eastern and south-western boarders of the site, which limits all but the most severe runoff events from reaching South Creek and Cobbitty Creek respectively. Despite this the south-eastern tributary exhibits good geomorphic characteristics with a defined and stable channel. The south-western tributary includes an incised channel flowing downstream as a result of level changes bought about by on-line storages.

3.4 Salinity

The accumulation of salt in soil, ground water and surface waters has been identified as a problem within Western Sydney. Salinity associated with the Winnamata Shale Groups that underlie Oran Park has become a problem due possibly to rising water tables resulting from current and historic agricultural practices including irrigation and land clearing, and exposure of sodic soils in the waterways and farm dams.

Salinity is known to occur in low lying lands where water accumulates. Salinity mapping of the Oran Park site carried out by Environmental and Earth Sciences (2006) has identified areas of highly and extremely saline lands typically along creeks and drainage depressions at depths of 0.5 to 1.5 m.

Salinity is potentially toxic to plants, causes severe land degradation, can damage concrete pipes and brick structures, and reduces water quality in surface waters. High risk activities and land uses that relate to the implementation of WSUD across the Precinct include systems promoting infiltration to soil or groundwater, waste water re-use for open space watering, or treatment systems and major landscape re-shaping

that may expose the highly dispersive sodic soils in the area. Prevention of stream erosion in the many gullies and ephemeral creeks in the area is an important management objective for the development. Salinity management is required in the design and construction of WSUD and close reference will be made to the Western Sydney Salinity Code of Practice. Specific salinity management will include:

- Using best practice management techniques to reduce exposure and disturbance of sodic and saline sub-soils.
- Maintaining and restoring riparian vegetation where possible.
- Using impermeable liners around wetlands, water bodies, and bioretention gardens to minimise infiltration and interception of ground water.
- Avoid WSUD strategies that encourage infiltration.
- Selecting appropriate clay, brick and concrete construction materials and vegetation to resist the salts present.

4 SITE OPPORTUNITIES AND CONSTRAINTS

The development of the WSUD strategy included the identification of a range of site opportunities and constraints, which impact on the suitability or otherwise of WSUD elements. These opportunities and constraints are described in the following sub-sections.

4.1 Site constraints

The main site constraints relate to the soils and the state of the waterways. It is noted that the site is in a relatively arid area and the soils appear to be moderately to highly erodible, as noticed by evidence of erosion in drainage lines. As also noted in Section 3.4, highly saline soils have been with areas typically along creeks lines at depths of 0.5 to 1.5 m, and around dams and areas of exposed dispersive soil and water infiltration. WSUD treatment elements and drainage infrastructure often extend into these depths and have the potential to cause erosion of highly dispersive soil or promote infiltration into these zones. Specific designs and construction techniques must be implemented where ever stormwater infrastructure will disturb saline soils and potentially affect ground water conditions.

Salinity also limits the application of WSUD techniques that encourage infiltration and dispersal of stormwater through intensive irrigation.

The poor state of the waterways across the site is due to the removal of vegetation within gullies and altered hydrology resulting from agricultural practices. The development will result in an increase in runoff of up to double current runoff volumes and even higher discharge rates. This has the potential to further degrade riparian habitat by increasing erosion and further altering stream hydrology if WSUD management practices are not adopted. In order to preserve the geomorphic and ecological integrity of the creeks in the area, there may be a need to control the frequency and volume of runoff entering creeks and to potentially retain and reuse much of the runoff from the site.

4.2 Site opportunities

There are a number of existing drainage lines that provide an opportunity to retain and rehabilitate ephemeral creeks and riparian habitats throughout the site, particularly for South Creek and its tributaries and for Cobbitty Creek and its tributaries. The opportunity exists to maintain the ephemeral hydrology of the creek lines to suit vegetation communities such as the Eucalyptus spp that are currently drought affected and provide greener spaces (than the current arid nature of the site) while minimising erosion risk.

Due to the nature of the site there is also an opportunity for stormwater flow in excess of that reflecting the natural hydrology of the catchment for the frequent storm events to be diverted away from the natural creeks and conveyed in pipes to an end of pipe treatment (e.g. wetlands located with an retarding basin). This strategy will significantly reduce the risk of erosion along the ephemeral creeks in the area.

For larger less frequent events, the ephemeral creek corridors can provide flood conveyance (up to 100yr ARI) with flood extents largely expected to be contained within the riparian width in the majority of cases. Flood prone areas fringing the riparian corridors could provide opportunities for passive recreation.

The retention and modification of large farm dams at the north-eastern and south-western edges of the precinct provide an opportunity for detention of large flows as well as water quality treatment through constructed wetlands for end-of-pipe treatment. These storages can provide stormwater harvesting opportunities and provide scenic vistas, and can be managed to discourage the establishment of nuisance bird populations.

Linear bioretention systems can be incorporated into vegetated buffer zones to protect the integrity of riparian corridors. Utilising indigenous tree and ground cover species and intense planting densities will enable bioretention cells to function as effective barriers to human and vehicle traffic into riparian zones. These systems will also contributing to micro-climate buffering and provide a self evident pollutant control function. Some maintenance will be required but correctly planted and mulched bioretention systems should also prevent propigules entering waterways or taking hold within the riparian zones.

There is also an opportunity to provide an enclosed storage (e.g. underground tank) in the vicinity of retarding basins and wetlands for stormwater harvesting and reuse to minimise potable water demands and provide supply for regional fire fighting. Alternatively, there is opportunity to utilise treated wastewater in a third pipe system along with rainwater tanks to provide hot water. This is not a widely accepted but is an emerging concept.

In densely developed areas such as commercial centres and employment areas, stormwater management can combine OSD with stormwater harvesting and reuse. This provides the benefit of reduced land take for water quality treatment elements and allows reduced stormwater pipe capacity requirements. Stormwater reuse provides an alternative non-potable water supply where the high nutrient loads in recycled effluent render it inappropriate for certain uses such as air conditioning and in water features.

The Indicative Layout Plan also provides many opportunities for interpretation and education regarding urban water cycle management.

While discussions about creek categorisation are ongoing, it is likely that the majority will fall into Category 2 and Category 3, with South Creek and Cobbitty Creek being instated as Category 1 waterways. Where creeks/gullies, beyond what are identified in the Indicative Layout Plan, are nominated by DNR for provision of riparian corridor there is opportunity to provide for this

5 WSUD STRATEGY

A WSUD strategy has been developed for the precinct based on the objectives, constraints and opportunities outlined above. The strategy has been developed in consultation with the masterplanners for the site to ensure that it is consistent with the development approach and layout. The elements of the strategy include:

- Stormwater quantity control so as to mitigate the flooding impacts of the development on South Creek. This is to be achieved through a two-pronged approach of minor and major OSD basins including –
  - o minor flows up to the 5 year ARI will be detained in minor OSD basins adjacent to the creeks, and potentially lot scale OSD within the town centre and employment zones
  - o flows up to the 1 in 100year ARI event will be detained in major OSD basins.
- Stormwater quality control – stormwater treatment through a combination of wetlands and bioretention facilities to meet the stormwater quality reduction load targets, stormwater harvesting and reuse may be incorporated where nearby land is not available; and
- Riparian zone and creek management –
  - o The ephemeral hydrology of creeks will be maintained or restored where possible.
  - o Flows to creeks will meet the stream erosion index objectives established by DEC.
  - o Flows beyond this level and up to the five year ARI event will bypass the creek via intercepting stormwater pipes to downstream storage for reuse or further attenuation. These elements will utilise and complement the minor OSD basins and ornamental water body storages.
  - o Erosion control and bank stabilisation measures within the waterway.

A schematic representation of the Stormwater Management strategy is shown in Figure 5-1 with a summary of their function and relevant management objectives presented in Table 5-1. All of these elements are describeed in greater detail in the following sections, with Table 5-1 providing a reference to appropriate sections in the report for this information. Further information on the stormwater quantity controls is provided by WP Brown (2006), as they have been engaged to undertake this work.

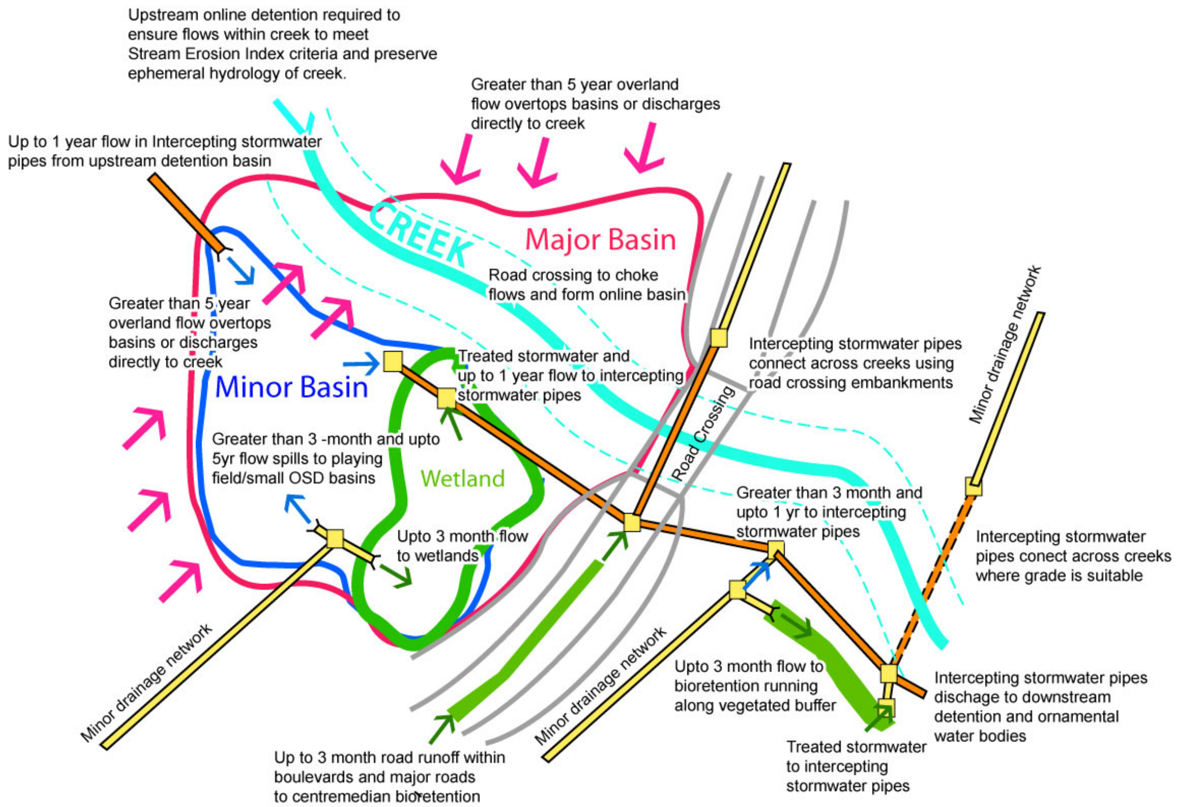

Figure 5-1: Stormwater management strategy schematic

Table 5-1 : Summary of stormwater management elements, function, and performance objectives*

Element (Report Section)	Operational Recurrence Interval	Function	Description	Performance objective
Minor OSD basin (Section 6.1)	3 month to 5 year	Regional Flooding and Erosion Management	Collects flows within minor drainage network and provides attenuation in offline basins. Basins discharge to intercepting stormwater pipes that bypass erosive flows away from creeks to downstream storages.	Stream Erosion Index no greater than 5.
Major OSD basins Section 6.2	5 to 100 year	Regional Flooding	Collects overland flow during rare events and from provides attenuation within reserves and the riparian corridors.	No increase in flooding risk and flood severity downstream of the development.
Wetlands and Bioretention Section 7.4 and Section 7.5	Up to 3 month	Stormwater Quality Treatment	Removal of pollutants from stormwater during minor storms before storage for reuse or discharge to receiving waters	45% reduction in the mean annual load of TN. 65% reduction in the mean annual load of TP 85% reduction in the mean annual load of TSS..
Ornamental Water Bodies Section 9 and Section 9.4	All events	Regional Flooding Erosion Management and Stormwater Harvesting	Store treated stormwater for reuse, and provide flood storage. Integrated into visual landscape to provide high visual amenity.	
Erosion Controls and Bank Stability Measures *	All events	Erosion Management	In stream structures, revegetation and rehabilitation to stabilise the creek channel and prevent erosion.	
Intercepting stormwater pipes Section 10.6	No less than 1 year and up to 5 year	Riparian Corridor Protection and Erosion Management	Bypass treated stormwater and erosive flows to downstream storages for reuse and further attenuation respectively.	Maintain ephemeral hydrology Stream Erosion Index no greater than 5.

*Note: Not shown in Figure 5-1

6 STORMWATER DETENTION

A series of regional flood detention basins will ensure the proposed development will not exacerbate the risk and severity of flooding on downstream environments, as required by Council. Major and Minor On Site Detention (OSD) Basins will be sized and located to maintain the existing peak discharges up to the 100-year ARI peak flow from the site. Lot scale OSD may be incorporated within the commercial centres and employment zones to manage flows through the site.

WP Brown Consultants have been engaged to undertake this work and have sized these structures using event based hydrologic models. Ecological Engineering has developed this WSUD strategy in consultation with WP Brown Consulting so as to optimise the stormwater storages on site.

A brief description of these elements is provided in the following sub-sections, with further details on the size, location and configuration of these elements provided in WP Brown's Stormwater Quantity Management and Flooding Report (2006).

6.1 Minor OSD basins

Minor OSD basins will be typically located off-line and provide flood detention of storm events of up to the 5 year Average Recurrence Interval (ARI). An online basin will be required at the upstream end of retained and rehabilitated ephemeral creeks to retain the hydrological conditions in these watercourses during frequent events. Flow will be delivered to these detention basins via the minor stormwater drainage network. The detention basins will be subject to frequent inundation and with careful design can provide locations for stormwater quality treatment facilities thereby reducing the associated land take.

Minor OSD Basins also serve a flow attenuation function within the site to protect creeks from erosive flows and attain the stream erosion control objective as outlined in Table 2-1. This function is represented in Figure 5-1.

Minor OSD Basins may form part of the storage within a Major OSD Basin. During storms greater than the 5 year ARI event, inundation within these basins will extend to cover a larger area including the natural watercourses forming the flood extend of the Major OSD Basin as illustrated in Figure 5-1..

6.2 Major OSD basins

The footprints of Major OSD Basins will be formed online at road crossings inundating the riparian corridor and adjacent floodplain to provide flood detention of major storm events. As noted in the previous section, inundations of the Major OSD Basins are generally triggered by overflows from the Minor OSD Basins. Major OSD Basins will manage downstream flooding risk up to the 100-year event, receiving overland flow via the major drainage network. Basin locations and sizes are described in detail in WP Brown's Stormwater Quantity Management and Flooding report (2006). Schematic representation of Major OSD basins is presented in Figure 5-1 and summarised in Table 6-1.

6.3 Lot scale OSD

Lot scale OSD within the commercial centres and employment zones may be utilised to manage flows through the site and reduce the size of minor drainage infrastructure required to convey 10-year events through commercial areas under Camden Councils Engineering Guidelines. Rainwater harvesting could be incorporated into the OSD storages to provide benefits to the stormwater quality treatment and rainwater harvesting discussed in Section 7.3 and Section 8.4 respectively.

7 STORMWATER QUALITY TREATMENT

All stormwater corresponding to frequent events and generally up to the 3-month storm will be treated to improve water quality prior to reuse or discharge to receiving waters. Stormwater quality objectives to be attained are in accordance with the Development Code for the Growth Centre Commission Lands, which require reduction in the mean annual loads of Total Suspended Solid, Total Phosphorus, and Total Nitrogen , by 85%, 65% and 45% respectively. .

7.1 Development of the stormwater treatment masterplan

The strategy for stormwater quality treatment at Oran Park has been developed to address the broad set of objectives of stake holders in the precinct planning. The strategy represents a balance between the GCC land development targets, amenity and urban planning ideals, maintenance and life cycle costs and uncertainties in climate change.

The strategy utilises a combination of regional treatment elements across the site and street scaped treatments within a number of catchments around the town centre. Street scaped areas will be amongst the first stages of land to be released and from an urban planning standpoint require a level density and amenity that cannot be afforded by a suitably located regional stormwater treatment system. The incorporation of stormwater quality treatment into streetscape forms part of the diffused approach to stormwater management favoured in Water Sensitive Urban Design. Diffused treatments add to the sophistication of a development, taking footprints normally associated with street side landscape amenity. Street trees can be designed to function as stormwater treatment measures as can bioretention raingardens incorporated into traffic island or traffic calming systems. The incorporation of these system in the streetscape adds an ecological functionality to what were traditionally a landscape amenity. These systems have been designed in other estates that do not inhibit the effective use of local streets. The distribution of treatments will be determined at a detailed design stage.

Elongated bioretention systems have been retained as linear systems along riparian corridors and park edges to integrate landscaping and environmental functions, and maximise the developable area.

While reducing the associated land take, the stormwater treatment strategy has a level of inbuilt redundancy to address uncertainty in climate change. Should future climate patterns generate frequent large volumes of stormwater, wetlands and storm water storages can be sacrificed for more efficient bioretention treatment facilities.

A representation of regional stormwater treatment elements within the WSUD strategy is presented in Figure 5-1 and summarised in Table 7-1.

7.2 Modelling stormwater treatment elements

Stormwater modelling was undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC), a model developed by the CRC for Catchment Hydrology, for determining the impact of water quality treatment measures. The model used fourty nine years (1954 - 1993) of 6 minute rainfall data from the Richmond RAAF Base which has a mean annual rainfall of 827 mm, mean annual evapo-transpiration 1200 mm and 110 mean annual rain days. Richmond RAAF base has an average of 110 rain days which compares with Camden Airport which has an average of 109 rain days year and average annual rainfall of 828 mm..

MUSIC modeling was used to determine the size of bioretention and wetlands required to treat a representative 1ha area of development with a generic 60% of impervious area directly connected to the stormwater system. The target density of the precinct is approximately 15 lots per hectare, which will translate to higher impervious fractions but not al of these areas will be directly connected to the stormwater system. At this stage, the distribution of these densities is not known outside the commercial centres and will therefore be assessed on a stage by stage basis during detailed design. The intention of this method is to aid in the determination of indicative sizes of stormwater treatment areas for the many sub-catchments in the development area.

MUSIC modeling shows that a gross pollutant trap in combination with a $750m^2$ wetland with an extended detention depth of 300 mm, will deliver the required water quality treatment to treat 1 ha of development with an average impervious (roofs and paved surfaces) fraction of 60%. A similar footprint will be effective for areas with more impervious areas.

MUSIC modeling shows that a bioretention system area of $120m^2$, with an extended detention depth of 200 mm and filter depth of 500 mm, will deliver the required water quality treatment to treat 1 ha of development with an average impervious (roofs and paved surfaces) fraction of 60%. A footprint of 150 m^2 will be required for areas with 80% effective imperviousness.

7.3 Stormwater quality treatment masterplan

MUSIC modelling results were used to determine notional sizes and locations of regional bioretention systems and wetlands as presented in Figure 7-1.

Where insufficient area is available to locate regional stormwater treatments, notional areas of street-scale treatment elements have been identified. The details of these

and other opportunities for street-scale water quality elements will need to be investigated on a stage-by-stage basis. A breakdown of regional wetland and bioretention and street-scale treatments for catchments across the Eastern Portion of the development is presented in Figure 7-1with labelled sub-catchments. For the purposes of representation, bioretention swales have been presented as continuous 4m wide strips, but allowance has been made for breaks within these systems. Treatment areas presented in Table 7-2 are a better indication of the areas required, and these may be landscaped as appropriate.

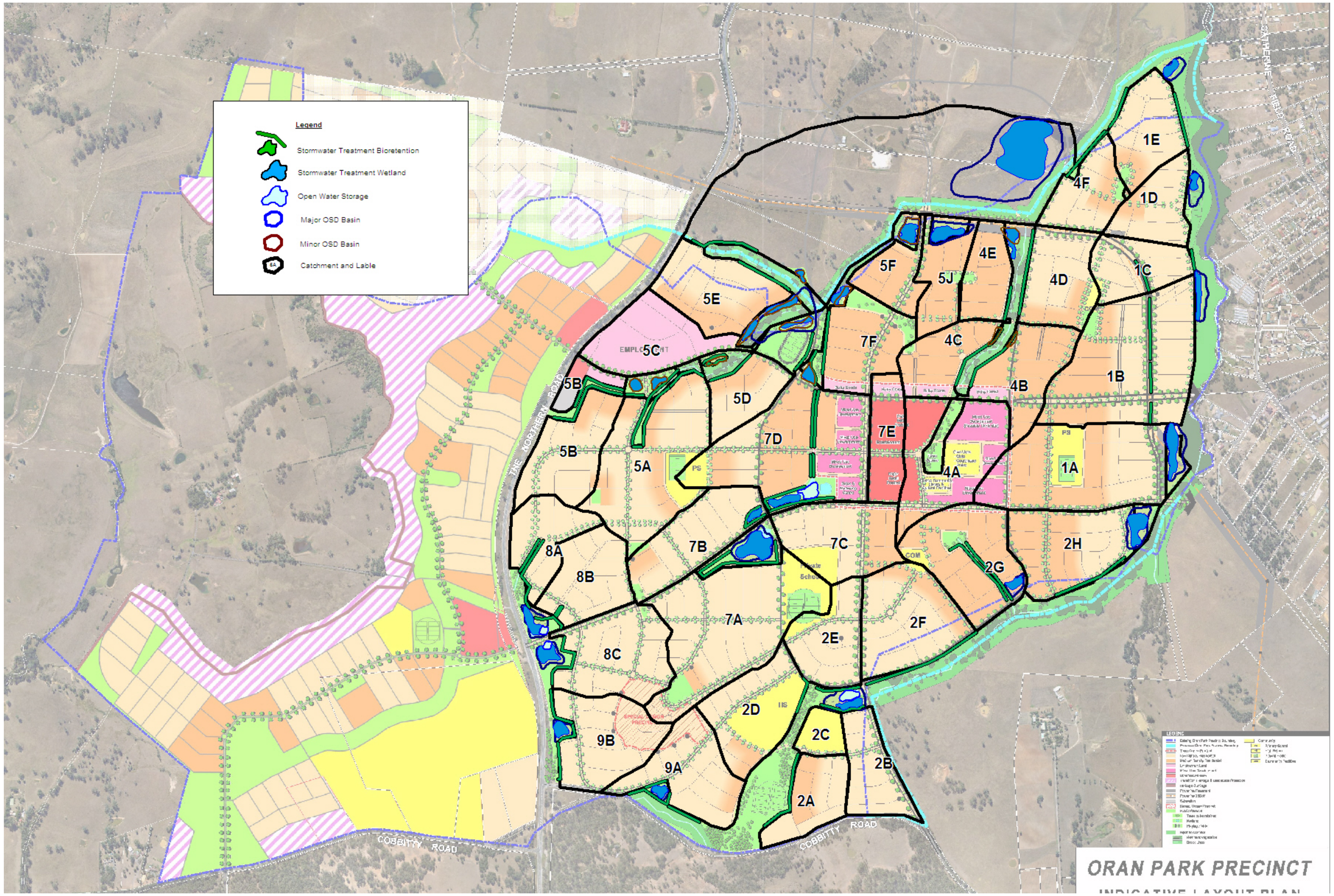

Figure 7-1 : Stormwater quality treatment strategy for Eastern Oran Park

Table 7-2 – Stormwater treatment masterplan for Eastern Oran Park

Catchment	Catchment Area (ha)	Impervious Area (ha)	Wetland Footprint Area (ha)	Bioretention Footprint (ha)
1A	26.53	15.92	0.83	0.23
1B	30.82	18.49	0.40	0.38
1C	9.49	5.69	0.00	0.14
1D	9.27	5.56	0.21	0.10
1E	10.51	6.31	0.29	0.10
2A	8.92	5.35	0.00	0.13
2B	11.1	6.66	0.31	0.10
2C	3.65	2.19	0.00	0.05
2D	14.62	8.77	0.00	0.22
2E	11.21	6.73	0.00	0.17
2F	17.3	10.38	0.00	0.26
2G	18.27	10.96	0.25	0.22
2H	16.77	10.06	0.78	0.10
4A	17.65	10.59	0.00	0.26*
4B	12.65	7.59	0.00	0.19
4C	9.15	5.49	0.00	0.14
4D	12.23	7.34	0.00	0.18
4E	7.77	4.66	0.40	0.04
4F	9.08	5.45	0.00	0.14
5A	25.27	15.16	0.44	0.29
5B	15.98	9.59	0.00	0.24
5C	13.62	8.17	0.00	0.20
5F	7.94	4.76	0.00	0.12
7A	31.78	19.07	1.24	0.23*
7B	14.59	8.75	0.00	0.22*
7C	15.04	9.02	0.00	0.23*
7D	30.33	18.20	0.26	0.40
7E	8.12	4.87	0.00	0.12*
7F	12.82	7.69	0.30	0.13
8A	9.7	5.82	0.00	0.15
8B	11.96	7.18	0.51	0.08
8C	16.61	9.97	0.59	0.13
9A	14.83	8.90	0.26	0.17
9B	14.99	8.99	0.33	0.16

* Note : Catchments incorporating street scaped bioretention treatment

A breakdown of regional wetland and bioretention and street-scale treatments for catchments across the Western portion of the development is presented in Figure 7-2 with labelled catchments.

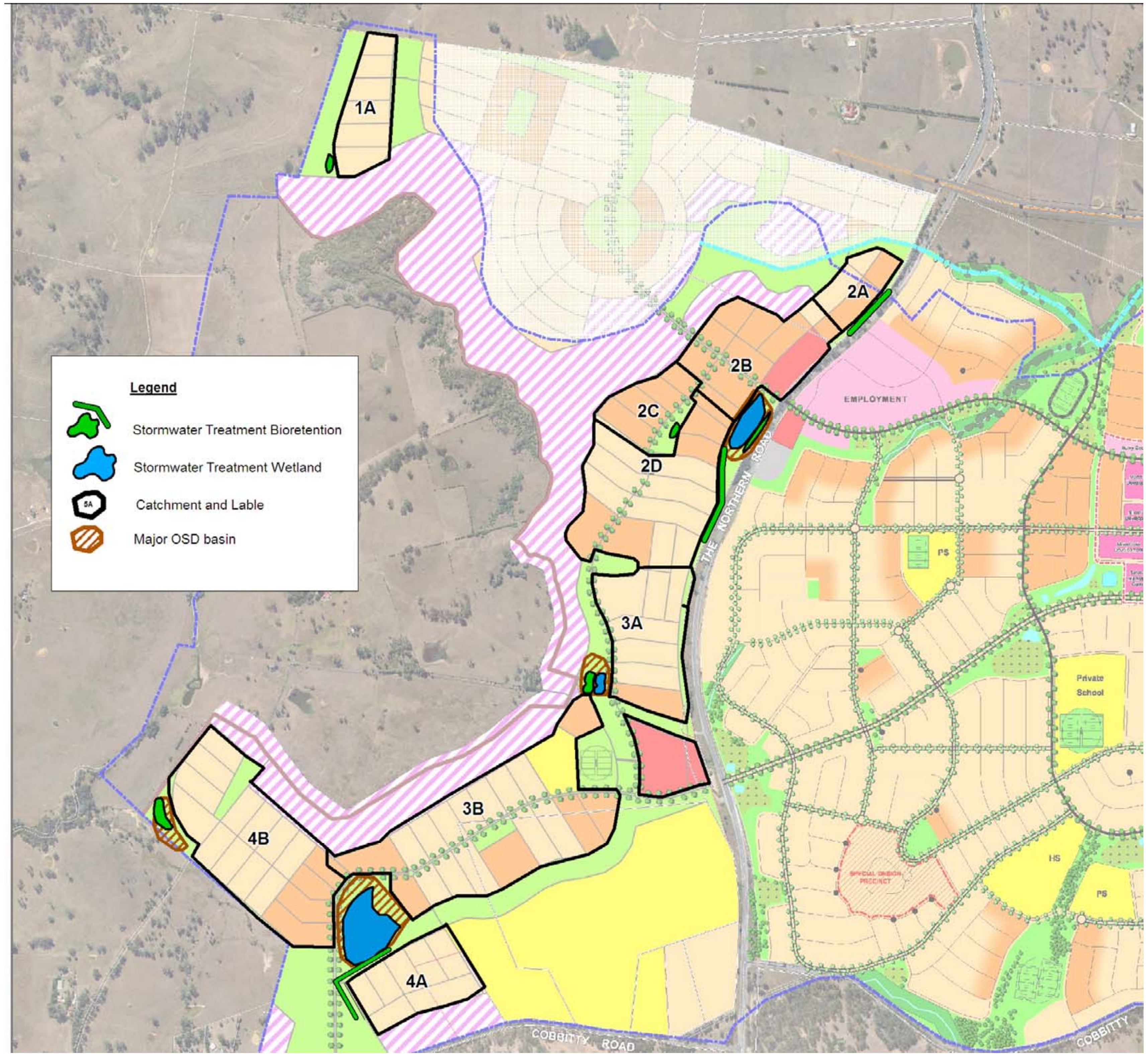

Figure 7-2 : Stormwater quality treatment strategy for Western Oran Park

A breakdown of treatment elements for each catchment is presented in Table 7-3.

Table 7-3 - Stormwater treatment masterplan for Western Oran Park

Catchment	Catchment Area (ha)	Impervious Area (ha)	Wetland Footprint Area (ha)	Bioretention Footprint (ha)
1A	7.00	4.20	0.00	0.10
2A	4.10	2.46	0.00	0.06
2B	12.90	7.74	1.02	0.00
2C	5.15	3.09	0.00	0.08
2D	19.43	11.66	0.00	0.29
3A	12.72	7.63	0.20	0.15
3B	33.80	20.28	2.89	0.00
4A	8.76	5.26	0.00	0.13
4B	22.04	13.23	0.00	0.33

7.4 Wetlands

Constructed wetlands are commonly used to achieve nutrient reduction targets and can be integrated within the landscape to meet design objectives such as flow management, irrigation water supply, passive recreation and aesthetic landscaping.

Wetlands can form part of a treatment train that incorporates a gross pollutant trap (GPT) as pre-treatment to reduce incoming suspended solids load. Within the wetland, frequent flows from low magnitude storms pass through a series of zones that serve specific functions of nutrient and sediment removal.

Inlet zones provide conditions for heavier sediments (> 0.125 mm) to be removed from the water column prior to the stormwater entering the wetland macrophyte zone. The inlet zone will be planted with a range of ephemeral marsh and low profile terrestrial plant species to provide protection from erosion.

The macrophyte (marsh) zone is shallow and densely vegetated and provides a low velocity environment where the smaller suspended particles settle out of suspension or adhere to the vegetation. Soluble pollutants such as nutrients may be adsorbed onto the surfaces of suspended solids and entrained within the wetland sediments, or biologically absorbed by the epiphytic biofilms present upon the macrophytes or by the macrophytes themselves. The macrophyte (marsh) zone is designed with a gradually varying depth that comprises regions of ephemeral swamp, shallow marsh, marsh and deep marsh and is planted with suitable species resembling examples presented in Figure 7-3

Figure 7-3: Examples of planting species and wetland areas.

The open water zone is designed to be greater than 1.5m deep to restrict emergent plant growth and can account for 30% of the wetland footprint. The open water zone is required for light penetration to enable photosynthesis and sustain biomass within the wetland.

Wetlands provide a permanent pool with an average depth of 0.3m, with provision for extended detention of 0.5m and a notional detention period of 72 hours.

The configuration of a wetland can vary, however the preferred ratio of length to width is between 1:4 and 1:10. Where wetland cells have irregular shapes it is suggested that the flow direction and conditions in the wetlands are regulated by berms placed in the wetland. Examples of wetlands in green field and brown filed developments are presented in Figure 4.

Figure 7-4a: Wetland at Woolworths Industrial estate Wyong (Industrial / Forest edge) NB photo is shortly after planting
Figure 7-4b: Wetland at Coomera Waters Brisbane (Parkland edge)

Figure 7-4c: Wetland at Melbourne Docklands (Urban edge)

Figure 7-4d: Wetland at Waitangi Park NZ

(Urban edge)

To avoid issues associated with salinity, wetlands will require a waterproof base constructed from an impermeable membrane to prevent interception of ground water and to prevent infiltration to the groundwater. Research carried out by Ecological Engineering at Second Ponds Creek in Western Sydney, has demonstrated local clays can be successfully incorporated into treatment element liners. This must be assessed at each site as some clays may be too saline and have inappropriate structural strengths for such a purpose. Without proper treatment, wetlands may potentially become barriers to subsurface flow, bringing saline groundwater to the grounds surface resulting in salinity. Subsurface drainage may be required to allow groundwater to flow beneath and around the impermeable base and sides of a wetland. Sodic solids exposed during construction must also be properly managed.

7.5 Bioretention basins and bioretention swales

Bioretention systems can be designed as large systems within detention basins or linear systems to run along park edges and within riparian corridor buffer zones to integrate with the landscape design and to provide protection to riparian corridors.

A schematic cross section of a bioretention system is illustrated in Figure 7-5 in which stormwater is designed to pond to a depth of approximately 0.2m, then filter through the soil media to a sandy drainage layer where it is collected in perforated pipes and can be directed to a storage tank or discharged to the stormwater system and downstream environment.

Bioretention systems require a smaller area than wetlands to achieve the same level of pollutant reduction. Bioretention systems provide water quality treatment by filtering stormwater through vegetated soil media. Ponding above the bioretention system enables a larger proportion of the stormwater volume to be treated. The bioretention area is defined as the area of the base of the bioretention system and does not include the batter slopes which are required to provide the extended detention depth. A cross section of a typical bioretention system is presented in Figure 7-5, and examples of bioretention types are presented in Figures 7-6.

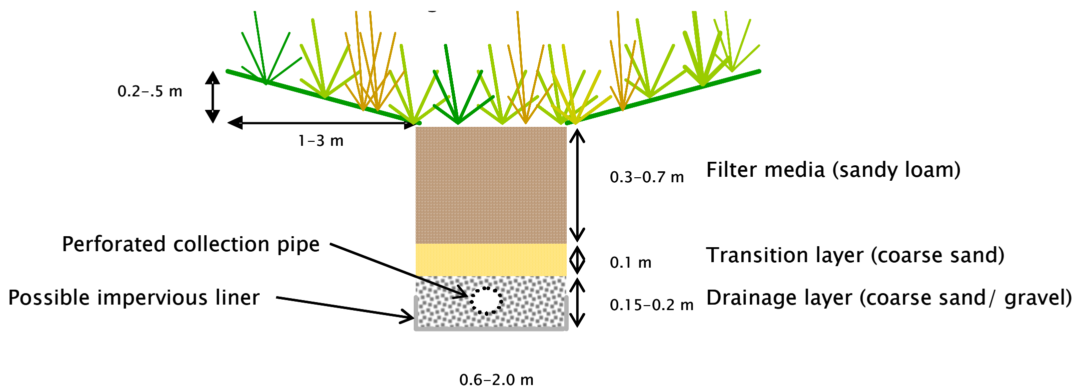

Figure 7-5- Cross section of a bioretention system

Figure 7-6 a – Bioretention at Docklands Park, Melbourne.
Figure 7-6 b – Bioretention basin at Richmond, Melbourne

Figure 7-6 c – Bioretention basin at Coomera Waters, Gold Coast.
Figure 7-6d – Bioretention basin at Victoria Park, Zetland

8 ORAN PARK PRECINCT WATER BALANCE

A water balance for Oran Park precinct has been developed based on an assessment of the likely water demands and potential supply options. Oran Park water users were identified as including the residential population, commercial / retail areas and external demands such as irrigation of open space. The water balance assesses the relationship of the three urban water streams: potable mains water, wastewater and stormwater, and their transformation through the site, to include such factors as evaporative losses, wastewater generation, and losses to groundwater. Each major facet of water use is presented in the following sections.

The following section presents the likely demands for water through the development and how they can be managed. Section 8.2 describes how some of these demands may be met with alternative sources of water to potable mains. The reliability of harvested stormwater for open space irrigation is investigated in Section 8.2.2, and two scenarios are presented for residential and commercial potable water substitution with treated backwater, and a combination of treated blackwater and rainwater.

8.1 Water demand and demand management

8.1.1 Residential water consumption data

The proposed residential component of the Precinct will incorporate a mix of

- 696 high density apartment dwellings (1,252 residents);
- 2,344 medium density attached and semidetached dwellings (6,798 residents); and
- 4,577 low density detached dwellings (15,104 residents).

The BASIX scheme aims to reduce average per person water consumption for all new dwellings in NSW. BASIX has benchmarked the typical per person water usage in Sydney at 256L/p/day, which is broken into the following uses:

Indoor demand	190 L/p/d	(74% total water use)
Garden irrigation	48 L/p/d	(19% total water use)
Other (car washing, pool use etc)	18 L/p/d	(7% total water use)
TOTAL	256 L/p/d	

Through demand management (specifically the installation of water efficient fittings) water consumption can be significantly reduced. As illustrated in Table 4.1, indoor demand can be reduced from 190 L/p/d to 118 L/p/d (28% reduction in total usage).

Demand management alone cannot meet the 40% BASIX potable mains reduction target in single dwelling developments where there is a significant demand for irrigating gardens. Alternative water sources such as rainwater tanks or reclaimed wastewater are required. Sydney Water is proposing to supply reclaimed wastewater to Oran Park, which can be supplemented with harvested stormwater from rainwater tanks and regional stormwater collection storages.

Table 8-1 - Oran Park residential water consumption with demand management.

Internal Domestic Usage	Sydney Base Case	Demand Management feature	Oran Park Water Efficient
	L/P/d		L/P/d
Kitchen sink	12.0	flow regulator	6.5
Bathroom basin	5.9	flow regulator	3.2
Laundry	5.9	NA	5.9
Bathroom	8.7	NA	8.7
Shower	56.9	AAA rated	37.1
Toilet	35.2	6/3 L dual flush	17.5
Washing Machine	49.1	AAA front loader	32.6
Dishwasher	3.9	AAA rated	6.5
TOTAL	190		118
EXTERNAL			
Residential Garden	47.9		47.9
Swimming Pool	9.3	Pool cover	
Leaks	12.1		12.1
Car Wash	6.0		1.3
Cooling Tower	0.5		
Fire Test	3.2		
SUB-TOTAL EXTERNAL	79.0	-	61.2
TOTAL	256.6		179.3

Note: L/p/d = Litres per person per day. ML/yr = Megalitres per year

Residential water demand through Oran Park is shown in Table 8-1 and can be summarised as:

- The ultimate total population of Oran Park is projected to be 23,155 people across low, medium and high density dwellings.
- BASIX estimates the typical Sydney resident uses 256.6 L/d which can be reduced to 179.3 L/d using water efficient devices.
- Allowing less irrigation demand for high density dwellings, the annual benchmark demand for Oran Park would be 2170 ML/yr with no demand management in place, and 1509 ML/yr with water efficient devices installed.
- Water efficient devices can reduce potable mains water usage by 30%, but non potable substitution will be required to meet BASIX 40% reduction target.

8.1.2 Commercial and retail water consumption data

The Oran Park precinct is proposed to include 16.63 ha of retail and commercial land and 16.24 ha of employment land, with a projected 2,450 jobs according to the land budget provided.

Commercial buildings in Sydney use an average of 1.4 kL/m²/yr (NABERS 2004), based on a building with over 10,000 m² of net lettable area. This data shows that commercial office buildings can reduce their water consumption to 0.8-1.0kL/m²/yr using demand management, a reduction of between 29% to 42%. Alternative water supplies will be required to meet further reductions in potable water consumption.

The base case consumption and demand management savings are summarised in Table 4.2 and are based on combined floor areas of the precinct commercial, retail and employment lands. 'Mixed use' land has not been included in this analysis.

Table 8-2- Oran Park water consumption with demand management for commercial, retail and employment lands.

	Base Case		Demand Management		
	L/m²/yr	(%)	L/m²/yr	(%)	ML/yr
Toilet	448	32	210	23.5	30.2
Shower	105	7.5	43	4.5	6.2
Kitchen	112	8	66	7.5	9.5
Hand basin	105	7.5	35	4	5
Cleaning	14	1	16	1.5	2.3
Other - miscellaneous	126	9	43	4.5	6.2
Cooling Tower*	490	35	-	-	0
TOTAL	1400	100	413	100	59.3

*Note: Cooling towers are used in existing high density multi story buildings but are not common in new smaller buildings and have not been adopted in the analysis of the precinct.

Demand management initiatives include 3A toilets, 2.8L manual or on-demand automatic urinals, 5A kitchen and washroom taps and 3A showers. Toilet flushing accounts for 32% of an efficient commercial building's water usage. Retail and commercial demands are shown as the same as it is unknown as to the make-up of retail shopping through the site.

Commercial, retail and employment water demand through Oran Park is shown in Table 4.2 and can be summarised as:

- The total employment, commercial (and retail) net lettable area is 143,600m² and is projected to provide 2,450 jobs.
- The total demand base case is 201ML/yr, (1400 L/m²/yr) and 130ML/yr where cooling towers are not in use.
- Disregarding cooling towers, water efficiency can achieve approximately 45% potable water savings, reducing the base case to 59.3ML/yr, (413 L/m²/yr).
- Based on the projected employment and water usage and management rates adopted here the average daily water consumption per person while at work is 100 L/day.

Further reductions in potable water consumption can be made by substituting alternative water streams as for residential water demand management.

8.1.3 Irrigation water consumption data

Irrigation demand for the garden, parkland and active open space within Oran Park precinct is dependent on the landscaped area, species selection and irrigation methods.

The planted areas within the precinct consist of approximately

- 55.61 ha of passive public open space (POS);
- 16.37 ha of active POS; and
- 157 ha of private gardens assuming 30% of low and medium density residential areas(excluding parks) will be lawns and gardens;

High density residential developments are not included in this analysis, but an irrigation demand is acknowledged and explained later in this chapter.

Irrigation demands are shown in Table 4.3. The irrigated area has been estimated as a percentage of the pervious open space, ie. 30% of the residential blocks and street corridors, 100% of the park areas. Irrigation demand for these areas is estimated to be 0.5m/yr to represent grassed areas and planting requiring light aerial irrigation. This application rate is based on the seasonal variation in rainfall, evapotranspiration and aerial application. Based on these assumptions the total estimated irrigation demand is 1145 ML/yr. This estimate gives a likely irrigation demand for Oran Park, which may be refined through the detailed design stage.

Table 8-3- Oran Park irrigation demands.

Area	Irrigation		
	Irrigated Area (ha)	Application rate (m/yr)	Consumption (ML/yr)
Passive Parkland	55.6	0.5	278
Active Recreation	16.4	0.5	82
Street and Gardens	157.0	0.5	785
TOTAL	231		1145

The BASIX benchmark presented in Section 8.1.1 predicts 405.7 ML/yr for private garden water usage in Oran Park. This is significantly less than the 785 ML/yr

estimate presented here. For the purposes of this study, the values presented in this section will be adopted for Low and Medium density as they represent the amount of water actually required in Camden rather than the amount of water applied across Sydney. For high density dwellings, 1.9L/p/day is used which is as a BASIX target for multi dwelling buildings (Department of Planning, 2005).

Water saving measures such as sub surface irrigation and moisture sensors can be utilised to reduce irrigation demands. Harvested stormwater from regional facilities within public open space is the preferred stream of water to substitution. The suitability of treated blackwater for garden irrigation needs to be demonstrated before it is recommended to the community.

It is acknowledged that rainwater tanks carry an expense that must be borne by the user in addition to the obligated cost of purchasing recycled blackwater. Passive irrigation may provide an attractive alternative, where stormwater from rooves and hard surfaces is directed to garden beds thereby increasing the volume of rain reaching the root zone in every rain event.

8.1.4 Water demand summary for Oran Park with demand management

The water balance for Oran Park is made up of the three urban water streams – potable mains water, stormwater and wastewater. Table 8-4 presents the potable mains demands generated by the development with water efficient fittings in place as per BASIX legislation.

Table 8-4 – Water consumption through Oran Park

Usage	Residential		Commercial and Retail		Irrigation	TOTAL
	L/P/d	ML/yr	L/m2/yr	ML/yr	ML/yr	ML/yr
INTERNAL						
Kitchen Sink	6.5	55	66	9		64
Bathroom basin	3.2	27	35	5		32
Laundry	5.9	50	16	2		52
Bathroom	8.7	74				74
Shower	37.1	314	43	6		320
Toilet	17.5	148	210	30		178
Washing Machine	32.6	276				276
Dishwasher	6.5	55				55
SUB-TOTAL INTERNAL	118	997	370	59		1050
EXTERNAL						
Residential Garden	47.9	80				80
Passive POS					28	28
Active POS					8	8
Swimming Pool						
Leaks	12.1	97				97
Car Wash	1.3	10				10
Other			43	6		6
SUB-TOTAL EXTERNAL	61.3	87	43	6	36	229
TOTAL	179.3	1184	413	59.3	36	1279

Further demand reductions can be achieved through supplementing non-potable mains water with a combination of reticulated treated blackwater and stormwater from regional treatment facilities and rain water tanks, which is discussed in the following sections.

8.1.5 Treated blackwater for non potable substitution at Oran Park

The proposed upgrade of the West Camden Sewage Treatment Plant will supply treated blackwater to the precinct via dual reticulation. Where dual reticulation is provided, initially harvested stormwater (supplemented with mains water) can be used as the alternative water source. Plumbing design should be configured to adapt to future opportunities, specifically centralised provision of non potable water.

At a minimum, treated blackwater is considered suitable for toilet flushing and car washing, and is usually used to irrigate private gardens. The applicability of Camden STP recycled blackwater for use in laundry and on gardens has not yet been resolved. While recycled stormwater is the preferred alternative for garden irrigation in areas impacted by salinity, suitably treated blackwater such as supplied in Newington has a very low nutrient content and could be used in gardens in Western Sydney.

It is appreciated that the new community at Oran Park may not be expected to purchase rain water tanks in addition to reticulated treated blackwater, utilising treated blackwater for garden irrigation and laundry is not advised without a complete risk analysis undertaken. With suitable treatment of blackwater at the West Camden STP, a breakdown of the water balance with minimal stormwater harvesting in residential and retail\commercial\employment developments is presented in Table 8-5. In the analysis, harvested stormwater is given priority over treated blackwater for irrigation of public open space and it is assumed that 80% of demand is achieved with 20% top up supplied by potable mains.

Table 8-5 - Water stream consumption through Oran Park with preference for reticulated treated blackwater and minimal stormwater harvesting

Usage	Potable Mains (ML/yr)	Stormwater / Rainwater (ML/yr)	Recycled Blackwater (ML/yr)	TOTAL (ML/yr)
INTERNAL				
Kitchen Sink	64	0	0	64
Bathroom basin	32	0	0	32
Laundry	2	0	52	54
Bathroom	74	0	0	74
Shower	320	0	0	320
Toilet	0	0	178	178
Washing Machine	0	0	276	276
Dishwasher	55	0	0	55
SUB-TOTAL INTERNAL	546	0	505	1051
EXTERNAL				
Residential Garden	0	0	80	80
Passive POS*	6	22	0	28
Active POS*	2	6	0	8
Leaks	97	0	0	97
Car Wash	0	0	10	10
Other	6	0	0	6
SUB-TOTAL EXTERNAL	110	29	90	229
TOTAL	656	29	595	1279

* Note: Assumes 80% of water demand can be met by harvested stormwater

Reticulated blackwater can provide up to 96% of total non-potable demand and 46% of the total water demand for the precinct, reducing the annual potable mains demand to 656 ML or 51% of the annual demand after demand management reductions. This substitution scenario achieves a 76% reduction in potable mains water from the BASIX Sydney benchmark.

8.2 Stormwater for non potable substitution at Oran Park

Harvested roofwater and treated stormwater can be collected throughout the development and reused within public open spaces, residential, school, retail, employment and commercial areas or as an alternative to or as supplementary to treated blackwater from Camden STP. .

Roof runoff is the preferred source for reuse in hot water systems which disinfect the water and make it fit for human contact. Within the major retail areas where roof areas are large and the workforce is constant, roofwater harvesting can contribute to many of the internal demands of a building.

Harvested stormwater is recommended for irrigation of public open space. If treated blackwater from the Western Camden Sewerage Treatment Plant (STP) is not approved for laundry and garden irrigation, then stormwater is will be the preferred substitute in these applications.

The following section investigates the reliability of rainwater tanks in providing internal hot water for residential, retail, commercial and employment lands and residential garden irrigation.

The reliability of harvesting treated stormwater from regional storages for public open space irrigation water is investigated in Section 8.2.2.

8.2.1 Stormwater harvesting for residential reuse

Rainwater tank harvesting for typical residential dwellings was undertaken using MUSIC software to derive a relationship between rainwater tank volume and reliability of rainwater supply for internal hot water usage and garden irrigation. Seasonal variability in irrigation demand and daily hot water demands was simulated over 39 years of daily rainfall data. Half the approximate roof area of residential buildings was assumed to flow to the rainwater tanks, which is conservative given that up to 80% of roof water is often harvested. The resulting reliability curves are presented in Figure 8-1 .

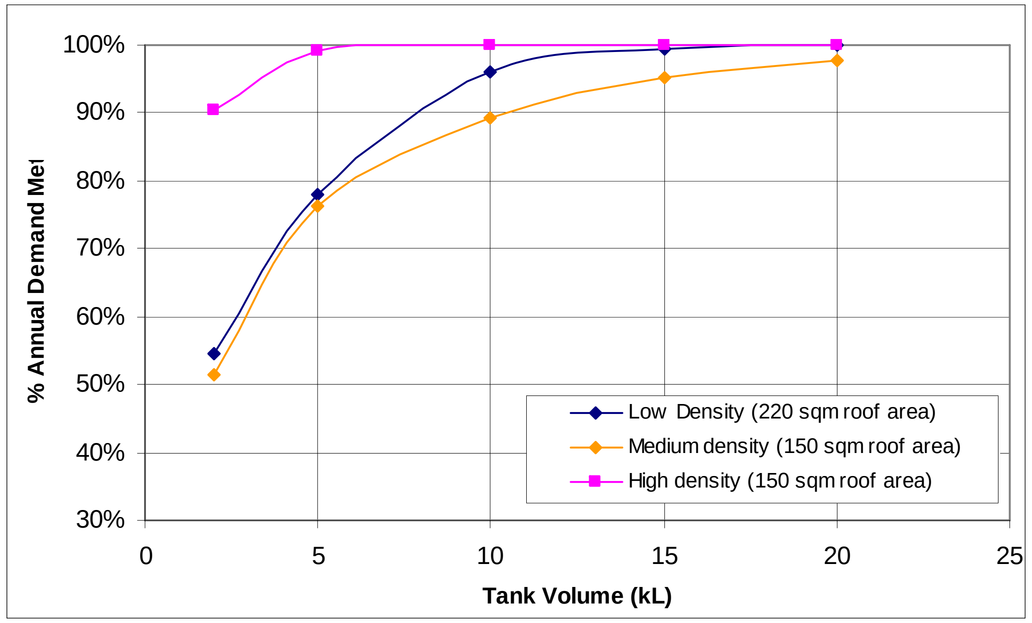

Figure 8-1 : Rainwater tank analysis for Oran Park residential densities

The curves in Figure 8-1 show that a reliable supply of irrigation and hot water can be sourced from rainwater harvesting with relatively small storage requirements for three typical densities. A 10kL tank would supply a typical low density residential dwelling with 86kL a year meeting 96% of annual hot water and irrigation requirement demand. A similar tank could supply approximately 54kL a year to medium density dwelling providing 90% of annual hot water and irrigation requirement requirements. The low density residential tank has a higher irrigation demand and more frequent draw down that the medium density residential tank, and is measured more efficient. It is recognised that 10kL is a large tank for a medium density dwelling but this analysis shows that a 5kL tank van provide up to 76% reliability. High density dwellings with minor irrigation requirements can achieve a high level of service from a 2kL tank which could provide approximately 23kL per year or 99% of annual hot water requirements.

8.2.2 Stormwater harvesting for employment, retail and commercial reuse

Rainwater tank harvesting for typical employment lands and commercial and retail zones was investigated. Roof areas were adopted from the Oran Park land budget provided in February 2007.

Employment lands are estimated to have a total floor space of 8.1 hectares and provide 300 jobs. A 30kL daily demand for rainwater reuse in hot water systems was assumed based on the precinct water balance. Modelling of the supply and demand was undertaken using MUSIC software to derive a relationship between rainwater tank volume and reliability of rainwater supply for internal hot water usage over 39 years of daily rainfall data. The resulting curve is presented in Figure 8-2.

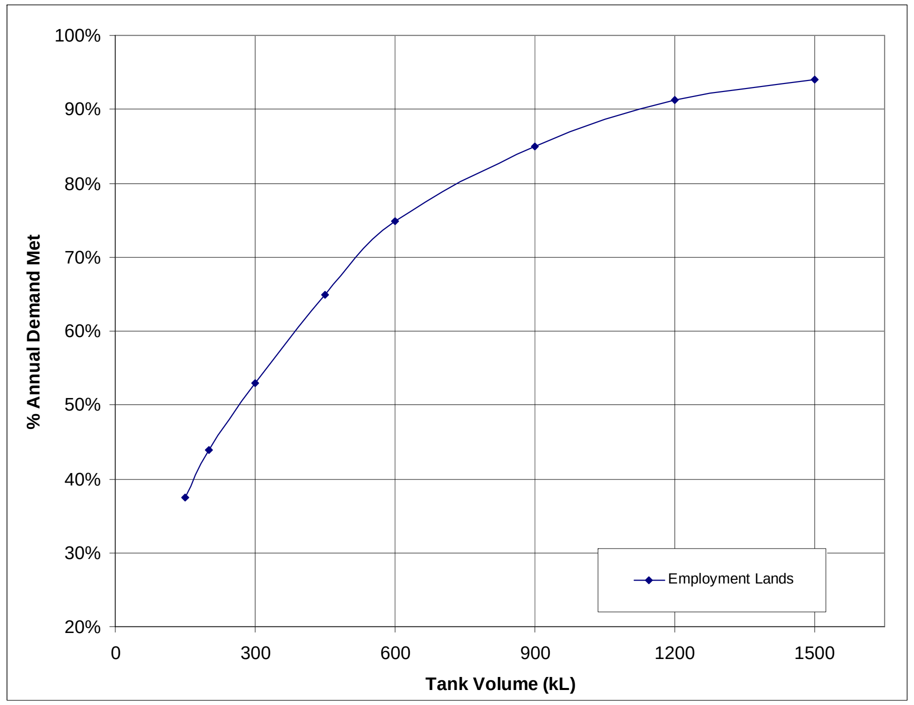

Figure 8-2 : Rainwater tank analysis for Oran Park Employment Lands

The curve presented shows that a significant percentage of internal hot water demands can be met with rainwater tanks. A storage of 1200kL will supply 10 ML annually and provide 90% of the annual hot water demand. This storage can be provided at a rate of 150 kL / ha of floor space or on a basis of 4kL per worker.

The commercial and retail precincts of Oran Park will have total floor spaces of 0.5 ha and 5.44 ha respectively. Each land use is projected to provide 250 and 1800 jobs with potential hot water demands of 9.1 and 65.7 ML/year. The floor areas and associated roof catchments are too small to provide sufficient harvested rainfall for either workforce, however the demands provide a significant stormwater source control to aid in stormwater flow management and harvesting is recommended on this basis. Alternative methods of supplying a reliable supply of stormwater can be further investigated at a detailed design stage.

8.2.3 Stormwater harvesting for public open space irrigation

Harvesting treated stormwater from regional wetlands and bioretention facilities was investigated as a source of irrigation water. Some 3,780 ML of stormwater will run off

the precinct annually, and up to 90% will be treated to best practice levels in stormwater treatment facilities. Treated stormwater can be stored within open water storages or within underground tanks.

A typical harvesting scenario was investigated using MUSIC software to determine a relationship between storage tank volume, catchment, irrigated area and reliability of supply. For the purposes of analysis, a 10 ha catchment model was developed to provide 5 ML annual irrigation water, which equates to an equivalent demand for a 1 ha open space. The planted open space to be irrigated represents approximately 10% of the residential catchment in this analysis.

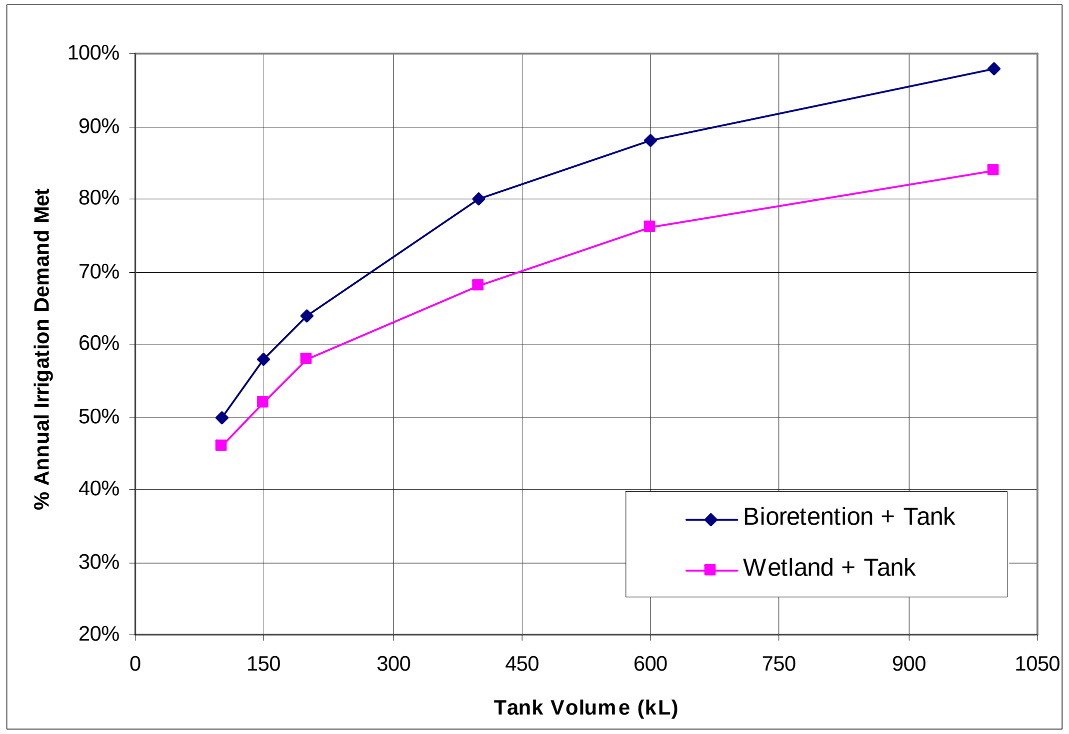

Figure 8-3 : Rainwater tank analysis for Oran Park Employment Lands

The curve presented shows that regional stormwater harvesting can provide a reliable supply of irrigation for parklands across the development with a 80% reliability of supply achieved with a 400kL tank. Evaporative losses from wetlands reduce the harvestable volume and achieve a reliability of 69% with a 400kL tank.

Open water storages also provide a stormwater harvesting function but are not as efficient due to evaporative losses. The drawdown of a water body water surface must be limited to protect the fringing vegetation and prevent frequent exposing of sediments. Seasonal variation in water level is limited to 400mm with 600mm draw downs limited to an average recurrence interval of 10 years. A 10ha catchment can support a 1,500 square meter water body without adverse draw down and supply approximately 1.5 ML of irrigation water for 3000 m² of planting annually. A plot of water level over the simulation period is presented in Figure 8-4.

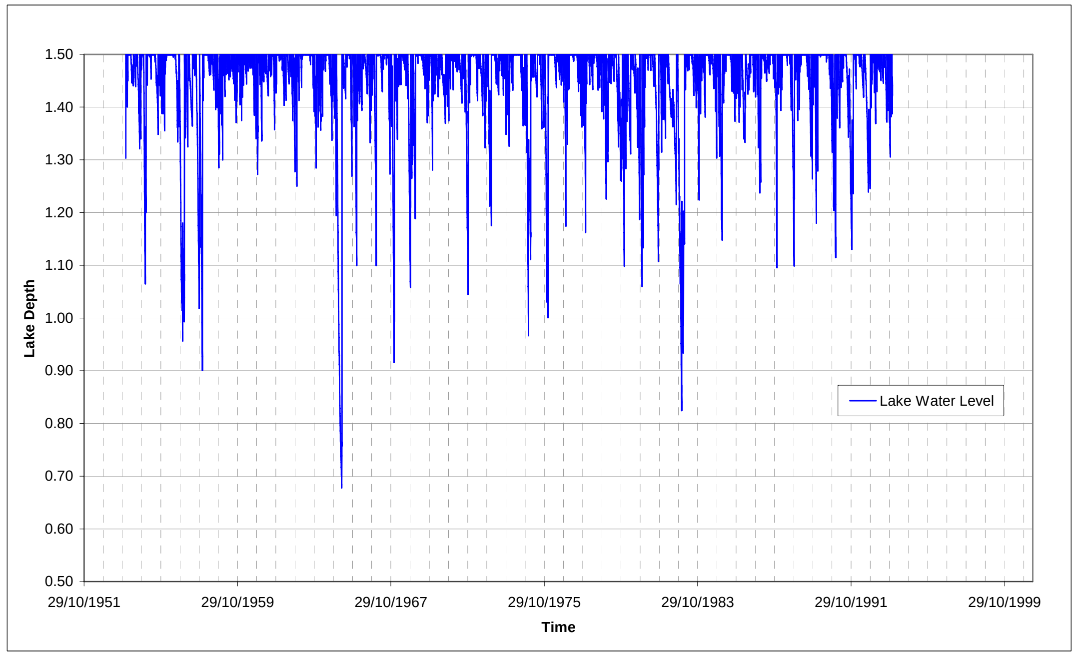

Figure 8-4 : Rainwater tank analysis for Oran Park Employment Lands

The assessment indicates that open water bodies can be implemented across the development at a rate of approximately 3% of the catchment area. This represents a hydrologic sustainability, which is different from algal bloom risk which dictates water body volumes be approximately 0.3% of the feeding catchment. Water bodies in excess of this 0.3% will need an accompanying wetland and circulation pump to treat water quality during dry periods, which is further discussed in Section 9.

8.2.4 Water balance with combined stormwater harvesting and treated blackwater

The water balance for each combined blackwater and stormwater substitution scenario is presented in Table 8-6 with the water balance split into the three water streams. The water balance is based on achieving 90% of residential irrigation and hot water requirements through rainwater tanks as demonstrated in Section 8.2.1.

It is anticipated that treated blackwater will ultimately be available in sufficient volumes to satisfy all toilet flushing requirements and be provided for laundry use.

Stormwater harvesting from regional stormwater treatment facilities can be utilised to supply at least 80% of public open space irrigation. The deficit is assumed to be provided by potable mains.

Table 8-6 – Water consumption through Oran Park with combined treated blackwater reticulation and stormwater harvesting

Usage	Potable Mains	Stormwater / Rainwater	Recycled Blackwater	TOTAL ML/yr
INTERNAL				
Kitchen Sink	33	31	0	64
Bathroom Basin	17	15	0	32
Laundry	2	0	50	52
Bathroom	34	40	0	74
Shower	150	170	0	320
Toilet	0	0	178	178
Washing Machine	0	0	276	276
Dishwasher	55	0	0	55
SUB-TOTAL INTERNAL	290	256	503	1049
EXTERNAL				
Residential Garden	0	80	0	80
Passive POS	0	28	0	28
Active POS	0	8	0	8
Leaks	97	0	0	97
Car Wash	0	0	10	10
Other	6	0	0	6
SUB-TOTAL EXTERNAL	103	116	10	229
TOTAL	393	372	513	1279

The water balance for Oran Park shows that only 393 ML of the total 1288 ML water demand will be provided by potable water and achieves a 85% reduction in potable mains from the BASIX benchmark for Sydney.

9 OPEN WATER BODIES

The master planners have identified a series of large open water bodies in line with the developers' wishes to provide high amenity lots with water views. These areas will be met with a combination of stormwater collection ponds/open water bodies for harvesting (no water quality treatment) and regional wetlands (providing water quality treatment). Poorly designed open water bodies can lead to conditions which are conducive to algal blooms, which can impact on the amenity of the surrounding areas. Factors affecting poor water quality and conditions conducive to algal blooms can be managed by a combination of improving inflow water quality, hydrology and water circulation characteristics of the water bodies.

Managing nutrient inflows to a water body and managing the water quality within the water body is important in controlling algal blooms. Without proper management, even low levels of nutrient inflows can accumulate over long periods to become available at some point spurring an algal bloom. The frequency of turnover, or flushing is often an important encompassing factor in defining conditions conducive to algal blooms within a water body.

Wetlands are less prone to conditions conducive to algal blooms compared with open water with no stormwater treatment. Macrophytes and epiphytes can out-compete algae in its ability to assimilate available nutrients and consequently effectively controlled algal growth in these water bodies. Regional stormwater treatment wetlands can consist of open water area, which is normally up to 30% of the wetland surface area. This area is fringed by macrophytes. Open water area can be expanded by incorporating submergent macrophytes within the open water areas thus enabling these systems to be effectively wetland systems whilst having the appearance of an open water system. Submergent macrophyte species will rarely break the surface of the wetland, and will give the impression of open water from a distance. From closer, the macrophytes will be visible beneath the surface giving the water a dark appearance. With suitable design, wetlands can be designed to

9.1 Ecological sustainability

Typically large water bodies with relatively small catchments experience water quality problems due to insufficient inflows to circulate and flush the water body. Long periods of detention (residence time) provide algal populations time to grow to numbers where an algal bloom is inevitable. Australian Runoff Quality (Engineers Australia) describes a simple relationship between time and algal growth rate at a number of reference ambient temperatures to determine how long it will take for an algal population to reach bloom proportions. For Oran Park, it is recommended that the 20th percentile residence time does not exceed 20 days, which is recommended for climates where water temperature reaches 25 degrees during summer. The methodology is based on the notion that a 20% risk of water body conditions that are conducive to algal bloom as a reasonable risk, acknowledging that there may be other factors that would influence whether algal bloom would actually occur when the conditions are favourable.

Water body residence time analysis can be used to assess the appropriate size of open water bodies to minimise algal bloom risk to a reasonable level. Residence time is a function of water body volume and inflow, which is dependent on seasonal distribution of rainfall and catchment size and characteristics.

The sensitivity of algal growth to residence time is shown in Figure 9-1.

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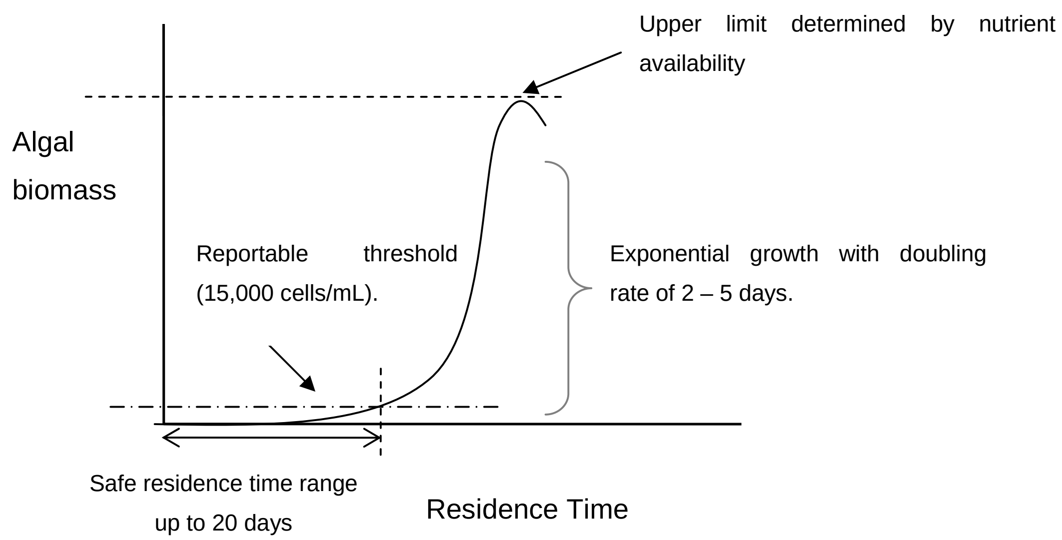

Figure 9-2 Sensitivity of Algal growth to residence times

A MUSIC model was established to model long term runoff volumes and calculated the frequency of flushing for a given catchment size and water body volume. To achieve the 20th percentile residence time does not exceed 20 days, water body volume (m^3) should be 0.35% of catchment area (ha). Open water needs to be more than 1.0m deep to prevent macrophytes growth.

9.2 Hydrologic sustainability

The drawdown of a water body surface must be limited to protect the fringing vegetation and prevent frequent exposing of sediments. Seasonal variation in water level should be limited to 400mm with 600mm lake water surface draw down limited to an average recurrence interval of 10 years. An example of this analysis and plot of water level over the simulation period is presented in Section 8

9.3 Water quality management

Where catchment inflows are insufficient and risk of conditions conducive to algal blooms unacceptable, management of water quality inflows and of the water body itself needs to be considered.

Open water body water quality can be adversely affected by stratification during summer months, where a dense layer forms at the bottom of the water body. This layer is prone to becoming oxygen starved which promotes the remobilisation of sediment nutrients to the water column further reducing water quality. Destratification often occurs naturally when the surface of the water body cools, but may need to be forced using some form of mechanical mixing such as a surface impeller, a submerged bubble plume or recirculating pump. These strategies have an associated energy and maintenance cost, and should be avoided through careful volume and bathymetry design.

The preferred method of managing water quality is through recirculating water through a constructed wetland as represented in Figure 9-3. This would promote a range of wetland processes that would out-compete algal growth in the water column when passed through the wetland.

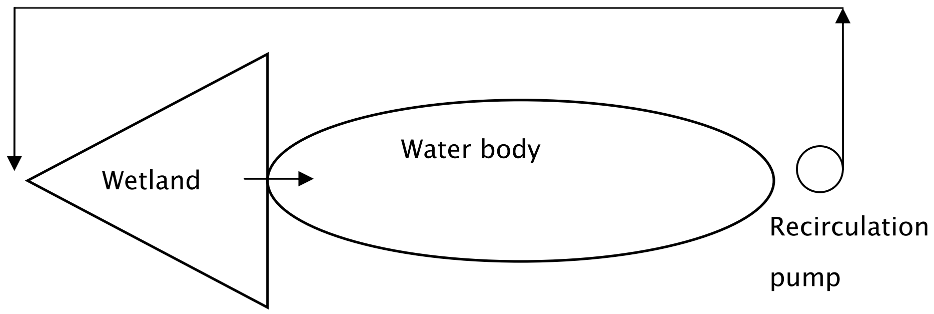

Figure 9-3 Open water body and recirculating wetland schematic

While inflows to water bodies will be treated by wetlands and bioretention to reduce nutrient loads, it may also be necessary to provide additional treatment to remove nutrients that accumulate within the water body by circulating water through a constructed wetland during the high risk periods. Constructed wetland systems have the capacity to remove nutrients and algal cells from water. The rate of circulation needs to be such that safe residence times in the water body are maintained.

Generally, the larger the water body:

- the greater the residence time and risk of conditions conducive to algal growth;
- the greater the required area of wetland to recirculate flows through during high risk times; and
- the greater the pump size, pump rate, and energy expense associated.

Recirculation can be provided by the same pumps used for irrigation and harvesting. Pump operation costs and associated emission offsets can be determined at development application stage.

9.4 Open water bodies as stormwater harvesting storages

Stormwater can be harvested, treated, stored and reticulated to provide a reliable source of non-potable water for demands including open space irrigation, toilet flushing in private dwellings and commercial buildings and air conditioning in commercial buildings. This is considered particularly appropriate during the early staging of the project where treated wastewater may not yet be available while a dual water supply reticulation system is already in place. Stormwater pollutant levels are

significantly less than those in wastewater and thus simpler technologies and less energy is required in the treatment process.

9.5 Management of nuisance roosting bird populations

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Populations of Ibis are known to colonise suitable habitats within proximity of open water and food sources. While Ibis prefer island habitats and roost in trees with horizontal branches. Colonisation of areas around open water can be minimised by implementing a number of strategies developed in consultation with Steve House of Eco Logical Australia:

- Designing wetlands and open water without wetlands;
- Avoiding trees species that do not have lots of horizontal branches
- Avoiding thicket species and managing weeds;
- Removing fallen trees

10 WATERWAY REHABILITATION INITIATIVES

10.1 Oran Park riparian corridors –nomination of stream categories

The Oran Park site contains a wide range of waterways, ranging from defined creek lines to slight depression in the landscape that form ephemeral drainage lines. A preliminary nomination of stream riparian categories is provided below based on assessment of the likely ecological functions of each water course or drainage line on the site. This assessment was based on site inspections, review of aerial photography and preliminary results from a vegetation assessment of the site.

The categories assume an ecological function and riparian width (from the bank of the water course) as described in the Draft Riparian Objectives and Principles for Structure Planning in the North West and South West Sectors, that is:

- Category 1 - Environmental Corridor includes a 40m core riparian zone and a 10m buffer to counter edge effects of urban interface
- Category 2 - Terrestrial & Aquatic Habitat includes a 20m core riparian zone and a 10m buffer to counter edge effects of urban interface
- Category 3 - Bank Stability & Water Quality includes a 10m from the bank of the watercourse.

Across the site understorey vegetation has been severely modified or lost as a result of past and present agricultural practices.

10.2 Stormwater Treatment – protection of Category 1 and 2 streams

Drainage lines (d1 to d13) and Category 3 streams are likely to provide sites for stormwater detention and treatment to protect the more valuable sites downstream that are better connected to off site downstream environments. The stormwater features are likely to include measures such as retarding basins and wetlands.

Category 1, 2 and 3 waterways will be protected from increases in post development flow through stormwater detention, erosion control and bank stabilisation measures within the waterway.

10.3 Riparian zone width

It is proposed that the waterways nominated have a core riparian zone width and additional buffer zone width as stated in the *Draft Riparian Objectives and Principles for Structure Planning in the North West and South West Sectors*. On considering the design of the riparian zone and its integration with the urban form, it is proposed to allow the waterways to meander within the middle third of the corridor. This design has the advantage of maintaining an adequate riparian width for aquatic environment protection while also allowing a more flexible integration with the urban form.

A meander of the channel within the riparian zone results in a riparian width that will vary somewhat along the length of the reach but has an average prescribed width from the edge of the channel. This design provides for a more natural alignment of the low flow channel, increasing the ecological value of the channel, without causing inefficient land-take from a development standpoint. An illustration of this design is shown in Figure 10-1 below.

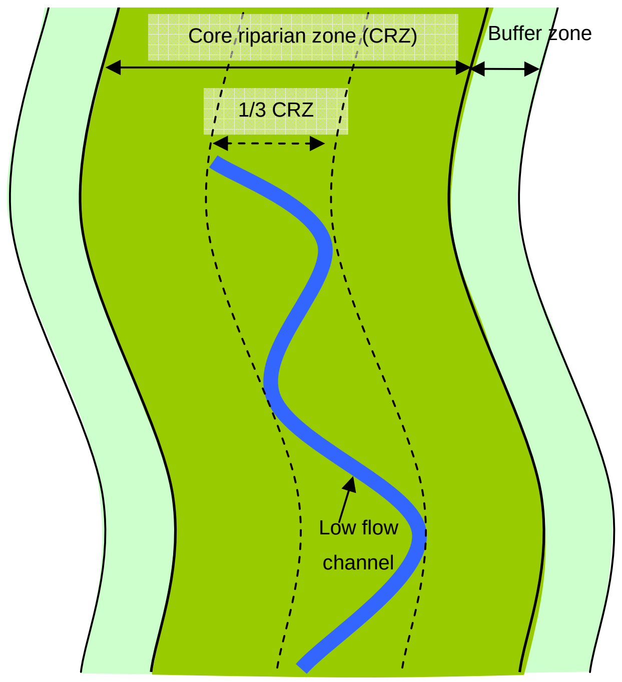

Figure 10-1: Illustration of meandering channel within the Core Riparian Zone.

10.4 Riparian corridor protection

Declared riparian corridors will require protection from increased flows associated with the proposed development. This will be achieved by maintaining the ephemeral hydrologic conditions of the creeks, and providing resilience to creek channels and providing a buffer zone to protect core riparian zones from edge effects of adjacent lands.

A system of stormwater bypasses will be established to divert erosive flows around creeks to downstream storages. A certain amount of flow will be allowed to discharge to the creek to maintain predevelopment ephemeral character and hydrology. Increased flows associated with the development that do not meet the DEC's flow management criteria, will be piped to downstream storages for reuse or further attenuation.

The diversions will comprise a network of flood detention basins, intercepting stormwater pipes and downstream storages as represented in Figure 10-2.

10.5 Vegetated buffer zones

The establishment of 10m wide vegetated buffers along riparian corridors will protect riparian corridors in the following ways:

- prevention of weed invasion from adjacent lands;
- buffering of micro-climate
- litter and pollution removal
- trampling

Integration of bioretention systems within these areas will meet the above criteria if properly designed and planted. Locating bicycle paths within the vegetated buffer must not compromise these functions.

10.6 Intercepting stormwater pipeline

Intercepting stormwater pipes will run parallel to Category 1 and 2 creek corridors and function as a bypass for erosive flows up to the 1-year event. The pipes will collect flows from the minor drainage network where post development discharges do not meet the DEC's flow management target. Flows will be conveyed to downstream storages for reuse or further attenuation and discharge to receiving waters. Intercepting pipes will also be utilised to convey treated stormwater from wetlands and bioretention to stormwater harvesting storages. A schematic diagram of the intercepting stormwater pipe function is presented in Figure 5-1 and pipe alignments throughout the precinct are presented in Figure 10-2. This figure shows pipelines in orange protecting the more ecologically valuable creeks.

Pipelines along South Creek are not a requirement due to the already highly disturbed geomorphology of the creek.

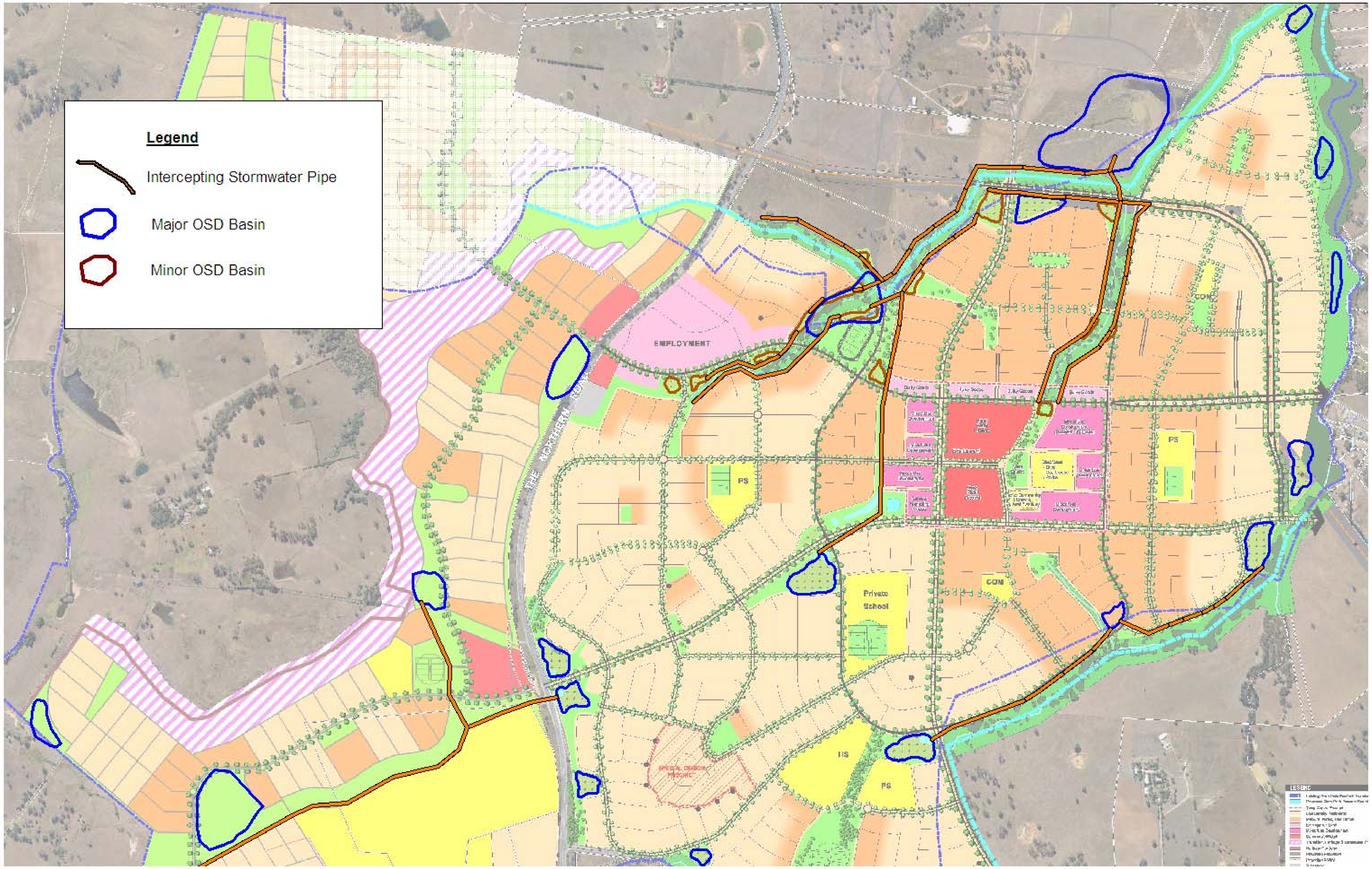

Figure 10-2: Alignment of intercepting stormwater pipes throughout the precinct

10.7 Creek rehabilitation strategy

Preliminary investigation of the fluvial geomorphology of the stream network at Oran Park indicates significant channel degradation has occurred (and is ongoing). Degradation is evidenced by the presence at various locations in the site of incision headcuts, oversteepened banks, mass failure erosion of banks, and localised channel aggradation.

It is not clear at this stage what the drivers of the channel degradation are, but it is likely that a combination of vegetation clearance, modification of the pre-European channel form and damage from stock have led to increased erosional forces being exerted on the channel and consequent initiation of channel incision. The current fluvial geomorphology at Oran Park indicates the process of degradation is ongoing and is likely to lead to further erosion and channel instability unless addressed. Unchecked, degradation will lead to continued loss of inchannel and riparian habitat, elevated sediment delivery to downstream reaches and ongoing channel instability.

In order to stabilise and rehabilitate the stream network at Oran Park, it is necessary to carry out a number of activities:

- Accurately assess the current condition of the channel network and the trajectory of its likely future geomorphological development. The assessment must take into account the location of the site in the catchment and the condition of the channel in the reaches up and downstream of the site
- Develop rehabilitation objectives for the channel network in the site. For example, is landscape or visual amenity an important driver, or is improved inchannel habitat for specific faunal species the key required outcome
- Develop a strategy to address the channel instability, using the condition assessment as a starting point. The strategy will determine the location and type of rehabilitation treatments required to meet the rehabilitation objectives. The suite of treatments likely to be required at Oran Park include bank reprofiling and revegetation, implementation of grade control structures or rock chutes to address channel incision and implementation of pool-riffle sequences (if appropriate)
- Develop a detailed design of the rehabilitation treatments identified in the rehabilitation strategy so the strategy can be implemented.

The outcomes from rehabilitating the channel network at Oran Park will be enhanced instream and riparian ecological health within the site, reduced impact on downstream ecosystem health and improved visual and landscape amenity within the site.

10.8 Riparian Sections

A typical section of a Category 2 and Category 3 stream have been prepared accoutring to the proposed strategy. Further details of sections will be prepared incorporating landscaping master plans when available

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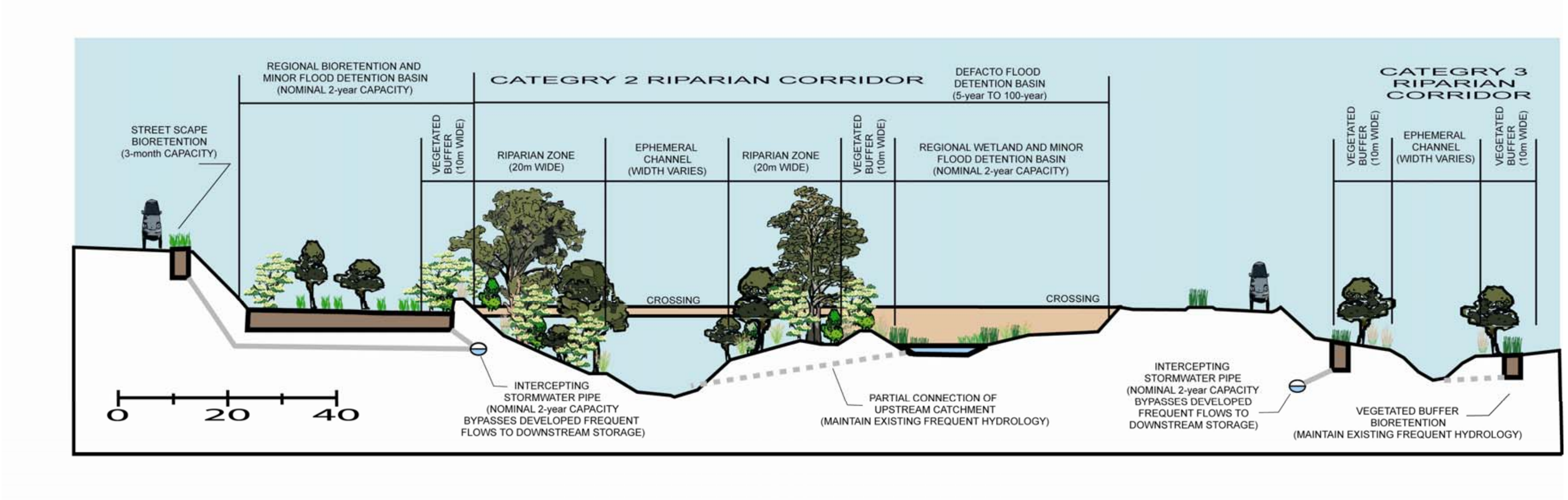

Figure 10-3: Category 2 and Category 3 typical sections

11 LIFE CYCLE COST ANALYSIS AND MAINTENTANC

The capital costs for the WSUD Strategy are presented in Table 11-1 below. These costs are based on costing algorithms in MUSIC software, which are industry standard.

Table 11-1 - Water consumption through Oran Park with stormwater harvesting

Catchment	Total Area (m^2)	Rate ($ / m^2)	Capital Cost ($)	Annual Maintenance ($)
Eastern Precinct				
Regional bioretention	58,500	185[1]	10,813,500	184,000[2]
Street scale bioretention	10,600	275[1]	2,912,800	30,000[2]
Wetlands	93,800	70[3]	6,564,700	200,000
Gross Pollutant Traps [4]	-	65,000 (10ha catchment) 130,000 (20-30 ha catchment)	1,888,500	121,900[5]
Open water bodies	11,300	50[6]	556,500	30,000
Intercepting stormwater pipes	8,360 m	835 ($/m)[7]	6,983,000	-
Western Precinct				
Regional bioretention	11,500	185[1]	1,924,000	36,000
Wetlands	41,100	70	2,877,000	73,000
Gross Pollutant Traps [4]	-	65,000 (catchment <15 ha) 130,000 (catchment > 15 ha)	260,000	25,000
Intercepting stormwater pipe	2,025 m	835 ($/m)[7]	1,694,000	-
TOTAL			**$ 36,474,000**	**$ 700,000**

1. Cost estimates for bioretention include earthworks, structures, impermeable liner, bypass channels, rock protection, filter media and establishment with aquatic plants.
2. Annual maintenance adopted from MUSIC alternative algorithm.
3. Cost estimate for wetlands includes earthworks, structures, impermeable liner and planting.
4. Gross pollutant traps adopted at inlets to wetlands.
5. Annual maintenance figure includes cost estimate for maintenance on bioretention sediment fore bays.
6. Cost estimate for wetlands includes earthworks, structures, impermeable liner and planting. Pumps have not been included as they are considered to be part of irrigation infrastructure.
7. Cost estimate for intercepting stormwater pipes includes an estimate for increasing pipe diameter along reach, trenching, and pits.

In relation to ongoing maintenance costs, it is important to note that once established, and with the contributing catchments stabilised, the maintenance of the WSUD systems is expected to be only minor with periodic management of vegetation similar to other elements of landscape within the Oran Park development.

11.1 Maintenance of stormwater treatment facilities

WSUD infrastructure such as bioretention systems, constructed wetlands and stormwater storages require ongoing inspection and maintenance to ensure they establish and operate in accordance with the design intent. Potential problems associated with WSUD 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).

The following sections summarise the maintenance requirements of the bioretention systems, constructed wetlands, stormwater and storages. Detailed maintenance schedules are to be developed as part of the Monitoring and Maintenance Plan that will accompany the Operation Works Application for the development. These maintenance schedules will be developed in collaboration with Council assets and maintenance departments to ensure the structure and frequency of maintenance is consistent with current Council procedures. This will also provide an opportunity for transfer of knowledge in this regard to allow Council to effectively operate the WSUD infrastructure.

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 WSUD designs developed for Oran Park development 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 Stage (ie by taking it offline). 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) and importantly also reduces the seed load being deposited in the pods 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 least 12 months after planting (ie at least one growing season such that root/rhizome establishment and foliage density are well developed) or when allotment construction is completed in the contributing catchment, whichever occurs later.

11.1.1 Bioretention systems

Typical maintenance of bioretention systems during operation will involve:

- Routine 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 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.
- Where a sediment forebay is adopted, removal of accumulated sediment.
- 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.
- Resetting (i.e. complete reconstruction) of the bioretention system will be required if the system fails to drain adequately after tilling of the surface. 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.

11.1.2 Constructed wetlands & open water bodies

Typical maintenance of constructed wetlands and water bodies involve:

- Routine inspection of the wetland to identify any damage to vegetation, scouring, formation of isolated pools or litter and debris build-up
- Routine inspection of all hydraulic control structures (inlet pond connection to macrophyte zone, slotted riser and outlet pits/pipes) to identify any areas of scour, litter build up and blockages
- Inspections following large storm events to check for scour.
- Removal of litter and debris
- Removal and management of invasive weeds
- Repair to wetland profile to prevent the formation of isolated pools
- Periodic (usually every 5 years) draining and de-silting of the inlet pond
- Regular watering of littoral vegetation during plant establishment
- Water level control during plant establishment
- Replacement of plants that have died (from any cause) with plants of equivalent size and species as detailed in the planting schedule
- Vegetation pest monitoring and control
- Maintenance programmes for the wetlands and open water bodies are to be developed for the Construction, On-Maintenance, and Operational Phases of the precinct. These maintenance programmes will be submitted as part of detailed design.
- Pump maintenance is expected to occur as part of irrigation infrastructure repairs.

12 CONCLUSIONS

A Water Sensitive Urban Design (WSUD) strategy for the Oran Park Precinct has been developed to comply with the SEPP Growth Centres Development Code.

The Strategy presents stormwater management options to meet the objectives outlined in the Code, and has been developed taking into consideration salinity, erodible soils and the ephemeral nature of the creeks that cross the site and recognises the potential to rehabilitate and enhance the values of the local creek systems. The strategy has also been developed in consultation with the masterplanners for the site to ensure that it is consistent with the development approach and layout. The elements of the strategy include:

- Stormwater quantity control so as to mitigate the flooding impacts of the development on South Creek and erosive flows within creeks across the site. This is to be achieved through a two-pronged approach of minor and major OSD basins including –
  - minor flows up to the 5 year ARI will be detained in minor OSD basins adjacent to the creeks, and potentially lot scale OSD within the town centre and employment zones
  - flows up to the 1 in 100year ARI event will be detained in major OSD basins.
- Stormwater quality control – stormwater treatment through a combination of regional wetlands and bioretention facilities and distributed street scale stormwater treatments where required to meet the stormwater quality reduction load targets set by the DEC, and
- Riparian zone and creek management –
  - Flows that meet the stream erosion index objectives established by DEC will flow into the creek
  - Flows beyond this level and up to the two year ARI event will bypass the creek via intercepting stormwater pipes to downstream storage for reuse or further attenuation. These elements will utilise and complement the minor OSD basins and ornamental water body storages.
  - erosion control and bank stabilisation measures within the waterway.

The strategy for potable mains water conservation and reducing wastewater discharge from the site includes:

- potable water demand management through the use of water efficient fittings
- utilisation of alternative water sources on a fit-for-purpose basis including treated stormwater harvested on site and recycled waster water either treated on site or supplied by a dual pipeline

The Oran Park development has the opportunity to be a flagship for sustainable and water sensitive development in the growth centres of western Sydney underpinned by strong principles of environmental protection and the conservation of our precious water resources.

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