Macarthur Memorial Park – Catholic Cemeteries and Crematoria

Water Cycle Management Plan for D.A.

October 2017

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Author/s	Lucie Bright, Andrew McMillan
Checked	Richard McManus
Approved	Richard McManus

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1 Introduction

Catholic Cemeteries and Crematoria is proposing to develop a 113-hectare site on St Andrews Road, Varroville. The site is made up of three lots that span the property from north to south, in a roughly rectangular shape, as shown in Figure 1. The site is bound by St Andrews Road to the west, a ridgeline to the north, a rural property to the east and the Hume Highway to the south (separated by a parcel of crown land). The topography is undulating, with both forested areas and open, grassy slopes. The site contains eight existing dams and several watercourses.

This water cycle management plan has been prepared to accompany the Macarthur Memorial Park masterplan development application (DA). The water management strategy has been developed in conjunction with the landscape architect, civil engineers and with reference to other consultants including geotechnical, hydro-geological and riparian zone assessor.

An objective of the Macarthur Memorial Park development is to ensure that the Campbelltown City Council's stormwater management objectives are achieved with the treatment of runoff from the site to appropriate standards. At present there are no specific stormwater treatment facilities onsite, however the existing dams would be acting as sediment basins for surface runoff.

Figure 1: Macarthur Memorial Park proposal overview (Florence Jaquet Landscape Architect, 2017)

This report proposes a water sensitive urban design (WSUD) strategy to manage surface water at the site. WSUD generally involves:

- Treating urban stormwater to meet water quality objectives for reuse and/or discharge to the downstream receiving waters
- Reducing potable water demand
- Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent reuse opportunities
- Matching the natural runoff regime as closely as possible
- Protection and enhancement of natural waterways and receiving waters
- Integrating water management elements into the landscape and urban design so as to maximise the visual and recreational amenity of urban development

This report presents the following information:

- Section 2: WSUD objectives for the site, taken from the Development Control Plan and other guidance documents
- Section 3: Existing conditions and background information on the site, relevant to WSUD
- Section 4: A summary of the proposed WSUD strategy and systems
- Section 5: Water quality modelling, to demonstrate the anticipated improvements to water quality from the WSUD strategy
- Section 6: Additional water management issues
- Section 7: Maintenance considerations
- Section 8: Conclusions

2 Stormwater Management Objectives

2.1 Development Control Plan

The *Campbelltown (Sustainable City) Development Control Plan 2015* has been considered in the development of the stormwater management strategy for Macarthur Memorial Park. The relevant stormwater management requirements for the development covered by the DCP are outlined in the following sections.

DCP Section 2.4 – Sustainable Building Design

The requirements included in Campbelltown's DCP Section 2.4, as relating to water management, are listed in Table 1along with comments outlining where this is addressed in this report.

Table 1: Selected requirements from DCP Section 2.4 with comments

DCP requirements	Comments
2.4.1 Rain Water Tanks	
a) In addition to satisfying BASIX, residential development is encouraged to provide a rain water tank for new buildings.	This development is not residential.
b) A rain water tank shall be provided for all new buildings containing a roof area greater than 100sqm for all development not specified by BASIX. The rain water tank shall have a minimum capacity in accordance with Table 2.4.1. **Table 2.4.1 Rainwater Tank Capacity** Roof Area: 101 m² to 200 m² — Capacity of Rainwater Tank: 3,000L 201 m² to 1,000 m² — 5,000L 1,001 m² to 5,000 m² — 10,000L 5,001 m² to 10,000 m² — 20,000L 10,001 m² to 20,000 m² — 50,000L above 20,000 m² — 100,000L	Proposed rainwater tanks have been sized according to Table 2.4. Refer to Section 4.6 and to the architectural drawings.
c) All rainwater tanks shall comply with AS3500 (as amended) - National Plumbing and Drainage Code Guidelines for Plumbing Associated with Rainwater Tanks in Urban Areas and Sydney Water's Guideline for Rainwater Tanks on Residential Properties.	All proposed rainwater tanks will be required to comply with the AS3500.
d) The rainwater tank incorporated in new commercial and industrial development exceeding 5,000 sqm shall be connected to the plumbing in the building to provide water for toilets.	Where possible rainwater tanks will supply water for toilet flushing. Refer to Section 4.6
e) Where it is intended that the development be strata title subdivided, the tank shall be sited in a location to be common property.	N/A
f) Above ground water tanks shall be located behind the primary or secondary building line.	All tanks will be behind the primary building line. Refer to architectural documentation.

DCP Section 2.7 – Erosion and sediment control

The requirements included in Campbelltown's DCP are listed in Table 2 along with comments outlining where this is addressed in this report.

Table 2: Requirements from DCP Section 2.7 with comments

DCP requirements	Comments
Objectives:	
■ *Ensure that any potential loss of soil from a site and/or into the stormwater system is prevented by means of:* • *appropriate planning prior to the start of construction works; and* • *the effective interception, diversion and control of stormwater within the site.*	A sediment and erosion control plan will be developed prior to construction to prevent loss of soil from site during construction. Refer to Section 6.7 Proposed stormwater treatment systems (eg. swales and bioretention systems) will capture sediment from site runoff after construction. Refer to Section 4.
Design Requirements *a) An Erosion and Sediment Control Plan (ESCP) shall be prepared and submitted with a development application proposing construction and/or activities involving the disturbance of the land surface. For requirements relating to the preparation of an ESCP, refer to Appendix 5 of Volume 1 and Council's Engineering Design Guide for Development available from Council's website at www.campbelltown.nsw.gov.au .*	Refer to civil engineers (*Warren Smith & Partners*) documentation
b) Site activities shall be planned and managed to minimise soil disturbance.	
c) Catch drains or diversion banks shall be designed and constructed to divert water around any area of soil disturbance.	
d) All stockpiles shall be located within the sediment control zone and shall not be located within an overland flow path.	

DCP Section 2.10 – Water Cycle Management

The requirements included in Campbelltown's DCP are listed in Table 3 along with comments outlining where these are addressed in this report.

Table 3: Requirements from DCP Section 2.10 with comments

DCP requirements	Comments
Objectives:	
■ *Ensure that water cycle management appropriately responds to site and water catchment conditions.*	The proposed water cycle management strategy incorporates existing site conditions (water courses, dams and topography) to naturally drain and treat runoff. Impervious surfaces have been minimised to maximise infiltration and as a result the natural hydrology of the site will largely be retained. Refer to Sections 3 and 4
■ *Ensure that Water Sensitive Urban Design (WSUD) principles are incorporated into development.*	WSUD principles have been incorporated throughout the development with a decentralised treatment approach primarily including vegetated systems that will be integrated into the landscape. Refer to Section 4
■ *Retain and reinstate (where appropriate) the natural water course into stormwater management measures.*	Natural water courses have been retained in accordance with riparian zone requirements. Refer to reporting by *Travers Bushfire and Ecology*.
■ *Ensure that the development is protected from mainstream, local catchment and overland flow aspects of flooding.*	A flood study has been undertaken by *WMAWater* which has been used to determine flood planning levels for floor levels. Refer to Section 6.5

DCP requirements	Comments
2.10.1 Water Cycle Management Design Requirements	
a) A comprehensive Water Cycle Management Plan (WCMP) shall be prepared and submitted as part of a development application. *Note: For requirements relating to the preparation of a WCMP refer to Council's Engineering Design Guide for Development* *Note: Refer to Table 2.1 Thresholds for when a WCMP is needed…* *Will the development involve any of the following:* *a) A site that is below the flood planning level?* *b) A site that is within 40 metres of a water course?* *c) drains directly to a water course?* *d) is inundated by the predicted 100 year ARI event; or* *e) Work that is of a large residential scale (> 2000sqm site area) or any new commercial/ industrial building?*	Based on the thresholds outlined in the DCP (Table 2.1) the proposed development requires a WCMP. This document forms the WCMP for the proposed development.
2.10.2 Stormwater Design Requirements	
a) All stormwater systems shall be sized to accommodate the 100-year ARI event (refer to Section 4 of Council's Engineering Design Guide for Development)	A 'major-minor' approach has been taken to the design of the new stormwater systems. The new piped drainage systems servicing the roads and associated upstream subcatchments have been designed for the minor (10 year ARI) event and flows from the major (100 year ARI) event will be conveyed within natural overland flow paths within the site. Proposed culverts will accommodate the 100-year ARI event. Refer to Section 6.5 and *Warren Smith & Partners* design documentation.
b) The design and certification of any stormwater system shall be undertaken by a suitably qualified person.	Proposed stormwater systems have been designed by a suitably qualified person.
c) Water quality control structures shall be located generally off line to creek paths or other watercourses. Major detention storages shall not be located on areas of native vegetation or within riparian areas.	All proposed water quality treatment systems have been located to allow them to be 'offline' with a high flow bypass to be included in the detailed design stage. No new detention storages are proposed. Refer to Section 4.
d) Development shall not impact on adjoining sites by way of overland flow of stormwater unless an easement is provided. All overland flow shall be directed to designated overland flow paths such as roads.	The development will retain existing overland flow paths as defined by the existing natural water courses. Refer to Section 6.5.
e) Safe passage of the Probable Maximum Flood (PMF) shall be demonstrated for major systems.	Refer to flooding assessment documentation by WMAwater.
f) A treatment train approach to water quality shall be incorporated into the design and construction of major systems.	A treatment train approach has been adopted with decentralised WSUD elements. Refer to Section 4.
g) A major/minor approach to drainage is to be taken for stormwater flows. Generally the piped drainage system shall be sized to accommodate the difference between the 100-year ARI flow and the maximum safe overland flow, with minimum requirements as set out in section 4 of Council's Engineering Design Guide for Development	The piped drainage system has been sized to accommodate the 10 year ARI (10% AEP), as outlined for 'industrial areas' in Table 4.5 in the Engineering Design Guide. Refer to *Warren Smith & Partners* documentation.
h) Stormwater collected on a development site shall be disposed of (under gravity) directly to the street or to another Council drainage system/device. Where stormwater cannot be discharged directly to a public drainage facility, a drainage easement of a suitable width shall be created over a downstream property(s) allowing for the provision of a drainage pipe of suitable size to adequately drain the proposed development to a public drainage facility. Note: Rubble pits and charged lines are not generally considered a suitable drainage solution.	Collected stormwater drains under gravity via the existing dams and watercourses to Bunbury Curran Creek. Refer *Warren Smith & Partners* documentation.

DCP requirements	Comments
i) All proposed drainage structures incorporated within new development shall be designed to maintain public safety at all times.	The proposed drainage structures have considered public safety. The key aspects at this site relate to excluding people from unsafe areas (dams and waterways) via the use of vegetated buffers and fencing where appropriate. Refer *FJLA* documentation.
j) Development shall not result in water run-off causing flooding or erosion on adjacent properties.	Whilst the vast majority of runoff from the site drains to the existing dams and watercourses, some small peripheral areas of the site currently drain onto adjacent rural properties. All proposed piped drainage systems will be directed to water courses, with only some small pervious areas draining onto adjacent properties as per the existing conditions. Refer to section 6.5.
k) Stormwater run-off shall be appropriately channelled into a stormwater drain in accordance with Council's Engineering Design Guide for Development.	Stormwater runoff is collected and conveyed by a number of proposed piped drainage systems that connect to existing water courses and drainage paths off-site. Refer *Warren Smith & Partners* documentation
l) Where applicable, the development shall incorporate the creation of an appropriate easement to manage stormwater in accordance with Council's Engineering Design Guide for Development	The Engineering Design Guide outlines that a developer is required to obtain an easement through downstream land "*where stormwater is concentrated or discharged onto adjoining lands other than an existing easement or natural watercourse*". The watercourse that drains across St Andrews Rd is a third order natural stream (refer *Travers* report) and no easement is considered necessary over the property on the western side of St Andrews Rd.
2.10.3 Stormwater Drainage Design Requirements	
a) A stormwater Drainage Concept Plan shall be prepared by a suitably qualified person, and submitted with all development applications, involving construction (except for internal alterations/fitouts), demonstrating to Council how the stormwater will be collected and discharged from the site.	Refer *Warren Smith & Partners* documentation.
b) The stormwater concept plan shall include the following information as a minimum: *i) locations, layouts and sizes of stormwater pipes and pits;* *ii) minimum grades and capacity of stormwater pipes; and* *iii) existing and proposed easements, site contours and overland flow path/s.*	Refer *Warren Smith & Partners* documentation.

DCP Section 2.14 – Risk management

The requirements included in Campbelltown's DCP Section 2.14, as relating to water management, are listed in Table 4 along with comments outlining where this is addressed in this report.

Table 4: Selected requirements from DCP Section 2.14 with comments

DCP requirements	Comments
Objective: ■ *Ensure that hazards of the site are addressed so as to minimise the risk of:* • *injury to persons/property;* • *damage to the environment; and* • *financial loss.*	Potential hazards have been addressed to minimise risk, including: - Safety of water bodies (refer to Section 6.2) - Flora and fauna assessment (refer to section 3.2) - Groundwater quality (refer to Section 6.3) - Dam failure analysis (refer to Section 6.5)

DCP Section 2.16 – Provision of services
The requirements included in Campbelltown's DCP Section 2.16, as relating to provision of water, electricity and wastewater treatment are addressed by *Warren Smith & Partners*.

2.2 Engineering Design Guide

Council's Engineering Design Guide for Development (2012) requires the following aspects of design to be provided as a part of a development application.

Section 2.5 Stormwater Management Drawings
The requirements included in Council's Design Guide are listed in Table 5 along with comments outlining where this is addressed in this report.

Table 5. Requirements from Design Guide Section 2.5 with comments

Design Guide requirements	Comments
Drawings to include:	
■ *Catchment Plan showing contours, area of site affected and area of site not treated*	Refer WSUD drawings in Appendix A and Section 4.1
■ *Drainage design summary*	Refer to *Warren Smith & Partners* stormwater drainage drawings
■ *Calculations to confirm volumes, pipe sizes, size of overland flow paths and overflow weirs*	Refer to *Warren Smith & Partners* and *WMAwater* documentation.
■ *Detail Plan and sections*	Refer to Section 4, various typical sections provided for WSUD elements.
■ *Design Levels for top water/overflow; inverts of all drainage pits, pipelines and storage areas; overflow weir; surface of all drainage pits; and surfaces designed to control and direct stormwater*	Refer to *Warren Smith & Partners* drainage designs drawings.
■ *Details of Water Sensitive Urban Design elements*	Refer to Sections 4.2 – 4.8

Section 2.18 Other Stormwater Details
Additional requirements are listed in Section 2.18 of Council's Engineering Design Guide.

Council require all natural creeks to be retained and comply with requirements of the Office of Water. Existing water courses have been assessed and classed as stream order 1, 2 or 3. Proposed works have been located in accordance with Office of Water requirements.

The requirements of water quality and WSUD included in Council's Design Guide are listed in Table 6 along with comments outlining where/how they are addressed in this report.

Table 6. Requirements from Design Guide Section 2.18 with comments

Design Guide requirements	Comments
Drawings to include:	
■ *Details of any proprietary devices to be installed*	Proprietary gross pollutant traps are proposed as a pre-treatment where a high load of gross pollutants is expected. Refer to Section 4.1 and Section 4.4.
■ *Details of any non-proprietary devices/measures to be installed*	The majority of stormwater treatment systems proposed are vegetated systems such as swales, bioretention and wetlands. Refer to Sections 4.2 – 4.8
■ *Calculations of performance showing compliance with Council's requirements*	Compliance with Council's water quality requirements has been demonstrated using MUSIC modelling. Refer to Section 5.
■ *Details of maintenance demonstrating that any required equipment can access the facilities and that hardstand areas have been provided where necessary*	Refer to Section 7. Only the GPT's will require vehicular access and these are located adjacent to the proposed roads.

Design Guide requirements	Comments
■ *Work method statements for new devices*	To be provided by GPT supplier during detailed design.
■ *Indicative maintenance costs are to be identified*	Refer to Section 7.

Section 4.15 Stormwater Quality

Council require inclusion of stormwater quality measures for commercial developments greater than 2500m^2. General water quality objectives from the Design Guide Section 4.15 are listed in Table 8 with comments provided.

Table 7. Stormwater Quality Objectives from Design Guide Section 4.15 with comments

Design Guide Water Quality objectives	Comments
■ *A treatment train approach to water quality should be used*	A treatment train approach has been taken, with treatment systems distributed throughout the site. Many subcatchments require a single treatment system node to meet water quality targets. Refer to Section 4.1
■ *Systems must be designed to take into consideration local and site conditions*	The proposed treatment systems have been designed according to upstream subcatchment type and size, and to work with the existing topography. Refer to Sections 4.2 – 4.8
■ *Designs must be functional and aesthetically pleasing*	The proposed vegetated systems will be designed to industry best practice. The proposed vegetated systems will be aesthetically pleasing, with dense plantings of local native plant species. Refer to Sections 4.2 – 4.8
■ *Maintenance requirements must be considered in terms of both plant equipment required and occupational health and safety issues for staff*	Treatment systems have been proposed in locations that are accessible by staff and machinery. Batter slopes and water depths (where relevant) are designed at safe and workable grades and depths. Refer to Section 7.

Section 4.16 Water Sensitive Urban Design

Council require inclusion of Water Sensitive Urban Design (WSUD) measures for commercial developments greater than 2500m^2. General objectives from the Design Guide Section 4.16 are listed in Table 8 with comments provided.

Table 8. Objectives from Design Guide Section 4.16 with comments

Design Guide WSUD planning and design objectives	Comments
■ *Protect and enhance natural water systems in urban developments*	The existing streams within the site are proposed to be retained. In addition to this works are proposed to enhance the riparian corridors through weed removal, revegetation and stabilisation works where required. The stream environment will be improved as the quality of water discharging to the downstream environment will be improved. Refer to Section 4.1 and Vegetation Management Plan by *Travers*.
■ *Integrate stormwater treatment into the landscape by incorporating multiple-use corridors, that maximise the visual and recreational amenity of the development*	The stormwater treatment systems have been positioned in the landscape where they can be viewed by visitors to the site. Refer to WSUD plans in Appendix A.
■ *Systems that are aesthetically pleasing*	Where possible vegetated systems have been proposed to be aesthetically pleasing and to suit the natural Cumberland Plain Woodland environment.
■ *Protect water quality draining from development areas*	The quality of water discharging to the downstream environment will be improved by the proposed treatment systems, in accordance with the stormwater quality objectives. Refer to Section 5.

Design Guide WSUD planning and design objectives	**Comments**
■ *Reduce runoff and peak flows from developments by employing local detention measures, minimising impervious areas and maximising re-use (for example through rain water tanks)*	Impervious areas have been minimised with the use of reinforced turf for off-road parking. Runoff modelling has been carried out by *Warren Smith & Partners* and there is not expected to be any impact on downstream drainage assets. Rainwater tanks are to be installed on buildings, reducing runoff and providing non-potable water supplies.
■ *Stormwater management must form a key component in the overall water cycle management for the site*	Stormwater management has driven key aspects of the site's design including road and drainage layout. The design has aimed to ensure that flows are not significantly concentrated and that the hydrology to existing drainage lines is not significantly altered.
■ *Add value while minimising drainage infrastructure development and maintenance costs*	Informal, natural drainage lines have been incorporated in the design where appropriate. Existing drainage lines and water courses have been retained to reduce the need for built drainage infrastructure and to avoid concentrating flows at a small number of large outlets. The treatment train approach aims to provide systems that allow straightforward maintenance in accessible locations rather than allowing pollutants to accumulate only in the existing dams where they are more difficult to remove.
■ *Retention of vegetation on site*	Vegetation and significant trees will be retained wherever possible. The riparian corridors of the existing water courses include zones of protection. Refer to *Florence Jaquet Landscape Architect* documentation.
■ *Use of indigenous (local) vegetation*	Plants within the vegetated stormwater treatment systems will be selected to include local species. Refer to *Florence Jaquet Landscape Architect* documentation.
■ *Community involvement, understanding and appreciation of the environment*	The proposed development will provide significant opportunities for community appreciation of the environment. Public access will be provided by a significant path network including for observation of the water cycle management elements within the site.

2.3 Landcom Guidelines

Council has indicated that suitable pollutant removal targets for the site would be the targets adopted by Landcom (pers. comm). These targets are:

- 85% TSS reduction
- 65% TP reduction
- 45% TN reduction
- 95% Gross pollutant reduction

2.4 Summary

The DCP requires that WSUD principles are adopted by developments and that stormwater drainage ensures the integrity of watercourses is protected and enhanced, but the DCP contains only a set of minimum pollutant reduction targets. It has been recommended to adopt the above Landcom WSUD pollution reduction targets as part of the site's water quality objectives. This Water Cycle Management Plan demonstrates that the proposed development will meet Council's objectives to manage and treat stormwater.

3 Existing Conditions

3.1 Stormwater infrastructure

The site contains only minimal stormwater infrastructure, in the way of culverts for drainage under roads and off-site. Being almost completely pervious, runoff drains across the turf and vegetated surfaces to different streams that drain to one of eight dams. These dams are run in series and connect to watercourses offsite via natural drainage paths. Drainage lines connect to Bunbury Curran Creek on the western and southern boundaries. An aerial image of the site is shown in Figure 2, indicating existing stream, water bodies and built stormwater infrastructure. These drainage corridors and water bodies have a riparian zone that cannot be developed.

The site is dominated by rural open space and bushland in the northern portion of the site with other, smaller patches of vegetation throughout the site. There are three buildings currently onsite that will be retained. There is a battleaxe shaped plot of land (Varroville House) within the site of development that will remain and is not included as part of the proposed development. The site generally slopes from north to south, with a ridge roughly dividing the southern portion in two on east-west lines. The topography of the site varies in elevation from RL 100m AHD at the northern end of the site to 43m AHD at the south-eastern corner.

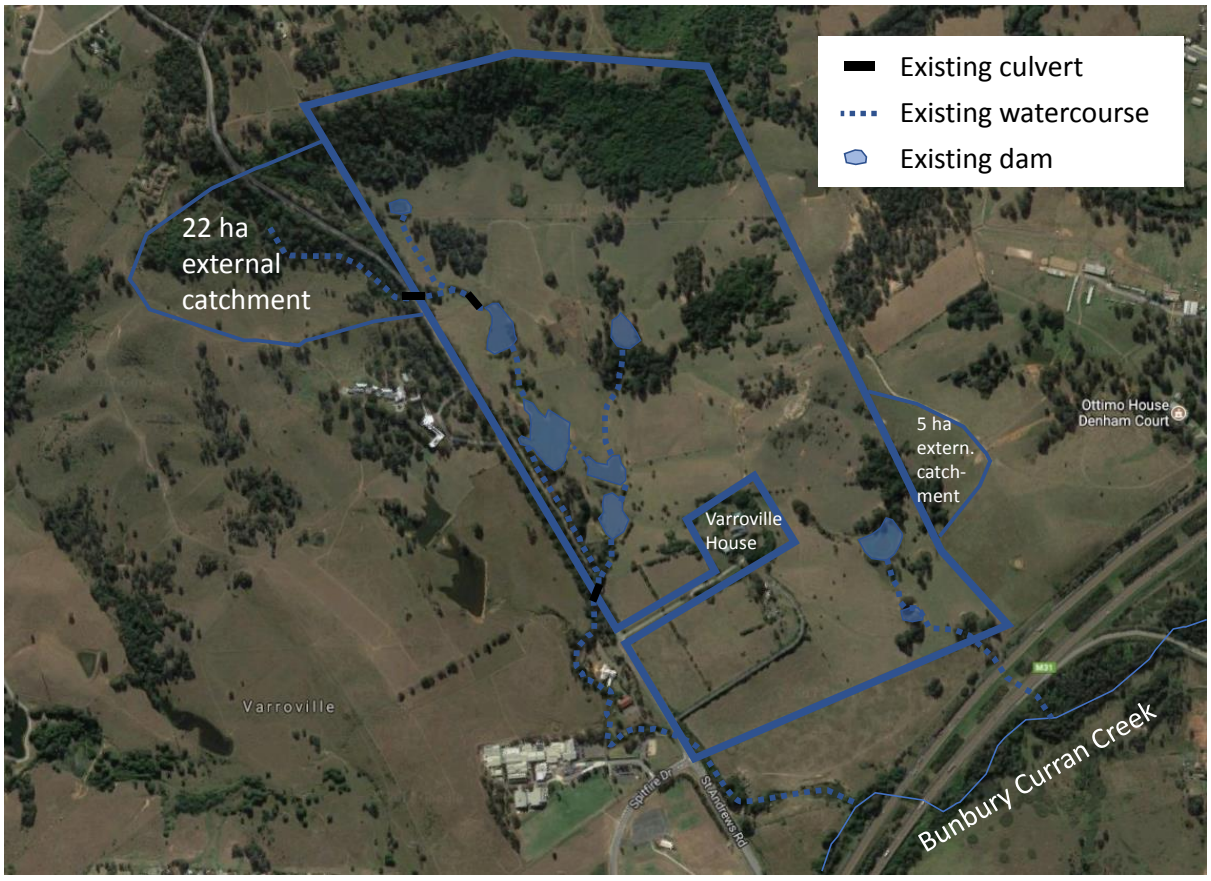

Figure 2: Macarthur Memorial Park aerial image (Google) with indicative existing drainage

3.2 Receiving environment

Bunbury Curran Creek, the receiving water for most flows from the proposed development runs on the southern side of the Hume Highway. Bunbury Curran Creek continues north-east, concrete-lined in places, to the suburb of Glenfield where it meets the Georges River.

Flora and Fauna

Within the site, there are two remnant endangered ecological communities – Cumberland Plain Woodland and Moist Shale Woodland (Urbis, 2015). The northern most section of the site is densely vegetated by Moist

Shale Woodland and the Cumberland Plain Woodland occurs in the middle and lower slopes of the site. Apart from small, isolated growths the site is otherwise cleared of native vegetation.

These remnant EECs and the riparian corridors of the watercourses and water bodies provide habitat that will be enhanced by the proposed water cycle management infrastructure.

Soils
Three broad soil types have been identified at this site, based on eSpade mapping (Red Earth Geosciences, 2014). They include: Luddenham Soil Landscape (considered 'erosive', associated with the ridgeline and steep slopes), Blacktown Soil Landscape (considered 'residual', associated with undulating and gentle slopes) and South Creek Soil Landscape (may occur in the north-east corner of the site and the southern boundary).

The soil investigations in 24 pits undertaken as part of the geoscientific investigations found that "the predominant soil textures observed were a sandy clay, clayey sand or highly plastic clay, occasionally silty in parts". Further review of the pit logs revealed that most of the topsoil (0.5m depth) was found to be sandy clay and this was adopted for the MUSIC modelling.

Riparian Zones
The watercourse assessment undertaken by Travers (2013) identified first, second and third order streams within the site. Riparian protection zones were identified and acceptable works noted in accordance with the NSW Office Of Water *Controlled activities on waterfront land – Guidelines for Riparian Corridors on Waterfront Land* (July 2012). Figure 3 shows the outcome of the assessment, with validated watercourses highlighted and associated riparian buffers.

As shown in the WSUD drawings in Appendix A, the bioretention systems have been located within the outer 50% of the riparian corridor.

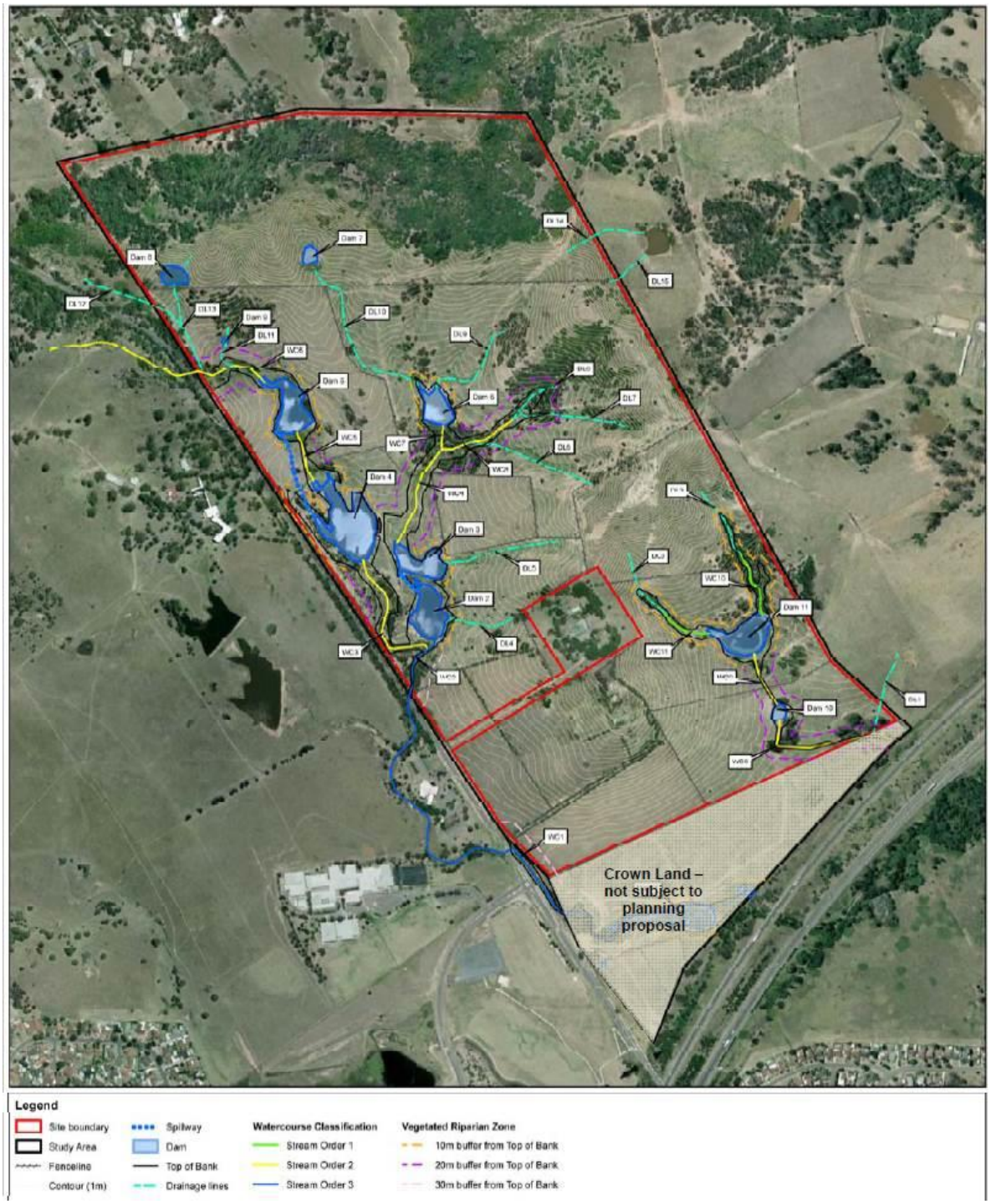

Figure 3. Travers' Watercourse assessment - stream orders and vegetated riparian zones

4 Proposed WSUD Strategy

4.1 WSUD strategy overview

The proposed stormwater treatment strategy for the Macarthur Memorial Park development is to install a range of treatment systems throughout the development to achieve the nominated pollution reduction targets.

Given the large area of the site and that the drainage arrangement includes many smaller piped drainage systems, each with their own outlet, a large number of small WSUD treatment systems is the most appropriate method of treating the majority of runoff.

The proposed treatment systems include:

- Gross Pollutant Traps (GPT's) on large subcatchments and downstream of carparks where there is potential for a significant load of gross pollutants
- Vegetated swales, where a subcatchment drains to a natural drainage line that is not part of a riparian corridor
- Bioretention basins
- Vegetated treatment wetlands, integrated into existing dams to treat incoming flows from a piped drainage system
- Stormwater harvesting from existing dams for irrigation
- Rainwater tanks

Due to the local topography approximately 17% of the site area drains directly off-site as disperse flow without treatment. All of these areas that run off the site are pervious areas. The pollutant loads from these untreated pervious catchment areas are offset by treating incoming stormwater runoff from external catchments (by harvesting for irrigation). The 27-hectares of external catchments that drain into the site have been included in modelling of the site's flows and harvesting volume from the dams.

The modeling of this WSUD stormwater treatment strategy is outlined in Section 5.

In addition to the systems to treat stormwater runoff, the vegetation along drainage lines/water courses will be retained and enhanced with native plants to stabilise the banks and provide a natural riparian corridor.

The strategy for minimizing the use of potable water within the development will be addressed by the servicing strategy and each stage of the development will be subject to sustainability assessments. Rainwater tanks to buildings are included in this WSUD strategy and are detailed in Section 4.6. Stormwater harvesting from several of the dams is proposed to be used for irrigation and is detailed in Section 4.8.

4.2 Bioretention

Bioretention systems, also known as raingardens, are commonly constructed in Sydney to meet stormwater quality targets. They are suitable in a range of areas, and can be implemented at a range of scales in almost any size and shape.

Bioretention systems are vegetated soil filters. Stormwater runoff is treated by draining vertically through a vegetated filter media (typically a sandy loam). Treated stormwater is then collected by a perforated underdrain and directed to the downstream stormwater drainage system. A schematic of a typical bioretention system is shown in Figure 4.

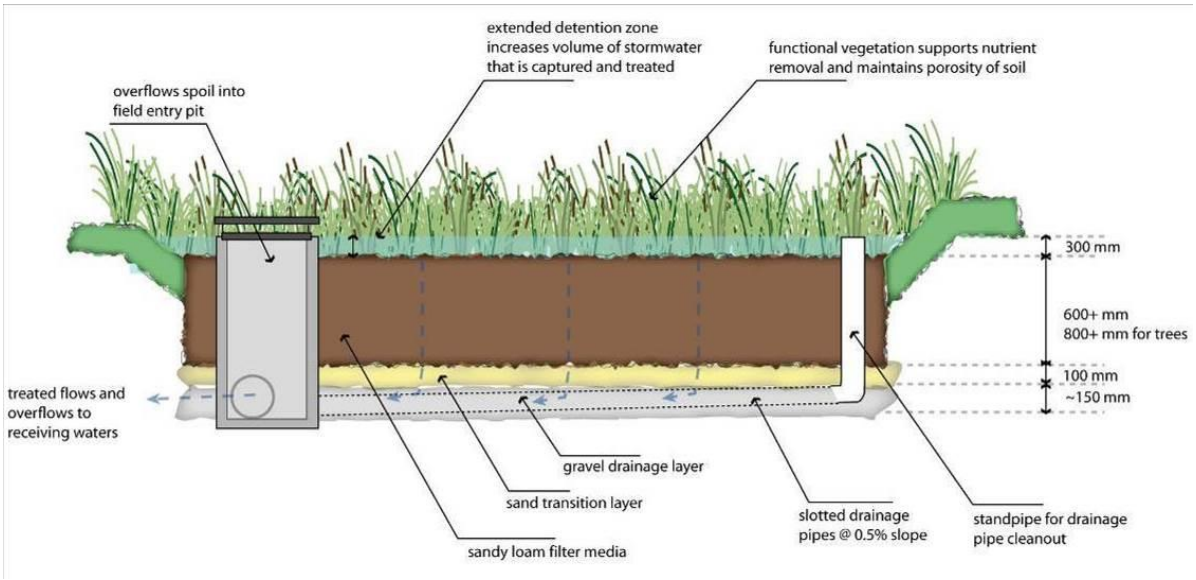

Figure 4: Schematic section through a typical bioretention system

Bioretention systems have a temporary ponding depth (extended detention) of between 100 - 300mm above the filter media surface to temporarily store stormwater thereby increasing the volume of runoff treated through the filter media.

Vegetation plays a key role in bioretention systems. The surface is densely planted with ground level grasses, sedges, and also some selected tree and shrub species. The agitation of the surface of the bioretention caused by movement of the vegetation and the growth and die off of root systems helps to prevent sediments from clogging the filtration media. Beneath the surface, vegetation provides a substrate for biofilm growth within the upper layer of the filter media. Vegetation facilitates the transport of oxygen to the soil and enhances soil microbial communities which enhance biological transformation of pollutants.

The bioretention systems will be designed to include vegetation species that are appropriate for the location of the treatment systems, particularly where systems are overshadowed. In addition to this the vegetation chosen will be drought tolerant species such as *lomandra longifolia*.

Bioretention systems are proposed at the pipe outlet of 20 subcatchments. These bioretention raingardens will be offline, treating diverted 'low' flows (typically the 3 month ARI event) from the piped stormwater drainage system. Treated flows will be directed to the downstream drainage system and flow to the waterways and dams on the site. Precedent images for bioretention systems in a natural setting are provided in Figure 5.

The positioning of the bioretention systems in the proposed Macarthur Memorial Park has taken into consideration the riparian protection zones (RPZ) and all bioretention systems have been placed in the outer 50% of the RPZ.

Figure 5: Precedent images of bioretention basins in a natural open space setting

4.3 Vegetated swales

Vegetated swales are grassed or vegetated channels capable of conveying stormwater runoff. Swales contain overland flows on mild or moderate slopes to slowly convey water downstream. The interaction with vegetation facilitates pollutant settlement and retention in the vegetation. Scour protection such as rock riprap protects the swale from erosion.

At Macarthur Memorial Park vegetated swales have been proposed where a small piped catchment discharges to a natural drainage line. The drainage lines will be enhanced with suitable plants and scour protection as required, particularly if steep slopes may result in high velocity flows.

Precedent images for vegetated swales in a natural setting are provided in Figure 6.

Figure 6: Precedent images of vegetated swales

4.4 Gross pollutant traps

Gross pollutant traps (GPTs) target gross pollutants including litter, coarse sediment, leaves and other vegetative matter. Many GPTs will also capture significant loads of coarse suspended solids. GPTs are often the first treatment measure in a treatment train, for example they can be used upstream of wetlands and creeks to protect them from gross pollutants.

Pollutant capture efficiency of coarse material varies between different types of GPTs, however most GPTs cannot remove fine sediments, nutrients or other pollutants to any significant degree. Therefore GPTs are not recommended as the sole treatment system to meet the water quality targets identified by Council.

A gross pollutant trap (GPT) is proposed to be installed on four subcatchments, upstream of proposed bioretention systems. These GPT's will provide pre-treatment for bioretention systems with a large contributing catchment. A schematic image of the proposed CDS GPT is shown in Figure 7.

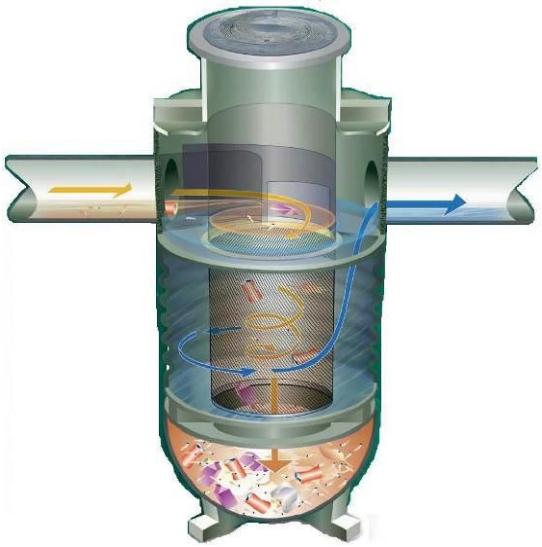

Figure 7: Illustrative section through a Rocla CDS 'Nipper'

4.5 Vegetated Wetlands

Vegetated wetlands are proposed within dams 3 and 5. The wetlands will be 'offline' and stormwater will be diverted to these fringing treatment systems from piped subcatchments upstream, rather than treating all flows that drain to these dams via the upstream watercourses.

Wetland systems are shallow vegetated areas with permanent water. Stormwater runoff is treated by sedimentation of fine particles due to the low velocities in the wetland, by filtration of particles as they pass through densely vegetated aquatic plants and by direct uptake of pollutants from the water by plants and biofilms. Water in the wetland flows horizontally from the inlet to the outlet of the wetland.

Inflows to a stormwater treatment wetland are captured during a rain event in a temporary storage volume ('extended detention' above the normal water level). This captured water is slowly released from the wetland over 1 to 2 days, giving the captured stormwater sufficient contact time with the wetland plants for nutrient uptake. Critical to the performance of the wetland system is the control of flows through the wetland via a riser outlet. The riser outlet includes specially designed orifices to ensure that the water level rises in the wetland during rainfall events and empties slowly over approximately 1 to 2 days after the rain event ceases.

A low flow diversion will be fitted into the proposed junction pits on the drainage line that discharges to the dam to protect the wetland from high flows in extreme storm events. A weir will be constructed within the pit which will direct low flows to the wetland through a small diameter pipe whilst high flows will bypass over the weir and continue to the primary outlet.

Vegetation plays a major role in wetland systems. The wetland is to be densely planted with aquatic plants both emergent and submerged plants. Without the vegetation the wetland has a risk of algal blooms and invasion by aquatic weeds species such as salvinia and azolla.

A schematic of the proposed wetland systems are shown in Figure 8. This shows how the wetland will be formed on the edge of the existing dams.

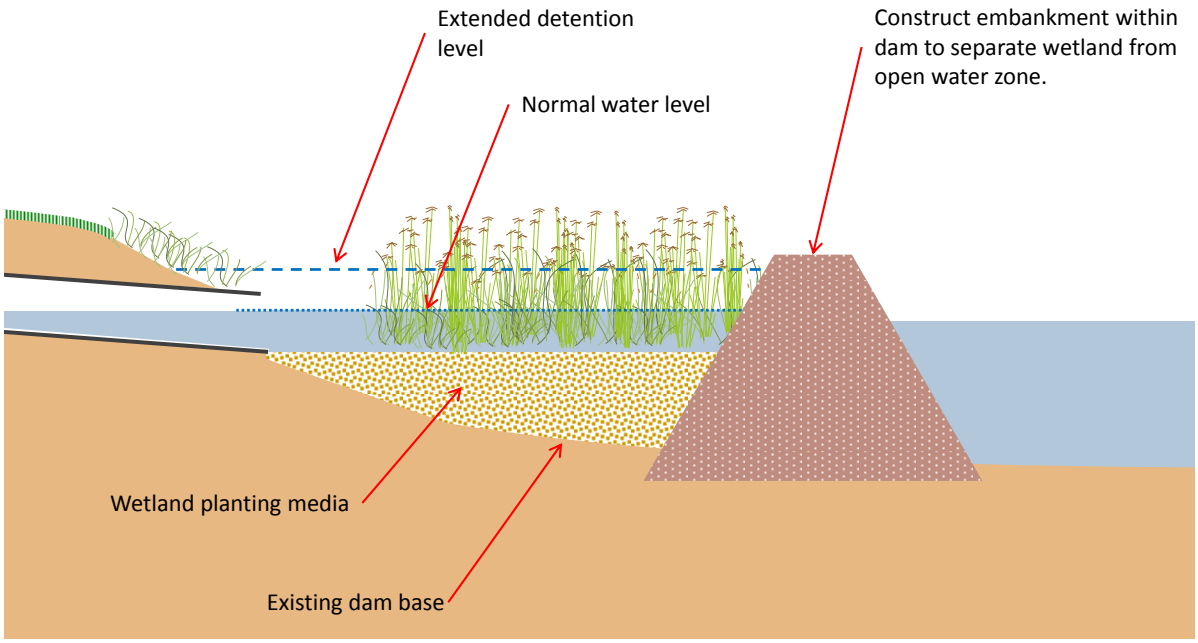

Figure 8: Schematic section through proposed vegetated wetland, to be constructed as a fringing wetland within existing dams

4.6 Permeable paving

Permeable paving is a means of reducing runoff from hard (impervious) surfaces. It can be used in the place of ordinary concrete or asphalt paving; however permeable paving is typically only appropriate for footpaths, parking areas or very low speed, low traffic roads or laneways.

Unlike a bioretention system, permeable paving cannot treat a large upstream catchment area, as the various permeable paving systems have limited infiltration capacity. However in place of ordinary paving, permeable paving can reduce stormwater runoff and associated pollutant loads.

At Macarthur Memorial Park it is proposed to include the parking lane as a reinforced turf permeable paving. This will aid in reducing runoff and minimise the visual impact of new roadways at the site.

A precedent image of a turfed permeable parking lane is shown in Figure 9.

Figure 9: Precedent image of permeable parking on edge of roadway

4.7 Rainwater harvesting

The proposed development includes several buildings, used as a function centre, chapel, café, and site administration/maintenance. The roof areas of each of these buildings will connect to a rainwater tank to collect water for either toilet flushing or irrigation use. The tanks have been sized according to Council's requirements, outlined in Table 2.4.1 of the DCP.

The proposed buildings, with their roof areas and tank volumes, are:

Chapel - 1848m^2 - 10,000L
Gatehouse - 370m^2 - 5,000L
Administration - 758m^2 - 5,000L
Function - 640m^2 - 5,000L
Cafe - 387m^2 - 5,000L
Garden Staff - 984m^2 - 5,000L

4.8 Stormwater harvesting

Stormwater is proposed to be harvested from five of the existing dams. The remaining three dams which are proposed to have adjacent buildings (café or function centre etc) will remain as aesthetic water bodies and not be affected by drawdown.

Water demands will vary according to the area of the site that is under irrigation, which will increase over time. Ultimately the total irrigation demand, if all areas of the site are irrigated, may rise to 200ML/year. MUSIC modelling has been used to estimate that around 30 ML/year of stormwater could be harvested for irrigation use.

Stormwater harvesting from the dams will be carried out in accordance with licensing requirements under the *Water Management Act*.

As outlined in Section 6.3 additional alternative water supplies will be pursued as required.

4.9 Water body recirculation

A pump and rising main system is proposed to recirculate water through selected drainage swales and through the dams. Recirculation systems are designed to maintain water quality within water bodies during dry weather periods by preventing stagnation and ensuring a hydraulic turnover of water to reduce the risk of algal blooms. Passing recirculated flows through vegetated swales will promote aeration and nutrient removal of the pumped recirculated flows.

The proposed recirculation systems will operate to recirculate water from the outlet of the dam to the upstream end of the vegetated swale. Though recirculation is primarily designed for dry weather periods it is also acceptable to provide a simple timed pump operation (operating every day) that also remains in operation during rainfall events. The main intention of recirculation is to prevent stagnation of water within the dams. By 'turning over' all of the water volume within the dams every 30 days the risk of algal blooms is reduced. The pump flow rate will be set to achieve this turnover period.

The recirculation pumps will be installed within a pump sump adjacent to the dam. A coarse screen installed in the pump pit will prevent large debris from fouling the pumps, and the pumps will be wastewater pumps capable to passing small objects.

5 Stormwater Quality Modelling

5.1 Stormwater quality requirements

Council's Development Control Plan only requires standard pollutant reduction percentages 85/45/45 (see Section 2). However, Council has advised that runoff from the site will need to be treated to meet industry best practice standards (based on the Landcom guidelines). Therefore, the following reductions are taken as best practice targets for nutrient and sediment reduction at the Macarthur Memorial Park development:

- Total Suspended Solids - 85% reduction
- Total Phosphorus - 65% reduction
- Total Nitrogen - 45% reduction
- Gross Pollutants – 95% reduction

Council has indicated that it is appropriate to take a modelling approach whereby only the areas of the site that are to be developed (including the roadway, buildings and proposed burial and landscaped areas) require treatment to meet the stormwater pollutant reduction targets. Therefore the relatively low stormwater loads generated from the forested areas (cumberland plain woodland and moist shale woodland) are not included as part of the total pollutant load to be reduced.

5.2 Modelling parameters

Water quality modelling has been carried out using MUSIC (Model for Urban Stormwater Improvement Conceptualisation) software (version 6) to determine the treatment areas required to achieve the water quality targets. The modelling parameters and results are described below.

The rainfall station closest to the Macarthur Memorial Park development site with a long period of rainfall is Minto Surrey Street rainfall station (BOM station 68043) which was open from 1889 to 1990. Over that 100 year period this station had a median annual rainfall of 777 mm. For modelling of stormwater quality, 6 minute pluviograph data from Richmond UWS Hawkesbury (BOM station 67021) was used. Whilst the Richmond UWS Hawkesbury rainfall station is not the closest pluviograph station to the development site, it was adopted for the modelling as the period from 1965 to 1969 constitutes an appropriate period of continuous 6 minute data, with a rainfall pattern that closely matches the average monthly rainfall found at the Minto Surrey Street rainfall station.

The rainfall / runoff parameters for 'sandy clay' and pollutant concentration parameters were taken from the *NSW MUSIC Modelling Guidelines* (Greater Sydney Local Land Services, 2015) as outlined in Table 9 and Table 10.

Table 9: Soil properties for MUSIC Source Nodes

Parameter	Unit	Adopted values
Impervious area parameters		
Rainfall Threshold (mm)	mm	1
Pervious area parameters		
Soil Storage Capacity (mm)	mm	142
Initial Storage (%)	%	25
Field Capacity (mm)	mm	94
Infiltration Capacity Coefficient a		180
Infiltration Capacity Coefficient b		3.0
Groundwater Properties		
Initial Depth (mm)	mm	10
Daily Recharge Rate (%)	%	25
Daily Baseflow Rate (%)	%	5

Parameter	Unit	Adopted values
Daily Deep Seepage (%)	%	0

Table 10: Stormwater Quality Parameters for MUSIC Source Nodes (from LLS, 2015)

Land-use category (per NSW MUSIC modelling guidelines)	*Notes*		Log10 TSS (mg/L)		Log10 TP (mg/L)		Log10 TN (mg/L)	
			Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow
Residential	*Not used in the MUSIC modelling for Macarthur Memorial Park*	Mean	2.15	1.20	-0.60	-0.85	0.30	0.11
Business		Std Dev	0.32	0.17	0.25	0.19	0.19	0.12
Industrial								
Sealed road pavements	*Adopted for all roads proposed within the site*	Mean	2.43	---*	-0.30	---*	0.34	---*
		Std Dev	0.32	---*	0.25	---*	0.19	---*
Roof Areas	*Adopted for all buildings proposed within the site*	Mean	1.30	---*	-0.89	---*	0.30	---*
		Std Dev	0.32	---*	0.25	---*	0.19	---*
Rural	*Adopted for the existing rural portion of the site*	Mean	1.95	1.15	-0.66	-1.22	0.30	-0.05
		Std Dev	0.32	0.17	0.25	0.19	0.19	0.12
Agricultural	*Not used in the MUSIC modelling for the existing site condition as this applies to intensive farming such as market gardening or intensive dairying*	Mean	2.15	1.30	-0.22	-1.05	0.48	0.04
		Std Dev	0.31	0.13	0.30	0.13	0.26	0.13
Forest	*Adopted for bushland areas within the site*	Mean	1.60	0.78	-1.10	-1.22	-0.05	-0.52
		Std Dev	0.20	0.13	0.22	0.13	0.24	0.13
Re-vegetated Land	*Adopted for all areas proposed to be used for gravesites or landscaped open space in the proposed development*	Mean	1.95	1.15	-0.66	-1.22	0.30	-0.05
		Std Dev	0.32	0.17	0.25	0.19	0.19	0.12

***** Base flows are only generated from pervious areas, therefore these parameters are not relevant to impervious areas

The bioretention systems were modelled with the parameters as shown in Table 11.

Table 11: Properties for MUSIC bioretention system treatment nodes

Parameter	Adopted values
Extended detention depth	300 mm
Saturated Hydraulic conductivity	100 mm/hr
Filter Depth	0.5 m
TN Content of the filter media	400 mg/kg
Orthophosphate Content of the filter media	40 mg/kg
Exfiltration	0 mm/hr
Vegetated with Effective Nutrient Removal plants	Yes

The wetland systems were modelled with the parameters as shown in Table 12. The two treatment wetlands were modelled without an inlet pond (sediment basin) as they will be a part of an existing dam structure which does not allow for adjustments to the banks.

Table 12. Properties for MUSIC wetland treatment nodes

Parameter	Adopted values
Inlet pond volume	0 m^3
Extended detention depth	500 mm
Average wetland depth	0.3 m
Exfiltration	0 mm/hr
Equivalent pipe diameter	Varies (Sized to meet 72hr detention time)

The MUSIC modelling was undertaken for Macarthur Memorial Park for two scenarios:

- Proposed development, without any treatment
- Proposed development, with treatment systems

The site catchment areas are summarised in Table 13.

Table 13. MUSIC modelling scenarios, catchment area summary

Scenario	Catchment type	MUSIC Node pollutant parameters	Total Area	Percentage of site
Existing	Bushland	Forest	27.8	25%
	Farming (low intensity)	Rural	85.2	75%
Proposed	Bushland	Forest	27.8	25%
	Gravesites and open space landscaping	Re-vegetated land	79.3	70%
	Roadways	Urban - sealed roads	5.4	5%
	Roofs	Urban - roof	0.5	1%

The MUSIC modelling of the proposed development utilise the subcatchments that will be created by the proposed road and piped drainage layout. The treatment system sizes were modelled as outlined in Table 14, Table 15 and Table 16. The systems were sized to ensure that the pollution reduction targets are met for the proposed developed areas.

A snapshot of the MUSIC model is shown in Figure 10 and the treatment systems and associated subcatchment areas are shown in the WSUD drawings in Appendix A.

Impacts from creek vegetation retention and enhancement, and slope stabilisation cannot be modelled in MUSIC, however this action has been assumed to be net-positive due to its prevention of increased loads of sediment from erosion.

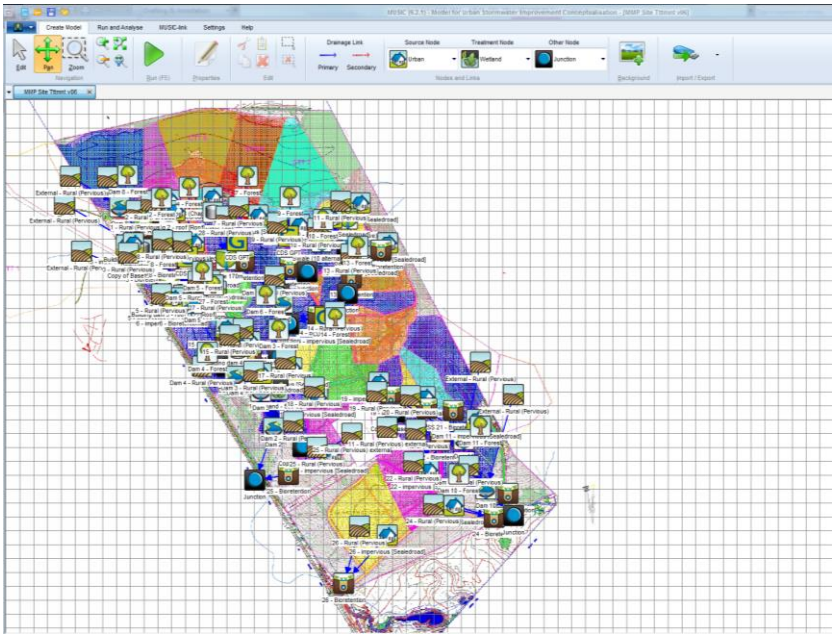

Figure 10: Screenshot of MUSIC model

The bioretention treatment areas shown in Table 14 are for the area of filter surface, not including batter slopes, pits or other structural/landscaping components.

Table 14: Bioretention systems – treatment area

Bioretention reference number	Contributing impervious catchment area (sqm)	Bioretention filter area (sqm)
1	800	**12**
2	1,030	**16**
3	1230	**19**
4	2840	**43**
5	490	**8**
6	720	**11**
7	6150	**93**
9	4,380	**66**
12	810	**13**
13	890	**14**
14	4,435	**67**
15	2,935	**45**
16	965	**15**
17	780	**12**
19	550	**9**
20	1,240	**19**
22	2575	**39**
24	4640	**70**
25	2200	**33**
26	4250	**64**

The proposed vegetated wetlands were modelled with the areas as outlined in Table 15.

Table 15. Wetland systems – treatment areas

Wetland reference number	Contributing impervious catchment area (sqm)	Wetland treatment area (sqm)
18	3,190	**550**
27	2,720	**500**

The proposed vegetated swales were modelled as outlined in Table 16.

Table 16. Swales - treatment areas

Swale reference number	Contributing catchment area (sqm)	Swale length (m)
10	13,710	**190**
11	540	**80**
28	19,260	**170**

5.3 Modelling results

The results of the stormwater quality modelling are provided in Table 17. These modelling results show that the proposed treatment systems will meets Council's stormwater pollutant load reduction targets.

Table 17: Stormwater treatment modelling summary

	Total suspended solids (TSS)	Total phosphorous (TP)	Total Nitrogen (TN)
Pollutant load generated by proposed site developed areas	14,700 kg/yr	30.2 kg/yr	209 kg/yr
Pollutant removal targets	85%	65%	45%
Pollutant removal targets	12,495 kg/yr	19.6 kg/yr	94.1 kg/yr
Pollutant removal achieved by all proposed treatment systems	12,669 kg/yr	24.0 kg/yr	141.1 kg/yr
Council pollutant removal targets met?	YES	YES	YES

6 Additional Water Management Issues

6.1 Riparian zones

As outlined in Section 3.2 a riparian assessment has been carried out by *Travers Bushfire and Ecology*.

The *Travers* report includes verification of the riparian corridor zones, which have been adopted in the positioning of the proposed bioretention systems.

6.2 Assessment of existing dams

A geotechnical assessment of the existing dams has been completed by *JK Group* as well as a dam break analysis undertaken by *GRC Hydro*.

The safety of the dams has also been taken into consideration and it is proposed that regrading of the dam edges is carried out to ensure that there is a 'safety bench' as shown in Figure 11. Where a safe edge cannot be achieved then fencing will be installed as required.

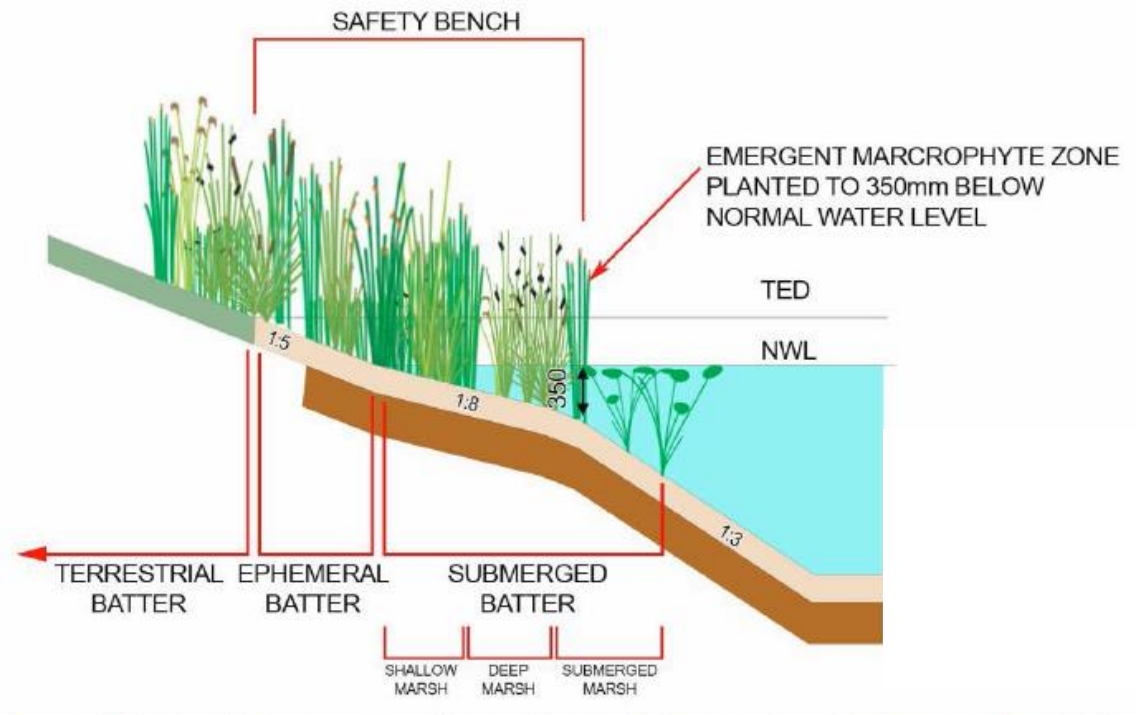

Figure 11: Indicative section of water body edge with safety bench (Melbourne Water)

6.3 Groundwater

A hydrogeological study has been completed for the site by *RedEarth Geosciences*. That report has addressed the requirements for the proximity of burial sites to drainage lines as recommended in the World Health Organisation guidelines. It is proposed to implement a groundwater quality monitoring scheme through the operation of the Memorial Park. Whilst *RedEarth Geosciences* have reported that the cemetery operations should not affect groundwater quality, a monitoring scheme will allow for any changes to be discovered and addressed in future.

In future, if irrigation requirements increase beyond the capacity of the surface water harvested in the dams a groundwater bore may be investigated. Any groundwater extraction would be carried out in accordance with licensing requirements under the *Water Management Act*. The bore would be constructed as per the 'Minimum Construction Requirements for Water Bores in Australia' (National Uniform Drillers Licensing Committee, 2012)

6.4 On Site Detention

When the site is completed the total impervious area will be approximately 5% and the resulting increase in peak flow discharged from the site will be negligible. As outlined by *Warrren Smith & Partners*, there is not expected to be an impact on the downstream Council drainage assets.

6.5 Flooding and overland flows

A flooding assessment has been completed by *WMAwater* to determine the flood planning levels for the proposed buildings and to assess the flooding impacts of the proposed development.

An objective of the proposal is to retain all existing riparian corridors where possible. These corridors will continue to function as flow paths for extreme storm events.

6.6 Bushfire water reserves

As per DCP Section 2.14 …

> *e) Adequate water reserves for fire fighting shall be available and accessible on site as specified in 'Planning for Bushfire Protection', as amended.*

As outlined by Travers Bushfire & Ecology, the site is to have a reticulated water supply.

6.7 Construction water management

Council requires sedimentation and erosion controls be implemented until the site has been landscaped and/or revegetated however they do not specify particular requirements. Landcom's 'Blue Book' (2004) is suggested as a guide to sediment and erosion controls.

Construction would be carried out to avoid erosion and sedimentation of the site and surrounding areas. Erosion and sediment control measures would include:

- temporary structures to prevent offsite movement of sediment such as silt fences surrounding stockpiles and construction compounds;
- control of drainage from areas adjacent to construction areas using earth bunds or drains;
- cessation of work, or implementation of further suppression measures if excessive fugitive dust emissions are observed;
- providing a dedicated parking area for construction vehicles and equipment;
- revegetation of all disturbed surfaces as soon as practical to prevent extended exposure to erosion.

Detailed site water management plans will be developed with each appointed contractor during the Construction Certificate phase. Sediment controls would be maintained around the perimeter of the site to treat any local runoff as per the Soil and Water Management plan (refer *Warren Smith & Partners* drawings).

7 Maintenance Considerations

WSUD infrastructure such as bioretention systems 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 proposed WSUD systems.

It is recommended that the personnel who are to undertake the operation and maintenance of the bioretention systems be briefed and trained on procedures and protocols. Keeping and maintaining records on the condition of the systems and all maintenance works required will be important to inform and schedule future maintenance works.

Importantly the most intensive period of maintenance in vegetated stormwater treatment systems 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 Macarthur Memorial Park will 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 construction and establishment phase (i.e. 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 weed seed load being deposited in the basins 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 bioretention systems will become well established prior to bringing them online – which will occur at least 12 months after planting (i.e. at least one growing season such that root/rhizome establishment and foliage density are well developed).

7.1 Bioretention maintenance

Typical maintenance of bioretention systems during operation will involve:

- Routine inspection of the bioretention system to identify any areas of obvious increased sediment deposition, scouring from storm flows, erosion of the batters from lateral inflows, and clogging of the bioretention system (evident by a 'boggy' filter media surface).
- Routine inspection of inflow system, 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.
- During the establishment phase, irrigation of vegetation until plants are established and actively growing.
- Removal and management of invasive weeds (herbicides should not be used).
- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule.

- Pruning to remove dead or diseased vegetation material and to stimulate growth.
- Vegetation pest monitoring and control.

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

7.2 GPT maintenance

Typical maintenance of the GPT's during operation will involve:

- Routine inspection and removal of pollutants by eductor (vacuum) truck.

7.3 Water body (dam) maintenance

Typical maintenance of the dams during operation will involve:

- Routine inspection of the sediment collection zone.
- Routine inspection of the recirculation pump control panels for any fault alarms.
- Removal of accumulated sediment
- Removal of debris from the overflow pits (where applicable)
- Servicing of recirculation pumps (by qualified pump service technician)

8 Conclusion

It is proposed to incorporate the following stormwater management systems as part of the Macarthur Memorial Park development:

- Bioretention treatment systems
- Vegetated wetlands
- Vegetated swales
- Gross pollutant traps
- Rainwater tanks
- Dual reticulation for non-potable supplies, with non-potable water to be supplied by harvested stormwater and potentially supplemented in the future with bore water and/or recycled wastewater.
- Water efficient fixtures and fittings

As shown by the results of the water quality modelling in Section 5, the WSUD strategy proposed for the Macarthur Memorial Park development will achieve the industry best practice stormwater pollutant reduction targets.

9 References

Bureau of Meteorology (2016) Climate Data Online; Available at http://www.bom.gov.au/climate/data/

Campbelltown Council (2012) Engineering Design Guide; available at: https://www.campbelltown.nsw.gov.au/RBD/BuildAndDevelop/PlanningPoliciesandControls/DevelopmentControlPlans/CampbelltownSustainableCityDevelopmentControlPlan2015

Campbelltown Council (2015) Development Control Plan, available at: https://www.campbelltown.nsw.gov.au/RBD/BuildAndDevelop/PlanningPoliciesandControls/DevelopmentControlPlans/CampbelltownSustainableCityDevelopmentControlPlan2015

Engineers Australia (2006) Australian Runoff Quality: A Guide to Water Sensitive Urban Design

eWater – MUSIC software
http://www.ewater.com.au/products/ewater-toolkit/urban-tools/music/

Landcom (2009) Water Sensitive Urban Design – Book 1 Policy; available at: http://www.landcom.com.au/publication/water-sensitive-urban-design-book-1-policy-draft/

Local Land Services NSW (2015) NSW MUSIC Modelling Guideline

Red Earth Geosciences (2014) *Geoscientific Investigation (with special emphasis on groundwater attributes) – Proposed Macarthur Memorial Park at Varroville, NSW*, prepared for the Trustee for The Catholic Metropolitan Cemeteries Trust, November 5, 2014

Travers Bushfire & Ecology (2013) *Watercourse Assessment*, September 2013.

Urbis (2015), *Conservation Management Plan, Varroville Estate: 166-176 St Andrews Road, Varroville*, prepared for the Catholic Metropolitan Cemeteries Trust, October 2015.

Appendix A – WSUD Concept Plans