Water Sensitive Urban Design Strategy
60 Wallgrove Road, Minchinbury

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Author(s):	Courtney Henderson, Glenn Browning
Approved by:	Gary Walsh, Vanessa Sutton, James Rosenwax
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Appendix

Water Sensitive Urban Design Strategy for 60 Wallgrove Road, Minchinbury

Executive Summary

This report presents the Water Sensitive Urban Design (WSUD) strategy for the development proposed for the site of 60 Wallgrove Road, henceforth in this report referred to as the Minchinbury Employment Park, located within the Blacktown City Council (BCC) local government area.

The strategy addresses the objectives of the Blacktown City Council WSUD Development Control Plan (DCP). These relate to potable water conservation, stormwater quality improvement and waterway stability management.

The site of 22 hectares is zoned for use for industrial use. It consists of three sub-catchments; a small catchment to the north-east of the site, and larger catchment to the east and the largest to the west. Their areal extent is 1.72, 9.13, 11.02 hectares respectively. The WSUD strategy for the site considers only runoff generated onsite as there are no upstream catchments.

The WSUD DCP objectives were met through the following strategies.

Potable water reduction:

- The installation of dual reticulation for alternative non-potable water sources. This includes access to recycled water in the case that the recycled water pipeline from Quakers Hill to Parramatta is augmented to service the nearby Western Sydney Parklands.
- All industrial users of the site agreeing to implement water demand management strategy that requires the installation of water efficient features (for example, toilets and fittings) and ensures equipment such as hoses are maintained to prevent leaks.
- A landscape strategy that comprises native plants that require little or no irrigation.

Stormwater quality targets:

- Treating the water from the western catchment in a constructed wetland designed for stormwater treatment
- Treating the water from the east catchment in a bioretention system. Water will also be diverted from the small north-east catchment to the east catchment for treatment in this bioretention system.

These treatment devices have been sized to ensure that the water quality targets described in the BCC WSUD DCP will be met. This requires pollutant reductions of:

- Gross Pollutants – 90 %
- Total Suspended Solids (TSS) – 85 %
- Total Phosphorus (TP) – 65 %
- Total Nitrogen (TN) – 45 %

Waterway stability management objectives will be met through the construction of flood detention basins. Storage for flood detention will be co-located with the stormwater quality treatment devices. Discharge from the site currently occurs from the east catchment via a 900 mm pipe underneath Wallgrove Road, and from the western catchment via a culvert and waterway to the cemetery to the north. Discharge from both of these catchments will be attenuated so as to protect the stability and capacity of these two outlets. On site detention has been designed so as not to increase peak flows or flooding in either catchment for runoff from events of 1, 2, 5, 10, 20, 50, and 100 annual recurrence intervals (ARI). Addressing these flooding requirements will provide ample space to refine detention outlet structures to meet BCC WSUD DCP objectives for waterway stability management.

Since the use of land for flood detention and stormwater treatment is complementary, these two functions have been co-located. In the western catchment, flood detention will be provided above and around the stormwater treatment wetland. This will be located in the lowest topography of the catchment. The planting of this area will comprise plant species appropriate to the likely hydrologic regime of the detention basin. In the east catchment, flood detention will be provided directly above and around the stormwater bioretention system at the lowest part of the catchment. Additional flood detention storage will be provided further upstream in a series of cascading detention basins created in the vegetated corridor along the east extremity.

Three drainage options are presented that represent different potential developments. Each option has a different catchment size, because depending on the nature of development, benching through the middle of the site may be used to divert water to the western catchment. This is advantageous for the development because it permits a reduction in the size of the flood detention basin in the east catchment, thus increasing the area of developable land where it is most desired. Diverting water to the western catchment is also advantageous for the cemetery to the north of 60 Wallgrove. The cemetery has large areas of irrigable landscapes and consequently high water demands. They have requested that as much water as possible be diverted from the western catchment of 60 Wallgrove to their water storage pond. Thus the diversion of water has the benefit of reducing the potable water demands of the cemetery by supplying them with an alternative source of treated water suitable for irrigation. Diverting water for irrigation also has ecosystem benefits for Eastern Creek downstream by further attenuating flows and reducing nutrient loads.

1 INTRODUCTION

This report supports the Environmental Assessment for the proposed redevelopment of 60 Wallgrove Street, Minchinbury, henceforth referred to as the Minchinbury Employment Park, in line with the State Environmental Planning Policy (Western Sydney Employment Area 2009). This policy allows the site to be developed for employment generating uses (Industrial). This site of 22 hectares is located within the jurisdiction of the Blacktown City Council (BCC) and as such it is appropriate to manage stormwater on this site according to the BCC Water Sensitive Urban Design (WSUD) Development Control Plan (DCP).

A WSUD strategy for the future development of the site has been devised to meet the WSUD objectives set out in the BCC WSUD DCP. This report outlines how the WSUD objectives of the site can be met for future development. This report details the hydrologic and hydraulic calculations used to determine the potable water conservation, Onsite Detention (OSD) and stormwater treatment requirements for the site. The management of water on this site has been integral to guiding the Masterplan development as detailed within the *Urban Design Report and Design Guidelines*, also prepared by EDAW AECOM.

2 BLACKTOWN WSUD DCP OBJECTIVES

The BCC WSUD DCP states that the following objectives apply for water management in new developments.

Potable Water Conservation
Buildings not subject to BASIX such as those in industrial estates must meet minimum water conservation ratings as defined by the Water Efficiency Labelling Standards (WELS) Scheme and investigate the use of rainwater tanks to supplement potable water supply. For any water use within public open space an alternative water source must be identified to meet at least 80% of all irrigation demand.

Stormwater Quality
Reduction in the post development average annual load of gross pollutants (>5mm), TSS, TP and TN of 90%, 85%, 65% and 45%, respectively.

Waterway Stability
Post development duration of flows greater than the “stream-forming flow” should be no greater than 3-5 times the natural duration of this flow. “Stream-forming flow” is defined as 50% of the 2year flow rate estimated for the catchment under natural conditions.

The waterway stability objective will be indirectly addressed by the provision of flood storage adequate for runoff events from the 1 to 100-year Annual Recurrence Interval (ARI). Research has shown that addressing peak flow objectives will mitigate runoff sufficiently to meet the waterway stability objectives. This research produced the following report: Stream Erosion Index - A Discussion paper prepared for Blacktown City Council, Prepared by Tony Wong & Katie Brookes, EDAW AECOM Australia, 3 October 2008). The flood detention storage will require a multiple outlet riser, the design of which can be refined at the detailed design stage.

3 CATCHMENT INFORMATION

The site is located to the north west of Sydney. Currently the site is being used as a quarantine station. The quarantine station is to be decommissioned and redeveloped into an industrial estate. The site is split into two main catchments by a ridgeline that runs north-south through the centre of the site (Figure 1). The western catchment falls to a gully that drains north under Melville Road to a cemetery. Stormwater from the east catchment flows from the ridgeline to a 900 mm diameter culvert that drains underneath Wallgrove Road. There is also a small catchment to the northeast of the site that drains to Wallgrove road or the cemetery via overland flow.

3.1 Constraints

The site presents some constraints to water management:

- Runoff from the east catchment must be attenuated so as to preserve the current standard of service provided by the conveyance capacity of the culvert underneath Wallgrove Road. Runoff from the western catchment must be attenuated to protect the stability of the waterway that flows north to the cemetery. Attenuation of runoff will require that some land be set aside for temporary flood water storage.
- There is a small north-east catchment that currently sheds water towards the cemetery and/or Wallgrove Road. This will no longer be acceptable once development increases the imperviousness of this catchment due to the associated increases in runoff volumes. The north-east catchment needs to be raised with 1 to 1.5 m of fill so that flow can be redirected south.
- Stormwater treatment devices are not appropriate directly alongside roads in industrial zones as they are at risk of being disturbed by vehicular traffic or industrial activities.

3.2 Opportunities

- The area required for stormwater treatment is less than that required for flood detention and hence stormwater treatment systems can be located within flood detention basins. Co-locating these facilities provides an efficient and complementary use of space.
- There are areas in both the east and western catchments with stands of trees of habitat, shade and scenic amenity value . This land use is also compatible with flood detention and stormwater treatment. Where possible, flood detention and stormwater treatment systems can be located within these areas to maximise the developable footprint of the site, without compromising the health of these trees.
- The cemetery located adjacent to and downstream of the site would like to receive more runoff in order to increase water availability for irrigation. Harvesting stormwater runoff has additional benefits for the downstream environment (Eastern Creek). Specifically, a further reduction in pollutant loads due to nutrient-containing stormwater being harvested and irrigated rather than being delivered to the creek; and additional mitigation of the impacts of imperviousness on the hydrology of the catchment due to a reduction in both the frequency and volume of flows.
- Industrial development often requires benching of large areas to make the landscape suitable for industrial activity. This type of landscape alteration makes possible the partial diversion of water from the east catchment to the western catchment. Such diversion has the benefit of increasing the supply of water to the neighbouring cemetery. It also reduces the area required for flood attenuation in the east catchment, creating more developable area where it is most valuable.

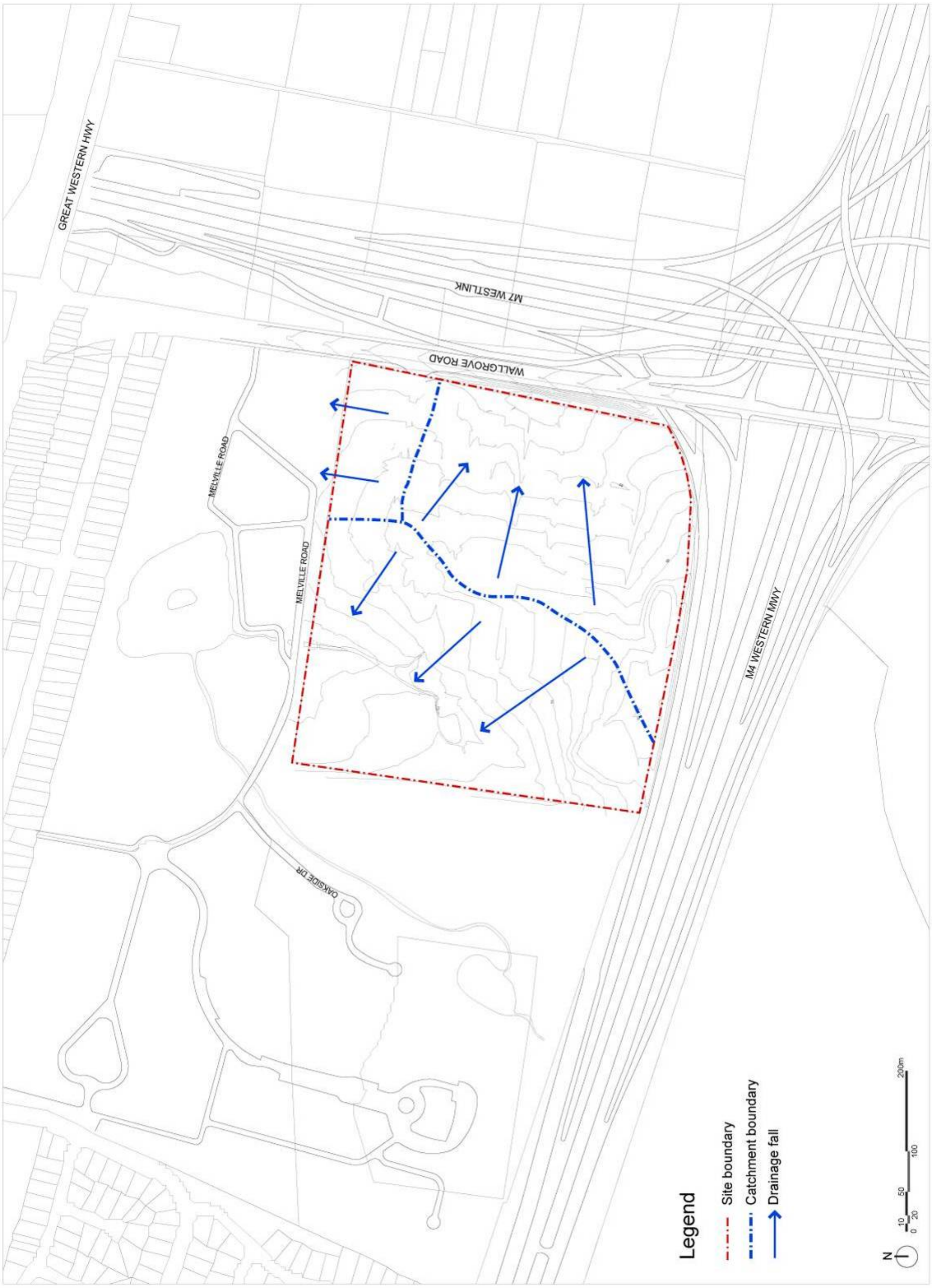

Figure 1 Catchment boundaries in existing or pre-developed condition

4 WATER SENSITIVE URBAN DESIGN STRATEGY

4.1 Potable Water Conservation

The development of a potable water conservation strategy for an industrial subdivision is difficult because the sites will attract a large variety of users, each with different water demand and quality requirements. Maximum potable water savings in an industrial area can be attained if it involves the industrial uses of water. Therefore significant savings may be achieved through a strategy tailored to the needs of specific occupiers of the development, but such a strategy is not possible where occupants are likely to change; such is the case for the Minchinbury Employment Park site.

In lieu of a water conservation strategy tailored to the needs of individual occupants, the following recommendations are made:

- Potable water demands must be reduced through demand management including the installation of water efficient fixtures and using alternative sources of water based on matching water quality to uses on a "fit-for-purpose" basis.
- Potable water demands can be firstly reduced by ensuring all industrial users of the site agree to implement a water demand management strategy that requires the installation of water efficient features (for example, toilets and fittings). Water use fittings must demonstrate minimum standards defined by the Water Efficiency Labelling and Standards (WELS) Scheme. Minimum WELS ratings are 4 star dual-flush toilets, 3 star showerheads, 4 star taps (for all taps other than bath outlets and garden taps) and 3 star urinals. Water efficient washing machines and dishwashers are to be used wherever possible. The water demand management strategy must also ensure that equipment such as hoses is maintained to prevent leaks. Where cooling towers are used they are:
    - To be connected to a conductivity meter to ensure optimum circulation before discharge.
    - To include a water meter connected to a building energy and water metering system to monitor water usage.
    - To employ alternative water sources for cooling towers where practical
- Landscapes should be vegetated using species native to the local area that have low water demands. If irrigation is required, efficient systems such as drip irrigation should be used, and irrigation should only be conducted at night.
- Alternative supplies of water for non-potable demands can be supplied from captured roof runoff, stormwater or treated wastewater. The collection, treatment and subsequent reuse of wastewater, rainwater and stormwater should be optimised to minimise the quantities of potable water consumed by the site. As a minimum requirement, all buildings must install rainwater tanks to supply demands such as outdoor use, toilets, laundry or hot water. Fifty (50) percent of non-potable water requirements are required to be met as per the amended IWCM DCP for BCC. The large roof areas and small demands for non-industrial uses make this objective attainable using rainwater.
- Water use within public open space (for uses such as irrigation, pools, water features etc.) can be feasibly supplied from alternative sources to meet 80% this demand. If a connection to recycled water is made available, a requirement for it to supply non-potable demands should replace the requirement for rainwater tanks.

Dual reticulation may also permit future access to recycled water in the case that the recycled water pipeline from Quakers Hill to Parramatta is augmented to service the Western Sydney Parklands.

4.2 Three catchment drainage options

The lots along the east extremity of the site have been identified as some of the most valuable for development. However, this location also co-incides with an area required for flood detention, making it potentially unsuitable for development. Therefore, in order to maximise the developable area in this location, various different ways of draining the catchments were investigated. Three proposed options were assessed. Each option alters the drainage by shedding an increasing area of catchment to the west and in doing so, reducing the requirement for flood detention in the east.

- Drainage Option 1: Natural drainage. Most of the site will drain as for the existing condition. The small north-east catchment will be filled so that it drains towards the larger east catchment (Figure 2).
- Drainage Option 2: Benching of lots on ridge. As above except that the lots that are benched across the ridge will be constructed so that all runoff from these lots drains to the western catchment, and correspondingly decreasing the area of the east catchment (Figure 3).
- Drainage Option 3: Diversion. As for option 2 except that more of the east catchment will be diverted to the west by piping runoff underground through the ridge. This further decreases the size of the east catchment (**Figure 4**).

Options 2 and 3 provide additional benefits beyond the site. Increasing the proportion of runoff that drains to the western catchment will provide the cemetery with additional water for use in the irrigation of their grounds, thereby reducing their demands on the potable water supply. Furthermore, harvesting stormwater runoff has benefits for the downstream environment (Eastern Creek). These being:

- A further reduction in pollutant loads delivered to the creek
- Additional mitigation of the impacts of imperviousness on the hydrology of the catchment (= reduction in frequent flows).

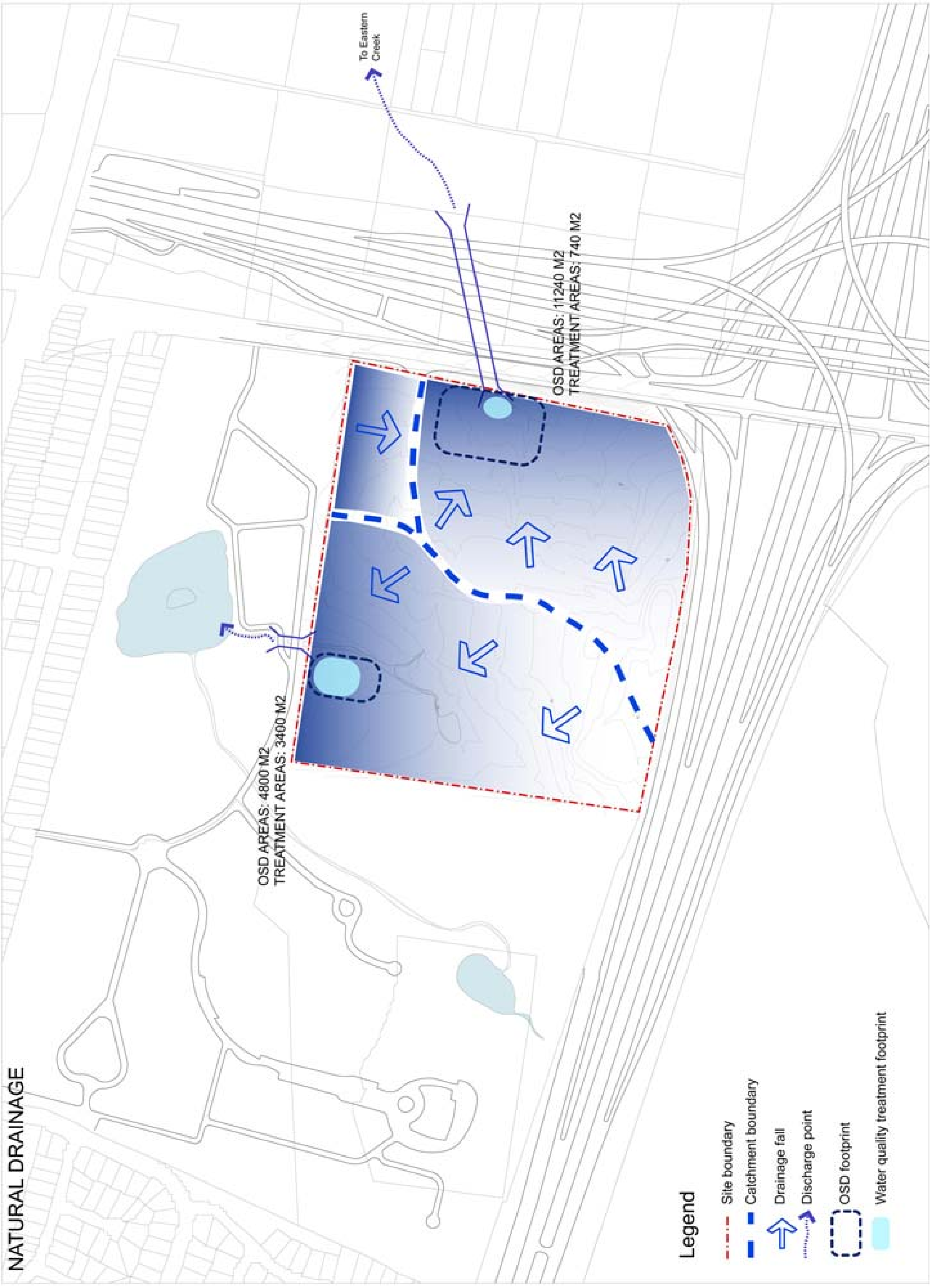

Figure 2 Catchment boundaries in modelled Drainage Option 1 – Natural Drainage

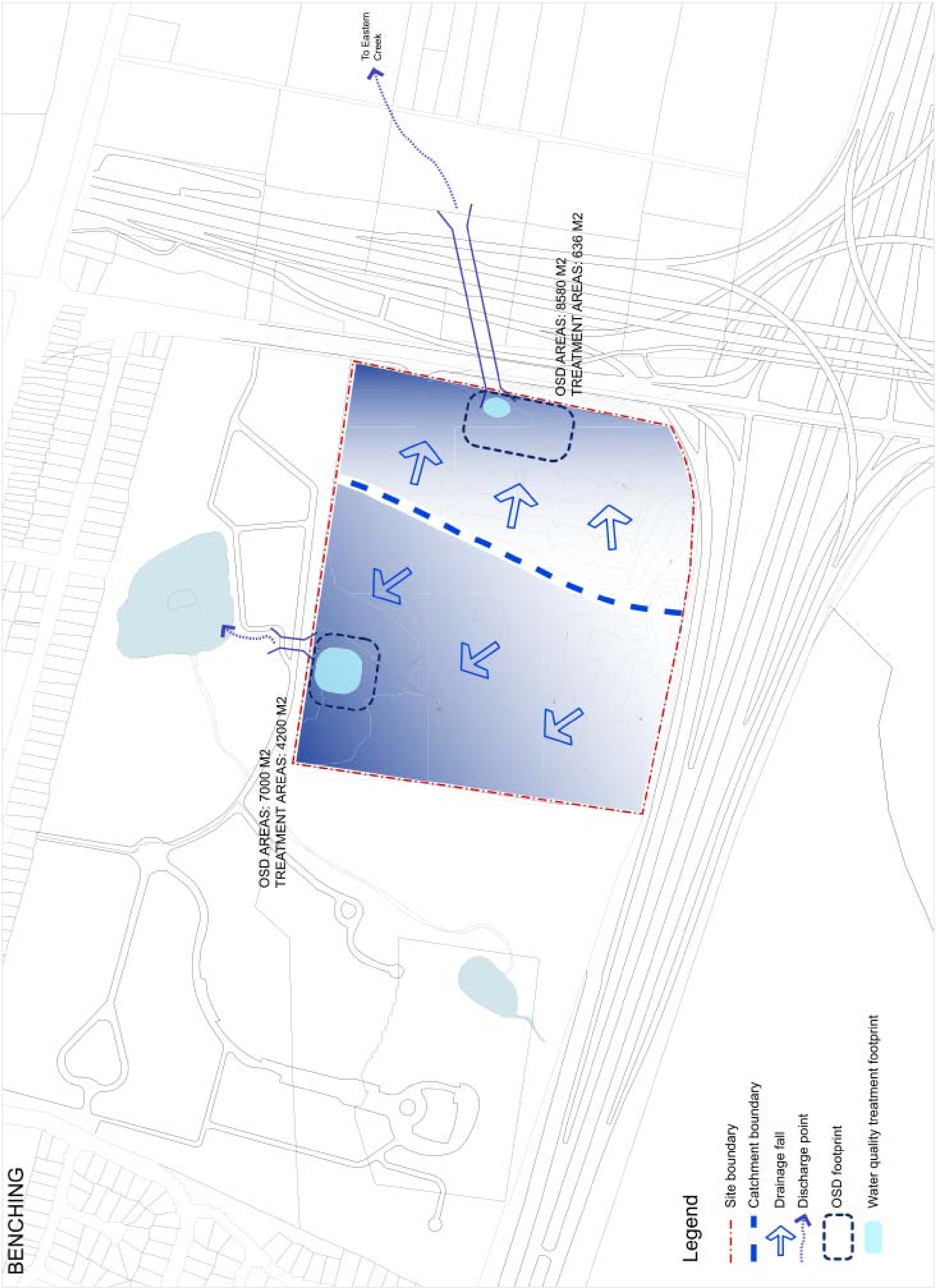

Figure 3 Catchment boundaries in modelled Drainage Option 2 – Benching

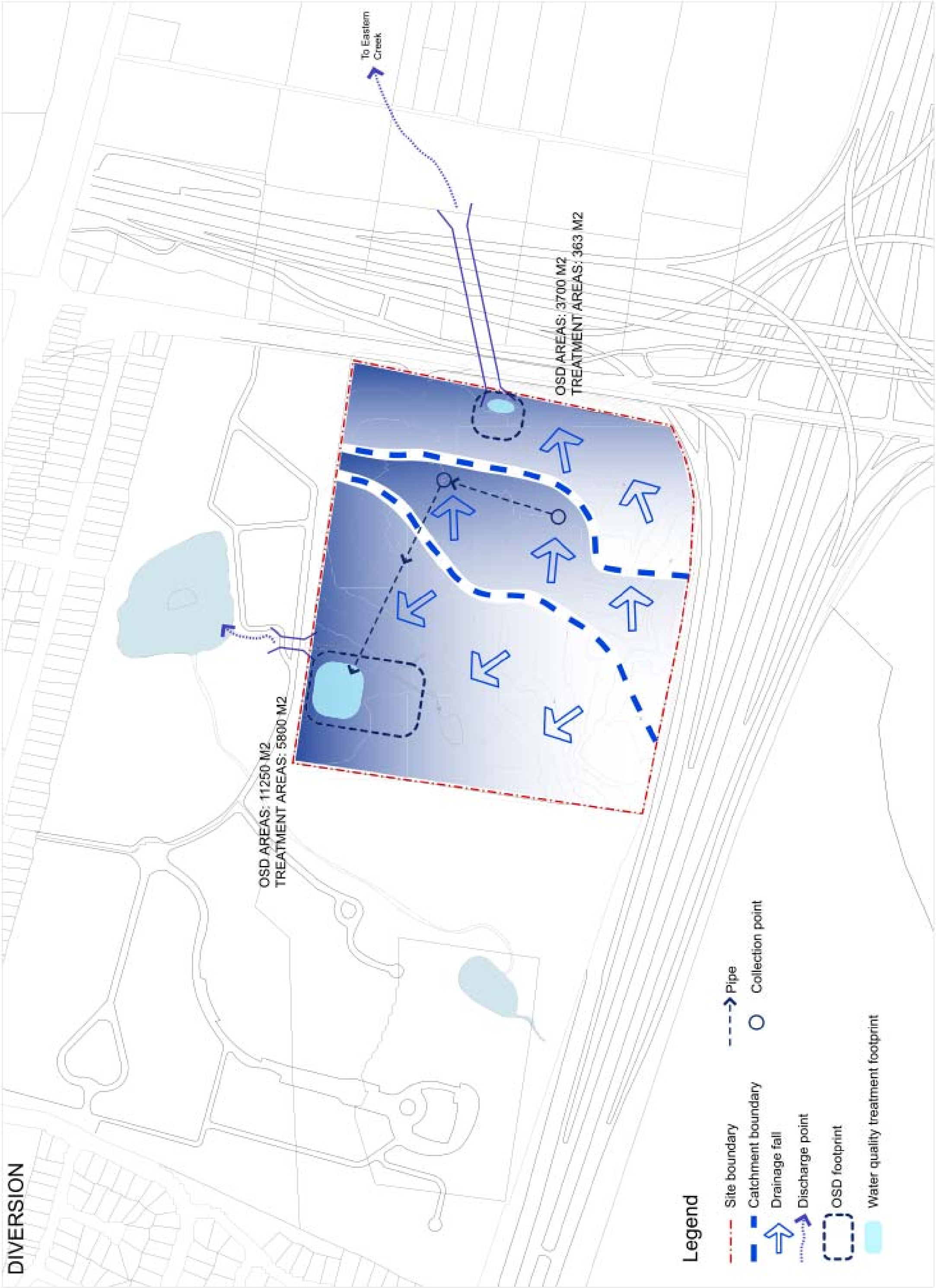

Figure 4 Catchment boundaries in modelled Drainage Option 3 - Diversion

4.3 Stormwater Quality

4.3.1 Objective

To safeguard the quality of the downstream aquatic environment by improving the quality of stormwater run-off to achieve best practice standards.

4.3.2 Performance Criteria

Current stormwater management best practice specifies that runoff must be treated to meet the following targets. These targets are relative to a developed but unmitigated scenario:

- 90% reduction in the post development average annual gross pollutant (>5mm) load.
- 85% reduction in the post development average annual Total Suspended Solids (TSS) load.
- 60% reduction in the post development average annual Total Phosphorus (TP) load.
- 45% reduction in the post development average annual Total Nitrogen (TN) load.

4.4 Stormwater Quality Management

4.4.1 Building Design Guidelines for Minchinbury Employment Park

The first step towards reducing pollutant runoff from industrial estates is good site design. Stormwater pollution in industrial precincts has two risk profiles, one associated with its typically high percentage of impervious surfaces and traffic volumes, and the other related to industrial practices that have the potential to result in pollution entering the stormwater drainage system. It is the latter that differentiate stormwater pollution characteristics in industrial precincts from that of a typical high-density urban environment. Studies have shown that the risk present by industrial sites will be no different to typical development if industrial activity can be separated from surfaces that drain to stormwater systems and downstream waterways. The simplest way to ensure this is to limit industrial activity to undercover areas. Inappropriate drainage of works areas and inappropriate work practices are largely responsible for a wider range of pollutants types and concentrations experienced in industrial precincts and are the main causes of stormwater pollution during dry-weather conditions. This approach, termed “structural isolation” is superior to approaches that focus on attempts to filter out industrial pollutants once they have mixed with stormwater.

Difficulties will arise in the long term if stormwater treatment devices are tailored to known pollutants from a particular business activity as businesses will change premises and devices tailored to the needs of one business are unlikely to suit subsequent businesses. Building design guidelines can be developed to ensure that pollution sourced from work areas does not enter into stormwater drains and thence to the downstream environment. This is the most effective method in implementing WSUD in industrial precincts in a sustainable manner and can be achieved by:

- Roofing work areas,
- Directing wash-down to storage (which is subsequently pumped out as industrial waste), or
- Directing wash-down to sewer and controlling activities undertaken in areas connected to stormwater drains.

It is important to isolate industrial work activities from stormwater runoff to ensure that standard WSUD treatment measures designed to treat stormwater from typical urban environments are not compromised by the wider range of pollutants types and concentrations associated with industrial activities. If structural isolation has been achieved, conventional WSUD practices for the management of stormwater runoff from impervious surfaces other than work areas can be implemented along the same basis as other urban environments.

Programs to promote good environmental practice in businesses in industrial precincts are seen as an essential part in helping sites meet water quality objectives. Programs may specifically promote good environmental practices in the operation of individual businesses, with structural measures physically separating work areas from stormwater runoff into the drainage system. Other programs aim to raise awareness and responsibility for appropriate environmental protection behaviour of individuals working in industrial precincts.

4.4.2 Stormwater treatment

The stormwater pollutant load reduction objectives stipulated for Minchinbury Employment Park will be met by consolidating treatment for each catchment to large stormwater treatment devices at the bottom of the catchment. Gross pollutant traps (GPT) should be installed as a pre-treatment device to any of the wetlands or bioretention systems discussed below. GPTs will help to protect the wetland or bioretention system from litter, sediment, and oils and grease.

North-east Catchment

Runoff from the north-east catchment is currently shed north towards the cemetery and/or towards Wallgrove Road. Directing water to these areas will no longer be appropriate after development due to the substantial increase in runoff and pollutants generated that result from the creation of impervious surfaces. It is therefore proposed that the north-east lots be raised with approximately 1 to 1.5 m of fill to provide sufficient grade for water to drain south. Runoff will then be treated in the east catchment.

East Catchment

Runoff from this catchment is currently untreated except for some conveyance via grassy swales. These are directed to a 900mm pipe under Wallgrove Road.

It is proposed to treat runoff from the future developed east catchment firstly in a gross pollutant trap and then through a bioretention basin. These will be located at the bottom of the catchment as close as practicable to the existing 900 mm pipe. The bioretention system will be sized to meet the BCC WSUD DCP criteria for pollutant removal. To make the best use of space, the bioretention basin will be built within a flood detention basin. Overflows and treated flows from the bioretention basin will be discharged to Eastern Creek.

Bioretention systems may also be incorporated into the road reserve of the east catchment. This will have the benefit of reducing the area that must be allocated for stormwater treatment at the bottom of the east catchment. It does not increase the developable area, because an equivalent area must still be set aside for flood attenuation. It does however increase the opportunities to use the flood storage area for other open space uses such as passive recreation. Where bioretention systems are located in the road reserve they should be separated from vehicular traffic as indicated in Figure 5.

Figure 5 Bioretention systems constructed within road reserve and suitably protected by appropriate landscaping

Western Catchment

Stormwater generated from the western catchment will be treated through a constructed wetland. The constructed wetland will consist of an inlet zone, a macrophyte zone and ephemeral zone. A gross pollutant trap will be included upstream of the inlet zone to provide primary treatment. The Stormwater treatment wetland will be sized to meet the BCC WSUD DCP criteria for pollutant removal.

In the western catchment, flood detention will be provided over and around the stormwater treatment wetland. Stormwater volumes that exceed the capacity of the wetland will inundate the flood detention basin to meet flood detention requirements. Flows discharged from this system will flow to the cemetery lake.

The wetland and flood detention basin system will be located in the lowest topography of the catchment in an area set aside for flood detention purposes. These two functions have been co-located because the use of land for flood detention and stormwater treatment is complementary. The planting of this area will comprise plant species native to the Cumberland Plain and appropriate to the likely hydrologic regime of the detention basin. An indicative sketch is provided to illustrate the relative size and functional elements that will be required in the design of the wetland (Figure 6).

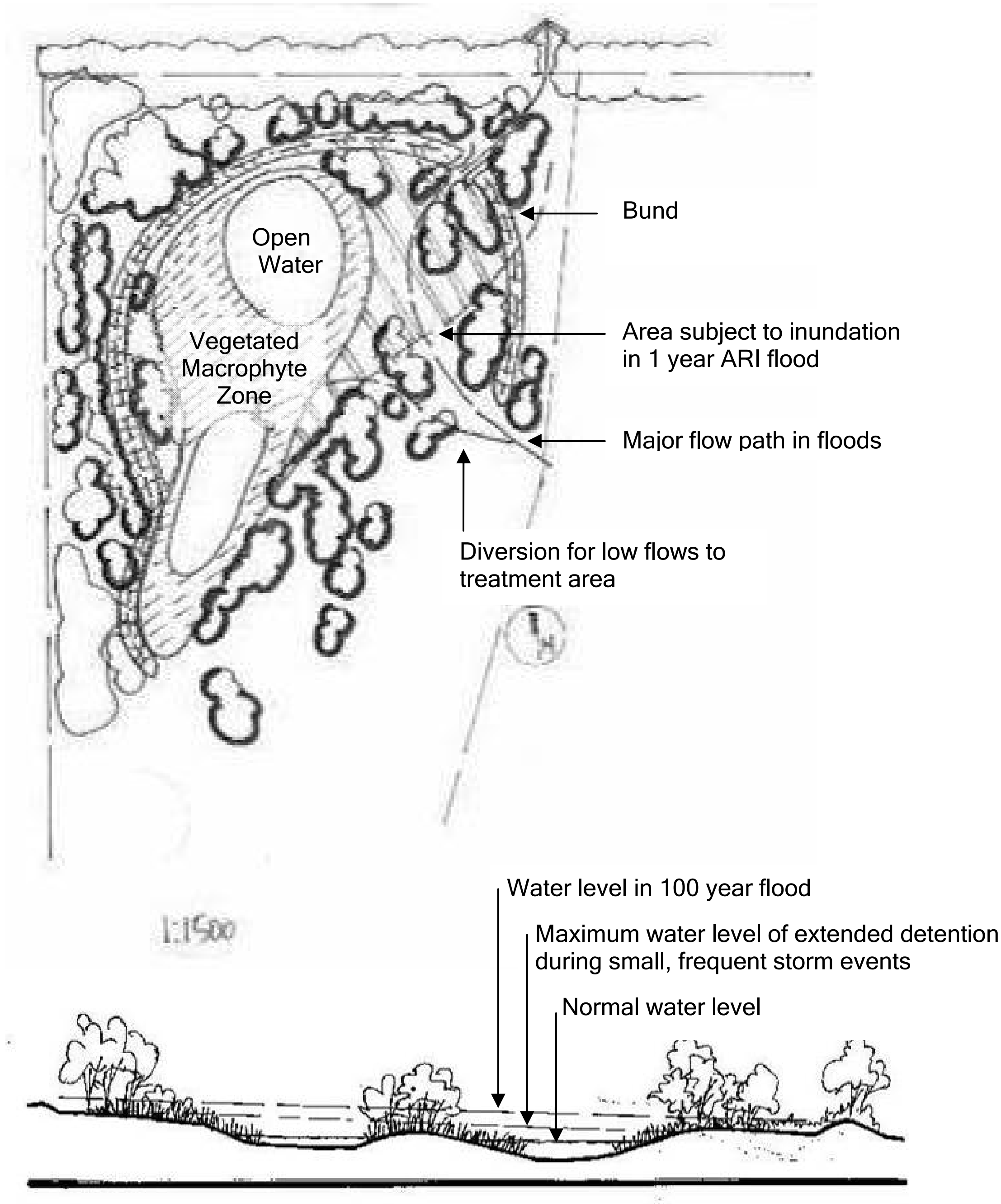

Figure 6 Indicative sketch of constructed wetland for stormwater treatment indicating functional elements required for effective water treatment. Both the wetland and the on-site flood detention storage can be integrated amongst the remnant vegetation. (Note – section is vertically exaggerated and not to scale.)

4.4.3 Modelling of stormwater treatment devices

Stormwater treatment was modelled using MUSIC (Modelling Urban Stormwater Improvement Conceptualisation) software. This software was developed by the Cooperative Research Centre for Catchment Hydrology (now eWater CRC) as a decision support system for the design of stormwater treatment devices.

The following parameters were assumed in the modelling to derive the treatment area requirements (Table 1).

Table 1 Meteorological data

Meteorological Station	Liverpool
Data record	1967-1977
Time step	6 minute

Stormwater treatment devices were modelled using the following parameters (Table 2) and catchment characteristics (Table 3).

Table 2 Modelling parameters for stormwater treatment devices

Constructed wetland	
Detention time	72 hours
Extended detention	0.5m
Length to width ratio	4:1
Vegetation cover in macrophyte zone	80 %
Size of sedimentation/inlet zone (relative to macrophyte zone)	10 %

Bioretention system	
Extended detention	0.5 m
Saturated hydraulic conductivity	100 mm h^{-1}
Mean particle size	0.5 mm
Depth of filter media	0.8 m

Table 3 Catchment characteristics for modelled drainage options

Parameter PROPOSED	Unit	West	East
Drainage Option 1			
Subcatchment Area	ha	11.02	10.85
% impervious	%	72%	82%
area impervious	ha	7.93	8.88
area pervious	ha	3.08	1.97
Drainage Option 2			
Area Diverted West	ha	2.00	
Subcatchment Area	ha	13.02	8.85
% impervious	%	75%	83%
area impervious	ha	9.76	7.35
area pervious	ha	3.25	1.50
Drainage Option 3			
Area Diverted West	ha	5.66	
Subcatchment Area	ha	16.68	5.19
% impervious	%	78%	77%
area impervious	ha	13.01	4.00
area pervious	ha	3.67	1.19

The required sizes of the stormwater treatment systems are as follows (Table 4). Note that the required size of the treatment device changes in proportion to the size of the catchment. As the east catchment gets smaller, the footprint required for the bioretention system gets smaller.

Table 4 Treatment area requirements for modelled drainage options

Treatment area requirements	West Catchment Wetland (m^2)	East Catchment Bioretention (m^2)
Drainage Option 1. Natural drainage	3600	740
Drainage Option 2. Benching and drainage	4200	636.4
Drainage Option 3. Diversion	5800	362.6

Draining part of the east catchment to the west has the benefit of reducing the area that must be allocated for stormwater treatment at the bottom of the east catchment. It does not increase the developable area, as the treatment area is only a portion of the area that must be set aside for flood attenuation. It does, however, increase the opportunities to use the flood storage area for other open space uses such as passive recreation.

4.5 Waterway stability management

4.5.1 Introduction

This section details the hydrologic and hydraulic calculations used to determine the flood/Onsite Detention (OSD) requirements for the site. As noted in Section 2, a study by EDAW has confirmed that the waterway stability management objectives will be delivered if peak flow based control objectives are met by means of on-site detention.

To determine OSD requirements, RAFTS hydrologic models were developed as part of this assessment.

4.5.2 Objective

To control the impacts of urban development on channel erosion by controlling the magnitude, velocity and duration of sediment-transporting flows.

4.5.3 Performance Criteria

The waterway stability criteria stipulate that the post-development duration of flows greater than the stream forming flow should be no more than to 3-5 times longer than the undeveloped duration. The stream forming flow is defined as the following % of the 2 year ARI flow rate estimated for the catchment under natural conditions: 10%-cohesion less (e.g. sandy) bed and banks; 25% moderately cohesive bed and banks; 50%-cohesive (e.g. stiff clay) bed and banks.

In order to achieve this criterion, it is also important to minimise the impervious areas that are directly connected to the stormwater system.

4.5.4 Modelled Drainage Options

Currently the site is being used as a quarantine station. This is modelled as the *Existing Condition* (refer Figure 1). The quarantine station is to be decommissioned and redeveloped into an industrial estate (*Proposed Drainage Options 1, 2 and 3*). A *Predeveloped Condition* has also been assessed as part of this study. For the predevelopment condition the site is assumed to be in a totally natural condition, without impervious surfaces. Catchment information for the pre-developed and existing conditions is tabulated below (Table 5).

Table 5 Catchment Information – Pre-developed and Existing

Parameter	Unit	West	East	North East
PRE DEVELOPED				
Subcatchment Area	ha	11.02	9.13	1.72
% impervious	%	0%	0%	0%
Slope	%	2.72%	3.16%	2.09%
EXISTING				
Subcatchment Area	ha	11.02	9.13	1.72
% Impervious	%	7.3%	25.4%	4.1%
Area impervious	ha	0.81	2.32	0.07
Area pervious	ha	10.21	6.81	1.65
Slope lots impervious	%	2.13%	2.63%	2.09%
Slope pervious	%	2.72%	3.16%	2.09%

As part of this study, three proposed drainage options were assessed. The strategy for each of the proposed options was to increase the proportion of developable land whilst minimising flooding impacts on downstream areas. They are described below:

Drainage Option 1

- Diversion of the north-east catchment southwards, to be combined with the east catchment

Drainage Option 2

- Diversion of the north east catchment
- Diversion of part of the east catchment, to be combined with the west catchment

Drainage Option 3

- Diversion of the north east catchment
- Diversion of a larger portion of the east catchment , to be combined with the west catchment

Catchment information for the each of the proposed options are illustrated in Figure 2, Figure 3, and Figure 4 and detailed in Table 6 below.

Table 6 Catchment Information for modelled options

Parameter PROPOSED	Unit	West	East
Drainage Option 1			
Subcatchment Area	ha	11.02	10.85
% impervious	%	72%	82%
area impervious	ha	7.93	8.88
area pervious	ha	3.08	1.97
Slope lots impervious	%	1%	1%
Slope pervious	%	1%	1%
Drainage Option 2			
Area Diverted West	ha	2.00	
Subcatchment Area	ha	13.02	8.85
% impervious	%	75%	83%
area impervious	ha	9.76	7.35
area pervious	ha	3.25	1.50
Slope lots impervious	%	1%	1%
Slope pervious	%	1%	1%
Drainage Option 3			
Area Diverted West	ha	5.66	
Subcatchment Area	ha	16.68	5.19
% impervious	%	78%	77%
area impervious	ha	13.01	4.00
area pervious	ha	3.67	1.19
Slope lots impervious	%	1%	1%
Slope pervious	%	1%	1%

4.5.5 RAFTS Parameters

RAFTS is a non-linear hydrologic model. It was used to determine the peak flow from subcatchments for the pre-developed, existing and proposed cases. The model was also used to determine the onsite detention basin requirements. Peak flows were calculated for the 1, 2, 5, 10, 20, 50 and 100-year Average Recurrence Interval (ARI) storm events. Standard storm durations ranging from 15 minutes to 4.5 hours were modelled in RAFTS (parameters listed in Table 7). Rainfall losses were chosen based on values from Table 3-2 of Australian Rainfall and Runoff (AR&R) Vol 1, Book II Section 3.

Table 7 RAFTS Parameters

Parameter	Unit	Pervious	Impervious
Initial Losses	mm/hr	10	1.5
Continuing Losses	mm/hr	2.5	0
Manning's n		0.035	0.015

4.5.6 Detention Basins

The main objective of an OSD basin is to match the peak flow leaving the site in the proposed condition to the peak flow leaving the site in the existing condition. For safety reasons the depth in the detention basins were limited to 0.6 m. A number of iterations of the model were run until the above desired peak flows were achieved.

Table 8 Basin outlet assumptions

Parameter	Assumption
Pipe diameter and number	1/900mm (east)
	3/900mm (west)
Length of pipe	20m
Slope of pipe	0.5%
Assumed Tailwater depth	0m
Manning's n of pipe	0.013
Batter slopes of basin	1v: 6h

Table 8 above lists the main assumptions used in the basin model. These assumptions will need to be revisited during later stages of the project once detailed survey information becomes available.

A summary of the required area and OSD volume for each of the drainage options is listed in Table 9. Additional area will need to be set aside to account for batters and perimeter bunding. Typically this can range from 5% on flat sites to 40% on steep sites. Allowance should also be made for freeboard (typically 0.3m depth). This may mean that additional area is required.

Table 9 OSD Volume and Area assuming a nominal depth of 0.6m

			West	**East**
Drainage Option 1	Area	m2	4800	11240
	Volume	m3	2600	6310
Drainage Option 2	Area	m2	7000	8580
	Volume	m3	3840	4770
Drainage Option 3	Area	m2	11250	3700
	Volume	m3	6310	1980

Notes: For all basins (except Option 3 - East) the invert level of the basin outflow pipe is assumed to be the same as the basin RL. The pipe invert level for Option 3 - East has been lowered below the basin RL by 0.5m to optimise footprint area and depth requirements.

4.5.7 Results

Results from the pre-developed and existing conditions are summarised in Table 10 below. Results for each of the three proposed drainage options are detailed in Table 11 and Table 12.

Table 10 Results – Predeveloped and existing conditions

	Predeveloped Peak Flow m3/s		Existing Peak Flow m3/s	
ARI	West	East	West	East
1	0.43	0.39	0.44	0.60
2	0.72	0.65	0.74	0.87
5	1.09	0.97	1.11	1.31
10	1.28	1.18	1.29	1.54
20	2.05	1.83	1.58	1.88
50	2.36	2.12	1.96	2.19
100	2.67	2.39	2.30	2.55

Table 11 Results – Proposed conditions

		Drainage Option 1		**Drainage Option 2**		**Drainage Option 3**	
	ARI	West	East	West	East	West	East
Proposed	1	1.69	1.88	2.07	1.56	2.76	0.85
Peak Flow m3/s	2	2.18	2.43	2.67	2.01	3.56	1.10
	5	2.80	3.13	3.44	2.59	4.58	1.41
	10	3.15	3.50	3.86	2.89	5.14	1.58
	20	3.64	4.02	4.46	3.33	5.92	1.82
	50	3.91	4.30	4.77	3.55	6.30	2.00
	100	4.37	4.78	5.31	3.96	7.01	2.22
Proposed Mitigated	1	0.48	0.15	0.45	0.14	0.42	0.53
Peak Flow m3/s	2	0.72	0.22	0.67	0.21	0.62	0.59
	5	1.06	0.32	0.98	0.31	0.93	0.65
	10	1.25	0.38	1.15	0.36	1.11	0.69
	20	1.51	0.46	1.40	0.44	1.37	0.75
	50	1.76	0.55	1.66	0.53	1.62	0.79
	100	1.97	0.63	1.89	0.61	1.85	0.83
Proposed Mitigated	1	0.27	0.26	0.26	0.26	0.26	0.04
Peak Basin Stage (m)	2	0.34	0.32	0.33	0.32	0.31	0.08
	5	0.42	0.40	0.40	0.39	0.39	0.12
	10	0.46	0.44	0.44	0.43	0.43	0.15
	20	0.52	0.49	0.50	0.48	0.49	0.20
	50	0.58	0.55	0.55	0.54	0.55	0.24
	100	0.62	0.61	0.61	0.59	0.60	0.29

Table 12 Comparison of Results – Proposed conditions

	ARI	Drainage Option 1 West	Drainage Option 1 East	Drainage Option 2 West	Drainage Option 2 East	Drainage Option 3 West	Drainage Option 3 East
Difference mitigated to pre developed Peak Flow m3/s	1	0.04	-0.24	0.01	-0.25	-0.02	0.14
	2	0.00	-0.44	-0.05	-0.44	-0.10	-0.07
	5	-0.03	-0.65	-0.11	-0.66	-0.15	-0.31
	10	-0.03	-0.80	-0.13	-0.81	-0.17	-0.48
	20	-0.54	-1.37	-0.65	-1.39	-0.68	-1.08
	50	-0.60	-1.57	-0.70	-1.59	-0.74	-1.33
	100	-0.70	-1.76	-0.78	-1.78	-0.81	-1.56
Difference mitigated to existing Peak Flow m3/s	1	0.03	-0.45	0.00	-0.46	-0.03	-0.07
	2	-0.02	-0.65	-0.07	-0.66	-0.11	-0.28
	5	-0.05	-0.99	-0.13	-1.00	-0.18	-0.66
	10	-0.03	-1.16	-0.14	-1.17	-0.17	-0.84
	20	-0.07	-1.43	-0.18	-1.45	-0.22	-1.14
	50	-0.20	-1.63	-0.30	-1.65	-0.34	-1.39
	100	-0.34	-1.92	-0.41	-1.93	-0.45	-1.71

The peak basin stage (i.e. depth of the water in the basin) was generally kept below 0.6m for the 100 year ARI for all the drainage options. It can be seen from the Table 12 results that peak flows from the existing condition are slightly higher than the pre-developed condition for the 1 to 20 year ARI storms. The proposed options for development reduce the peak flows leaving the site back to existing conditions. There are negligible increases in peak flow for drainage option 1 and 2 (western catchment 1 year ARI event).

Any of the three drainage options can be used to adequately address the requirements for flooding provided that adequate storage is available. All of the options discussed will provide sufficient area for stormwater treatment devices to be located within the footprint of the flood detention basin. Drainage options 1 and 2 for the western catchment have similar storage requirements. This means that there is little benefit gained by diverting the east catchment west for drainage option 2.

4.5.8 Recommendations

- Assumptions regarding tailwater levels and geometry of downstream pipes need to be reassessed at a later stage of the project.
- The onsite detention volumes outlined in this report should be set aside to prevent detrimental increase in the peak flows leaving the site.
- To meet waterway stability objectives, a multi-stage outlet must be designed in the detailed design stage for the On-Site Detention basins.

4.6 Stormwater and WSUD during Construction

During the construction period, and in normal daily operations, the lot owner must ensure that an appropriate strategy is in place to protect the catchment and water treatment devices from erosion and sediment build up. This needs to be a whole of site and construction works approach to control Siltation, runoff and temporary and permanent drainage. Initiatives required include:

- The connection of building roofs to on-site water storage or to discharge as early as possible;
- Construction operations, including cleaning of equipment and tools, within the site boundaries and in designated areas to contain pollutants;
- All solid waste generated by the site to be placed in wind proof containers and protected from surface runoff;
- Accidental spills of soil or other materials onto roads, drains, swales or other locations must be removed promptly. Washing of any such materials down drains is strictly prohibited;
- Sediment control devices be inspected and all excess material removed prior to and after storm events;
- Site entry points to be managed to control tracking of soils and other materials off the site;
- Sediment control devices to be used around soil stockpiles or any exposed soil and checked regularly for build up and functionality, and
- Construction Management Plan to address how WSUD will be implemented across the site is to be prepared and sighted by the Design Review Panel at application or condition stage.

4.7 Stormwater and WSUD during Operation

Maintenance strategies must be implemented to ensure that no soils, sedimentation or other eroded materials enter the stormwater system. All inadvertent discharge from equipment and vehicle cleaning, servicing and so forth (not captured by the wastewater system) must be cleansed and filtered prior to entry into the stormwater system.

5 CONCLUSIONS

This report outlines the requirements for development on the 60 Wallgrove Rd site to meet the objectives of the Blacktown City Council Water Sensitive Urban Design Development Control Plan.

The development of a potable water conservation strategy for an industrial subdivision is difficult because the sites will attract a large variety of users, each with different water demand and quality requirements. Maximum potable water savings in an industrial area can be attained if it involves the industrial uses of water. Therefore significant savings may be achieved through a strategy tailored to the needs of specific occupiers of the development, but such a strategy is not possible where occupants are likely to change; such is the case for the Minchinbury Employment Park site. However, guidelines are provided that recommend suitable approaches to addressing water demands on industrial sites.

Stormwater quality management can be achieved by consolidating treatment in large treatment systems at the bottom of each catchment. The success of this strategy is also dependent on appropriate building design guidelines and good environmental practices.

Analysis has confirmed that flow duration based waterway stability objectives will be met through attaining peak flow control objectives. Flood detention basins designed for these peak flow objectives will be located on the same footprint as the stormwater quality treatment systems.

Several drainage options were presented. The preferred option (Drainage Option 3) requires the diversion of runoff through pipes from part of the east catchment to the western catchment. The first benefit of this diversion is reduced flood storage requirements and thus the creation of more developable land in the most valuable part of the east catchment. However this strategy also has other benefits. The diversion of water from the east to the west catchment increases the supply of water suitable for irrigation at the cemetery downstream, thus reducing their demands on the community's potable water resources. The reuse of stormwater for irrigation provides the dual environmental benefits of further reducing the nutrient and sediment load to the downstream ecosystem, while assisting to mitigate the detrimental impact that urbanisation has on waterway health due to increase in the frequency and volume of flow.