WSUD Asset Selection and Design Standards Guideline

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Client:	Wyndham City Council
Author(s):	Jason Sonneman, Georgie Wettenhall
Reviewed By:	Georgie Wettenhall
Approved By:	Kuan Yeoh
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Chapter 1 Introduction

1.1 Overview

The Wyndham WSUD asset selection and design standards guideline has been developed to enable applicants to better understand Council's expectations and ensure that that a uniform approach to the implementation of WSUD treatment assets is achieved within the Wyndham municipality

The guideline will assist applicants to select WSUD treatment assets that are appropriate to for site conditions, reflect the size and type of a development, and respond to Council's long term WSUD asset management objectives.

The WSUD design standards define the key design requirements for each WSUD treatment asset type that are acceptable to Council, thus ensuring a consistent approach to the design of WSUD treatment assets within the Wyndham municipality.

The guideline clearly defines the information that must be provided to Council when submitting WSUD treatment asset designs for review. This will provide a transparent design approval process for applicants and enable Council to process applications in a more timely and effective manner.

The adoption of consistent design parameters will ensure that all WSUD treatment assets are designed to best practice standard and provide best value to the community, by considering long term asset performance, public safety, ease and cost of maintenance, amenity and integration with urban design.

The document is divided into four chapters:

Chapter 1: Introduces the WSUD Selection and Design Standards, and provides an overview of the Council approval process.

Chapter 2: Describes the WSUD treatment assets that are accepted by Council, and defines the scenarios in which each WSUD asset type should be implemented.

Chapter 3: Describes the design standards for Council approved WSUD treatment assets.

Chapter 4: Outlines the information that needs to be provided to Council when submitting designs for approval.

1.2 Design approval process

The design approval process involves a three tiered submission process involving a pre-application consultation, concept design and detail design phases. Council approval of stormwater treatment assets is subject to the submission of relevant design information to Council at each stage of the approval process.

It is recommended that WSUD treatment asset designs submitted to Council comply with the design standards outlined in the guideline. Failure to comply with Council's design standards will not necessarily result in the rejection of proposed WSUD treatment asset designs, however the applicant will need to demonstrate that the proposed design complies with Council's core design requirements (Section 3.2), and there is no guarantee that alternative designs will be accepted by Council.

1.2.1 Pre-application consultation

Council recommends that applicants consult with Council in the early development planning process to discuss the proposed stormwater treatment options, and to clarify Council's WSUD asset selection and design standards requirements.

It is recommended the applicant demonstrates the following information at the pre-application consultation:

- Development location
- Type of development (e.g. residential, industrial, commercial)
- Proposed area and number of lots
- Development density
- Detail of any existing water quality assets
- Proposed outfall/legal point of discharge
- Proposed WSUD treatment strategy (e.g. treatment assets)
- Possible site constraints and the proposed approach to overcome these
- Liaison with Council's landscape architect on the landscape outcomes

The pre-application consultation will provide the applicant with an indication of which WSUD treatment assets Council is prepared to accept, as well as Council's visions on landscape design in the area, and provide a level of certainty for the applicant to proceed with the WSUD asset concept design.

1.2.2 Concept design/Stormwater Management Strategy

The concept design must be submitted to Council's Planning and Engineering Departments. The concept design must demonstrate that the proposed location provides adequate space for the proposed WSUD asset footprint and associated infrastructure, and requires that all design opportunities and constraints are considered.

The WSUD concept design must be accompanied by both the urban and landscape design concept plans (approved by Council's Landscape Subdivision Team). The landscape design of WSUD treatment assets should aim to support system function and provide aesthetic, ecological and economic benefits. This ensures that the proposed WSUD asset is integrated into the overall development planning.

The concept design/stormwater management strategy must demonstrate that the WSUD asset is able to satisfy Council's core WSUD asset design requirements and design standards (Chapter 3).

The information that must be submitted to Council as part of the concept design package is outlined in Section 4.1. If the concept design package is incomplete or not submitted to Council's satisfaction, then the application may not be assessed until all relevant information is provided.

1.2.3 Detailed design

The detailed design must be submitted to Council's Engineering Department for approval. The detailed design must include all of the documentation required for the asset construction and establishment stages, including how the asset will be maintained.

The detailed design must be in accordance with the concept design approved by Council. Any aspects of the design package that vary from the approved concept design, or do not conform with Council's design standards should be noted and a justification provided as to how the proposed alternative design approach achieves equivalent or better outcomes than Council's requirements.

The information that must be submitted to Council as part of the detailed design package is outlined in Section 4.2. If the detailed design package is incomplete or not submitted to Council's satisfaction, then the application may not be assessed until all relevant information is provided.

Chapter 2 WSUD Asset Selection Guideline

2.1 Council approved WSUD treatment assets

The following section describes WSUD treatment assets that are approved by Council for use in new developments. For each WSUD treatment system type, a functional description is provided together with a summary of the associated constraints and benefits, and the preferred applications.

2.1.1 Bioretention systems

Description

Bioretention systems, also referred to as raingardens and bioretention tree pits, comprise of a vegetated filter bed designed to infiltrate and treat stormwater runoff (Figure 1).

Figure 1 Examples of bioretention systems.

Stormwater is diverted to the bioretention system where it temporarily pools on top of the filter bed surface, prior to infiltrating down through the filter bed layers where the pollutants are removed. Soluble phosphorus and some metals are removed by adhesion onto the soil particles or by direct uptake through the plant roots. Organic pollutants are broken down by the soil microbes (bacteria), and nitrogen transformed via nitrification and denitrification and released from the filter bed as gaseous nitrogen. Soluble nutrients are also directly uptaken by the plant stems and leaves.

The filter bed comprises of three distinct layers: a) filter media layer, b) transition layer, and c) drainage layer (Figure 2). The filter media layer comprises of a sandy loam which is designed to infiltrate stormwater and provide a substrate for plant growth. The transition layer comprises of coarse sand and prevents fine sediments from washing out of the filter media layer. The drainage layer comprises of coarse gravel which enables the treated stormwater to freely drain into the underdrain system. The underdrain system comprises of a network of slotted pipes that convey the treated stormwater to an outlet pit or directly to the downstream drainage system (Figure 2).

The presence of plants within the bioretention system is crucial to the ongoing treatment performance of the bioretention system. The plants maintain the porosity of the filter media via physical agitation of the filter media surface and through the growth of the root systems. The renewal of root biomass and the leakage of organic compounds from the plant roots into the filter media provides a constant source of organic material to the soil microbial communities.

The treatment performance of the bioretention system is also heavily reliant upon the health of the microbial communities in the filter media. Filter media with a hydraulic conductivity ranging between 100–300 mm/hr are considered to provide an optimal balance between the infiltration rate and the retention of soil moisture suitable for both plant and microbial survival.

When the inflow rate to the bioretention exceeds the infiltration capacity of the filter media, stormwater pools on the surface of the filter bed. When the storage volume above the filter bed is full, all further flows bypass the bioretention via an overflow weir or via feedback through the inlet and back along the kerb and channel in streetscape systems.

Bioretention systems with saturated zones

Bioretention systems are typically constructed with a saturated zone 'wet sump' in the base of the filter bed (Figure 3a). The saturated zone provides a water reserve that the plants can utilise during dry periods. Water stored in the saturated zone is drawn up through the transition layer into the filter bed by capillary action, where it can be accessed by the plant roots. Once established, the plant roots will also grow down to the surface of the saturated zone to access the soil moisture.

The saturated zone includes the drainage layer and may extend into the transition layer. The level of the saturated zone can be temporarily increased (i.e. to the base of the filter media layer) to provide moisture during plant establishment, however care must be taken to ensure that the upper half of the filter media layer remains free-draining (i.e. not water-logged to ensure that the plant seedling roots actively grow).

Free draining bioretention systems

Free draining bioretention systems are constructed without a saturated zone (Figure 3b). Water exits the drainage layer via a slotted pipe and/or infiltration into the surrounding soils.

Bio-infiltration systems

Bioretention systems may be constructed without a liner to encourage filtration of the stormwater into the surrounding soils (Figure 3c). Unlined systems can be used to recharge the local water table and to reduce net stormwater runoff volumes discharged to downstream waterways.

Bio-infiltration systems may include a saturated zone by using an impervious liner only to the top of the saturated zone. This provides a water reserve within the base of the system whilst enabling water to be infiltrated to the in-situ soils via the filter media and transition layers above the saturated zone.

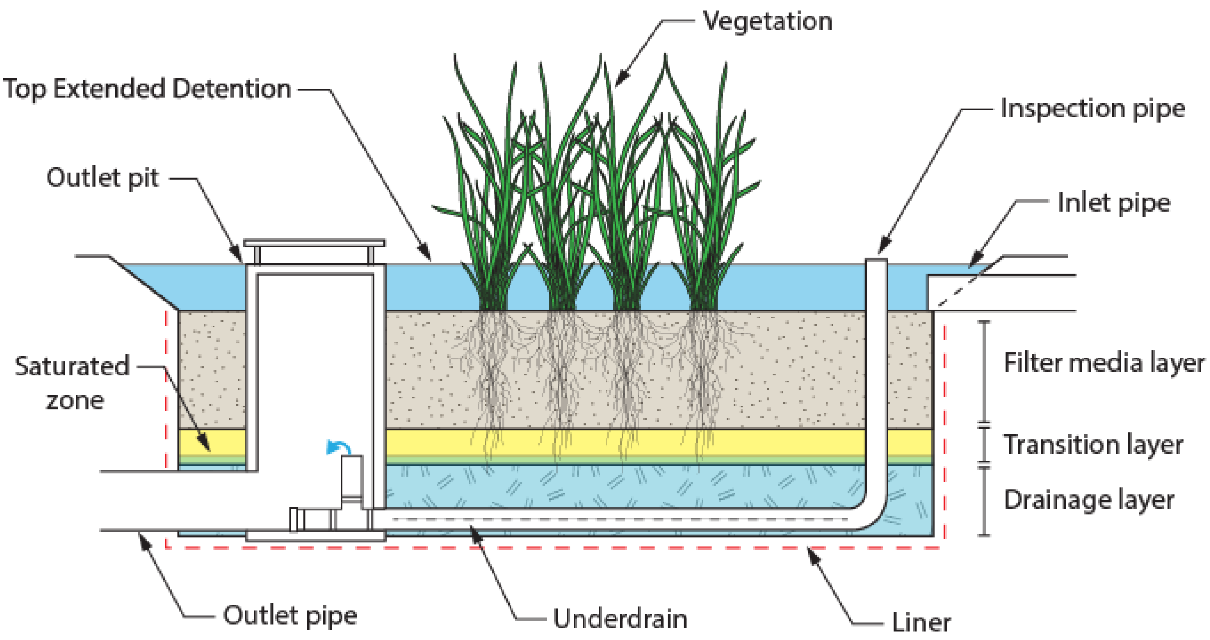

Figure 2 Typical bioretention system with a saturated zone within the base of the filter bed.

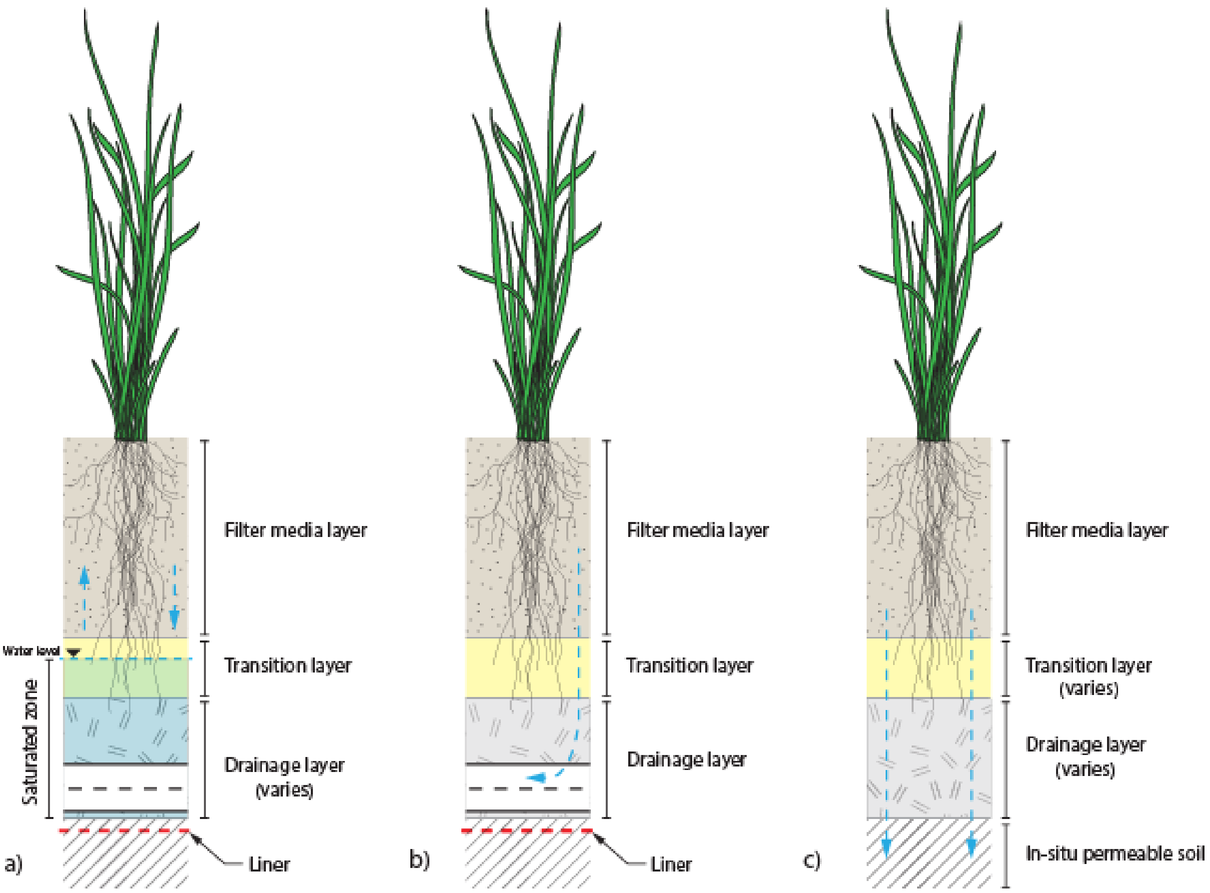

Figure 3 Bioretention system profiles for: a) saturated zone, b) free draining, and c) infiltration systems.

Advantages

- Flexible design – able to be adapted to range of site conditions and catchment scales
- Can be at-source treatments or end-of-pipe treatments
- Effective stormwater quality treatment
- Water retardation – the pooling of water above the bioretention surface can assist with the restoration of the hydrological regime in downstream waterways.
- Bioretention systems require notably less area than constructed wetlands due to the higher areal rates of pollutant removal.
- Provision of green spaces within the urban landscape providing increased aesthetics and amenity
- Once established, bioretention systems are generally self-watering and self-fertilising, although supplementary watering may be required during extended dry periods.
- Provision of cooler urban microclimates providing human health benefits (shading and cooler local temperatures)
- Enhanced urban biodiversity and habitat.

Disadvantages

- Are more expense to construct (per m^2) than wetlands
- Bioretention systems can be expensive to maintain compared to other WSUD assets such as wetlands.
- The expected lifespan of bioretention systems may be less than other WSUD assets such as wetlands.

Preferred use

- Open spaces (i.e. drainage reserves, parklands),
- Nature strips at intersections and along roads,
- Carparks, roundabouts and pavements in plazas and shopping centres, commercial and high profile areas, or
- Landscaping on private developments

Bioretention systems must be designed in accordance with an approved urban/landscape concept plan. Bioretention systems constructed on private developments must comply with the endorsed Landscape Planning Permit Plan. Landowners are responsible for the maintenance of the treatment system.

Non-preferred use

- Nature strips and central medians where VicRoads and OH&S clear zones cannot be met for maintenance workers without lane closures,
- Locations subject to compaction due to vehicle parking or pedestrian traffic,
- Sites which cannot be accessed for maintenance workers and vehicles, or
- Sites with insufficient elevation where the treated stormwater cannot freely drain to the receiving waterway.

2.1.2 Sediment ponds

Description

A sediment pond is an open water body that is designed to reduce the velocity of inflowing stormwater and capture coarse sediments (Figure 4). A sediment pond may be constructed as standalone system, or more commonly, as part of a wetland system where it functions to protect the wetland macrophyte zone from sediments. Sediment ponds may also be constructed above bioretention systems to protect the filter bed from sediments.

Figure 4 Examples of sediment ponds.

Stormwater enters the sediment pond via an inlet (drainage inlet pipe, drainage channel or waterway) and flows through the pond where coarse sediments (>125 um diameter) are removed.

In standalone systems, the stormwater is discharged from the sediment pond via an overflow weir to the downstream waterway. In sediment ponds that are part of a wetland system, low flows (flow up to the three month Average Recurrence Interval (ARI) flow) are discharged to the wetland macrophyte zone via an outlet pit and pipe, culvert or weir. This protects the wetland vegetation from sediment deposition and scouring flows (Figure 5).

When flows entering the sediment pond exceed the three month ARI flow, or the extended detention depth of the macrophyte zone is full, stormwater is discharged from the sediment pond via an overflow weir into the high flow bypass channel. The bypass channel conveys high flows around the macrophyte zone and protects the macrophyte zone from high velocities and sediment deposition.

Sediment ponds are maintained as open water systems. Dense vegetation is normally planted around the margins of the sediment pond to assist with bank stability, improve visual amenity and to discourage public access.

A maintenance access track to the sediment pond and a hardstand area is required for vehicular access during sediment cleanout events (Figure 5). An access track to the base of the sediment pond is required for large systems which require vehicles to enter the pond to remove sediment. Smaller sediment ponds which can be cleaned from the edge will require a maintenance access track around the edge of the pond.

A sediment dewatering area must be provided adjacent to the sediment pond. This enables the sediment removed from the sediment pond to be stockpiled and dewatered prior to removal from the site.

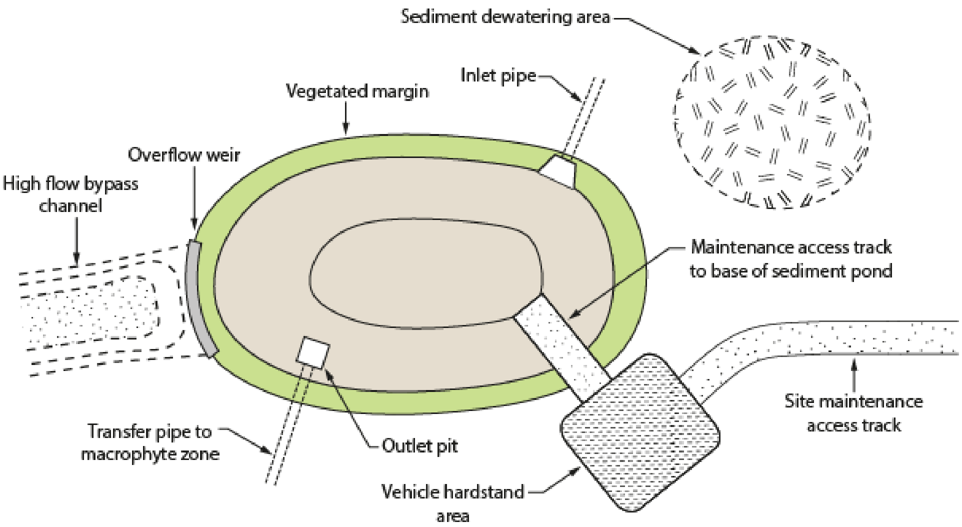

Figure 5 Typical components of a sediment pond constructed as part of a treatment wetland.

Advantages

- Highly effective at removing coarse sediments
- Protect downstream ecosystems from sediment deposition, e.g. urban streams
- Easily maintained – accumulated sediment removed once every 3-5 years

Disadvantages

- Low amenity
- Poor water quality and potential odours
- Sediment dewatering area required
- Wet stockpiled sediments can be a public safety and community amenity issue
- Double handling of sediments is expensive
- Disposal costs associated with contaminated sediments

Preferred use

- Standalone systems
- Part of a treatment wetland system
- Integrated with other WSUD treatment assets (i.e. placed above a bioretention system) as part of a treatment train
- Standalone systems used in conjunction with the Melbourne Water offset scheme
- Temporary coarse sediment treatment measure during the construction phase of a development

Non-preferred use

- Sediment ponds must not be used as standalone systems to treat stormwater to best practice standard (i.e. by oversizing the sediment pond).

2.1.3 Constructed wetlands

Description

Constructed wetlands are shallow, extensively vegetated waterbodies that use enhanced sedimentation, fine filtration, chemical and biological uptake processes to remove pollutants from stormwater. Constructed wetlands may also provide additional benefits such as: flood detention, management of runoff volume and frequency, stormwater harvesting opportunities, wildlife habitat and diversity, amenity and recreational value to the community.

Constructed wetlands comprise of three major components: sediment pond, macrophyte zone, and bypass channel (Figure 6).

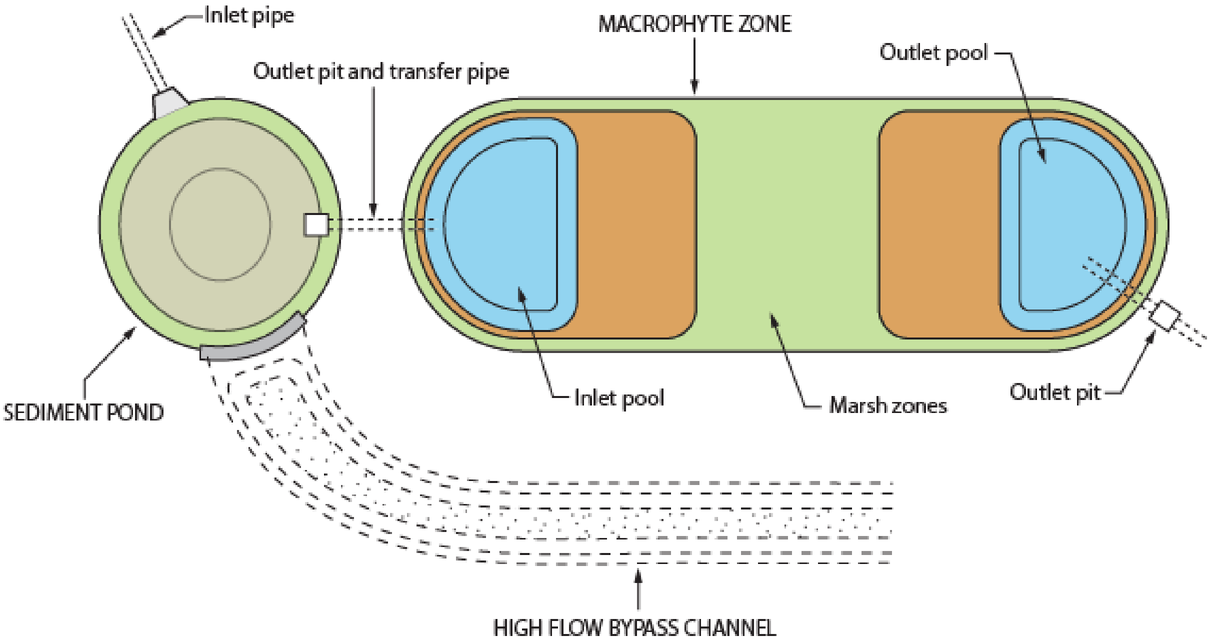

Figure 6 Typical components of a constructed wetland system.

<u>Sediment pond</u>

The sediment pond is located upstream of the macrophyte zone and functions to remove coarse sediments from the stormwater before it enters the macrophyte zone. Refer to Section 2.1.2 for further information on sediment ponds.

<u>Macrophyte zone</u>

The macrophyte zone consists of a densely planted, shallow waterbody (Figure 7). The presence of dense vegetation provides a low velocity environment that enables the smaller suspended particles to settle out of suspension or adhere to the vegetation. Soluble pollutants, i.e. nutrients, are adsorbed onto suspended solids and entrained within the wetland sediments, or biologically absorbed by biofilms (algae, bacteria) present on the macrophytes or by the macrophytes themselves.

Microbial activity within the biofilms or upper sediments helps to decompose organic matter and facilitates the transformation and export of carbon, nitrogen and sulphur (in gaseous forms) from the wetland. The aquatic plants (macrophytes) help to maintain aerobic sediments which prevents the release of phosphorus (from the sediments). The macrophyte zone also provides habitat and food resources for aquatic fauna such as invertebrates, waterbirds and amphibians.

Stormwater enters the macrophyte zone inlet pool where energy is dissipated and the velocity of inflowing stormwater is reduced. The macrophyte zone is designed so that stormwater passes through a sequence of densely vegetated zones (shallow, deep and submerged marshes) prior to exiting the macrophyte zone via the outlet pool (Figure 8).

Figure 7 Examples of macrophyte zones.

The marsh zones are arranged in parallel bands, perpendicular to the flow direction, so that the stormwater flows evenly through the vegetation. This ensures that the stormwater interacts with the macrophyte stems and the biofilms present upon the surfaces of the macrophytes.

Open water areas (including areas of submerged marsh) in the macrophyte zone include the inlet, outlet and intermediate pools, and must not exceed more than 20% of the macrophyte zone area.

Plant species planted within the shallow and deep marsh zones should be sufficiently robust to cope with the expected hydrologic regime within the wetland. The species planted within the macrophyte zone should be selected based on predicted water levels relative to the height of the plant species, and their tolerance to inundation frequency and duration.

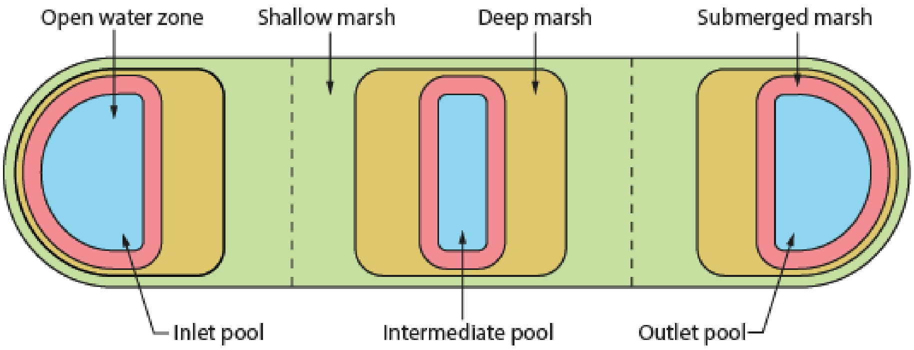

Figure 8 Typical configuration of the macrophyte zone.

It is important that the macrophyte zone is protected from high flows so that biofilms on the macrophytes are not removed and that fine sediments accumulated within the wetland are not scoured from the wetland by high flows.

Outflows from the macrophyte zone are regulated by a controlled outlet located adjacent to the outlet pool. The controlled outlet sets the normal water level within the macrophyte zone and controls the release of water from the wetland. The controlled outlet generally comprises of a weir, riser or plate (with orifices) located within the outlet pit (Figures 9 and 10).

As stormwater enters the macrophyte zone, the wetland water level increases until it reaches the top of extended detention (TED), the maximum design water level. When the TED of the macrophyte zone is exceeded, all further inflows are discharged from the macrophyte zone via an overflow pit or overflow weir, or the overflow weir located in the sediment pond (via feedback from the macrophyte zone). Only water that has been treated in the wetland for approximately three days is released through the controlled outlet (Figure 9).

Figure 9 Examples of wetland controlled outlets: a) riser pipe, and b) weir plate.

Figure 10 Examples of wetland controlled outlets: a) vertical slot weir, and b) Sidewinding penstock valve (photo Melbourne Water).

<u>High flow bypass</u>

The high flow bypass enables flows to be diverted around the macrophyte zone when the water level is at TED. The bypass protects the macrophyte zone from scour during high flow events, and enables the wetland to be temporarily taken off-line for maintenance (i.e. by blocking the transfer pipe to the macrophyte zone). The high flow bypass is generally vegetated, i.e. grassed, however it may also comprise of a pipe or culvert.

Advantages:

- Highly effective at removing dissolved nutrients and metals from stormwater
- High visual amenity
- High passive recreational value for the community
- Enhances urban biodiversity
- Provides habitat and food resources for fauna
- Can be used to manage stormwater runoff volume and frequency

- Can be integrated with flood detention
- Stormwater harvesting opportunities

Disadvantages:

- Mainly restricted to flat terrain
- Requires significantly more land area than other WSUD treatment assets (i.e. bioretention)
- Macrophytes susceptible to extended periods of inundation
- Can be difficult to construct on rocky terrain or near coastal areas

Preferred use:

- In open space reserves
- In developments with catchments greater than 15 hectares

Non-preferred use:

- Constructed wetlands should not be used in developments with catchments less than 15 hectares.

Floating wetlands

Floating wetlands comprise of a dense vegetated mat of emergent macrophytes supported by a floating raft structure. In contrast to constructed wetlands, the plant root systems are suspended in the water column rather than being rooted in the soil. Floating wetlands function in a similar way to hydroponic systems, where the plants derive nutrition directly from the water column rather than the soil.

The use of floating wetlands to treat stormwater will not be accepted by Council. The use of floating wetlands to treat stormwater runoff quality is currently subject to investigation, and the treatment performance of floating wetlands cannot be accurately modelled using continuous simulation modelling programs such as MUSIC.

2.1.4 Gross pollutant traps

Description

Gross pollutant traps (GPTs) are devices that use physical screening, sedimentation and separation processes to trap solid wastes such as gross pollutants and sediment from stormwater runoff.

GPTs are commonly used in urban catchments to trap gross pollutants such as litter, plastic bags, bottles, cigarette butts and organic matter from stormwater.

A wide range of devices are used to trap gross pollutants such as flexible booms/floating traps (waterways), direct screening devices (litter baskets and trash nets), non-clogging screens and sediment traps.

The majority of GPTs are located underground and are integrated with the conventional drainage pipe systems. Commonly used GPTs include direct screening systems (litter baskets) which can be physically removed and emptied, and centrifugal systems (filter screens and sediment sumps) which are maintained using vacuum equipment.

GPTs must be regularly maintained to ensure that the trapped litter and debris does not inhibit the flow of stormwater and that pollutants are not leached from the trapped material to downstream waterways.

Advantages:

- Highly effective at removing gross pollutants
- Have a relatively small footprint and are usually hidden from view
- Usually integrated with conventional drainage system
- Can be easily retrofitted into existing urban catchments

Disadvantages:

- Do not provide effective removal of fine sediments and nutrients
- Suited to small to medium catchments (< 100 hectares)
- Potentially high capital cost
- Require regular cleaning
- Maintenance generally requires the use of dedicated equipment (i.e. crane and/or eductor trucks)
- Poorly maintained systems can be a flood hazard

Preferred use:

- On all stormwater outlets to conservation corridors
- Commercial catchments (unless approved otherwise).
- Education precincts

Non-preferred use:

- Gross pollutant traps are not required for residential catchments less than five hectares (unless the stormwater directly discharges to a conservation corridor)
- Should not be placed in locations where access is limited.

2.1.5 Swales – Bioretention Swales

Description

A swale is a shallow, linear, vegetated channel that is designed to convey stormwater flows and remove gross pollutants and medium to coarse sediments (Figure 11). Swales are constructed with a gentle longitudinal gradient (1-4%) to ensure that the stormwater is conveyed slowly downstream. Vegetation within the base of the swale spreads the water flow across the channel, slows the water velocity, traps gross pollutants and promotes sediment deposition within the base of the channel.

Figure 11 Examples of: a) conventional swale, and b) bioretention swale.

A range of vegetation types are planted within swales ranging from turf to dense vegetation. The vegetation selected for a swale should be sufficiently robust to be able to cope with the expected design flows and have sufficient roughness to facilitate the modelled system treatment performance.

Swales in isolation are unable to treat stormwater runoff to best practice standards, and are therefore used in combination with other WSUD treatment assets, e.g. a swale may be located above a bioretention system to remove the sediment load.

Swales may be integrated with bioretention systems (known as bioretention swales) to provide enhanced stormwater treatment and infiltration. Bioretention swales are configured similar to a conventional swale, except that a filter bed is constructed within the base of the swale (Figure 12).

The construction of berms across the bioretention swale at regular intervals enables the water to be temporarily ponded, increasing the infiltration of the stormwater through the filter bed and resulting in the treatment of a greater stormwater volume. This is often achieved passively using driveway crossovers. An overflow pit must be provided within a bioretention swale above a driveway crossover to prevent flooding (Figure 13).

Bioretention swales may be constructed without a liner to promote the exfiltration of treated stormwater into the surrounding soils.

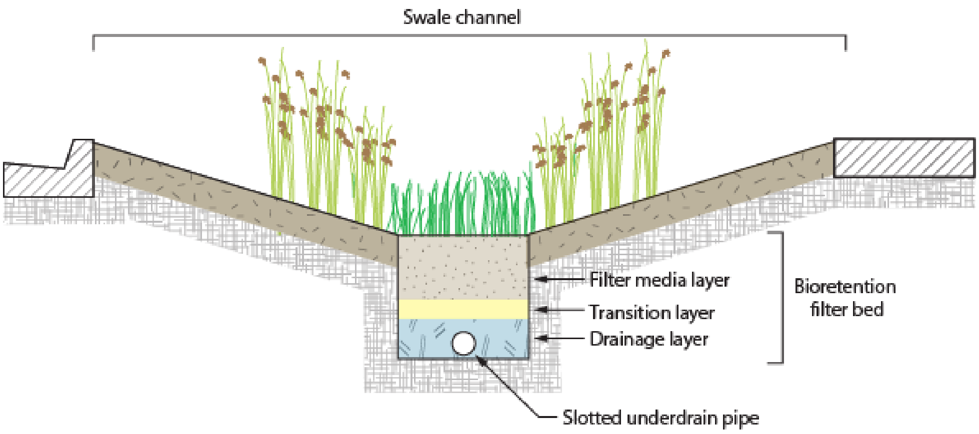

Figure 12 Typical bioretention swale profile.

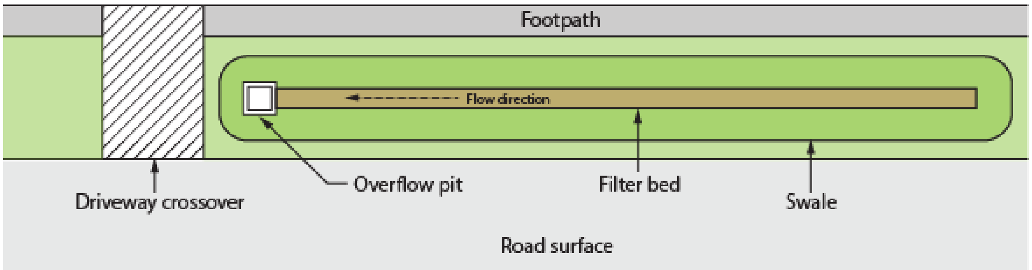

Figure 13 Typical layout of a bioretention swale located within a street nature strip.

Advantages:

- Highly effective at removing medium to coarse sediments and gross pollutants

- May be used in lieu of conventional drainage systems (i.e. underground pipes)
- Low capital cost
- Landscape amenity
- Easily maintained, i.e. mowed turf
- Can be used to retard and temporarily store stormwater
- Can be integrated with bioretention function, i.e. bio-swales

Disadvantages:

- Do not provide effective removal of fine sediments and nutrients
- Unable to treat stormwater runoff quality to best practice standard
- Must be constructed on slopes with less than a 5% gradient
- Require more space than other streetscale WSUD treatment assets, i.e. can restrict car parking space
- Prone to maintenance issues such as physical damage and compaction, i.e. car wheel rutting, scour
- Prone to drainage issues, i.e. poor drainage, ponding
- Poorly maintained systems can be a flood hazard

Preferred use:

- Swales and bioretention swales may be integrated as part of a treatment train to provide sediment removal upstream of other WSUD treatment assets such as bioretention systems
- Street nature strips, centre median strips of roads, run-off collection points in car park areas

Non-preferred use:

- Swales must not be used on sites with a catchment area >1 hectare

2.2 Selection guideline

The following section provides guidance on the selection of WSUD treatment assets. The asset selection matrix provided in Section 2.2.2 should be used to guide the selection of WSUD treatment assets for catchment land use scenarios.

The selection WSUD treatment assets that are deemed to be most appropriate for the various catchment land uses has been guided by a number of factors including:

- Stormwater treatment objectives
- Catchment scale
- Land use characteristics
- Asset maintenance requirements
- Ongoing costs

Proposals to use WSUD treatment assets that are not covered by the selection matrix will not be considered by Council, unless it can be clearly demonstrated that the benefits of the proposed treatment system exceed the minimum requirements outlined in Sections 3.2 and 3.3.

2.2.1 Treatment scale

The use of regional scale treatment systems is preferred over the use of distributed streetscale WSUD treatment assets, as regional scale systems are easier to manage and more cost effective for Council to maintain. Streetscale WSUD treatment assets will only be accepted where it can be clearly demonstrated that the stormwater runoff cannot be treated using a regional scale treatment system.

2.2.2 Asset selection matrix

It is recommended that the selection matrix provided in Table 1 is used to guide the selection of WSUD treatment assets. The selection matrix separates WSUD treatment asset options between residential and commercial/industrial catchment land uses. In mixed catchment scenarios where it is difficult to separate catchment land uses, it is recommended that the dominant land use category be used.

The selection of WSUD treatment assets involves a two-step process: the first step determines whether a GPT is required for gross pollutant removal, and the second step determines the Council preferred WSUD treatment asset for water quality treatment.

It is important that site characteristics are also taken into consideration when selecting WSUD treatment assets using Table 1. For example, the Council preferred WSUD treatment asset based on the selection matrix may be deemed unfeasible due to site specific constraints (e.g. the presence of large remnant trees or growling grass frogs) and an alternative WSUD treatment asset may need to be selected.

Table 1 Selection matrix based on Council approved WSUD treatment assets.

	COUNCIL ASSET			PRIVATE ASSET		
	Residential/Commercial Estate			Residential	Commercial	Industrial
	<5 ha	5-15 ha	>15 ha		>1 ha	>1 ha
Step 1 – Gross pollutant removal						
Grated pit	Yes	Yes	Yes	Yes	Yes	Yes
Gross pollutant trap	No	Yes	Yes	No	Yes[1]	Yes[6]
Step 2 – Water quality treatment						
Bioretention	No	Yes	No	No	Yes	Yes
Bioretention swale	No	No	No	No	Yes	Yes
Sediment pond[2]	Yes	Yes	Yes	No	No	No
Constructed wetland	No	Yes	Yes	No	Yes	Yes
Rainwater Tank[3]	No	No	No	Yes	Yes	Yes
Stormwater quality offsets[4]	Yes	No	No	Yes	Yes	Yes

Preferred asset (green) Permitted asset[5] (blue)

[1] GPT required in mixed residential and commercial catchments.

[2] Sediment ponds may be used as standalone systems where they are offset with other stormwater treatment assets within the catchment. Refer to Section 2.1.2 for further information.

[3] Rainwater tanks must be plumbed to toilet to be considered treatment.

[4] The Melbourne Water stormwater quality offset/contribution may be considered in lieu of on-site treatment subject to Melbourne Water and Council approval.

[5] Permitted assets may be accepted subject to Council approval.

[6] May not be required. Refer to development planning permit conditions for information.

Case study

A stormwater strategy is being prepared for a mixed use residential development. The overall development will be 15 ha comprising of 13 ha residential and 2 ha commercial land use. A drainage assessment determined that all of the stormwater runoff from the development can be directed to a single treatment location within the south-east corner of the development.

The selection of WSUD treatment assets based on the selection matrix provided above involves:

Step 1 –The catchment's land use is for both residential and commercial purposes, and the catchment area is greater than 5 ha. Hence, a GPT is needed to treat stormwater runoff from the catchment.

Step 2 – Based upon a residential catchment area >5 ha, there are two stormwater treatment options: a) bioretention with sediment pond, or b) a constructed wetland. The selection matrix colour coding (green) indicates that a constructed wetland is the preferred Council WSUD treatment asset for catchments >5 ha.

The use of bioretention will only be accepted if the treatment system is to be located within or adjacent sensitive habitat such as Growling Grass Frog habitat or where there are geological constrains. This is to minimise the construction footprints and disturbance during maintenance.

Chapter 3 WSUD Standards

3.1 Introduction

The WSUD design standards define the key design requirements for each WSUD treatment asset type. The design of all WSUD treatment assets must be in accordance with the design standards. This ensures that a consistent approach to the design of WSUD treatment assets is undertaken within the Wyndham municipality.

The WSUD design standards include both core applicable to all WSUD asset types and asset specific design requirements. The core requirements define a set of non-negotiable objectives which must be achieved when designing WSUD treatment assets. The asset specific design requirements define the key design components which are fundamental to the long term functional performance of each WSUD treatment asset type, and ensure that maintenance and safety requirements are considered during the design process.

The adoption of consistent design parameters will ensure that all WSUD treatment assets are designed to best practice standard and provide best value to the community, by considering long term asset performance, public safety, ease and cost of maintenance, amenity and integration with urban design.

The design standards are not intended to be prescriptive, and aim to provide sufficient flexibility to develop innovative designs that respond to both site specific constraints and other planning and design objectives.

3.2 Core requirements

The design of all WSUD treatment assets must achieve the following core requirements:

- Provide effective pollutant removal
- Consider community and maintenance staff safety
- Enable cost effective maintenance
- Be robust and sustainable – i.e. have an expected life cycle of a least 25 years
- Consider landscape context

Compliance with each of the core requirements must be demonstrated at the concept design phase. Failure to comply with any of the core outcomes must be highlighted to Council, including a summary of the reasons why the core requirements cannot be achieved. Where possible, Council will work with applicants to identify alternative treatment options that comply with the core requirements and will be acceptable to Council.

3.3 General requirements

The following general requirements apply to the design of all WSUD treatment assets:

3.3.1 Treatment performance objectives

The stormwater treatment strategy for all new developments must achieve the best practice water quality performance objectives set out in the Urban Stormwater Best Practice Environmental Management Guidelines (Victorian Stormwater Committee, 1999):

- Suspended solids – 80% retention of typical urban annual load
- Total nitrogen – 45% retention of typical urban annual load
- Total phosphorus – 45% retention of typical urban annual load

- Litter – 70% retention of typical urban annual load[1]

Stormwater treatment asset retrofits, e.g. bioretention systems retrofitted within existing streetscapes and reserves, should aim to achieve the best possible stormwater treatment performance considering the site specific constraints.

3.3.2 Treatment performance modelling

The treatment performance of stormwater treatment assets must be modelled in MUSIC, or similar conceptual modelling software as approved by Council, according the following guidelines:

- Assets located within catchments covered by a Melbourne Water Drainage Scheme should be modelled in accordance with the Melbourne Water MUSIC Guidelines (2018).
- Assets located within catchments not covered by a Melbourne Water Drainage Scheme should be modelled in accordance with the Wyndham City MUSIC Software Guidelines (2017). This includes asset retrofits and stormwater harvesting schemes.

<u>Wyndham City MUSIC Software Guidelines</u>

The Guidelines provide guidance on the input parameters and modelling approaches for MUSIC specific to Wyndham City Council municipality. Stormwater treatment assets must be modelled using a representative 10-year rainfall dataset from the BOM station at Little River (1992 to 2001). The rainfall dataset has been infilled with data from a neighbouring BOM station to generate a better representation of the Wyndham region.

The representative rainfall dataset is to be used for modelling stormwater treatment assets within the Wyndham municipality and is available for download from the Wyndham City Council website.

Note: the Guidelines recommend using a minimum of 20 years continuous rainfall data (Little River station – 1982-2001) for modelling stormwater storage and harvesting systems.

<u>Melbourne Water MUSIC Guidelines</u>

The Melbourne Water MUSIC Guidelines (2016) divides the Wyndham Council municipality into two rainfall zones based on the average annual rainfall (Figure 14):

- Western municipality – BOM station Little River (1992 to 2001), and
- Eastern municipality – BOM station Melbourne Airport (1971 to 1980).

The BOM station appropriate to the proposed development location should be selected for stormwater treatment performance modelling. The rainfall templates for each of the rainfall zones Wyndham municipality are available from the Melbourne Water website and should be used to model the stormwater treatment systems.

[1] The Wyndham City Council Environment & Sustainability Strategy 2016-2040 sets a target to have all waterways and beaches to be free from litter by 2040.

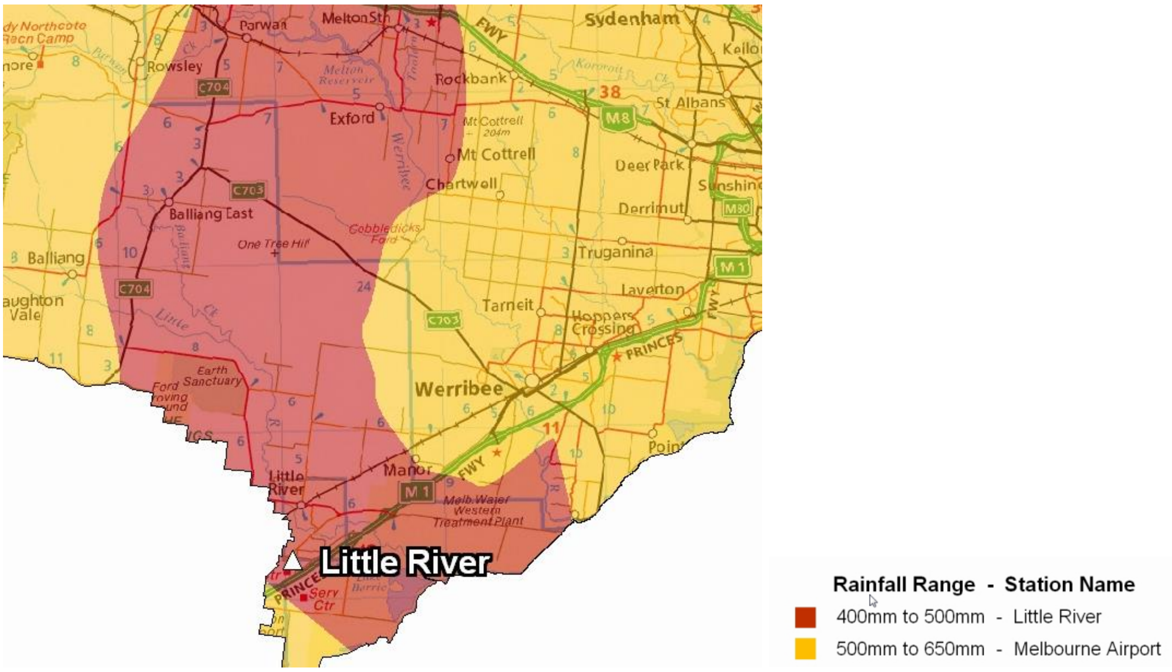

Figure 14 Melbourne rainfall distribution map for the Wyndham municipality.

3.3.3 Flow estimation

The peak design flows should be estimated in accordance with methods outlined in Australian Rainfall and Runoff (Commonwealth of Australia, Geoscience Australia, 2016).

3.3.4 Safety in design

A safety in design risk assessment must be undertaken for all stormwater treatment asset designs in accordance with the principles of AS/NZS 31000:2009 Risk Management.

The risk assessment should be conducted at the detailed design stage, and must consider all possible health risks to the public and maintenance staff. The design response to any safety risks identified by the risk assessment should be outlined in the detailed design report (refer to 4.2).

3.3.5 Cost effective maintenance

WSUD treatment assets must be designed to enable cost effective maintenance. The maintenance requirements for a proposed WSUD treatment system is a key design component, and must be considered in terms of the long term costs associated with the operational and maintenance requirements.

The WSUD treatment system selection guidance provided in Section 2.2 considers treatment solutions that respond to catchment land use and scale, and represent cost effective maintenance solutions to Council.

Council recommends that where possible, stormwater treatment strategies should aim to minimise the number of WSUD treatment assets required and seek end of pipe solutions (i.e. regional WSUD treatment systems). The consolidation of WSUD treatment requirements into fewer locations and large systems is preferred, as this minimises the long term maintenance cost to Council.

3.3.6 Landscape context

WSUD treatment assets located in public realm and need to be considered in broader landscape context. All WSUD treatment assets and the surrounding landscapes must be designed in accordance with the objectives of the Wyndham Landscape Context Guidelines.

The Wyndham Landscape Context Guidelines aim to protect the characteristics that define Wyndham, such as waterways and wetlands; and contribute to a positive focus on Wyndham's image, appearance and landscape qualities, to ensure they are appealing to residents, investors and visitors alike.

Recommendations outlined in the Landscape Context Guidelines that must be considered when designing WSUD treatment assets include:

- The design of infrastructure should be sympathetic to the natural environment.
- Stormwater treatments and retarding basins should be strategically located to prevent the loss of the natural appearance and functioning of waterways, their tributaries and wetlands. Stormwater from surrounding development must be treated prior to it entering a natural waterway or wetland.
- The natural heritage values of endangered fauna species (such as the Growling Grass Frog and their habitats) and ecotones (including native grasslands, water courses, wetlands and old remnant trees) must be preserved and acknowledged.
- Hydrological systems must be preserved to support the continued health of old River Red Gums. The placement of WSUD treatment assets within drainage lines must not impact on the health of remnant vegetation upstream or downstream of the asset.
- Landscaping and revegetation should promote local indigenous species to highlight and identify the character of the Western Plains and other relevant Ecological Vegetation Classes. Exotic species are not to be planted within and adjoining natural environmental features.
- The integrity of waterways, their tributaries and floodplains must be protected from development, with buffer zones on each side of the embankment. This includes protecting creek edges, particularly rocky escarpments of fauna habitat.
- Damming of natural waterways (and their tributaries) and wetlands should be avoided and likewise the use of piped or underground "environmental flow bypass systems". Existing in-stream damming along waterways and artificial damming of wetlands must be assessed to determine whether the dams should be retained or removed/opened to allow unimpeded water flows.
- Land filling, removal of rocky outcrops, realignment and development within the waterways are discouraged so as to maintain the qualities, function and natural landscape character of the waterway including serenity and tranquility values.
- Where development occurs adjacent to a waterway, any constructed batters should effect a gradual transition from waterway to plain. [2]
- If waterway tributaries that are not marked as a Key Site within the Special Landscapes and Places Map (Appendix 1, Landscape Context Guidelines) need to be re-modelled for drainage/flooding purposes then the shape, alignment and all rehabilitation facets (including revegetation) should resemble the natural appearance and form in accordance with Melbourne Water's Guidelines.

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[2] Where possible, a minimum batter slope of 1 in 6 should be adopted. Batter slopes greater than 1 in 6 are subject to Council approval.

3.4 Bioretention systems

These standards apply to all types of bioretention systems including:

- Unlined bioretention systems that promote infiltration of treated stormwater into surrounding soils (often referred to as bio-infiltration systems), and
- Bioretention tree pits

3.4.1 Maintenance provisions

Bioretention systems must be designed to enable maintenance staff to safely access the bioretention system. Bioretention systems located within public open spaces (i.e. parklands) must have an access track to enable maintenance vehicles to access and exit the site. The maintenance access track should enable direct access to the bioretention inlet area/s for sediment removal.

The maintenance access track must be at least 4 metres wide and comprise of a trafficable surface in accordance with Council Standard. At the road edge, the access track should have an industrial crossover to Council standard and a rolled kerb adjoining it.

Intersections between pedestrian pathways and maintenance access tracks should be clearly marked (i.e. using markers or different coloured concrete on the pedestrian path).

Large bioretention systems, i.e. filter bed area greater than 300 m^2, must be configured to enable maintenance vehicles to access at least 50% of the basin perimeter.

Bioretention systems located in public open spaces (e.g. parklands) must have a 200 mm wide concrete maintenance edge (minimum 250 mm depth) to delineate the bioretention system from the adjoining landscape areas and to minimise the risk of turf and weeds encroaching into the bioretention system.

3.4.2 Sizing

The maximum permissible area for a single bioretention filter bed is 500 m^2. If a larger bioretention treatment area is required, then the bioretention system must be separated into individual cells, with each cell not exceeding 500 m^2.

3.4.3 Layout

The layout of the bioretention system must not impact unacceptably on surrounding landscape features such as: existing vegetation, topography, pedestrian paths and roads, waterway and associated riparian vegetation, residential dwellings and public open space (e.g. parklands, playgrounds).

The design of street scale bioretention systems must also consider other streetscape components including: service locations, road pavement and trafficable lane widths, car parking, road base and kerb support, pedestrian paths, access and safety, street trees and lighting, location of existing drainage infrastructure, sight lines and visual amenity.

The layout of the bioretention system must be consistent with the modelling parameters used in MUSIC.

3.4.4 Liner

All bioretention systems must have an impervious liner to prevent water from ex-filtrating from the filter media to ensure that there is sufficient soil moisture retained for the plants, and to enable water to permanently pool within the saturated zone (refer to Section 3.4.5 for saturated zone requirements). The liner should extend to the top of the extended detention depth for conventional bioretention systems, and to the top of the saturated zone for bio-infiltration systems.

Permissible liners include:

- Clay - comprising of in situ or imported clay material.
- Bentonite geosynthetic clay liner - consists of a layer of bentonite bonded between two layers of geotextile.
- Welded premium grade HDPE plastic sheeting - minimum 1mm thick.

3.4.5 Inlet design

The design of the inlet is important is it dictates the amount of water that enters the bioretention system during runoff events. The inlet design must consider the following elements:

- Design inflows
- Inlet type
- Coarse sediment removal
- Energy dissipation
- Flow distribution

3.4.5.1 Design inflows

Inlets to the bioretention system must be designed to convey the design flow. The inlet must be designed to ensure that water ponds at the inlet to the bioretention for no more than one hour following the cessation of rainfall.

Note: The discharge of base flows[3] into a bioretention system is not permitted, as this can lead to the growth of algal biofilms and moss on the surface of the filter media resulting in clogging and reduced infiltration.

3.4.5.2 Inlet type

Stormwater may be discharged to the bioretention system directly from the drainage network or as a low flow diversion from a drainage system or kerb. The design of the inlet must ensure that the inlet is not prone to blockage and does not cause upstream inundation (e.g., inappropriate backwatering).

Inlet types accepted by Council include:

- Pipe
- Channel
- Kerb

The invert of an inlet pipe, channel or kerb cut-out must be located above the surface of the bioretention filter media surface to prevent sediment deposition within the inlet pipe or channel.

Kerb inlets are typically used to divert stormwater runoff from road surfaces to a bioretention system. The kerb inlet to a bioretention system must be designed to convey the design flow. The unrestricted entry of flows higher than the design flow to the bioretention system can lead to

[3] 'Base flows' are permanent flows that are present in stormwater drainage systems due to groundwater ingress, sewer or potable water pipe leakages or cross-connections.

scouring of the filter media. The use of stencilling (i.e. deflectors) cast into base of the kerb may assist with the diversion of stormwater flows into a bioretention system.[4]

A minimum kerb opening of 500 mm is required to reduce the risk of blockage by sediment and debris (Figure 15). A minimum 60 mm set down is required from the edge of the kerb inlet to the surface of the bioretention filter bed to ensure that sediment does not accumulate within the kerb break or upon the road surface.

Note: Flush kerbs inlets (i.e. where the edge of the bioretention filter media surface is level with the adjoining road surface) will not be accepted.

Kerb inlets for bioretention systems located in industrial and commercial zones should be equipped with a screen to prevent litter and organic debris entering the bioretention (Figure 16).

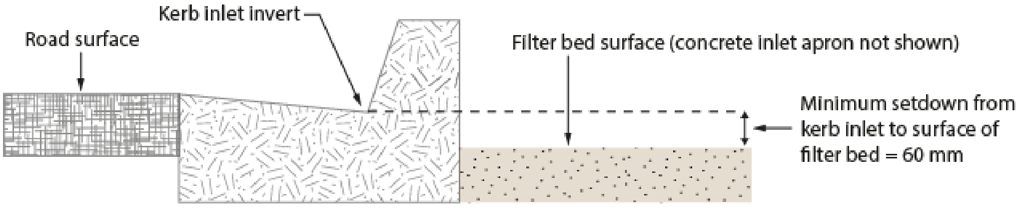

Figure 15 Minimum design requirements for kerb openings.

Figure 16 Example of inlet screens used to prevent litter and organic debris from entering a bioretention system.

3.4.5.3 Coarse sediment removal

The inlets to bioretention systems must be designed to prevent coarse sediments from being deposited onto the surface of the filter bed. Trapping sediments within a dedicated area at the inlet enables efficient and cost effective maintenance.

[4] Further information on the use of deflectors can be sourced at: http://www.unisa.edu.au/IT-Engineering-and-the-Environment/Natural-and-Built-Environments/Our-research/AFMG/South-Australian-Road-Stormwater-Drainage-Inlets-Hydraulic-Study/city-of-Campbeltown/

Bioretention systems with catchments <2 ha must have a concrete apron (1:4-1:6 slope) that enables sediment and organic litter to be trapped and easily removed. Note: this requirement does not apply to bioretention tree pits with covered inlets.

Bioretention systems which receive runoff from catchments <5 ha must have a formal sediment trap (i.e. a sediment forebay) at the inlet to prevent coarse sediment from being deposited on the surface of the filter bed. Note: the use of a swale to remove sediments in lieu of a sediment trap is also permissible. Examples of sediment traps used on bioretention systems are shown in Figure 17.

Sediment forebays must be designed to: a) remove 80% of particles that are greater than 1 mm or larger in diameter from the three-month peak ARI flow (a catchment loading rate of 0.6 m^3/ha/yr should be used), b) provide sufficient storage for coarse sediments so that desilting is required twice per year (maximum allowable storage depth = 300 mm), and c) provide energy dissipation of inflows.

Bioretention systems which receive runoff from catchments >5 ha must have an upstream sediment pond or GPT to trap coarse sediments.

Figure 17 Examples of sediment traps located at the bioretention inlet zone.

3.4.5.4 Energy dissipation and flow distribution

The inlet must be designed to dissipate the energy of the stormwater runoff entering the bioretention system to prevent filter media from being scoured during major storm events and to minimise the re-suspension of coarse sediments.

Acceptable energy dissipation options include the use of a rock apron with rock sized to withstand the maximum inlet design flow. Energy dissipation infrastructure such as a rock apron must be located downstream of the concrete channel/sediment trap.

The inlet must be designed to ensure that inflows are evenly distributed across the bioretention filter media surface. Bioretention systems must have a flat surface to ensure that inflows spread to all areas of the filter bed. The maximum possible flow velocity across the surface of the filter bed is 1 m/s[5], as flow velocities exceeding 1 m/s are likely to scour the filter media.

[5] The maximum flow velocity is calculated by dividing the flow rate (maximum flow rate that is able to enter the bioretention) by the cross-sectional area of the bioretention system at its narrowest point (calculated as the width x (EDD depth + 0.1 m)).

Large bioretention systems (>400 m^2) must have either: a) multiple inflow points, or b) distribution channel/s located along the edges of the filter bed to assist with the distribution of inflows to the filter media bed.

3.4.1 Ponding depth

The maximum allowable ponding depth (extended detention depth) within a bioretention system is 300 mm. Greater ponding depths will not be accepted due to the increased risk to the vegetation health and the public safety risk associated with ponded water.

3.4.2 Media specifications

The filter bed media must comply with the media specifications outlined in the Guidelines for Filter Media in Biofiltration Systems (Appendix C of the Biofilter Adoption Guidelines V2, CRC for Water Sensitive Cities (2015)). A summary of the specifications is provided for each of the filter bed media layers below:

3.4.2.1 Filter media

The filter media is to comprise of washed, well-graded sand or naturally occurring sand that has a hydraulic conductivity between 100-300 mm/hr. The filter media must have:

- low nutrient content to prevent the leaching of nutrients from the media (TN < 1000 mg/kg, Available phosphate < 80 mg/kg),
- minimum 5% organic matter content to assist with the retention of moisture for vegetation growth
- less than 3% (w/w) clay and silt (Particle size distribution (PSD) <0.05 mm) content to maintain hydraulic conductivity
- pH between 5.5 – 7.5 to support vegetation growth
- EC less than 1200 mS/m
- Agronomically acceptable (i.e. capable of sustaining plant growth)

The filter media depth must be greater than or equal to 500 mm. This is to ensure there is sufficient filter media depth to support vegetation growth. Lesser filter media depths may be considered at highly constrained sites, however Council will not accept a lesser depth where it is possible to achieve a depth of 500 mm.

Note: the nutrient content of the top 100 mm of the filter media layer may be ameliorated once only with supplementary organic matter, fertiliser and trace elements to assist with plant establishment (Table 2).

Table 2 Recommended recipe for ameliorating the top 100 mm of the filter media (sourced from CRC for Water Sensitive Cities, 2015).

Constituent	**Quantity (kg/100 m^2 filter area)**
Granulated poultry manure fines	50
Superphosphate	2
Magnesium sulphate	3
Potassium sulphate	2
Trace Element Mix	1
Fertilizer NPK (16:4:14)	4
Lime	20

3.4.2.2 Transition layer

The transition layer is to comprise of a clean well-graded sand to prevent the filter media washing down into the drainage layer. The hydraulic conductivity of the transition layer must be greater than the filter media layer to ensure that the filter media is able to drain freely.

The transition layer PSD must comply with the following bridging criteria - the smallest 15% of sand particles must bridge with the largest 15% of the filter media particles. This will ensure that the filter media does not migrate into the transition layer.

The transition layer must have a minimum depth of 100 mm or more to accommodate a deeper saturation zone.

3.4.2.3 Drainage layer

The drainage layer is to comprise of a clean, fine aggregate (2-7 mm washed screenings). The hydraulic conductivity of the drainage layer must be higher than the transition layer to ensure that the filter bed is free-draining.

The transition layer PSD must comply with the following bridging criteria - the smallest 15% of drainage layer particles must bridge with the largest 15% of the transition layer particles. This will ensure that the transition layer does not migrate into the drainage layer.

There is no minimum requirement for the depth of the drainage layer, however the drainage layer must be of sufficient depth to provide a minimum 50 mm cover over the underdrain pipe.

3.4.3 Underdrain system

The bioretention outlet system (drainage layer and underdrain pipe) should be designed to:

- Allow stormwater to be freely discharged from the bioretention filter bed (i.e. the outlet capacity must exceed the maximum infiltration rate of the filter media),
- Enable access for inspection and cleaning, and
- Prevent drainage layer material entering the underdrain pipes.

The underdrain pipe is to comprise of rigid slotted PVC pipe with a minimum diameter of 100 mm. The slotted perforations must be orientated horizontal, able to pass the maximum infiltration rate and sized to prevent the drainage layer material from washing into the underdrain pipes.

Where more than one underdrain pipe is required, the underdrain pipes must be spaced no further than 1.5 m apart. Where the underdrain pipes are connected to a larger collector pipe, the underdrain pipes must be connected to the collector pipe using a 45^{o} PVC fitting orientated to the direction of flow.

Note: Flexible slotted pipes will not be accepted as these cannot be adequately sealed to rigid pipes and/or outlet pit. The underdrain pipes must not be fitted with a filter sock.

3.4.4 Inspection pipes

Vertical inspection pipes must be fitted at the end of every underdrain pipe and at least every 20 m for underdrain pipe runs greater than 20 m. Inspection pipes are to comprise of a solid PVC pipe (no slots), extend at least 150 mm above the filter bed surface, have a screw cap fitted with a locking mechanism, be the same diameter as the underdrain pipes and be sealed to the underdrain with two 45^{o} PVC fittings to enable access for jetting if required (Figure 18).

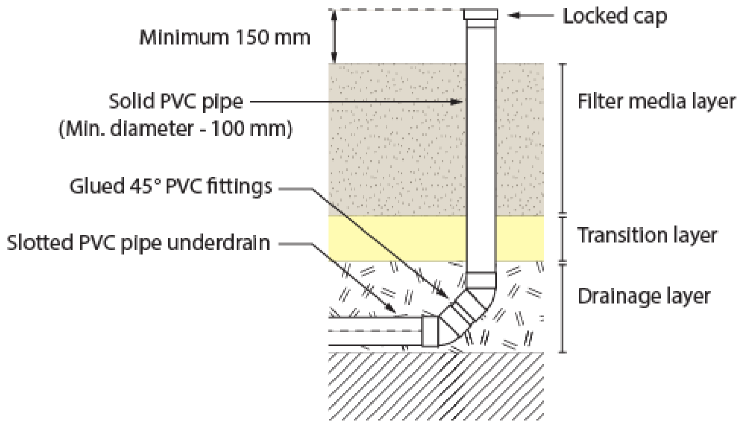

Figure 18 Typical configuration of an inspection pipe.

3.4.5 Outlet design

Bioretention systems must be configured to enable the drainage layer to be operated as a saturated zone (permanently saturated). The outlet system is to comprise of a vertical riser pipe and a horizontal pipe with a maintenance screw cap (or shut-off valve) located in the overflow pit (Figure 19). The riser pipe must be located within the overflow pit or inside the side-entry pit for streetscale systems which are directly connected to an adjacent side-entry pit. The riser pipe must be adjustable, i.e. the height of the riser pipe can be altered to enable the water level of the saturated zone to be adjusted. The maintenance screw cap (or shut-off valve) must enable the underdrain system to be drained via gravity.

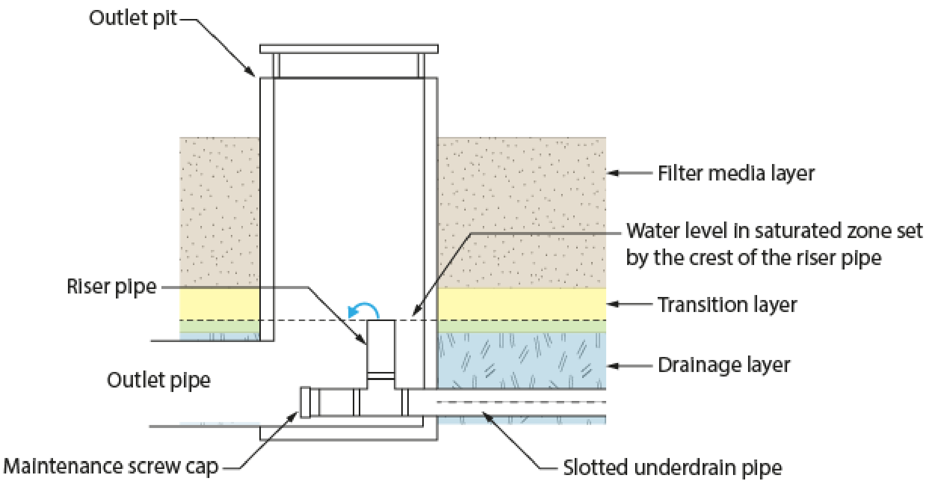

Figure 19 Recommended outlet design for saturated zone systems.

The saturated zone should be at least 450-500 mm deep (300 mm minimum) and may extend up into the transition layer.

The optimal depth of the saturated zone can be determined by estimating the time required for the water storage to be drawn down during the peak warmer months:

Drawdown period for saturated zone = (*Porosity* x *Depth*) / *Daily Evapotranspiration*

<u>where</u>:
Drawdown period for saturated zone – (Minimum 20 days recommended)
Porosity – estimated porosity of the saturated zone (0.4 recommended)
Depth – depth of the saturated zone (mm)
Daily Evapotranspiration – average daily evapotranspiration (4.2 mm/day recommended)

(Sourced from CRC for Water Sensitive Cities, 2015).

3.4.6 Overflow pit

Overflow pits should have a raised grate, positioned minimum 100 mm above the pit crest to minimise the risk of blockage. Note: flush grates will not be accepted. A minimum freeboard of 100 mm must be provided between the maximum water level above the pit crest during the peak inflow and the bioretention embankment level to ensure that water enters the pit without spilling from the bioretention basin.

A minimum pit size of 900 mm x 900 mm is required to enable maintenance access to the saturated zone outlet control pipe and valve.

3.4.7 Overflow weir

Overflow weirs must be designed to:

- Pass the peak major flow,
- Minimise blockage, and
- Minimise scour of the adjacent embankments during a peak major flow.

A minimum freeboard of 100 mm must be provided between the maximum water level above the weir during the peak major flow event and the embankment level.

3.4.8 Outlet pipe

The outlet pipe from the bioretention system must be sized to convey the peak minor flow to the downstream receiving drainage system or waterbody. A minimum pipe grade of 0.3 % must be provided to ensure that the bioretention system drains freely and that sediment does not accumulate in the base of the outlet pipe.

When discharging to a waterway, the outlet pipe must be angled downstream and free draining to the waterway (not backwatered). The outlet pipe must be provided with scour protection (i.e. rocks) at the transition to the waterway.

The outlet pipe must be fitted with an anti-seepage collar or cut-off wall where it passes through an embankment to prevent seepage along the pipe.

3.4.9 Vegetation

The presence of dense vegetation on the filter bed is essential to the functional performance and long term sustainability of a bioretention system.

Plant selection should be guided by the following functional attributes which contribute to pollutant removal and plant survival:

- Root structure – Plants with dense fibrous root systems are more effective at maintaining the porosity of the filter media than plants with tap root systems. The selection of plants with a mixture of different root types is desirable to ensure that the filter media is occupied by a matrix of root systems.
- Plant structure – Plants with dense spreading foliage function to reduce stormwater velocity and protect the filter bed surface from scouring.
- Plant growth – Plants with vigorous growth characteristics enable vegetation cover to be rapidly established over the filter bed surface and help to minimise weed establishment. Fast growing plants tend to have higher nutrient demands but are less effective at storing nutrients compared to slow growing species which are typically larger and have more well developed root systems. Slow growing species may be planted in bioretention systems as supplementary species
- Tolerance to wetting and drying cycles – Plant species must be selected that can tolerate prolonged dry periods as well as short periods of inundation. Note: Semi-aquatic plants must not be used in bioretention systems as they are unable to tolerate extended dry conditions.

Other objectives which may also guide the selection of the bioretention plants include:

- Maintenance requirements
- Public safety/barrier requirements
- Landscape amenity/aesthetic
- Potential microclimate benefits
- Enhanced biodiversity

Bioretention systems in the Wyndham region are subject to high moisture stress due to the low average annual rainfall volume. Plant selection should be guided by choosing plant species which are able to cope with extended dry periods (up to two months). The presence of a saturated zone within the base of the bioretention system enables a broader palate of plant species to be utilised as there is a source of moisture for the plants to access during dry periods.

Note: Bioretention systems located downstream of sediment ponds are more susceptible to moisture stress during dry periods. Plant species selected for these systems must be adapted to growing in dry conditions.

Where possible, the plant species selected for bioretention systems should be indigenous to the Wyndham Council region. A list of locally indigenous plant species suitable for planting in the bioretention filter bed and edges is provided in Appendix A. The use of deciduous trees within or adjacent to bioretention systems should be avoided as leaf fall during autumn results in the blockage of bioretention inlets and clogging of the filter bed surface.

The bioretention planting design should respond to the objectives outlined above, and also reflect the scale and landscape setting of the bioretention system. Examples of typical bioretention planting styles are provided in Table 3.

Table 3 Bioretention planting styles.

System	Scale	Planting style
Streetscape	Small systems <50 m^2	Low profile plantings
Parkland/Open space	Larger systems >50 m^2	Mixed native plantings including groundcovers, shrubs and small trees
Microclimate	Variable scaled systems (including tree pits) located in streets, carparks and parklands/open spaces	Medium to large trees to provide shading and maximise evapotranspiration

It is recommended that a diversity of plant types and species are used within a bioretention system. This will provide a high likelihood of successful plant establishment and ongoing sustainable vegetation cover. The plant species selected must be able to provide at least 90% coverage of the filter media bed within two years. As a guide, the minimum number of plant species to be planted in various scales of bioretention systems is provided in Table 4.

Table 4 Minimum number of plant species to be used in bioretention systems.

Planting scale	Minimum number of species	Minimum planting density (plants/m^2)
Streetscape - Filter bed <50 m^2	4	6
Parkland/open space - Filter bed >50 m^2	6	6
Microclimate	NA	NA
Biodiversity [6]	>6	4-8

The bioretention filter bed must be planted with plants grown in individual pots with a minimum volume of 200 cm^3 (i.e. forestry tubes), except for trees which must be provided in minimum 300 mm pots. This is to ensure that the plants have sufficient root biomass and associated potting

[6] Where appropriate, large bioretention systems (i.e. > 200 m^2) may be planted with a diversity of indigenous species representative of local vegetation communities. Bioretention systems with established bushland communities are often characterised by low weed cover (i.e. require low maintenance) and provide significant food and habitat resources for local wildlife.

material to withstand the potentially hostile planting conditions experienced in the bioretention filter media during establishment.

3.4.10 Mulch

The use of mulch on the bioretention filter bed is not preferred. Organic mulches are susceptible to floating and clogging the outlet, and are not permitted. The use of gravel mulch restricts the spread of the plants, and the sediment accumulation within the mulch layer is difficult to maintain.

Council may consider the use of gravel mulches (including crushed granite) in small bioretention systems being retrofitted within existing developed catchments where the risk of sediment accumulation is considered low.

3.4.11 Landscaping

The design of a bioretention system and surrounding landscape must support the treatment performance of the bioretention system, and provide environmental benefits such as amenity, microclimate (reduced temperatures) and increased biodiversity.

It is important that bioretention systems constructed within existing streetscapes and parklands are integrated with the surrounding urban landscape.

The design of bioretention systems may benefit from the input of landscape architects who can provide a high level of landscape integration expertise. Important landscape design considerations may include:

- Context – how the bioretention will relate to the landscape
- Form – how the bioretention will change over time as the vegetation matures
- Scale – ensuring that the bioretention is in proportion to its setting
- Seasonal variation – the choice of plant species can provide distinct seasonal changes in vegetation colour and form
- Plant layout – landscape colours and texture can be achieved through the placement of plants with contrasting form, foliage and flowers
- Colour and tone – different colours can be provided by flowers or foliage
- Texture – provided by the use of vegetation and hard landscaping elements

(Sourced from CRC for Water Sensitive Cities, 2015).

Note: Bioretention systems must be designed in accordance with an approved urban/landscape concept plan. The urban/landscape concept plan must be approved prior to the submission of the bioretention concept design to Council.

3.4.12 Edges

The design of the interface between bioretention and the surrounding landscape must consider public safety, maintenance and visual amenity.

The maximum permissible slope for earthen batters and embankments is 1:4. Steeper batters will not be accepted as these are deemed to represent an unacceptable public safety risk. The vegetation established on the batters must be low maintenance and not create a public safety hazard.

Low vertical edges or walls around the perimeter of the bioretention system represent a potential safety hazard. A maximum drop of 150 mm from the top of a low vertical edge (e.g. concrete footpath) to the surface of the filter bed or batter is permitted.

The use a wall greater than 150 mm is not preferred, however Council may be consider permitting the use of a wall, providing that the wall is a barrier to public access or a dense vegetated strip (minimum width 2m) is established on the upside side of the wall.

3.4.13 Safety

The bioretention design must consider all aspects of public safety, including pedestrians, vehicles and maintenance personal likely to be present in the vicinity of the bioretention system. Important safety components which must be considered include:

- Clear sightlines for traffic and pedestrians – the size and form of plant species planted within the bioretention system should reflect the site context, i.e. it may be prudent to use low-growing vegetation within streetscape systems to ensure that pedestrian and vehicle sightlines are maintained.
- Reduced ponding depths – it may be appropriate to consider adopting a lower extended detention depth for bioretention systems located adjacent to areas frequented by children such as play grounds and public parks.
- Edge design – vertical drops along the edges of bioretention systems should be avoided to prevent accidental falls. Where possible, gentle batter slopes should be adopted instead of vertical edges. The planting of dense vegetation along vertical edges can be used as an effective barrier where no other alternative is available.
- Streetscape bioretention systems located adjacent to vehicle parking areas – a flat extension of the kerb (minimum width - 400 mm) must be provided between the kerb and edge of the bioretention system to provide a safe area for vehicle occupants to alight.
- Pedestrian refuges – the placement of pedestrian refuges should be considered along the edges of bioretention systems in locations where pedestrians may be stranded, i.e. bioretention systems located in median strips. This may be achieved by breaking the edge vegetation using stepping stones or kerb extensions.
- Trip hazards – all components of a bioretention system must be evaluated for potential trip hazards. The selection of plant species to be established along the edges of bioretention systems should consider whether the foliage will protrude onto pedestrian pathways when mature and constitute a tripping hazard.

(Sourced from CRC for Water Sensitive Cities, 2015).

3.5 Sediment ponds

The design standards for sediment ponds are provided below. These design criteria are based upon the Melbourne Water Constructed Wetland Manual and have been modified to reflect specific Wyndham requirements.

3.5.1 Location

Sediment ponds may be constructed as standalone treatment stormwater treatment assets or integrated as part of a treatment train (i.e. part of a bioretention or wetland system).

Sediment ponds are to be located offline of waterways but online to the pipe or lined channel they are treating water from in accordance with the Melbourne Water Constructed Wetland Design Manual.

Wherever possible, all stormwater runoff should be directed to a single sediment pond upstream of a treatment train to enable efficient and cost effective maintenance. In situations where untreated ups stormwater runoff cannot be directed to a single sediment pond upstream of a treatment train; a sediment pond is required at each stormwater entry point to the treatment train where the catchment area of the incoming stormwater is ≥5% of the total treatment train catchment area.

3.5.2 Sizing

Sediment ponds must be sized to remove at least 95% of the course particles ≥125 µm diameter for the peak three month ARI, and have sufficient sediment storage volume to store at least five years sediment (i.e. have a minimum cleanout frequency of once every five years).

The configuration of the sediment pond also needs to ensure that the stored sediments are protected during high flow events. The maximum allowable velocity through the sediment pond during the peak 100 year ARI event is 0.5 m/s based upon the flow area cross-section at the narrowest width of the sediment pond.

Sediment ponds must not be oversized, i.e. be more than 120% of the area required to achieve the above treatment requirements. Oversized sediment ponds trap finer sediments and require more frequent cleaning.

Sediment ponds must be sized in accordance to the Fair and Geyer method described in WSUD Engineering Procedures: Stormwater (Melbourne Water, 2005). Note: the sediment pond must be modelled with a minimum hydraulic efficiency (λ) = 0.3, and the shape of the sediment pond consistent with the hydraulic efficiency value used in the Fair and Geyer equation.

3.5.3 Maintenance

Sediment ponds must be designed to enable maintenance vehicles and personnel to safely access and exit the site. The sediment pond design must include:

- A maintenance access track
- A maintenance access ramp to the base of the sediment pond (unless edge cleaned)
- A solid base
- Access to the perimeter of the sediment pond
- A hardstand area (for vehicle turning)
- A sediment dewatering area

3.5.3.1 Maintenance access track

The maintenance access track should enable maintenance vehicles to safely enter and leave the sediment pond site. Design requirements for the maintenance access track include:

- Access to the sediment pond and hardstand area
- Minimum track width = 4 metres
- Built to Council standards and reinforced to take a 22 tonne vehicle
- Intersections between pedestrian pathways and site maintenance access tracks should be clearly marked (i.e. using markers or different coloured concrete on the pedestrian paths).
- At the road edge, have an industrial crossover to Council standard and rolled kerb adjoining it.

3.5.3.2 Sediment removal access

All parts of the base of a sediment pond must be accessible for sediment removal. This is generally achieved via a maintenance access ramp into the base of the sediment pond, however smaller sediment ponds may be edge cleaned providing that a designated hard stand area is within 7 metres of all parts of the sediment pond base.

Maintenance access ramps are required on all sediment ponds that cannot be 'edge cleaned'. Design requirements for the maintenance access ramp include:

- Minimum ramp width = 4 metres
- Maximum ramp slope = 1:5
- Extend from the base of the sediment pond to at least 0.5 metres above the maximum water level (generally TED)
- Built to Council standards and capable of supporting a 22 tonne excavator
- A removable barrier located above TED to prevent unauthorised vehicle access (e.g. gate, bollard and/or fence).

3.5.3.3 Sediment pond base

The base of the sediment pond must be constructed of steel reinforced concrete (min. 200 mm thick with SL82 mesh centrally located) to ensure that excavator operators can detect the base of the sediment pond. The sediment pond base material must extend vertically up the batter by at least 300 mm (from the surface of the sediment pond base). Note: The concrete base must be constructed on top of the liner layer and is not considered a substitute for the liner.

3.5.3.4 Hardstand area

A hardstand area must be provided adjacent to the sediment pond maintenance access ramp to enable maintenance vehicles to safely reverse and exit the sediment loading area. The hardstand area should have a turning circle suitable for vehicles up to 9.5 m length.

3.5.3.5 Sediment dewatering area

Dedicated sediment dewatering areas must be provided adjacent to sediment ponds to enable sediments to be dried prior to being removed offsite. Design requirements for the sediment dewatering area include:

- Be accessible from the maintenance access ramp or sediment pond perimeter
- Have a length to width ratio no narrower than 10:1
- Be able to contain all sediment removed from the sediment accumulation volume spread out at 500 mm depth
- Be located above the peak 10 year ARI water level and within 25 m of the sediment pond or as close as possible,
- Be located at least 15 metres from residential areas and public access areas (like pathways, roads, playgrounds, sports fields etc), and consider potential odour and visual issues for local residents
- Address public safety and potential impacts on public access to open space areas,
- Be free from above ground obstructions (e.g. light poles) and be an area that Council has legal or approved access to for the purpose of dewatering sediment.

3.5.4 Maximum water level

Sediment ponds designed as part of a wetland system must have an EDD ≤350 mm. Sediment ponds that are standalone treatment assets or are hydraulically disconnected from the associated macrophyte zone (i.e. NWL in the sediment pond and macrophyte zone are different) may have an EDD >350 mm.

3.5.5 Outlet

The outlets from a sediment pond may comprise of pipes or culverts, overflow pit and pipe, or weir, and will depend upon whether the sediment pond is a standalone treatment system or part of a wetland system.

The outlet on a standalone sediment pond must be configured to pass the peak event flow to the downstream waterway.

Where the sediment pond is part of a wetland system, the connection between the sediment pond and the macrophyte zone must be configured to enable the sediment pond to be drained whilst maintaining the water level in the macrophyte zone at NWL.

Refer to Section 3.6.5 for the design requirements for the connection between the sediment pond and the macrophyte zone.

3.5.6 High flow bypass

Where the sediment pond is located upstream of other treatment systems (i.e. a wetland or bioretention system), a high flow bypass must be provided to protect the downstream treatment system from inflows during large runoff events. The high flow bypass generally comprises of an overflow weir and bypass channel, and must be sized to convey the maximum overflow from the sediment pond for events up to the 100-year ARI event.

Standalone sediment ponds do not require a high flow bypass. Where a sediment pond is located within a retarding basin, the high flow bypass must convey at least the peak one year ARI flow.

A minimum freeboard of 300 mm must be provided between the maximum water level above the overflow weir during the peak major flow event and the top of all embankments.

3.5.7 Liner

The sediment pond must have a compacted clay liner made from site soils and/or imported material (where site soils are unsuitable) to minimise leakage. This is particularly important where groundwater may interact with the sediment pond or where there are saline in-situ soils.

3.5.8 Gross pollutant control

The sediment pond must have an upstream GPT or sufficient gross pollutant control at the inlet such that litter does not accumulate within the sediment pond or enter downstream waterways during storm events.

3.5.9 Topsoil

A topsoil layer (minimum 200 mm depth) must be provided along the edges of the sediment pond to 350 mm below NWL to provide a substrate for the edge vegetation to establish. Topsoils used within the sediment pond must comply with AS 4419 Soils for landscaping and garden use[7].

[7] The AS 4419 requirement for % organic matter content does not apply. Topsoils used in and sediment ponds and wetlands must have a minimum of 5% organic matter content.

3.5.10 Edge profile

The edge profile of the sediment pond must consider public safety, structural stability and maintenance access requirements.

Minimum requirements for the sediment pond edges include (Figures 20, 24 and 25):

- Vegetated approach batters no steeper than 1:5, with a 2.8 m wide vegetated safety bench at 1:8 between NWL and 350 mm below NWL, and a maximum 1:3 slope beyond 350 mm below NWL, or
- Batters no steeper than 1:4 (between TED and 350 mm below NWL), with dense impenetrable planting that is a minimum of 2.8 metres wide and 1.2 metres high, or
- Batters steeper than 1:4 (between TED and 350 mm below NWL) - permanent fencing is required to preclude public access to the sediment pond.

Note: Batter slopes steeper than 1:2 are not permitted around permanent waterbodies (above or below water) due to stability and erosion risks.

The edge profile of the sediment pond must consider public safety, structural stability and maintenance access requirements.

Figure 20 Examples of well established, vegetated sediment pond edges.

3.5.11 Vegetation

Dense vegetation must be planted around the perimeter of the sediment pond to enhance sediment removal and also to provide a barrier to public access.

The sediment pond edge must have a 2 m band of vegetation planted above NWL and emergent macrophytes planted between NWL and 350 mm depth.

The vegetation planted around the perimeter of the sediment pond must conform to the vegetation requirements outlined for the wetland macrophyte zone in Section 3.6.11.

3.6 Constructed wetlands

The design standards for wetland macrophyte zones are provided below. These design criteria are based upon the Melbourne Water Constructed Wetland Manual and have been modified to reflect specific Wyndham requirements.

Wetlands generally comprise of a sediment pond and macrophyte zone. This section outlines Council's design standards for the wetland macrophyte zone. The design standards for sediment ponds are outlined in Section 3.5.

3.6.1 Location

The macrophyte zone must be located offline from all waterways, drains and high flow bypass routes. Please refer to the Melbourne Water Constructed Wetland Design Manual for the definition of waterways and drains.

The macrophyte zone must be located above the 10 year ARI flood level and not impact upon the flood storage capacity of the adjacent waterway up to the 100 year ARI flood level (i.e. the wetland must be located below the floodplain level or located above the 100 year ARI flood level).

A minimum offset of 10 metres (subject to Council approval) must be provided from the edge of macrophyte zones (at NWL) to any allotment or road reserve. This ensures that there is sufficient space available for public safety, maintenance access and landscaping.

3.6.2 Maintenance

The macrophyte zone should be configured to enable maintenance vehicle access to at least 50% of the perimeter. Vehicular access must be provided as close as possible to macrophyte zone structures that are prone to blockage including the outlet control pit, overflow weirs and pits.

Outlet pits must be easily identifiable and located within or adjacent to the maintenance access track where the pit can be accessed safely. Overflow pits (if present) must located near the edge of the wetland so that the edge of the pit closest to the bank (maintenance access point) is in less than 350 mm water depth.

A water level gauge must be located at the wetland outlet and enable the wetland water level (relative to NWL and EDD) to be read from the bank.

3.6.3 Bathymetry

Macrophyte zones must be configured to support the establishment and growth of emergent and submerged marsh vegetation.

The majority of a macrophyte zone (at least 80%) must be less than 350 mm deep (at NWL) to enable emergent macrophytes to grow. This means 20% or less of a macrophyte zone can be more than 350 mm deep and suitable for submerged macrophyte growth. Additional open water areas (in excess of 20% of the macrophyte zone area at NWL) must be located as a separate waterbody downstream of the wetland. The conceptual model for the wetland (e.g. MUSIC model) must assume that there is no reduction in pollutant loads within separate waterbodies.

Macrophyte zone bathymetry should be configured to provide approximately equal amounts of shallow marsh (≤ 150 mm deep) and deep marsh (150 mm to 350 mm deep), with an even transition in slope between the two marsh zones to enable the wetland to freely drain (minimum grade = 1:150) (Figure 21).

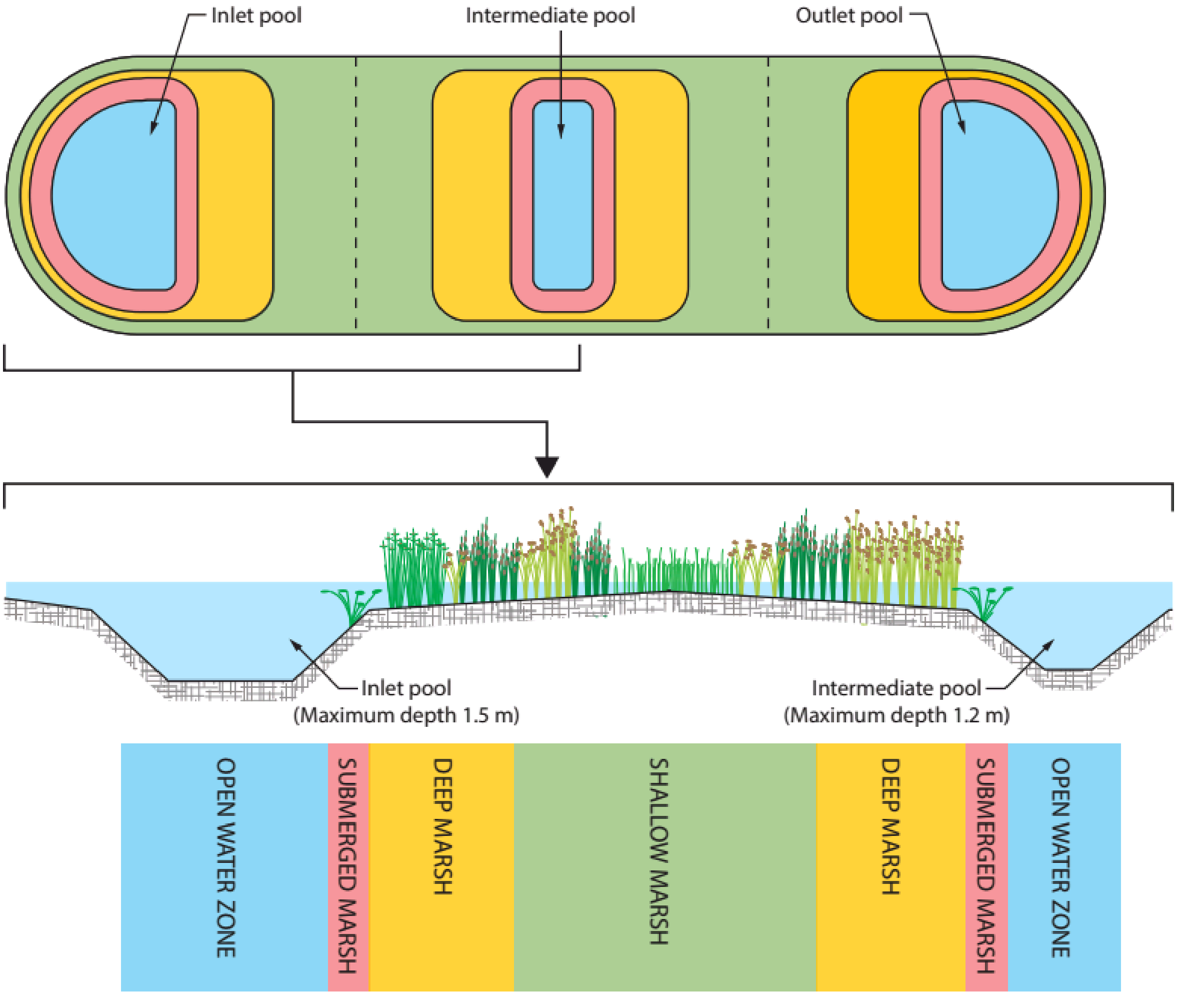

Figure 21 Typical macrophyte zone bathymetry showing the marsh and open water zones.

3.6.4 Configuration

The length of the macrophyte zone must be at least four times the average width of the macrophyte zone to ensure that the stormwater flows through a sequence and mix of submerged, shallow and deep marsh zones arranged in bands perpendicular to the direction of flow.

Macrophyte zones must have an inlet and outlet pool (located at opposite ends of the macrophyte zone). The inlet pool must be sized to dissipate the energy of inflows and to collect sediments that are not trapped by the sediment pond. The macrophyte zone may also have intermediate pools located between the inlet and outlet pools. The inlet and outlet pools must be less than 1.5 m deep, and the intermediate pools less than 1.2 m deep.

In situations where a macrophyte zone has multiple inlets, major inlets (i.e. those draining more than 10% of the catchment to be treated), must be located within the first 20% of the macrophyte zone.

3.6.5 Inlet connection

The connection between the sediment pond and macrophyte zone may comprise of pit and pipe, culvert or submerged weir. The connection must be sized such that (Figure 22):

- All flows less than the peak three month ARI event are transferred into the macrophyte zone when the EDD in the macrophyte zone is at NWL, and
- 60% of the peak 1 year ARI flow overflows from the sediment pond into the bypass channel/pipe when the water level in the macrophyte zone is at TED.

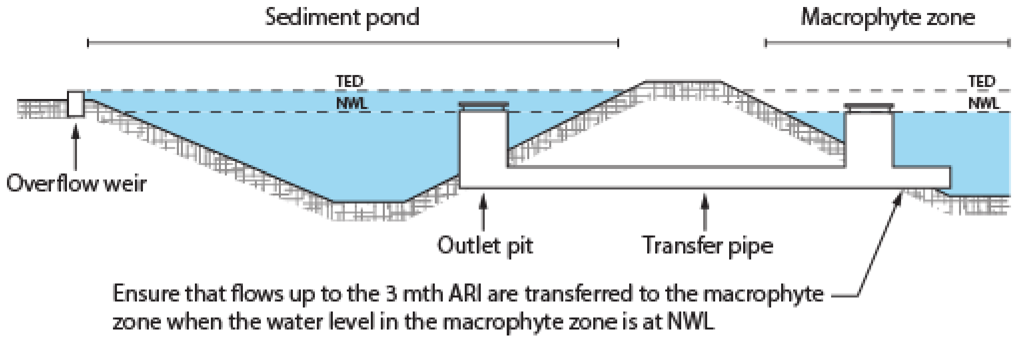

Figure 22 Conditions for sizing the connection between the sediment pond and macrophyte zone – 3 month ARI flow check.

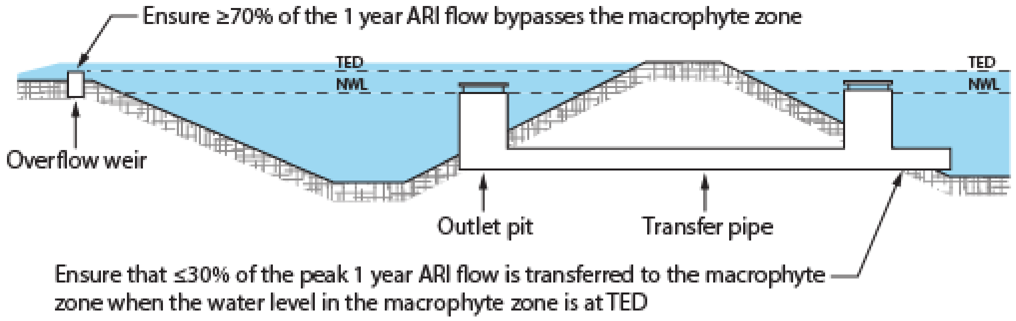

Figure 23 Conditions for sizing the connection between the sediment pond and macrophyte zone – 1 year ARI flow check.

3.6.6 Velocities

It is important that velocities through the macrophyte zone are considered during the design process to protect the accumulated sediment, biofilms and macrophytes from scour. Maximum allowable velocities within the macrophyte zone are:

- less than 0.05 m/s for the peak three month ARI
- less than 0.5 m/s for the peak 100 year ARI flow[8]

Refer to the Melbourne Water Constructed Wetland Manual for guidance on undertaking velocity checks within the macrophyte zone.

3.6.7 Hydraulic control

The macrophyte zone must have a controlled outlet that is configured to provide a 90th percentile residence time of 72 hours (assuming plug flow between inlet and outlet through the EDD and 50%

[8] Assuming the macrophyte zone is at TED if the wetland is not within a retarding basin or flood plain, OR Assuming the water level is at the peak 10 year ARI water level if the wetland is within a retarding basin or flood plain.

of the permanent pool volume). Refer to the Melbourne Water online tool and Melbourne Water Constructed Wetland Manual for guidance on determining the wetland residence time.

The controlled outlet, generally a riser pipe or weir located in a pit, must be configured so that:

- NWL can be drawn down by up to 150 mm during plant establishment and maintenance,
- The maximum EDD is less than 350 mm.
- NWL can be permanently adjusted up or down by 100 mm to respond to changes in wetland hydrology.

Where stormwater is to be harvested from the permanent pool of a wetland, water extraction must not occur if the wetland water level is more than 100 mm below NWL.

3.6.8 Inlet and outlet structures

The design of pits, grilles and structures must conform to the standards outlined in the Melbourne Water Land Development Manual and Standard Drawings. All covered pits must have approved lids and all uncovered outlet structures must have approved grilles/grates.

The connection from the macrophyte zone outlet pool to the pit containing the controlled outlet must be submerged to minimise clogging from floating debris (refer to Melbourne Water Standard Drawing WG020).

3.6.9 Overflow weir

An overflow weir comprising of either an overflow pit or weir located within the wetland embankment, must be provided to protect the macrophyte zone from additional inflows during large runoff events. The overflow weir must be sized to convey the maximum inflow to the macrophyte zone when the extended detention depth is full and the maximum design event is being bypassed by the sediment pond.

3.6.10 Balance pipes

Balance pipes must be placed between all open water zones within the macrophyte zone (inlet, intermediate and outlet pools) to enable water levels to be drawn down for maintenance.

The balance pipes must comprise of a minimum 300 mm diameter RCP (Note: the use of smaller diameter pipes is subject to Council approval). The invert of the balance pipes must less than 100 mm above the base of the macrophyte zone and fitted with a submerged offtake pit to minimise the risk of clogging (refer to the Melbourne Water Standard Drawings).

3.6.11 Vegetation

It is crucial that vegetation cover is established throughout the wetland to maximise stormwater treatment performance. This requires that at least 80% of the macrophyte zone (at NWL) is planted with emergent marsh vegetation. The remaining wetland area should be planted with submerged marsh vegetation.

The wetland design must include the following planting zones:

- Ephemeral batter NWL to 200 mm above NWL
- Shallow marsh NWL to 150 mm below NWL
- Deep marsh 150 to 350 mm below NWL
- Submerged marsh 350 to 700 mm below NWL

Where possible, the plant species selected for the wetland should be indigenous to the Wyndham municipal region. Plant stock of local provenance must be used where any planted part of a wetland system is located adjacent (defined as being within 50 m) to a local waterway. Wetland systems located away from local waterways may be planted with other plant species from outside the Wyndham municipal region.

A list of locally indigenous aquatic and terrestrial plant species suitable for planting within each of the wetland planting zones is provided in Appendix A.

The planting lists include a number of core plant species designated for each planting zone. A minimum of three core plant species must be selected for each planting zone. The core plant species must comprise of at least 90% of the plants established in the shallow, deep and submerged marsh zones, and at least 80% of the plants established in the ephemeral batter. The planting densities must be in accordance with densities provided in Appendix A.

The ephemeral batters must be planted with plants grown in individual pots or tray cells that are at least 90 cm^3 in volume (i.e. the minimum acceptable pot/cell size is a hiko cell).

Emergent and submerged macrophyte seedlings must be grown in individual pots with a minimum volume of 200 cm^3 (i.e. forestry tubes). Seedlings sourced from bare-root divisions from tub/tray grown stock or stock harvested from existing wetlands will not be accepted.

Seedlings grown in 200 cm^3 tubes must have:

- A minimum stem height of 300 mm, and
- A total stem area occupying at least 50% of the tube surface area, and
- A well developed, healthy root system that occupies the full tube volume (i.e. the growing media must remain intact when the plant is removed from the pot).

The minimum stem height criteria does not apply to submerged macrophyte species.

It is crucial that the plant species selected for each of the macrophyte zones are able to cope with the expected wetland hydrologic regime. For plants to survive, the effective water depth (permanent pool depth plus EDD) must not exceed half of the average plant height for more than 20% of the time. This requirement can be assessed by undertaking an inundation frequency analysis based on the modelled wetland hydrology.

Refer to the Melbourne Water online tool and the Melbourne Water Constructed Wetland Manual for guidance on how to undertake an inundation frequency analysis.

3.6.12 Liner

The macrophyte zone must have a compacted clay liner made from site soils and/or imported material (where site soils are unsuitable) to minimise leakage from the wetland. This is particularly important where groundwater may interact with the wetland or where there are saline in-situ soils.

3.6.13 Topsoil

A topsoil layer of minimum 200 mm depth must be provided in all areas of the macrophyte zone to provide a substrate for the wetland vegetation to establish. Topsoils used within the macrophyte zone must comply with AS 4419 Soils for landscaping and garden use[9].

3.6.14 Edge profile

The edge profile of the macrophyte zone must consider public safety, structural stability and maintenance access requirements.

All macrophyte zone edge profiles must comply with the edge risk assessment outlined in Section 3.6.15. Common edge profiles for macrophyte zones include:

- Vegetated approach batters no steeper than 1:5, with a 2.8 metre wide vegetated safety bench at 1:8 between NWL and 350 mm below NWL, and a maximum 1:3 slope beyond 350 mm below NWL (Figure 24), OR
- Batters no steeper than 1:4 (between TED and 350 mm below NWL), with dense impenetrable planting that is a minimum of 2.8 metres wide and 1.2 metres high (Figure 25), OR
- Batters steeper than 1:4 (between TED and 350 mm below NWL) - permanent fencing must be installed to preclude public access to the wetland. Where fencing is used, it must make up less than 10% of the wetland perimeter.

Note: Batter slopes steeper than 1:2 are not permitted around permanent waterbodies (above or below water) due to stability and erosion risks.

A minimum of 300 mm freeboard must be provided between the top of extended detention and the top of all embankments.

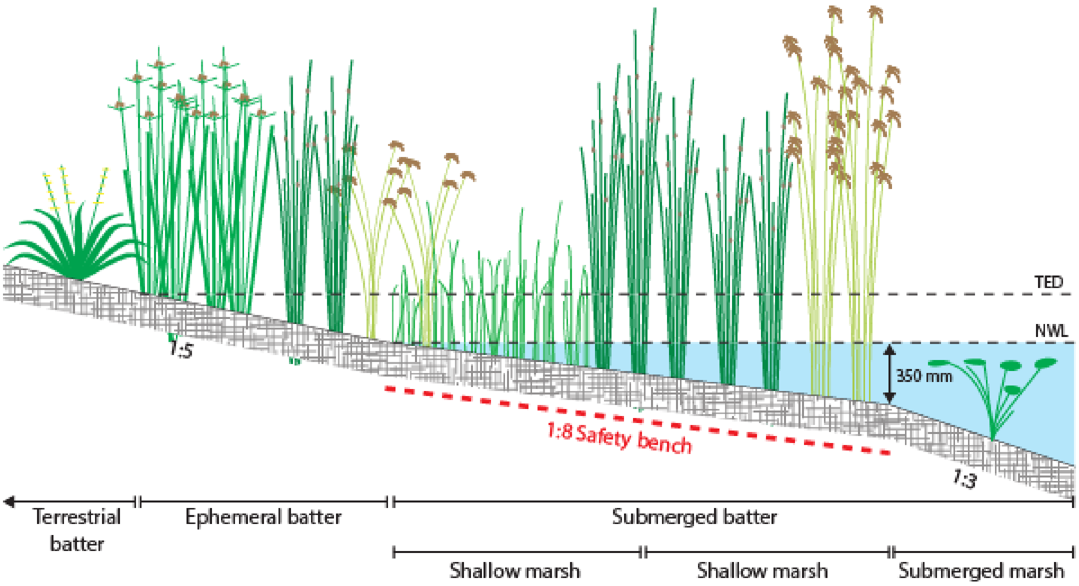

Figure 24 Wetland batter with submerged safety bench.

[9] The AS 4419 requirement for % organic matter content does not apply. Topsoils used in and sediment ponds and wetlands must have a minimum of 5% organic matter content.

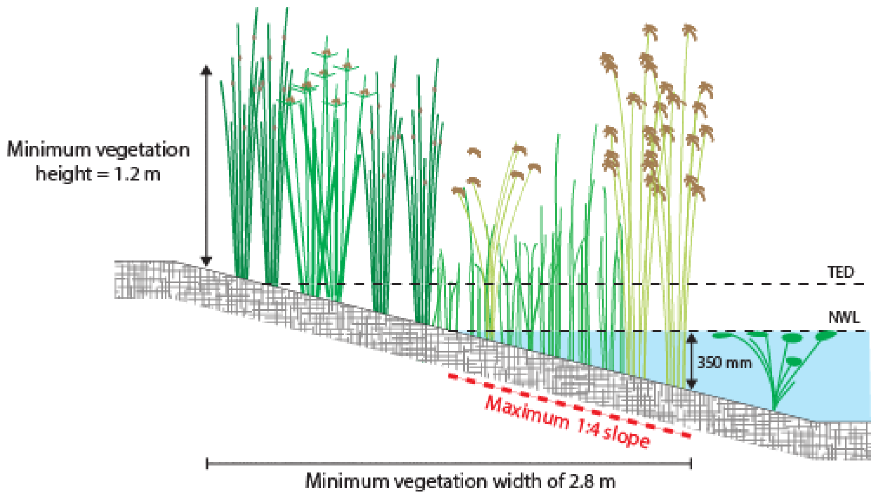

Figure 25 Wetland batter with densely vegetated edge barrier.

3.6.15 Edge risk assessment

An edge risk assessment must be conducted to access whether the proposed edge design provides a sufficient public safety barrier. The risk assessment is undertaken by scoring each of the risk factors outlined in Table 5. An overall risk score is determined by summing each of the risk factor scores and the recommended minimum edge treatment determined using

Table 6.

Table 5 Risk score table (adapted from *Batter Slope Treatment and Fencing Guidelines for Constructed Wetlands and Detention Basins*, Lake Macquarie City Council).

	Risk score
1. Approach batters (above normal water level)	
Batter slope 1:6 or flatter	0
Batter slope 1:4 to 1:6	2
Batter slope 1:2 up to 1:4	6
Vertical wall ≤ 500 mm within perimeter wetted by top of extended detention	8
Vertical wall >500 mm within perimeter wetted by top of extended detention	16
2. Vertical drop at water edge or below normal water level (and within 4m from normal water level edge)	
No vertical drop or drop ≤ 150 mm	0
Vertical drop > 150 mm and ≤ 300 mm	2
Vertical drop > 300 mm and ≤ 500 mm	8
Vertical drop > 500 mm	16
3. Water depth 4 m from inside of normal water level edge	
≤ 500 mm (1:8 batter or flatter)	0
> 500 mm and ≤ 670 mm (1:8 to 1:6 batter)	4
> 670 mm and ≤ 1,000 mm (1:6 to 1:4 batter)	8
> 1 m (steeper than 1 in 4 batter)	16
4. Distance from closest property boundary to normal water level	
> 20 m	0

≤ 20 m	4
5. Surveillance	
Residential area with good surveillance ≤ 150 m of normal water level	0
Good regular surveillance > 150 m of normal water level	4
6. Presence of young children	
Infant/primary school > 250 m from normal water level and playground/designated picnic area > 50 m from normal water level	0
Infant/primary school ≤ 250 m from normal water level and playground/designated picnic area > 50 m from normal water level	8

Table 6 Recommended edge treatment.

Recommended minimum edge treatment	Total risk score
Grass batter	≤ 11
Densely vegetated batter (2.5 m width minimum)	12-16
Densely vegetated batter plus accidental entry fence (1.2 m high cable fencing or equivalent)	17-21
Exclusion fencing (in accordance with AS 1926.1-1993)	> 21

3.6.16 Landscape features and infrastructure

All landscape features and infrastructure (i.e. boardwalks, piers, bridges, structurally treated edges, pedestrian paths and seating) are to be designed in accordance with relevant design codes and satisfy inundation and safety criteria.

All boardwalks, bridges and pedestrian paths, must be located at or above the peak 100 year ARI water level unless approved otherwise.

3.7 Gross pollutant traps

The design standards for GPTs are provided below. These design criteria have been modified to reflect specific Wyndham requirements.

3.7.1 Location

GPTs are required at all drainage connections to natural waterways. The location for a GPT should be consistent with the proposed catchment stormwater treatment strategy and located upstream of other WSUD assets such as bioretention systems and wetlands.

3.7.2 Operational performance

GPTs must be sized to treat a minimum design flow of the three month ARI event and require a minimum cleanout frequency of six months.

3.7.3 Device selection

A range of GPT devices are available for use in urban catchments including in-ground and end of pipe systems. Important elements that must be considered when selecting a suitable GPT device include:

- The GPT must be a proprietary product for which the treatment performance has been validated by manufacturer testing. GPTs do not provide the same level of treatment performance.
- The level of treatment performance provided by the type of GPT selected must be commensurate with the estimated treatment performance in the conceptual model developed for the GPT asset (e.g. MUSIC model).
- If a GPT is located downstream of a diversion pit (i.e. on a 3 month ARI pipe), a suitable GPT must be selected to treat 100% of the flow in the pipe.
- The lifecycle costs (including both installation and maintenance costs) should be used to compare GPT options. Note: Council may not accept GPTs selected on the basis of the capital costs alone, as the most cost effective GPT option to purchase and install may not be the most cost effective option over the life cycle of the GPT asset.
- Council will not accept GPT devices which require specialist maintenance equipment (other than crane and eductor trucks) or cannot be maintained by Council works crews (i.e. require staff to enter confined spaces).

3.7.4 Maintenance requirements

Maintenance access must be provided to the GPT for vehicles such as crane and eductor trucks, including the provision of hardstand areas. Maintenance access in developments and public areas must not require maintenance vehicles to reverse to the GPT site.

Maintenance of the GPT should involve no manual handling of the collected pollutants as they are considered hazardous material.

Chapter 4 Submission requirements

Council approval of stormwater treatment assets is subject to the submission of relevant design information to Council at each stage of the approval process. The minimum design information that must be provided to Council for each of the design approval stages including pre-application consultation, concept and detailed design stages is provided below.

4.1 Concept design package/Stormwater management strategy report

The concept design package must contain:

1. A concept design report that:
    a. Identifies the development location
    b. Describes the overall stormwater management strategy for the site
    c. Identifies how gross pollutants in the catchment will be managed
    d. Summarises the MUSIC modelling, including:
        i. Version of MUSIC
        ii. Rainfall data used
        iii. Catchment areas with impervious percentage
        iv. Details of any routing used
        v. Treatment node parameters
        vi. Details of any modelling parameters (i.e. land use zones and the pollution concentration data) that are not in accordance with Melbourne Water's 2016 MUSIC Modelling Guidelines
        vii. Pollutant removal results (percentage reduction for TSS, TN and TP) for the total treatment train and for each treatment system in the treatment train.
    e. A summary of site characteristics and constraints, including:
        i. Summary of the geology, soils and groundwater conditions at the site.
        ii. If applicable, a summary of the site Flora and Fauna survey, including a risk assessment as to whether species listed under the *Flora and Fauna Guarantee Act* and *Environmental Protection and Biodiversity Conservation Act* will be impacted by the proposed WSUD asset.
        iii. If applicable, a summary of the Cultural Heritage Management Plan which clearly identifies areas of cultural heritage importance that may be impacted by the proposed WSUD asset footprint.
        iv. Information on existing or proposed services or assets
2. An electronic copy of the MUSIC model
3. A plan showing catchment boundaries for each treatment system and location of receiving waterways
4. A plan of each proposed WSUD asset showing the indicative footprint (allowing for minimum offsets, batter slopes, high flow bypass, maintenance access routes and location of any pipe connections. The plan must show these items overlaid on site survey or a recent aerial photograph. The plan must show:
    a. The boundary of the reserve that the WSUD asset will be located within
    b. Existing waterways and/or pipe networks within or adjacent to the reserve
    c. Levels (m AHD) of land surrounding the WSUD asset
    d. The location of the inlet, high flow bypass and outlet

e. Locations of existing or proposed services determined from a desktop study (e.g. sewer, gas, mains water underground electrical cables and overhead power lines)
f. Locations of existing vegetation to be retained
g. Locations of cultural/historical features to be retained
h. Locations of existing or proposed community facilities adjacent to the WSUD asset location (e.g. playgrounds, buildings and/or walking paths)
i. The boundary of any planning overlays
j. Details on which assets the developer is proposing will be transferred to Council

5. An indicative long section for the proposed WSUD asset showing:
    a. Existing surface level
    b. NWL or filter bed surface (m AHD)
    c. TED
    d. Base of permanent pool or filter bed
    e. Invert of inlet pipe/channel(s)
    f. Invert of outlet pipe and how this relates to the receiving waterway/drain
    g. Weir crest levels (if applicable)
6. An indicative cross section showing batter slopes (if applicable)
7. If applicable, copies of the Urban and Landscape Design Concept Plans for the proposed development as approved by Council's Landscape Subdivision Team.

The concept design package is to be submitted in the following file formats:

Item	**Format**
Report	Pdf
Plans and sections	Pdf or jpeg

4.2 Detailed design package

The detailed design package must contain:

1) A statement that the WSUD asset design complies with Council's WSUD asset core objectives, asset selection and design standards.

2) A design report that describes:

    A. <u>General design requirements</u>
    - The overall operation of the system, including any changes to assumptions made during the concept design stage
    - A summary of any consultation with other approval authorities (e.g. Melbourne Water, Western Water)
    - The design flow rates and the method and assumptions used to estimate them
    - How gross pollutants will be managed
    - A summary of the water quality treatment performance (e.g. a report from MUSIC auditor tool)
    - All calculations and assumptions used to complete the final design (e.g. scour protection and energy dissipation).
    - How the surrounding environment will be protected during construction (e.g. protection of significant existing vegetation and preventing contaminated runoff leaving the site).

- Plan showing maintenance responsibility boundaries (i.e. which assets Council will be responsible for maintaining and which assets will be maintained by others – e.g. Melbourne Water).

Additional design information required for specific WSUD treatment asset types includes:

B. Bioretention systems

I. The calculations used to design the following components:
   - Saturated zone depth
   - Coarse sediment forebay (if applicable)
   - Inlet energy dissipation (if applicable)
   - Filter media scour check
   - Underdrainage system
   - Overflow pit
   - Outlet pipe
   - Overflow weir (if applicable)

II. The plant species and densities that will be planted in the filter bed and batters.

III. Details of the mulch to be used (if applicable)

C. Sediment ponds

I. The calculations used to size the sediment pond including:
   - Sediment pond basin (e.g. area and depth)
   - Connection between the sediment pond and high flow bypass (i.e. high flow bypass weir)
   - High flow bypass channel
   - The peak water levels above sediment pond and in surrounding reserve for 10 and 100 year ARI events, and the method and assumptions used to estimate them
   - Sediment dewatering area
   - Maximum flow velocities through sediment pond

II. A description of the updated MUSIC model, including matching:
   - The inlet pond volume in MUSIC to the sediment pond volume shown on plans (excluding the sediment accumulation volume)
   - The high flow bypass configuration to the design

   A description of how the sediment ponds can be dewatered during maintenance

D. Wetlands

IV. The calculations used to size each of the sediment pond and wetland components including:
   - The peak water levels above the wetland and in surrounding reserve for 5, 10 and 100 year ARI events, and the method and assumptions used to estimate them
   - Connection between the sediment pond and macrophyte zone
   - Macrophyte zone extended detention (e.g. controlled outlet)
   - Macrophyte zone overflow outlet
   - Maximum flow velocities through the macrophyte zone
   - The peak water levels above wetland and in surrounding reserve for 5, 10 and 100 year ARI events, and the method and assumptions used to estimate them

V. A description of the updated MUSIC model, including matching:
   - The inlet pond volume in MUSIC to the sediment pond volume shown on plans (excluding the sediment accumulation volume)
   - The high flow bypass configuration to the design

VI. If applicable, the plant species and densities that will be used in each zone.

VII. A summary of findings of geotechnical testing (full geotechnical report to be included as an appendix to the detailed design report). This summary must address:
   - Whether maximum groundwater level is within 0.5 m of the wetland base
   - Dispersiveness of soils
   - Whether wetland earthworks involve contaminated material and, if so, the required soil management approach and costs
   - Suitability of site soils to form an impervious wetland liner, for wetlands with a permanent pool
   - The likely infiltration rate from base of wetland, for ephemeral wetlands

VIII. A description of the updated MUSIC model, including matching:
   - The permanent pool volume to the proposed bathymetry (using the user defined stage-storage relationship)
   - The high flow bypass configuration to the design
   - The extended detention controlled outlet configuration to the design (using the user defined stage-storage relationship).

IX. An inundation frequency analysis of water levels in the macrophyte zone (refer to Melbourne Water Constructed Wetland Design Manual).

X. The 90th percentile residence time in the macrophyte zone (refer to Melbourne Water Constructed Wetland Design Manual).

XI. A table showing percentage of macrophyte zone (at NWL) that is in the following depth zones:
   - 0 to 150 mm below NWL
   - 150 to 350 mm below NWL
   - Greater than 350 mm below NWL

3) Scale plan(s) showing proposed surface levels (in m AHD) within the WSUD treatment asset and in the surrounding area (e.g. produced from earthworks model). The plan(s) must show lines indicating TED, NWL (wetlands), the edge of each planting zone, maintenance access tracks, sediment dewatering areas, any existing or proposed services within the treatment asset location and locations of any safety fencing. Note that the presence, alignment and estimate depth of any underground services must be based on physical site proving (unobtrusive testing using a detector is acceptable).

4) Indicative long section of WSUD treatment asset showing planting zones, topsoil, liner, peak 5,10 and 100 year ARI water levels (wetlands only) and the location and depth of any underground services.

5) Indicative long section of the high flow bypass.

6) Schematic dimensioned drawings with levels to “m AHD” of:
   - Inlet connections
   - Connection between the sediment pond and macrophyte zone (wetlands)

- Connection between the sediment pond and high flow bypass (wetlands)
- Sediment pond maintenance draw down outlet
- Macrophyte zone extended detention controlled outlet (including facility to temporarily lower the NWL by 150 mm)
- Outlet structures and connections
- Controlled outlet (wetlands)
- Connection of WSUD treatment asset outlet(s) to downstream drain/waterway (including the invert level of the outlet relative to the peak 1 year ARI water level in the downstream drain/waterway, and where applicable, the maximum high tide level (accounting for anticipated sea level rise))

7) Landscape concept plans for surrounding areas

8) Copy of supporting hydrologic, hydraulic and water quality models (e.g. MUSIC, RORB and HEC-RAS)

9) Civil and landscape construction drawings covering all aspects of the WSUD asset design including where applicable:
   - Dimensions and details for all hydraulic structures including inlets, pits, pipes, headwalls and weirs
   - Scour protection
   - Material for maintenance access tracks
   - Topsoil properties
   - Details of any fencing and signage

10) Civil and landscape specifications.

11) Details of establishment/maintenance to be undertaken in the first 24 months following construction (i.e. the practical completion period before the asset is transferred to Council).

12) A detailed maintenance plan outlining the ongoing maintenance requirements of the asset once handed over to Council.

13) Written approval from service authorities for any service alterations/relocations.

14) A summary of requirements of any Cultural Heritage Management Plan that relate to the WSUD asset construction.

The detailed design package will be reviewed by Council. Please note that some amendments may be required prior to detailed design acceptance.

The final detailed design package should include the following to be accepted:

- Detailed design report
- Final modelling files (MUSIC, RORB, HEC-RAS, TUFLOW etc)
- Detailed Design Plans, sections, schematic drawings, including civil and landscape construction drawings
- Letters of consent to works from other authorities, landowners agreeing to ownership, maintenance, works and/or downstream landowners.

The detailed design package is to be submitted in the following file formats:

Item	Format
Reports	Pdf
Models	MUSIC, RORB, HEC-RAS files
Plans	Pdf and dwg
Specifications	Pdf

References

CRC for Water Sensitive Cities (2015) Biofilter Adoption Guidelines V2. Monash University Clayton.

Melbourne Water and North West Growth Councils (2010) Design Construction & Maintenance of WSUD.

Melbourne Water and Wyndham City Council (2013) Water Sensitive Urban Design Guidelines Addendum Wyndham City Council.

E2DesignLab (2013) Bioretention in the West – Phase 1. Design for Sustained Health of Plants through Consideration of Soil Moisture Behaviour.

Local Government Infrastructure Design Association (2016) Infrastructure Design Manual.

Melbourne Water (2015) Constructed Wetland Manual.

Melbourne Water (2018) MUSIC Guidelines. Input parameters and modelling approaches for MUSIC users in Melbourne Water's Service area.

Water Technology (2015) Wyndham Stormwater Management Plan.

Wyndham City Council (2017) MUSIC Software Guidelines.

Appendix A: Plant species suitable for WSUD treatment assets

Bioretention systems:

Plant form	Scientific name	Common name	Filter bed ($<50\ m^2$)	Filter bed ($>50\ m^2$)	Batter
Grasses	*Amphibromus neesii*	Southern Swamp Wallaby-grass		✓	
	Amphibromus nervosus	Common Swamp Wallaby-grass	✓	✓	
	Imperata cylindrica	Blady Grass		✓	
	Lachnagrostis filiformis	Common Blown-grass		✓	
	*Poa labillardierei **	Common Tussock-grass	✓	✓	✓
	Poa morrisii	Soft Tussock-grass		✓	✓
	Poa poiformis	Coast Tussock-grass		✓	✓
	Poa sieberiana	Grey Tussock-grass		✓	✓
	Rytidosperma caespitosum	Common Wallaby-grass	✓	✓	
	Themeda triandra	Kangaroo Grass		✓	✓
Sedges/Rushes	*Carex appressa **	Tall Sedge	✓	✓	✓
	*Ficinia nodosa **	Knobby Club-sedge	✓	✓	
	Gahnia filum	Chaffy Saw-sedge	✓	✓	
	Gahnia sieberiana	Saw-sedge	✓	✓	
	Juncus amabilis	Hollow Rush	✓	✓	
	Juncus flavidus	Gold Rush	✓	✓	
	Juncus sarophorus	Broom Rush	✓	✓	
	Juncus semi-solidus	Pale Rush	✓	✓	
	Juncus subsecundus	Finger Rush	✓	✓	
	*Lepidosperma laterale **	Variable tall sedge	✓	✓	
	Lomandra filiformis	Wattle Mat-rush		✓	
	*Lomandra longifolia **	Spiny-headed Mat-rush	✓	✓	✓
	Lomandra longifolia var *'Tanika'*	Spiny-headed Mat-rush	✓		✓
Groundcovers	*Atriplex cinerea*	Coast Saltbush	✓	✓	✓
	Atriplex semibaccata	Berry Saltbush	✓	✓	✓

	Brachyscome dentata	Lobe-seed Daisy			✓
	Enchylaena tomentosa var. *tomentosa*	Ruby Saltbush	✓	✓	✓
	Myoporum parvifolium	Creeping Myoporum		✓	✓
	Goodenia ovata 'prostrate'	Prostrate Goodenia	✓	✓	✓
	Selliera radicans	Shiny Swamp-mat	✓	✓	
	Chrysocephalum apiculatum	Common Everlasting		✓	✓
	Cotula australis	Common Cotula	✓	✓	
	Craspedia glauca	Common Billy-buttons		✓	
	Einadia nutans	Nodding Saltbush	✓	✓	✓
Trees/Shrubs	*Acacia dealbata*	Silver Wattle		✓	✓
	Acacia melanoxylon	Blackwood		✓	✓
	Acacia paradoxa	Hedge Wattle		✓	✓
	Acacia pycnantha	Golden Wattle		✓	✓
	Banksia robur	Swamp Banksia		✓	✓
	Callistemon sieberi	River Bottlebrush		✓	✓
	Callistemon viminalis	Weeping Bottlebrush		✓	✓
	Cassinia longifolia	Shiny Cassinia		✓	✓
	Cassinia sp. aff. *arcuata*	Drooping Cassinia		✓	✓
	Casuarina glauca	Swamp Oak		✓	✓
	Bursaria spinosa	Sweet Bursaria		✓	✓
	Eucalyptus camaldulensis	River Red-gum		✓	
	Leptospermum obovatum	River Tea-tree		✓	✓
	Melaleuca linarifolia	Flax-leaved Paperbark		✓	
	Melaleuca viridifolia	Weeping Lily Pily		✓	
	Melicytus dentatus	Tree Violet		✓	✓
	Goodenia ovata	Hop Goodenia		✓	✓
	Leptospermum lanigerum	Woolly Tea-tree		✓	
	Rhagodia candolleana subsp. *candolleana*	Seaberry Saltbush	✓	✓	✓
	Rhagodia parabolica	Fragrant Saltbush		✓	✓

Constructed wetlands:

Planting zone	Scientific name	Common name	Comments
Macrophyte zone (350 mm above NWL to -700 mm depth)			
Ephemeral marsh	*Amphibromus nervosus*	Common Swamp Wallaby-grass	
(NWL + 350 mm)	*Baumea rubinginosa*	Soft Twig-rush	
	Brachyscome paludicola	Woodland Swamp-daisy	
	Carex appressa	Tall Sedge	
	Carex bichenoviana	Plains Sedge	
	Carex breviculmis	Common Grass-sedge	
	Carex inversa	Knob Sedge	
	Carex tereticaulis	Common Sedge	
	Craspedia paludicola	Swamp Billy-buttons	Near water edge
	Cyperus gunnii subsp. gunnii	Flecked Flat-sedge	Near water edge
	Cyperus lucidus	Leafy Flat-sedge	Near water edge
	Eragrostis infecunda	Southern Cane Grass	
	Eryngium vesiculosum	Prickfoot	
	Ficinia nodosa	Knobby Club-sedge	
	Isolepis inundata	Swamp Club-sedge	Near water edge
	Juncus amabilis	Hollow Rush	
	Juncus australis	Austral Rush	Near water edge
	Juncus flavidus	Gold Rush	
	Juncus holoschonoenus	Joint-leaf Rush	
	Juncus pallidus	Pale Rush	
	Juncus semisolidus	Plains Rush	
	Juncus subsecundus	Finger Rush	
	Lachnagrostis filiformis	Common Blown-grass	
	Lobelia anceps	Angled Lobelia	
	Lobelia pratioides	Poison Lobelia	
	Mentha australis	River Mint	Near water edge
	Persicaria decipiens	Slender Knotweed	Near water edge
	Poa labillardierei var. labillardierei	Common Tussock Grass	
	Poa labillardierei var. (Volcanic Plains)	Basalt Tussock Grass	

	Rumex bidens	Mud Dock	
	Rytidosperma semiannulare	Wetland Wallaby-grass	
Shallow marsh	*Alisma plantago-aquatica*	Water Plantain	Shallow water near water edge
(NWL – 150 mm)	*Bolboschoenus caldwellii*	Sea Club-sedge	
	Crassula helmsii	Swamp Crassula	Shallow water near water edge
	Eleocahris acuta	Common Spike-sedge	
	Marsilea drummondii	Common Nardoo	
	Schoenoplectus pungens	Sharp Club-sedge	Shallow water near water edge
	Schoenoplectus tabernaemontani	River Club-sedge	
Deep marsh	*Baumea articulata*	Jointed Twig-sedge	
(150 mm - 350 mm)	*Bolboschoenus caldwellii*	Sea Club-sedge	
	Bolboschoenus fluviatilis	Tall Club Rush	
	Bolboschoenus medianus	Marsh Club-sedge	
	Cycnogeton procera	Water Ribbons	
	Eleocharis sphacelata	Tall Spike-sedge	
	Schoenoplectus tabernaemontani	River Club-sedge	
Submerged marsh	*Potamogeton crispus*	Curly Pondweed	
(350 mm – 700 mm)	*Potamogeton ochreatus*	Blunt Pondweed	
	Potamogeton cheesmani	Small-fruit Pondweed	
	Myriophyllum crispatum	Upright Water milfoil	
	Myriophyllum salsugineum	Lake Water milfoil	
	Vallisneria australis	Ribbonweed	
Terrestrial zone (>350mm above NWL)			
- Grasses	*Austrostipa bigeniculata*	Tall Spear-grass	
	Austrostipa scabra	Spear-grass	
	Chloris truncata	Windmill Grass	
	Dianella revoluta	Black Anther Flax Lily	
	Dianella longifoila	Pale Flax Lily	
	Dianella brevicaulis	Small-flower Flax-lily	
	Dianella admixta	Spreading Flax-lily	
	Dicanthium sericeum	Silky Blue-grass	
	Dichelachne crinita	Long-hair Plume-grass	

	Gahnia filum	Chaffy Saw-sedge	
	Lomandra filiformis	Wattle Mat-rush	
	Lomandra longifolia	Spiny-headed Mat-rush	
	Microlaena stipoides	Weeping Grass	
	Rytidosperma caespitosum	Common Wallaby-grass	
	Rytidosperma duttonianum	Brown-back Wallaby-grass	
	Rytidosperma racemosum	Slender Wallaby-grass	
	Rytidosperma setaceum	Bristly Wallaby-grass	
	Themeda triandra	Kangaroo Grass	
- Herbs/Forbs	*Acaena novae-zelandiae*	Bidgee-widgee	
	Atriplex semibaccata	Berry Saltbush	
	Einadea nutans	Nodding Saltbush	
	Haloragis aspera	Rough Raspwort	
	Haloragis heterophylla	Varied Raspowort	
	Selliera radicans	Shiny Swamp-mat	
- Trees/Shrubs	*Acacia acinacea*	Gold-dust Wattle	
	Acacia implexa	Lightwood	
	Acacia mearnsii	Black Wattle	
	Acacia melanoxylon	Blackwood	
	Acacia paradoxa	Hedge Wattle	
	Acacia provincialis	Wirlida	
	Acacia pycnantha	Golden wattle	
	Acacia verniciflua	Varnish Wattle	
	Allocasuarina luehmannii	Buloke	Selected sites only
	Allocasuarina verticillata	Drooping Sheoak	
	Bursaria spinosa	Sweet Bursaria	
	Callistemon sieberi	River Bottlebrush	
	Correa glabra	Rock Correa	
	Dodonaea viscosa ssp. *spatulata*	Sticky Hop-bush	
	Eucalyptus baueriana ssp. *thalassina*	Werribee Blue Box	Selected sites only
	Eucalyptus camaldulensis	River Red Gum	
	Goodenia ovata	Hop Goodenia	

	Gynatrix pulchella	Hemp Bush	Ephemeral edge
	Leptospermum lanigerum	Woolly Tea-tree	Ephemeral edge
	Melicytus dentatus	Tree Violet	
	Melicytus sp.aff.dentatus	Volcanic plains Tree Violet	Selected sites only
	Melaleuca lanceolata	Moonah	
	Muehlenbeckia florulenta	Tangled Lignum	
	Myoporum insulare	Common Boobialla	Small numbers only to introduce diversity
	Rhagodia candoleana	Seaberry Saltbush	
	Rhagodia parabolica	Mealy Saltbush	
	Viminaria juncea	Native Broom	Ephemeral edge
	Solanum lanciniatum	Large Kangaroo Apple	