Chapter 22

Water Sensitive Design

22 Water Sensitive Design

22.1 Introduction

This Chapter contains Lismore City Council's requirements for the application of Water Sensitive Design (WSD) principles to developments in the Lismore local government area.

WSD is a multidisciplinary approach for integrating landuse and water management (water supply, stormwater, wastewater and groundwater) planning, with the aim of minimising the impacts of development on the natural water cycle. The main emphasis of this Chapter is stormwater management and water supply.

Development increases the area of impermeable surfaces (i.e. roads, buildings, driveways), leading to increases in the frequency, volume and magnitude of stormwater flows into natural waterways. Impermeable surfaces reduce the quantity of stormwater that can infiltrate into the soil, which results in an increase in stormwater runoff. The increase in stormwater runoff impacts on the natural water cycle and can lead to stream erosion, increased flooding, reduced groundwater recharge and increased pollution and sedimentation of waterways.

Improving water management in the design of developments, with particular emphasis on stormwater management, helps to protect aquatic ecosystems located both within the development and downstream. WSD seeks to ensure that developments are designed, constructed and maintained so as to minimise impacts on the natural water cycle.

Traditionally, stormwater management involved piped discharge from a site and the provision of stormwater detention for flood mitigation and drainage asset protection purposes. By contrast, contemporary management of the urban water cycle regards stormwater as a resource that can be reused and ensures appropriate treatment and attenuation of stormwater prior to discharge to receiving waterways.

WSD promotes a more decentralised approach to water management and gives greater emphasis to on-site collection, treatment and utilisation of water flows as part of an integrated 'treatment train'. WSD provides the opportunity for water management measures to achieve multiple objectives. For example, customised rainwater tanks can provide reuse and detention of stormwater, as well as benefits in regard to reducing reticulated water demand and reducing the frequency and pollutant load of stormwater discharge.

This Chapter sets bench marks for design and performance outcomes at the subdivision, street and lot scales. For the purposes of this Chapter, proposed land use changes are divided into two categories, namely 'developments' and 'subdivisions', and specific requirements for each category are provided. The provisions are designed to be applied to all developments and to be compatible with the Building Sustainability Index (BASIX).

22.2 Objectives

The objectives of this Chapter are:

1. To ensure that WSD techniques are incorporated in new developments.

2. To reduce the demand for reticulated water from the town water supply.

3. To ensure that stormwater discharged from new development minimises adverse impacts on the environment and receiving waters.

4. To utilise natural surfaces and landforms as stormwater flow paths and to allow for on-site treatment where suitable.

5. To ensure that water management is a key consideration in the urban design process to maximise opportunities for water reuse and ensure stormwater management infrastructure, in particular, is appropriately integrated with the site design.

6. To protect and restore aquatic ecosystems within the development site and downstream.

7. To ensure the function of the stormwater drainage and flood protection elements of designs are not compromised by incompatible or inappropriate WSD designs.

22.3 Applicability

This chapter applies to developments and subdivisions, unless otherwise excluded by this Chapter.

Developments

Developments may include residential development, commercial development, industrial development, tourist development, recreational development and car parks that have an impervious area greater than 300m².

Developments are classified as either minor development or major development for the purpose of this Chapter. Developments are required to satisfy the WSD performance criteria in Table 1 and meet the objectives of this Chapter.

For the purposes of this Chapter development is classified as follows:

Minor Development

- Development site area **less than** 2,500 m²; and
- Impervious area **greater than** 300 m².

Minor developments are required to satisfy the performance criteria in Table 1 by either implementing the 'deemed to comply' solutions, or preparing a Water Management Plan that demonstrates how the development satisfies the performance criteria in Table 1 and objectives of this Chapter.

Major Development

- Development site area **greater than** 2,500 m²; and
- Impervious area **greater than** 300 m².

Major developments are required to prepare a Water Management Plan that demonstrates how the development satisfies the WSD performance criteria in Table 1 and the objectives of this Chapter.

This chapter does not apply to the following developments:

- A single dwelling-house
- A dual occupancy development
- Development which creates an additional impervious area of less than 300 m^2.

If works that required consent have previously been conducted on a site without Council's consent, the area of unapproved works will be added to the area of the proposed works to determine the requirements for WSD associated with this Chapter.

Subdivisions

Subdivisions are required to:

1. Meet the performance criteria listed in Table 1 and the objectives of this Chapter, and

2. Be designed in accordance with the Northern Rivers Local Government Development and Design Manual.

This chapter does not apply to:

- Subdivision for residential purposes where the total land area is less than 2500 m^2
- Subdivision where no additional lots are created
- Strata subdivision
- Subdivision where no road works or drainage works are required

22.4 Performance Criteria

Developments and subdivisions are required to achieve the performance criteria specified in Table 1.

Table 1: Water Sensitive Design Performance Criteria

Component	Performance Criteria	Intent
Potable Water Consumption		
Reticulated water consumption for residential development	40% reduction in the consumption of reticulated water compared to baseline (to be consistent with BASIX)	Increase the level of water recycling, reduce the demand for reticulated water from the bulk water supply network, and help to alleviate the need for upgrades to bulk water infrastructure
Reticulated water consumption for all other development	40% reduction in the consumption of potable water for staff and customer facilities and outdoor use compared to baseline	
Stormwater Quality		
Total Suspended Solids	75% reduction in the mean annual load compared to baseline	Minimise the risk of water quality degradation in downstream waterways and thereby protect aquatic ecosystems
Total Phosphorus	65% reduction in the mean annual load compared to baseline	
Total Nitrogen	40% reduction in the mean annual load compared to baseline	
Gross Pollutants	90% reduction in the mean annual load compared to baseline	

Stormwater Quantity		
Flow rates (environmental protection)	Limit the post-development peak 1 year average recurrence interval (ARI) discharge from the site to the pre-development peak 1 year ARI discharge.	Reduce the likelihood of increased rates of bed and bank erosion and damage to benthic habitat in waterways
Flow rates (infrastructure protection)	Limit the post-development peak 10 year average recurrence interval (ARI) discharge from the site to the pre-development peak discharge for the same ARI and assess the capacity of existing flow paths to accommodate the post development 100 year average diversion of stormwater to a discharge location where the increased frequency of discharge will not have a detrimental impact on aquatic ecosystems. Reduce discharge from the site and provide necessary attenuation / infrastructure upgrade to ensure flow paths can accommodate anticipated flows.	Ensure that the development does not result in increased stormwater flows that exceed the capacity of the external stormwater drainage infrastructure and / or exacerbate overland flow problems

WSD measures constructed or approved as part of a broader scheme can be credited towards the achievement of the performance criteria for a subsequent development. For example, the design of an industrial subdivision may incorporate WSD measures designed to achieve the stormwater quality performance criteria based on an assumed impervious figure for the developed lots. The WSD measures implemented at the subdivision stage will be credited towards satisfying the performance criteria for the subsequent industrial development on the subject lot.

There may be circumstances in which there is no benefit in applying the Stormwater Quantity performance criteria listed in Table 1. In such instances, Council must agree that the relevant criteria are not applicable.

For some developments, particularly infill developments, it may be difficult to implement the WSD measures required to meet the performance criteria listed in Table 1. In these instances, Council may approve a request to adopt less stringent performance criteria where appropriate justification is provided eg. through MUSIC modelling.

Designs should aim to divert runoff from all impervious areas to the stormwater management device(s). If this cannot be achieved, Council may accept designs which allow runoff from a small portion of the impervious area to bypass the stormwater management device(s). However, the stormwater management device(s) must still be sized based on the whole development site area.

22.5 Suggested Solutions

22.5.1 Developments

Minor developments are required to meet the performance criteria specified in Table 1 by either:

- Implementing the relevant 'deemed to comply' solutions listed in Table 2 for Residential Developments or Table 3 for Other Developments; or
- Preparing a Water Management Plan that demonstrates how the development will meet the relevant performance criteria specified in Table 1.

Table 2: 'Deemed to Comply' Solutions – Residential Developments

Component	'Deemed to Comply' Solutions
Reticulated Water Consumption	Provide BASIX certificate with development application
Stormwater Quality	One, or a combination, of the following: ▪ Bioretention system(s), with a filter media area sized at 1.5% of the contributing catchment area. ▪ Constructed stormwater wetland(s), with a macrophyte zone area sized at 6.5% of the contributing catchment area. ▪ Proprietary stormwater treatment product that achieves the performance criteria.
Stormwater Quantity	Stormwater detention system designed to attenuate the 1 year ARI and 10 year ARI peak discharge to pre-development levels. NOTE: Most minor developments will require a stormwater detention system that has a volume equivalent to 4 – 5 L per m² of development site area.

Table 3: 'Deemed to Comply' Solutions – Other Developments

Component	'Deemed to Comply' Solutions
Reticulated Water Consumption	▪ Water efficient appliances and fittings - Water Efficiency Labeling and Standards (WELS) rating of a minimum of three stars. ▪ Rainwater tank(s) with a volume of 1.5 kL per toilet/urinal plus 0.05 kL per m² of irrigated landscaping. Tank(s) to be connected to 50 m² of roof area per toilet/urinal plus 2 m² per m² of irrigated landscaping (or the total roof area if this is less). NOTES: 1. Tank(s) must be connected to all toilets and water-using urinals and sufficient outdoor taps to serve the irrigated landscaping. 2. An appropriate mechanism is to be provided for automatically switching to the town water supply when the volume of water in the rainwater tank(s) is low.
Stormwater Quality	One, or a combination, of the following: ▪ Bioretention system(s), with a filter media area sized at 1.8% of the contributing catchment area. ▪ Constructed stormwater wetland(s), with a macrophyte zone area sized at 7% of the contributing catchment area. ▪ Proprietary stormwater treatment product that achieves the performance criteria.
Stormwater Quantity	Stormwater detention system designed to attenuate the 1 year ARI and 10 year ARI peak discharge to pre-development levels. NOTE: Most minor developments will require a stormwater detention system that has a volume equivalent to 4 – 5 L per m² of development site area.

Guidance on the design of the water sensitive design measures listed as 'deemed to comply' solutions in Table 2 is provided in Council's water sensitive design guidelines for minor developments.

Major developments require the preparation and implementation of a Water Management Plan that demonstrates how the development will meet the performance criteria specified in Table 1. Guidance on recommended water sensitive design measures and details to be included in the Water Management Plan are provided in Section 22.7 of this Chapter.

22.5.2 Subdivision

Subdivisions are required to be designed in accordance with the Northern Rivers Local Government Development and Design Manual and meet the objectives and performance criteria of this Chapter. All stormwater quality treatment devices for subdivisions are required to be sized to treat the 1 in 3 month rainfall event.

Subdivisions require the preparation of a Water Management Plan that demonstrates how the development will meet the performance criteria specified in Table 1. Section 22.6 provides guidance on recommended WSD measures. The details to be included in the Water Management Plan are provided in Section 22.7 of this Chapter.

Stormwater treatment devices that utilise soft engineering treatment solutions that can be contained within either existing or proposed public reserves are preferred. Treatment areas within private lands will be considered subject to registration of appropriate encumbrances upon the private land. All proposals should provide sufficient information to demonstrate that public safety, proposed infrastructure design levels and grades will fit within existing site contours, and proposed infrastructure can be maintained economically and feasibly. Solutions that propose the provision of publicly owned hard engineering treatment devices that can fail due to insufficient maintenance levels, or that require the use of specialist equipment for maintenance are generally not supported.

Residential Subdivision

Residential subdivisions must be designed in accordance with the Northern Rivers Local Government Development and Design Manual and include an allowance of 300 m^2 impervious area on each proposed residential lot to account for the likely impervious area associated with future residential development on the lots in addition to other constructed impervious areas such as roads. If this allowance is not representative of the proposed future residential development, the use of an alternative impervious area allowance should be discussed with Council.

Residential subdivision will incorporate WSD measures that are designed to achieve the stormwater performance criteria based on the assumption that a mixture of dwelling-houses and dual occupancies will be constructed on the residential lots. Therefore, the stormwater performance criteria can be considered to have already been satisfied for any subsequent dwelling-house or dual occupancy.

Industrial and Commercial Subdivision

Industrial and commercial subdivision must be designed in accordance with the Northern Rivers Local Government Development and Design Manual. The subdivision design must implement WSD measures for the roads and may incorporate broad WSD measures that account for the proposed future industrial or commercial development on the lots.

If the subdivision design only incorporates WSD measures for the roads, subsequent developments on the individual lots will be required to satisfy the stormwater performance criteria for industrial or commercial development.

If the subdivision design incorporates broad WSD measures based on a nominal figure of impervious area for the proposed future industrial or commercial development, the allowance will be credited toward satisfying the stormwater performance criteria for the subsequent development on the individual lots. A typical industrial or commercial development has an impervious area equal to at least 90% of the development site area.

22.6 Water Sensitive Design Measures

When preparing a Water Management Plan, the potential WSD measures that may be implemented, and methods for demonstrating compliance with the performance criteria, are listed in Table 4.

Guidance on the selection of appropriate WSD measures and their subsequent design, construction and establishment is provided in numerous industry publications, in particular the WSUD Technical Design Guidelines for South East Queensland.

With regard to treatment devices that will become public infrastructure, applicants are advised that due to public safety, maintenance and operational issues arising from some treatment solutions Council limits the array of treatment options that will be accepted as public infrastructure. It is recommended that prior to developing a Water Management Plan that proposes public infrastructure the designer contact Council to discuss requirements.

Table 4: Potential Water Sensitive Design Measures

Component	Potential Water Sensitive Design Measures	Method for Demonstrating Compliance
Reticulated Water Consumption	Appropriate combination of the following: ▪ Indigenous or low water use plants ▪ Water efficient appliances and fixtures ▪ Rainwater tank ▪ Stormwater tank ▪ On-site greywater system ▪ Recycled water supply	Water balance analysis using industry standard software, customised spreadsheet or other suitable means
Stormwater Quality	Appropriate combination of the following: ▪ Litter trap ▪ Gross Pollutant Trap (GPT) ▪ Bioretention system ▪ Vegetated swale ▪ Bioretention swale ▪ Sedimentation basin ▪ Constructed stormwater wetland ▪ Sand filter ▪ Porous pavement system ▪ Rainwater tank ▪ Stormwater tank ▪ Infiltration system ▪ Proprietary stormwater treatment product	Stormwater quality modelling using industry standard software
Stormwater Quantity	Appropriate combination of the following: ▪ Detention tank ▪ Detention basin ▪ Infiltration system	Hydrologic analysis using a runoff routing method

22.7 Requirements for Water Management Plans (WMPs)

Major Developments

Major developments require the preparation of a Water Management Plan. The Water Management Plan must demonstrate how the development or subdivision will meet the performance criteria specified in Table 1 and the objectives of this Chapter. The Water Management Plan must include the following information (where appropriate):

- **Site and catchment description** – site location, existing land use, available water supplies, description of broader catchment, surrounding land uses, soil types, hydrology, drainage characteristics, stormwater discharge locations, downstream waterways and any ecological habitats or species of particular significance.

- **Description of proposed development** – including proposed catchment plan with contours.

- **Summary of water sensitive design objectives / performance criteria**.

- **Reticulated water consumption** – water consumption assumptions, description of proposed water sensitive design measures, justification of selection, details of water balance analysis to demonstrate compliance.

- **Stormwater quality** – description of proposed water sensitive design measures, justification of selection, details of stormwater quality modelling to demonstrate compliance (including assumptions).

- **Stormwater quantity** – description of proposed water sensitive design measures, justification of selection, details of hydrologic analysis to demonstrate compliance (including assumptions).

- **Tailored ecological protection measures** – details of any strategies proposed to protect / enhance any identified ecological habitats or species of particular significance.

- **Responsibility** – specification of parties responsible for the supervision, construction, establishment / commissioning and ongoing maintenance of water sensitive design measures, including proposed methods for transferring responsibility for measures located on private property (if applicable).

- **Maintenance** – proposed maintenance regime for water sensitive design measures.

The information listed above is relevant to the water sensitive design aspects of the development. To consolidate the reporting process, designers and consultants may include other design information in the Water Management Plan. For example, it may be appropriate to include details of construction phase stormwater management (i.e. erosion and sediment control), flooding assessments, and wastewater management. Council officers can recommend appropriate documents to assist in the preparation of a Water Management Plan.

22.8 Definitions

Baseline - Refers to outcomes from a development scenario where no water sensitive design measures are implemented to improve or mitigate potential impacts of the development. The baseline is the “do nothing” or “business as usual” scenario.

BASIX – A web-based design tool that ensures residential developments meet the NSW Government's targets for reductions in water consumption and greenhouse gas emissions.

Bioretention system – A stormwater treatment system that utilises the natural filtering characteristics of soil and vegetation to remove pollutants from stormwater. Bioretention systems remain dry except during and immediately after rainfall.

Catchment – Area of land that contributes stormwater runoff to a specific location.

Coarse sediment – Sediment particles within the size range of 0.1 mm to 5 mm.

Constructed stormwater wetland – A densely vegetated wetland that is specifically designed to remove pollutants from stormwater. Constructed stormwater wetlands are permanently wet and typically have some open water zones.

Detention – The containment of runoff within a storage for relatively short periods to reduce peak flow rates. The volume of runoff that passes through the storage is relatively unchanged.

Detention basin – A reservoir or storage which temporarily contains stormwater runoff with the purpose of reducing peak flow rates.

Development site area – The area of the site of the proposed development.

Erosion and sediment control plan – A plan that specifies erosion and sediment control measures.

Impervious (or impermeable) surface – A surface that prevents infiltration of water into the ground. Impervious surfaces typically include roads, carparks, driveways, footpaths, roofs, paved areas and heavily compacted clay soils.

Infill Development – Development in an established urban area (e.g. town centre).

Irrigated landscaping – The area of landscaping (turf or garden) within the development site that is expected to require regular watering.

Non Reticulated water – Water that does not meet the requirements of drinking water as defined in the Australian Drinking Water Guidelines.

Nutrients – Substances that are needed by plants and animals for growth (e.g. nitrogen, phosphorus). In waterways, excessive quantities of nutrients can lead to degradation of water quality by promoting excessive growth, accumulation, and subsequent decay of plants, especially algae.

Porous pavement – A specially designed pavement that allows water to infiltrate through the pavement. Porous (permeable) pavements are typically constructed using either: (i) pavers that are physically shaped and/or arranged so that there are gaps between the pavers; (ii) pavers that allow water to pass through the paver itself (e.g. ‘no fines’ concrete pavers); or (iii) flexible or rigid pavements (e.g. asphalt or concrete) that are permeable.

Pervious (or permeable) surfaces – A surface that allows infiltration of water into the ground. Pervious surfaces typically include grassed or landscaped areas, parks, sporting fields and naturally vegetated areas (e.g. forests).

Reticulated water – Water that meets the requirements of drinking water as defined in the Australian Drinking Water Guidelines.

Riparian corridor – Riparian vegetation along a waterway network that provides linear habitat areas for fauna movement.

Riparian vegetation – Indigenous vegetation along the edge of a waterway that is part of the ecology of the waterway. This vegetation performs numerous functions including filtering runoff and providing habitat for fauna.

Rainwater Tank – A tank which collects roof water.

Roofwater – Water produced by rainfall onto the roof catchment of a building.

Runoff – The portion of rainfall that exceeds the infiltration capacity of the surface it has fallen onto and subsequently flows across the surface.

Sediment – Sediment is any particulate matter that can be transported by fluid flow and which eventually is deposited as a layer of solid particles on the bed or bottom of a body of water.

Stormwater – see Runoff.

Stormwater Tank – A tank which collects stormwater.

Water Management Plan (WMP) – A document, including relevant drawings, which describes how a proposed development will meet the performance criteria specified in this Chapter.

Water Sensitive Design
Technical Guidelines
for Minor Development

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Introduction

This document contains guidelines relating to water sensitive design measures for ‘minor development’, as defined in Lismore Development Control Plan (DCP): Part A – Chapter 22 Water Sensitive Design. These guidelines have been prepared to assist designers to ensure that development proposals meet Lismore City Council’s water sensitive design requirements.

1.1 Purpose

The purpose of this document is to provide guidance on the design, construction, establishment and maintenance of the water sensitive design measures listed as 'deemed to comply' solutions in Lismore DCP Chapter 22 – Water Sensitive Design. The water sensitive design measures covered in these guidelines are:

- bioretention systems;
- constructed stormwater wetlands; and
- stormwater detention systems.

The 'deemed to comply' solutions are only applicable to ‘minor developments’, as defined in Chapter 22 Water Sensitive Design. As such, the information provided in these guidelines is specifically tailored towards relatively small-scale water sensitive design measures. These guidelines should not be used to design larger water sensitive design measures for ‘major developments’. Council officers can recommend appropriate references for the design of ‘major developments’.

The ‘deemed to comply’ solutions presented in Lismore DCP Chapter 22 – Water Sensitive design represent standardised solutions that are acceptable to Council. It is anticipated that by adopting and implementing the ‘deemed to comply’ solutions, there will be cost savings due to the simplified design process. Standard drawings that assist to further simplify and expedite the design process are available from various organisations, including the South East Queensland Healthy Waterways Partnership (Water by Design program).

Designers and developers are not obliged to adopt and implement the 'deemed to comply' solutions. The alternative approach is to prepare a Water Management Plan (WMP), which describes how the proposed development will meet the relevant performance criteria specified in the DCP.

1.1.1 Note on rainwater tanks and proprietary stormwater treatment products

Rainwater tanks and proprietary stormwater treatment products are also listed as 'deemed to comply' solutions in Lismore Development Control Plan: Part A - Chapter 22 Water Sensitive Design. However, these measures are not covered in these guidelines.

Guidance on the design and installation of rainwater tanks is contained in Lismore City Council’s *Rainwater Tank Installation Guideline*.

The category of ‘proprietary stormwater treatment products’ includes an ever-changing range of commercially available products from numerous manufacturers / distributors. As such, it is not possible to provide comprehensive guidance on the design of these systems in this document. In any case, the relevant distributor should be contacted for up-to-date product information. Additional notes on proprietary stormwater treatment products are provided in Section 2.2.1

1.2 Structure

The following table provides a summary of the information provided in the subsequent sections of this document:

Table 1.1 Structure of Document

Section	Title	Description of Content
2	Selection of Water Sensitive Design Measures	General guidance regarding the key factors influencing the selection of WSD measures for a development site
3	Bioretention Systems	Guidance on the design, construction, establishment and maintenance of bioretention systems
4	Constructed Stormwater Wetlands	Guidance on the design, construction, establishment and maintenance of constructed stormwater wetlands
5	Stormwater Detention Systems	Guidance on the design of stormwater detention systems

1.3 Acknowledgements

Lismore City Council is grateful to the following organisations for the provision of text and images utilised in this document:

- Sydney Metropolitan Catchment Management Authority (Water Sensitive Urban Design in Sydney program)
- South East Queensland Healthy Waterways Partnership (Water by Design program)

2

Selection of Water Sensitive Design Measures

The sections below provide guidance on the selection of appropriate water sensitive design measures for ‘minor developments’, as defined in the WSD chapter of the DCP.

2.1 Reticulated Water Consumption

Rainwater tanks are the only water management measure specified as a 'deemed to comply' solution to meet the ‘reticulated water consumption’ performance criterion. Guidance on the design and installation of rainwater tanks is contained in Lismore City Council’s *Rainwater Tank Installation Guideline*.

2.2 Stormwater Quality

Three stormwater treatment devices have been specified as 'deemed to comply' solutions to meet the ‘stormwater quality’ performance criteria. These three devices are:

- bioretention systems;
- constructed stormwater wetlands; and
- proprietary stormwater treatment products.

Guidance on the design of bioretention systems and constructed stormwater wetlands is provided in this document. As mentioned in Section 1.1.1, proprietary stormwater treatment products are not covered in this document. However, some notes on proprietary stormwater treatment products are provided in Section 2.2.1.

There are opportunities for stormwater treatment devices to perform multiple functions. For example, bioretention systems and constructed stormwater wetlands can be landscape features as well as functional stormwater treatment devices. Similarly, most porous pavement systems (a type of proprietary stormwater treatment product) are specifically designed to be functional pavements. With appropriate design, some porous pavement systems can be utilised in areas with vehicular traffic, such as car parking areas.

Selection of the most appropriate stormwater treatment device for a particular development will be influenced by:

- availability of space on the site;
- landscape and site design objectives;
- slope of land; and
- level difference between the site and the water level at the stormwater discharge location in the receiving drainage system / waterway.

General guidance regarding each of these issues is listed below. Consideration of these issues in the context of an individual site should enable the designer to determine the most appropriate measure.

Space

In general, a proprietary stormwater treatment product will take up less space on a site than a bioretention system, which in turn will occupy less space than a constructed stormwater wetland. The total footprint of a bioretention system will typically be less than half that of a constructed stormwater wetland, assuming they are both sized to achieve the same level of stormwater treatment.

Landscape Objectives

A constructed stormwater wetland provides the best opportunity to create a landscape feature with a high level of amenity and ecological value, due to the ability to incorporate open water areas and a variety of vegetation types. Bioretention systems can also be designed as attractive landscape features and there is flexibility regarding overall shape and style. Proprietary stormwater treatment products are often located underground and, as such, do not enhance or detract from the landscape or site design. An exception to this is porous pavements, which can be designed to complement the overall site / landscape theme.

Slope

Flat sites pose a design challenge because once stormwater has been diverted into an underground pipe system, it can be very difficult to then bring the stormwater back to the surface and discharge onto a treatment device such as a bioretention system or a wetland. Therefore, on flat sites it may be appropriate to consider numerous devices spread throughout the site rather than a single lumped device. This allows stormwater to be treated on the surface before it is diverted to an underground pipe system. An alternative is to utilise a below-ground proprietary stormwater treatment product. Sloping sites are typically less constrained and support a variety of design solutions, although substantial earthworks may be required to create the flat pads required for bioretention systems or wetlands.

Level Difference

For the majority of stormwater treatment devices, the water level upstream of the device is higher than the water level downstream of the device. This is sometimes referred to as the head loss through the device. Bioretention systems typically require more head loss than a constructed stormwater wetland. However, the head loss through a bioretention system can be reduced if the system is designed to allow stormwater that has percolated down through the filter media to infiltrate into the underlying soil (refer to Section 3.2 for details). The head loss of proprietary stormwater treatment products varies greatly.

The implication for site design is that the greater the head loss through the stormwater treatment device, the greater the level difference needs to be between the site surface levels and the water level at the stormwater discharge location in the receiving drainage system / waterway. If this level difference is minimal, additional filling of the site may be required to allow the stormwater treatment device to function properly.

2.2.1 Note on proprietary stormwater treatment products

If a proprietary stormwater treatment product is proposed for a development, the following supporting information must be provided with the application:

- Brief description of how the product functions, including the pollutant removal mechanisms.
- Justification that the proposed system can meet the ‘stormwater quality’ performance criteria, including supporting documentation that presents the results of rigorous, independent scientific testing.
- Description of how the system has been sized, including any alterations to standard designs to account for local climatic conditions.
- Maintenance and renewal requirements.

At the time of writing this document, proprietary stormwater treatment products that may be capable of meeting the ‘stormwater quality’ performance criteria include the Enviss porous pavement system, StormFilter by Stormwater 360, Hydrofilter by Humes, and Filternator by Rocla. This is not an exhaustive list and the stormwater treatment performance of these products has not been assessed for compliance with the ‘stormwater quality’ performance criteria.

2.3 Stormwater Quantity

The 'deemed to comply' solution to meet the ‘stormwater quantity’ performance criteria is a stormwater detention system designed to attenuate the 1 year ARI and 10 year ARI peak discharges to pre-development levels. There are several types of stormwater detention systems that can be utilised on relatively small sites and these options are discussed in Section 5.

3

Bioretention Systems

3.1 Overview

Bioretention systems are commonly utilised throughout Australia to provide treatment of stormwater. Bioretention systems are also referred to as 'biofiltration systems' and 'rain gardens'. More specific terms such as 'bioretention basins', 'bioretention pods' and 'bioretention trenches' are sometimes used to describe bioretention systems of a particular shape and size. General information about bioretention systems can be found in water sensitive urban design guidelines and fact sheets produced by organisations such as the Facility for Advancing Water Biofiltration (FAWB), South East Queensland Healthy Waterways Partnership, NSW Department of Environment, Climate Change and Water, Brisbane City Council, Sydney Metropolitan Catchment Management Authority, and Melbourne Water.

3.2 Features

Bioretention systems consist of a flat vegetated area overlying a permeable soil layer that is typically 0.4 – 0.8 m deep. Stormwater that flows into the bioretention system is initially filtered through the densely planted surface vegetation. As the stormwater percolates down through the soil, pollutants are removed through fine filtration, adsorption and biological uptake. Key features of bioretention systems are shown in Illustration 1.1 and include:

- **Surface vegetation** – Typically native sedges, rushes and grasses.
- **Filter media** – Soil that has appropriate permeability (i.e. infiltration rate) and can sustain healthy vegetation. In general, suitable filter media comprises clean loamy sand with some organic matter.
- **High flow outlet(s)** – Pits, pipes or weirs to convey flows that exceed the infiltration capacity of the filter media.
- **Extended detention zone** – Bioretention systems are purposefully designed to allow temporary ponding of stormwater on the surface, typically to a depth of 200 – 400 mm. Stormwater that ponds in the extended detention zone ultimately infiltrates down through the filter media, rather than discharging via the high flow outlet(s). Therefore, the extended detention zone is located below the level of the high flow outlet(s). An additional 200 – 400 mm ponding depth is typically required above the level of the high flow outlet(s) to ensure efficient conveyance of stormwater in high flow events.
- **Bunds / Walls** – Earth bunds, concrete walls or some other means of containing ponded stormwater within the bioretention system.

If the in situ soils underlying the bioretention system are suitable, it may be appropriate to allow stormwater that has percolated down through the filter media to infiltrate into the underlying soil. If this approach is to be pursued, the saturated hydraulic conductivity (i.e. infiltration rate) of the underlying soil must be at least equivalent to the saturated hydraulic conductivity of the filter media. Groundwater levels must also be assessed and the bioretention system should be designed so that the base of the filter media is above the seasonal high groundwater level. In areas with shallow groundwater, it is recommended that the sides of the filter media be lined with an impermeable liner. The potential for localised groundwater mounding in the vicinity of the bioretention system should be assessed to ensure that no structures will be adversely affected.

If infiltration of stormwater into the underlying in situ soils is either inappropriate or undesirable, the following items need to be incorporated into the design of the bioretention system:

- **Under-drains** – Slotted PVC pipes at the base of the filter media that collect the filtered stormwater and convey this water to the outlet location.
- **Drainage layer** – A bedding layer of fine gravel in which the under-drains are laid.
- **Transition layer** – A layer of coarse sand to provide physical separation between the filter media and the drainage layer. The purpose of the transition layer is to prevent the filter media (loamy sand) being washed down into the drainage layer (fine gravel).

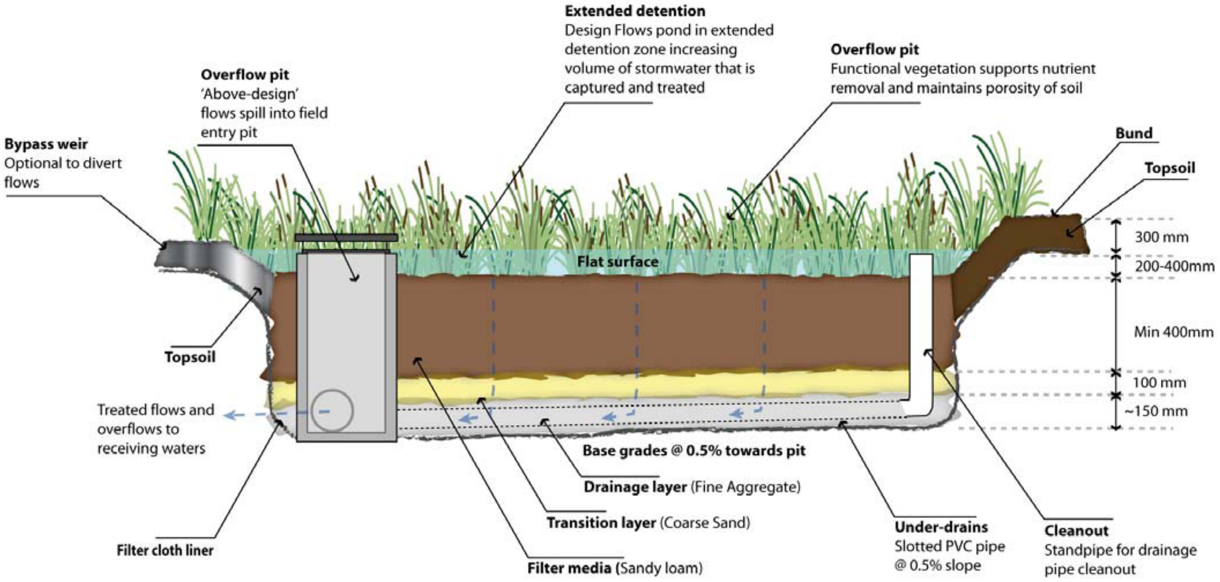

Illustration 1.1 **Typical cross section through a bioretention system (with under-drains)**
Illustration courtesy of South East Queensland Healthy Waterways Partnership (Water by Design program)

3.3 Design

Bioretention systems can be any shape and should be designed to complement the overall landscape and site design theme. For example, in a high density commercial zone it might be appropriate to have a bioretention system with straight edges, sharp corners and vertical walls. Conversely, in a residential setting with extensive landscaping, it might be appropriate to have a bioretention system with curved edges and gently sloping batters that are densely planted.

The following sections detail the steps that should be undertaken during the concept design phase and the subsequent detailed design phase. Concept design refers to the development of the initial site layout, which takes into account the opportunities and constraints of the site. Detailed design refers to the preparation of design drawings for submission to Council, either to support a development application or an application for a construction certificate.

3.3.1 Concept design phase

Given that a bioretention system will be a significant feature within the site layout, it is important that the bioretention system is appropriately considered during the concept design of the development. As a minimum, the following steps are recommended during the concept design phase:

1. Identify the location and level of the ultimate stormwater discharge location.
2. Identify a suitable location for the bioretention system (ensuring there is appropriate access for maintenance).
3. Determine the catchment area that will drain to the bioretention system.

4. Calculate the required size of the filter media area.
   As specified in the DCP:
   filter media area = 1.5 % of catchment area (residential development)
   filter media area = 1.8 % of catchment area (all other development)
5. Estimate the overall footprint of the bioretention system. Note: If the bioretention system will have sloping batters around the sides, the overall footprint of the system is likely to be 3 times the filter media area.
6. Ensure that the site layout allows sufficient area for the bioretention system.
7. Confirm that there is sufficient level difference for the bioretention system to function properly and drain freely after rainfall. Note: For bioretention systems with under-drains, the surface level of the bioretention system (i.e. top of filter media) typically needs to be at least 0.5 m above the normal water level in the receiving drainage system / waterway. Bearing in mind that the bioretention system needs to incorporate a ponding depth of at least 0.4 m (refer to description of 'extended detention zone' in Section 3.2), this means that there typically needs to be a level difference of at least 0.9 m between the minimum site surface level and the normal water level in the receiving drainage system / waterway. In some instances, stormwater drainage or flooding issues may dictate that this level difference needs to be even greater.

During the concept design phase, it may become apparent that a bioretention system is not an appropriate stormwater treatment system for the site. If this is the case, an alternative stormwater treatment system will need to be investigated.

3.3.2 Detailed design phase

The following table specifies the design requirements for the key features of a bioretention system.

Table 3.1 Design Requirements for Bioretention Systems

Feature	Design Requirement
Filter media area	1.5 % of catchment area (residential development) 1.8 % of catchment area (all other development)
Depth of filter media layer	400 mm (> 600 mm is preferable)
Depth of extended detention zone (i.e. depth of ponding below the level of the high flow outlet(s))	200 mm
Depth of transition layer (if applicable)	100 mm
Depth of drainage layer (if applicable)	150 mm
Type of under-drains (if applicable)	Slotted PVC pipes
Longitudinal grade of under-drains (if applicable)	0.5 %
Lateral offset between under-drains (if applicable)	1 m
Location of cleanout / inspection standpipes for under-drains (if applicable)	At the end of each under-drain and at each junction
Level of bunds / walls surrounding bioretention system	As required by stormwater drainage design

As a minimum, the following steps are recommended during the detailed design phase:

1. Confirm the size of the catchment area that will drain to the bioretention system.
2. Confirm the required size of the filter media area.
3. Design the layout of the bioretention system, including extent of filter media, location of outlets, extent of bunds / walls.
4. Determine whether under-drains are required or whether it is appropriate to allow infiltration into the underlying soil.
5. Set the key levels of the bioretention system ensuring that the minimum requirements are met (e.g. level of bunds / walls surrounding bioretention system, level of high flow outlet(s), top of filter media, transition layer, drainage layer, connection to outlet).
6. Prepare earthworks design of the bioretention system.
7. Design under-drains (if required) – layout, location of cleanout / inspection standpipes.
8. Design high flow outlet(s) – The design of the high flow outlet(s), including the pipes/ channels that connect to the ultimate discharge location, will typically be undertaken as part of the hydraulic design of the overall stormwater drainage system for the site. To simplify the hydraulic design process, infiltration of stormwater into the bioretention filter media can be ignored. The peak water level in the bioretention system will be determined during the hydraulic design and this will influence the required level of the bund or embankment surrounding the system.

The design drawings that accompany a development application or an application for a construction certificate should include the following information:

- **Drainage layout** – Information to be shown includes location of the bioretention system within the site layout, catchment boundaries (if applicable), drainage paths (surface and sub-surface), and connection to discharge location.
- **Bioretention system (plan view)** – Information to be shown includes extent of filter media, extent of surrounding bunds / walls, location of high flow outlet(s), key levels (e.g. surface level of filter media, level of high flow outlet(s), base levels), contours, maintenance access provision, layout of under-drains (if applicable).
- **Bioretention system (typical section)** – A typical section should be provided which shows the depth of each soil layer, key levels, details of surrounding bunds / walls etc.
- **Bioretention system (details & notes)** – Details are typically required for high flow outlet(s), headwalls, scour protection, and under-drains. Drawing notes should include construction advice and specifications for the soils and plants (refer to information below). In some instances, it may be more appropriate to include the plant specification on a separate landscape drawing.

3.3.2.1 Soil specification

The percolation of stormwater through the filter media soil layer is one of the key mechanisms for pollutant removal in a bioretention system. Therefore, it is critical that appropriate soil is utilised in the filter media layer. In general, the filter media should be clean loamy sand with an appropriately high permeability under compaction and should not be hydrophobic. The filter media should contain some organic matter for increased water holding capacity but be low in nutrient content.

Council officers may be able to recommend soil products from local soil suppliers that are suitable for use in the filter media layer. Alternatively, the following specification can be utilised:

> *The saturated hydraulic conductivity of the filter media is to be 200 – 400 mm/hr measured using the ASTM F1815-06 method. The filter media must also meet the filter media specifications detailed in the "Guidelines for Soil Filter Media in Bioretention Systems" published by the Facility for Advancing Water Biofiltration (FAWB). Refer to www.monash.edu.au/fawb for details.*

If a transition layer is required, it should consist of clean, well-graded coarse sand containing little or no fines. The average particle size should be approximately 1 mm.

If a drainage layer is required, it should consist of clean, fine gravel, such as 2-5 mm washed screenings.

3.3.2.2 Plant specification

The landscape architect / designer should prepare a planting plan or specification for the bioretention system, which complements the broader landscape design. Research needs to be undertaken to determine to determine the tolerance of different species to different depths of water.

The filter media area should be planted with native sedges, rushes and grasses. Depending on the species used a planting density of approximately 10 plants per square metre should be utilised. The following plants are considered to be suitable: *carex appressa; carex fasicularis; cyperus exaltatus; cyperus polystachyos; juncus usitatus; ficnia nodosa; pennisestum alopecuroides; lomandra longifolia; lomandra hystrix*. If earth bunds are utilised around the bioretention system, the lower portion of the batters should be planted with vegetation that can tolerate periodic inundation.

3.3.2.3 Safety issues

The design of a bioretention system needs to ensure public safety requirements are addressed through a risk based approach.

Fences or vegetation barriers to restrict access should be provided above vertical walls or steep embankments if:

- there is a risk of serious injury in the event of a fall.
- there is a high level of pedestrian or vehicular exposure (e.g. adjacent to footpaths / cycleways, playgrounds, sports fields).

Access to deep water (e.g. > 300 mm) should also be restricted through the utilisation of fences or vegetation barriers. As discussed in Section 3.2, bioretention systems are purposefully designed to allow temporary ponding of stormwater on the surface. The design of safety measures should take into account this temporary ponding.

If vegetation barriers are utilised to restrict access, plant species that are tall, dense and spiky will be the most effective. A temporary fence (e.g. sediment fence) will be required until the vegetation is sufficiently established to provide a physical barrier.

Where appropriate, signs should be provided to warn of deep and / or fast flowing water.

3.3.2.4 Designing to deter cane toads

The design of bioretention systems is to incorporate measures to discourage cane toads from breeding in these structures.

In order to breed in a waterbody, cane toads require easy access to the water's edge. A pond edge with a vertical, rather than sloping, profile can prevent cane toads from getting into and out of the water. Where a sloping pond edge is necessary, incorporating dense vegetation and low barrier fencing around the waterline, is an effective way to stop cane toads from accessing the water. It is desirable that these measures are installed as soon as practicable once construction is complete.

Densely planting the pond edge with native sedges, rushes and grasses will help to exclude cane toads, whilst providing habitat for native frogs and waterbirds. In order to form an effective toad barrier, the plants must be densely spaced and a minimum of three rows of planting installed directly adjacent to the waterline.

A cane toad exclusion fence (minimum 500mm in height) is to be installed behind the 3 rows of sedge planting. The fence is to be maintained until such time as the plants have matured enough to form an effective barrier. Suitable materials for cane toad exclusion fencing include shadecloth or sediment film supported by timber or metal stakes.

3.4 Construction and Establishment

Comprehensive guidance on the construction and establishment of bioretention systems is provided in the *Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands* (South East Queensland Healthy Waterways Partnership, Version 1 February 2009). Key issues associated with the construction and establishment process are summarised in the following sections.

3.4.1 Timing

Rainfall and the associated stormwater runoff can cause irreparable damage to a bioretention system during construction. In particular, sediment-laden inflows during the installation of the soil layers will typically require the installed soil layers to be completely removed and replaced. This highlights the importance of careful planning and efficient construction. The construction of a small bioretention system can be completed in a couple of days, so the risk of damage due to stormwater inflows can be minimised through appropriate planning and monitoring of weather forecasts.

3.4.2 Managing risk of damage during building construction phase

It is important to note that bioretention systems are designed to treat stormwater runoff from developed sites. They are not designed to be sediment and erosion control measures during the construction phase, although they can be temporarily modified to perform this function. Bioretention systems are quite robust to variations in stormwater inflows (both quantity and quality), but they can be damaged by inflows that contain unusually high concentrations of some pollutants, such as sediment or metals. This includes sediment-laden runoff from a typical building construction site. As such, there is a risk that the successful long term functioning of a bioretention system can be compromised by shock loads during the building construction phase.

The risk of damage to a bioretention system during the building construction phase needs to be managed by either:

- Delaying construction of the bioretention system until building construction is complete; or
- Initially establishing the bioretention system as a temporary shallow sediment basin.

If the first option is adopted, standard sediment and erosion control measures (e.g. sediment fences) need to be implemented across the site to protect downstream waterways.

The second option involves covering the surface of the filter media with a filter cloth or a 50 mm thick layer of coarse sand, and then placing a 25 mm thick layer of topsoil and turf over the top of the filter cloth / sand layer. Sediment fences should be installed around the perimeter of the filter media and the top of the batter to prevent sediment from being carried into the system by overland flow. The fences also prevent construction traffic from entering the system. In this form, the bioretention system can operate as a shallow sediment basin. The temporary protection measures remain in place until building construction is complete, at which time the filter cloth / sand layer, topsoil, turf, sediment fences and accumulated sediment can be removed. The bioretention system is then landscaped in accordance with the planting plan or specification.

3.5 Maintenance

Bioretention systems require ongoing inspection and maintenance to ensure they establish and operate in accordance with the design intent. Potential problems that may arise as a result of poor maintenance include:

- Decreased aesthetic amenity;
- Reduced treatment performance;

- Public health and safety risks; and
- Decreased habitat diversity (e.g. dominance of exotic weeds).

3.5.1 Plant establishment

Strong healthy vegetation plays a key role in maintaining the porosity and therefore the infiltration capacity of a bioretention system. The most intensive period of maintenance is during the plant establishment period (initial one to two years) when weed removal and replanting may be required.

Regular watering of bioretention system vegetation is essential for successful establishment and healthy growth. The frequency of watering to achieve successful plant establishment is dependent upon rainfall, maturity of planting stock and the water holding capacity of the soil. The following watering program is generally adequate, but should be adjusted to suit the site conditions:

- Week 1 - 6: 5 waterings/ week
- Week 6 - 10: 3 waterings/ week
- Week 11 - 15: 2 waterings/ week

In the absence of rain, it is recommended that each plant receives 2.5–5.0 litres of water per week during the first six weeks (40 mm of watering per week during establishment). After an initial four-month period, watering may still be required, particularly during the first winter / spring or dry period. Watering requirements for healthy vegetation can be determined by ongoing inspections.

3.5.2 General ongoing maintenance

Inflow pipes, headwalls, outlets and weirs require regular inspection, as these can be prone to scour and litter build up. Debris can block inlets or outlets and can be unsightly, particularly in highly visible areas. Inspection and removal of litter and debris should be done regularly.

Typical maintenance of a bioretention system involves:

- Routine inspection of the bioretention system to identify any areas of obvious increased sediment deposition, scouring from storm flows, rill erosion of the batters from lateral inflows, damage to the profile from vehicles and clogging of the bioretention system filter media (evident by prolonged ponding of water or a 'boggy' surface).
- Routine inspection of inlets, outlets and weirs to identify, clean and repair any areas of scour, litter build up and blockage.
- Removal of sediment where it is smothering vegetation and plant replacement if required.
- Repairing damage to the system profile resulting from scour, rill erosion or vehicle damage by replacement of appropriate fill (to match original soils) and revegetation.
- Tilling of the bioretention system surface, or removal and reinstatement of the surface layer, if there is evidence of clogging.
- Regular watering/irrigation of vegetation until plants are established and self sustaining.
- Removal and management of invasive weeds.
- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule.
- Pruning to remove dead or diseased vegetation and to stimulate growth.

Resetting (i.e. complete reconstruction) of the bioretention system will be required if the system fails to drain adequately after tilling of the surface and/or replacement of the surface layer. Regular inspections are required, as well as inspections following intense storm events to check for scour and other damage. Major maintenance involving machinery should only occur after a reasonably rain free period when the soil in the bioretention system is relatively dry.

3.6 Examples

Photos of bioretention systems are provided in the following plates.

Plate 1.1 Bioretention basin in a streetscape setting

Plate 1.2 Bioretention planter box

Photo courtesy of Sydney Metropolitan Catchment Management Authority (Water Sensitive Urban Design in Sydney program)

Plate 1.3 Bioretention basin with rock wall perimeter

Plate 1.4 Bioretention swale in the centre median of a road

Plate 1.5 Bioretention basin in medium density development
Photo courtesy of Sydney Metropolitan Catchment Management Authority (Water Sensitive Urban Design in Sydney program)

Plate 1.6 Bioretention pod in road
Photo courtesy of Sydney Metropolitan Catchment Management Authority (Water Sensitive Urban Design in Sydney program)

4

Constructed Stormwater Wetlands

4.1 Overview

Constructed stormwater wetlands are commonly utilised throughout Australia to provide treatment of stormwater. General information about constructed stormwater wetlands can be found in water sensitive urban design guidelines and fact sheets produced by organisations such as the Facility for Advancing Water Biofiltration (FAWB), South East Queensland Healthy Waterways Partnership, NSW Department of Environment and Climate Change, Brisbane City Council, Sydney Metropolitan Catchment Management Authority, and Melbourne Water.

4.2 Features

Constructed stormwater wetlands are relatively shallow, densely vegetated water bodies. As stormwater flows through a wetland, pollutants are removed through sedimentation, filtration, adhesion and biological uptake. Key features of wetlands are shown in Illustration 1.2 and include:

- **Inlet pond / sediment basin** – Relatively deep pond / basin located at upstream end of wetland that captures coarse sediment.
- **Macrophyte zone** – Shallow, densely vegetated area to remove fine particulates and soluble pollutants.
- **Vegetation** – Typically native reeds, sedges, and rushes.
- **Liner** – Compacted clay base or plastic liner to ensure wetland holds water.
- **High flow outlet(s) from inlet pond** – Pits, pipes, weirs and / or bypass channels to convey high flows from the inlet pond directly to the discharge location (i.e. high flows should bypass the macrophyte zone so that wetland plants are not damaged).
- **Low flow outlet from macrophyte zone** – Riser outlet (with associated pits and pipes) to control flow through the macrophyte zone and ensure the notional detention time is achieved.
- **Extended detention zone** – Wetlands are purposefully designed to allow additional ponding of stormwater above the normal water level, typically to a depth of 400 - 600 mm. Stormwater that temporarily fills this extended detention zone ultimately drains out via a low flow outlet. This extended detention zone is located below the level of the high flow outlet(s). An additional 200 – 400 mm ponding depth is typically required above the level of the high flow outlet(s) to ensure efficient conveyance of stormwater in high flow events.
- **Bunds / Walls** – Earth bunds, concrete walls or some other means of containing stormwater within the wetland.

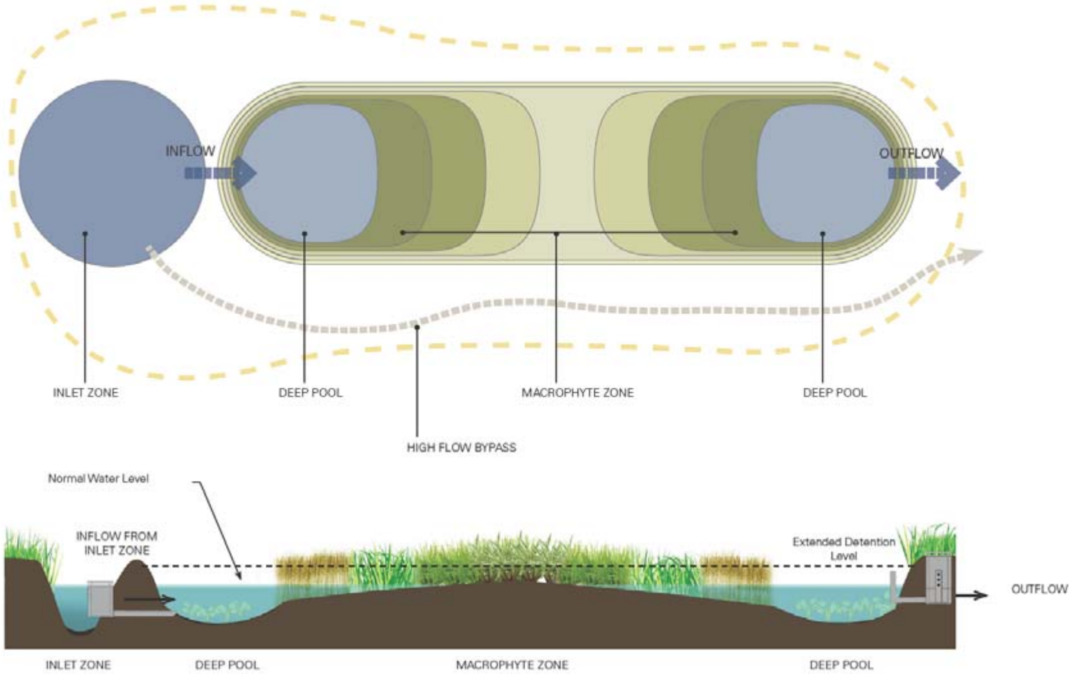

Illustration 1.2 **Typical plan and long section of a constructed stormwater wetland**
Illustration courtesy of South East Queensland Healthy Waterways Partnership (Water by Design program)

4.3 Design

There is considerable flexibility regarding the shape of constructed stormwater wetlands and they should be designed to complement the overall landscape and site design theme. For example, in a high density commercial zone it might be appropriate to have a wetland with straight edges, sharp corners and vertical walls. Conversely, in a residential setting with extensive landscaping, it might be appropriate to have a wetland with curved edges and gently sloping batters that are densely planted.

The following sections detail the steps that should be undertaken during the concept design phase and the subsequent detailed design phase. Concept design refers to the development of the initial site layout, which takes into account the opportunities and constraints of the site. Detailed design refers to the preparation of design drawings for submission to Council, either to support a development application or an application for a construction certificate.

4.3.1 Concept design phase

Given that a constructed stormwater wetland will be a significant feature within the site layout, it is important that the wetland is appropriately considered during the concept design of the development. As a minimum, the following steps are recommended during the concept design phase:

1. Identify the location and level of the ultimate stormwater discharge location.
2. Identify a suitable location for the wetland (ensuring there is appropriate access for maintenance).
3. Determine the catchment area that will drain to the wetland.
4. Calculate the required size of the macrophyte zone area.
   As specified in the DCP:
   macrophyte zone area = 6.5 % of catchment area (residential development)
   macrophyte zone area = 7.0 % of catchment area (all other development)

5. Estimate the overall footprint of the wetland. Note: If the wetland will have sloping batters around the sides, the overall footprint of the system is likely to be at least 2.5 times the macrophyte zone area.
6. Ensure that the site layout allows sufficient area for the wetland.
7. Confirm that there is sufficient level difference for the wetland to function properly. Note: The normal water level of the wetland typically needs to be at least 0.1 m above the normal water level in the receiving drainage system / waterway. Bearing in mind that the wetland needs to incorporate a ponding depth of at least 0.6 m (refer to description of 'extended detention zone' in Section 4.2), this means that there typically needs to be a level difference of at least 0.7 m between the minimum site surface level and the normal water level in the receiving drainage system / waterway. In some instances, stormwater drainage or flooding issues may dictate that this level difference needs to be even greater.

During the concept design phase, it may become apparent that a wetland is not an appropriate stormwater treatment system for the site. If this is the case, an alternative stormwater treatment system will need to be investigated.

4.3.2 Detailed design phase

The following table specifies the design requirements for the key features of a constructed stormwater wetland.

Table 4.1 Design Requirements for Constructed Stormwater Wetlands

Feature	Design Requirement
Volume of inlet pond (below normal water level)	0.01 m x catchment area (m^2)
Average depth of inlet pond	1.5 m
Macrophyte zone area	6.5 % of catchment area (residential development) 7.0 % of catchment area (all other development)
Length : width ratio of macrophyte zone	5 : 1 (minimum)
Depth of water in macrophyte zone (at normal water level)	Less than 0.5 m deep for at least 80 % of the area, with a mix of depths preferred. Ideally, there should be an even distribution of depths ranging from 0.5 m below the normal water level (NWL) to 0.2 m above the NWL. Open water zones should be restricted to 20 % of the area and need to be at least 1.0 m deep to discourage plant growth.
Slope of base of macrophyte zone	5 % (maximum)
Total depth of extended detention zone (i.e. depth of zone above the normal water level and below the level of the high flow outlet(s))	400 mm
Notional detention time (i.e. the time taken for water to pass through the wetland)	48 hr
Level of high flow outlet(s) from inlet pond	400 mm above NWL

Low flow outlet from macrophyte zone	Riser standpipe or plate designed to achieve 48 hr notional detention time for a range of extended detention depths from 0 – 400 mm
Topsoil	Silty or sandy loam topsoil to a depth of 300 mm (minimum) in all areas of the wetland that are less than 0.5 m below NWL (including all areas above NWL)
Liner	300 mm thick compacted clay liner (preferred) or suitable plastic liner
Level of bunds / walls surrounding wetland	As required by stormwater drainage design

As a minimum, the following steps are recommended during the detailed design phase:

1. Confirm the size of the catchment area that will drain to the wetland.
2. Confirm the required size of the macrophyte zone area.
3. Determine the required volume of the inlet pond and prepare concept design of pond geometry.
4. Design the layout of the wetland, including extent of macrophyte zone, location of outlets, location of inlet pond, extent of bunds / walls.
5. Set the key levels of the wetland ensuring that the minimum requirements are met (e.g. level of bunds / walls surrounding wetland, level of high flow outlet(s), normal water level, top of extended detention zone, base levels, connection to outlet).
6. Prepare earthworks design of the wetland.
7. Design connection between inlet pond and macrophyte zone – This connection should be capable of conveying the 1yr ARI peak flow.
8. Design low flow outlet from macrophyte zone – This outlet should comprise a riser standpipe or plate that has a series of orifice outlets spaced vertically over the 400 mm distance between the normal water level and the top of the extended detention zone. The orifices need to be designed so that the notional detention time of 48 hr is achieved for a range of depths above the normal water level (i.e. regardless of whether the wetland fills to a depth of 50, 100, 200, 300 or 400 mm above the normal water level after a rainfall event, the wetland will drain down to the normal water level in 48hr).
9. Design high flow outlet(s) – The design of the high flow outlet(s), including the pipes / channels that connect to the ultimate discharge location, will typically be undertaken as part of the hydraulic design of the overall stormwater drainage system for the site. The peak water level in the wetland will be determined during the hydraulic design and this will influence the required level of the bund or embankment surrounding the system.
10. Design maintenance drain – A mechanism needs to be provided to allow the wetland to be fully drained for maintenance purposes.

The design drawings that accompany a development application or an application for a construction certificate should include the following information:

- **Drainage layout** – Information to be shown includes location of the wetland within the site layout, catchment boundaries (if applicable), drainage paths (surface and sub-surface), and connection to discharge location.
- **Wetland (plan view)** – Information to be shown includes extent of macrophyte zone and inlet pond, extent of planting zones, extent of surrounding bunds / walls, location of high flow outlet(s), location of low flow outlet, key levels (e.g. normal water level, level of outlet(s), base levels), contours, maintenance access provision.

- **Wetland (longitudinal section)** – A longitudinal section, which extends from the inlet pond to the final discharge location, should be provided. Key levels and slopes should be noted on the long section.
- **Wetland (details & notes)** – Details are typically required for the high flow outlet(s), low flow outlet from macrophyte zone, connection between inlet pond and macrophyte zone, headwalls, and scour protection. Drawing notes should include construction advice and specifications for the liner, topsoils and plants (refer to information below). In some instances, it may be more appropriate to include the plant specification on a separate landscape drawing.

4.3.2.1 Plant specification

The landscape architect / designer should prepare a planting plan or specification for the wetland, which complements the broader landscape design. The wetland can be split into the following zones based on the water depth at the normal water level.

Table 4.2 Wetland Zones

Zone	Base Level relative to Normal Water Level (m)
Open Water & Transition Zone (if applicable)	> 0.50 m below NWL
Deep Marsh	0.35 to 0.50 m below NWL
Marsh	0.20 to 0.35 m below NWL
Shallow Marsh	0 to 0.20 m below NWL
Ephemeral Marsh	0 to 0.20 m <u>above</u> NWL
Batters (if applicable)	> 0.20 m <u>above</u> NWL

The following plants are considered to be suitable for the various wetland zones, but other species can be utilised if assessed as being suitable by a landscape architect / designer.

Table 4.3 Wetland Plants

Zone	Plant Species	Planting Density
Open Water & Transition Zone (if applicable)	No plants	-
Deep Marsh	*baumea articulata* *schoenoplectus validus* *bolboschoenus fluviatalis* *schoenoplectus litoralis*	6 plants / m^2
Marsh	*baumea rubiginosa* *schoenoplectus mucronatus* *baumea arthrophylla* *lepironia articulate*	6 plants / m^2
Shallow Marsh	*eleocharis equisetina* *juncus usitatus* *carex fasicularis* *cyperus exaltatus* *phylidrium lanuginosum*	8 plants / m^2
Ephemeral Marsh	*carex appressa* *ficnia nodosa* *juncus flavidus* *lepidosperma longitudinale*	8 plants / m^2

Batters (if applicable)	*lomandra longifolia* *cyperus polystachyos* *carex breviculmis* *gahnia siberiana*	8 plants / m^2

4.3.2.2 Safety issues

The design of a constructed stormwater wetland needs to ensure public safety requirements are addressed through a risk based approach.

Fences or vegetation barriers to restrict access should be provided above vertical walls or steep embankments if:

- there is a risk of serious injury in the event of a fall.
- there is a high level of pedestrian or vehicular exposure (e.g. adjacent to footpaths / cycleways, playgrounds, sports fields).

Access to deep water (e.g. > 300 mm) should also be restricted through the utilisation of fences or vegetation barriers. As discussed in Section 4.2, constructed stormwater wetlands are purposefully designed to allow additional ponding of stormwater above the normal water level, typically to a depth of 400 - 600 mm. The design of safety measures should take into account this temporary ponding.

If vegetation barriers are utilised to restrict access, plant species that are tall, dense and spiky will be the most effective. A temporary fence (e.g. sediment fence) will be required until the vegetation is sufficiently established to provide a physical barrier.

Where appropriate, signs should be provided to warn of deep and / or fast flowing water.

4.3.2.3 Designing to deter mosquitoes

To deter mosquitoes and minimise the risk of creating conditions that are conducive to mosquito breeding, the following approaches should be incorporated into the design:

- Incorporate a relatively deep open water zone to ensure there is still habitat for mosquito predators during relatively dry periods when the water level in the wetland drops.
- Design the bathymetry of the wetland so that water draws down evenly and isolated pools are avoided.
- Utilise relatively steep embankments (e.g. 1(v) : 3(h) or steeper). Note that this must not compromise public safety requirements.
- Implement measures to reduce the likelihood of litter accumulating in the wetland.
- Provide sufficient access for field personnel to monitor and treat mosquito larvae.

4.3.2.4 Designing to deter cane toads

The design of constructed wetlands is to incorporate measures to discourage cane toads from breeding in these structures.

In order to breed in a waterbody, cane toads require easy access to the water's edge. A pond edge with a vertical, rather than sloping, profile can prevent cane toads from getting into and out of the water. Where a sloping pond edge is necessary, incorporating dense vegetation and low barrier fencing around the waterline, is an effective way to stop cane toads from accessing the water. It is desirable that these measures are installed as soon as practicable once construction is complete.

Densely planting the pond edge with native sedges, rushes and grasses will help to exclude cane toads, whilst providing habitat for native frogs and waterbirds. In order to form an effective toad barrier, the plants must be densely spaced and a minimum of three rows of planting installed directly adjacent to the waterline.

A cane toad exclusion fence (minimum 500mm in height) is to be installed behind the 3 rows of sedge planting. The fence is to be maintained until such time as the plants have matured enough to form an effective barrier. Suitable materials for cane toad exclusion fencing include shadecloth or sediment film supported by timber or metal stakes.

4.4 Construction and Establishment

Comprehensive guidance on the construction and establishment of wetlands is provided in the *Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands* (South East Queensland Healthy Waterways Partnership, Version 1 February 2009). Key issues associated with the construction and establishment process are summarised in the following sections.

4.4.1 Timing

Rainfall and the associated stormwater runoff can cause significant damage to a wetland during construction. This highlights the importance of careful planning and efficient construction. The construction of a small wetland can be completed in a week, so the risk of damage due to stormwater inflows can be minimised through appropriate planning and monitoring of weather forecasts.

4.4.2 Managing risk of damage during building construction phase

It is important to note that wetlands are designed to treat stormwater runoff from developed sites. They are not designed to be sediment and erosion control measures during the construction phase, although they can be temporarily modified to perform this function. Wetlands are quite robust to variations in stormwater inflows (both quantity and quality), but they can be damaged by inflows that contain unusually high concentrations of some pollutants, such as sediment or metals. This includes sediment-laden runoff from a typical building construction site. As such, there is a risk that the successful long term functioning of a wetland can be compromised by shock loads during the building construction phase.

The risk of damage to a wetland during the building construction phase needs to be managed by either:

- Delaying construction of the wetland until building construction is complete; or
- Initially closing (or not installing) the connection between the inlet pond and the macrophyte zone so that all stormwater flows bypass the macrophyte zone.

If the first option is adopted, standard sediment and erosion control measures (e.g. sediment fences) need to be implemented across the site to protect downstream waterways.

The second option involves utilising the inlet pond as a sediment basin during the construction phase. The macrophyte zone can be constructed and planted in the early stages of site construction, but then needs to be isolated so that it does not receive heavily polluted stormwater flows during the building construction phase. The wetland design will include a high flow outlet from the inlet pond and this will be the sole outlet during the construction phase (i.e. the low flow outlet from the macrophyte zone will not operate).

4.5 Maintenance

Wetlands require ongoing inspection and maintenance to ensure they establish and operate in accordance with the design intent. Potential problems that may arise as a result of poor maintenance include:

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

4.5.1 Plant establishment

Strong healthy vegetation plays a key role in maintaining the treatment performance of a wetland. The most intensive period of maintenance is during the plant establishment period (initial one to two years) when weed removal and replanting may be required.

To maximise the chances of successful establishment of vegetation, it may be necessary to manipulate the water level of the wetland in the early stages of vegetation growth. When first planted, vegetation in the marsh zones may be too small for their prescribed water depths. Seedlings intended for inundated zones should ideally have half their stem height above water level, and must not have any less than one-third of their stem above the water level. If planting stock is immature, this may not be possible without manipulating the water levels.

The water depth can be controlled by manipulating the connection between the inlet zone and the macrophyte zone, as well as the maintenance outlet. If necessary, the water level in the wetland can be lowered to approximately 300 mm below the normal water level for at least the first 6–8 weeks. The normal water level can be established when it is clear the wetland plants have matured to the point where at least half of the stem is above the normal water level.

Regular watering of wetland vegetation is essential for successful establishment and healthy growth. The frequency of watering to achieve successful plant establishment is dependent upon rainfall, maturity of planting stock and the water holding capacity of the soil. The following watering program is generally adequate, but should be adjusted to suit the site conditions:

- Week 1 - 6: 5 waterings/ week
- Week 6 - 10: 3 waterings/ week
- Week 11 - 15: 2 waterings/ week

In the absence of rain, it is recommended that each plant receives 2.5–5.0 litres per week during the first six weeks to retain a muddy substrate (40 mm of watering per week during establishment). After an initial four-month period, watering may still be required within the ephemeral zones of the wetland and on the batters, particularly during the first winter / spring or dry period.

4.5.2 General ongoing maintenance

Inflow pipes, headwalls, outlets and weirs require regular inspection, as these can be prone to scour and litter build up. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of litter and debris should be done regularly.

Typical maintenance of a wetland involves:

- Desilting of the inlet pond once sediment has accumulated to a depth of approximately 0.5 m.
- Routine inspection of the wetland to identify any areas of obvious increased sediment deposition, scouring from storm flows, litter build up and blockages.
- Routine inspection of inlets, outlets and weirs to identify, clean and repair any areas of scour, litter build up and blockage.

- Repairing damage to the wetland profile resulting from scour or rill erosion by replacement of appropriate fill and revegetation.
- Removal of sediment and litter where it is smothering the vegetation.
- Regular watering/irrigation of vegetation until plants are established and self sustaining.
- Removal and management of invasive weeds.
- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule.
- Pruning to remove dead or diseased vegetation and to stimulate growth.

Regular inspections are required, as well as inspections following intense storm events to check for scour and other damage. Major maintenance involving machinery should only occur after a reasonably rain free period when the wetland is relatively dry.

4.6 Examples

Photos of constructed stormwater wetlands are provided in the following plates.

Plate 1.7 Constructed stormwater wetland in a residential setting

Plate 1.8 Constructed stormwater wetland with boardwalk
Photo courtesy of South East Queensland Healthy Waterways Partnership (Water by Design program)

Plate 1.9 Constructed stormwater wetland in urban park setting
Photo courtesy of Sydney Metropolitan Catchment Management Authority (Water Sensitive Urban Design in Sydney program)

5

Stormwater Detention Systems

5.1 Overview

The development of a site typically involves an increase in the area covered by impervious surfaces, as well as the introduction of an efficient stormwater drainage system to collect and convey runoff from the site. For a given storm event, the combination of these factors typically leads to a larger volume of stormwater being discharged from the site, with a higher peak flowrate, compared to the pre-development situation.

The purpose of stormwater detention systems is to control the flowrate at which stormwater is discharged from a site. The objective is usually to ensure that the peak flowrate in the post-development situation is no greater than the pre-development situation. This is achieved by temporarily detaining stormwater within a storage, which incorporates a restricted (or 'choked') outlet, so that the peak rate of outflow from the storage is lower than the peak rate of inflow. A stormwater detention system is designed to meet the detention objective for a specific theoretical design storm (e.g. 100yr ARI storm event of 1hr duration), or a range of design storms.

There are three main reasons why a reduction in the peak flowrate to pre-development levels may be desirable for a specific development site:

- **Ecological protection** – Reduce the likelihood of increased rates of bed and bank erosion and damage to benthic habitat in waterways located downstream of the site.
- **Infrastructure management** – Ensure that the capacity of existing stormwater drainage infrastructure is not exceeded.
- **Flood protection** – Ensure that the flood risk is not exacerbated in any other locations.

The selection of the design storm events that should be managed by a stormwater detention system is influenced by which of the above items is being addressed. Smaller design storm events (i.e. < 1yr ARI) are generally most critical for ecological protection. In most instances, detention of larger storm events will have minimal benefit with regard to ecological protection. The design storm events of most importance for infrastructure management are dependent on the design standards of the relevant infrastructure. Most stormwater drainage infrastructure within the Lismore LGA is designed for the 10yr or 20yr ARI storm event, with some large structures designed for the 50yr ARI storm event. Detention of stormwater for flood protection purposes typically needs to consider a range of design storm events (e.g. 5, 10, 20, 50 and 100yr ARIs).

Council has decided that for 'minor developments', as defined in the WSD chapter of the DCP, it is sufficient to provide detention of stormwater for the 1yr and 10yr ARI design storm events.

5.2 Features

A stormwater detention system includes two key features:

- **Storage** – To temporarily contain stormwater runoff.
- **Choked outlet** – To ensure that the peak flowrate out of the storage meets the detention objective (i.e. is less than or equal to the peak flowrate for the pre-development situation).

Aside from these features, there is considerable flexibility regarding the type, shape and style of a stormwater detention system. Options for providing the storage include tanks (above or below ground), earth basins, and bunded car parking areas. However, Council does not support the utilisation of permanently wet detention basins (i.e. the basin must fully drain after a rainfall event).

There are also options with regard to the choked outlet, including orifice plates, choke pipes and weirs. It is possible to design bioretention systems (refer to Section 3) and constructed stormwater wetlands (refer to Section 4) so that they perform the dual functions of stormwater treatment and stormwater detention.

5.3 Design

The 'deemed to comply' solution for stormwater quantity, as stated in the WSD chapter of the DCP, is to provide a stormwater detention system designed to attenuate the 1yr ARI and 10yr ARI peak discharges to pre-development levels. This document provides guidance on the sizing of the required storage volume and the sizing of the choked outlet to achieve this outcome. However, this document does not specify additional design requirements for stormwater detention systems. The *Northern Rivers Local Government Development & Design Manual* provides guidance regarding the design of specific types of detention systems (e.g. basins). The design procedure outlined in the following sections is only applicable to 'minor developments', as defined in the WSD chapter of the DCP, and must not be applied to larger development sites.

5.3.1 Storage volume

The storage volume will be dictated by the requirements for the 10yr ARI storm event. The storage volume should be calculated as follows.

10yr pre-development peak discharge

1. Determine the roof area (Ar), paved area (Ap) and pervious (e.g. vegetated) area (Av) in the pre-development scenario *(units: m^2)*.
2. Obtain the rainfall intensity (${}^{5min}I_{10}$) for a 10yr ARI design storm, with a duration of 5 min, for the location of the development *(units: mm/hr)*.
3. Calculate the peak discharge in the pre-development scenario as follows:

   Q_{10} (pre-dev) = (Ar + 0.9 . Ap + 0.6 . Av) . ${}^{5min}I_{10}$ / 3600 *(units: L/s)*

10yr post-development peak discharge

4. Calculate the peak discharge for the post-development scenario using the equation listed in step 3 utilising the roof area (Ar), paved area (Ap) and pervious area (Av) in the post-development scenario.

10yr storage volume

5. Calculate the storage volume as follows:

   10yr storage volume = [Q_{10} (post-dev) - Q_{10} (pre-dev)] . 300 *(units: L)*

5.3.2 Low level outlet

The low level outlet needs to be designed to ensure the post-development peak discharge in the 1yr ARI storm event equals the pre-development discharge. The low level outlet needs to be located at the bottom of the storage volume so that the storage fully drains after a storm event. The outlet should be sized as follows.

1yr pre-development peak discharge

6. Obtain the rainfall intensity (${}^{5min}I_1$) for a 1yr ARI design storm, with a duration of 5 min, for the location of the development *(units: mm/hr)*.
7. Calculate the peak discharge for the pre-development scenario using the following equation with the pre-development areas (refer step 1):

   Q_1 (pre-dev) = (Ar + 0.9 . Ap + 0.5 . Av) . ${}^{5min}I_1$ / 3600 *(units: L/s)*

1yr post-development peak discharge

8. Calculate the peak discharge for the post-development scenario using the equation listed in step 7 utilising the roof area (Ar), paved area (Ap) and pervious area (Av) in the post-development scenario.

1yr storage volume and water level

9. Calculate the storage volume as follows:

   1yr storage volume = [Q_1 (post-dev) - Q_1 (pre-dev)] . 300 *(units: L)*

10. Based on the geometry of the storage, determine the water level in the storage when the volume of stored water equals the 1yr storage volume.

Low level outlet

11. Select the type of low level outlet (e.g. orifice plate, choke pipe). Using the appropriate formula for the type of outlet and the water level determined in step 10, calculate the size of the outlet to achieve the required discharge - i.e. Q_1 (pre-dev). Additional guidance is provided in Appendix E of the *Northern Rivers Local Government Development & Design Manual*.

5.3.3 High level outlet

A high level outlet will typically be required to ensure the post-development peak discharge in the 10yr ARI storm event equals the pre-development discharge. The high level outlet needs to be located above the water level in the storage when the volume of stored water equals the 1yr storage volume. The outlet should be sized as follows.

12. Calculate the discharge through the low level outlet when the storage volume is full (i.e. at the 10yr water level). If the discharge through the low level outlet exceeds the pre-development 10yr ARI peak discharge, the storage volume and / or low level outlet must be reconfigured to ensure this is not the case. In most instances, the utilisation of a weir as the low level outlet will be problematic and will not lead to the most efficient design.
13. Determine the required discharge through the high level outlet as follows:

    Q_{10} (high level discharge) = Q_{10} (pre-dev) – Q_{10} (low level discharge)

14. Select the type of high level outlet (e.g. orifice plate, choke pipe, weir) and the level of the outlet. Using the appropriate formula for the type of outlet, calculate the size of the outlet to achieve the required discharge, as calculated in step 13.

5.3.4 Overflow

The high level outlet designed in the preceding section may not be capable of conveying flows that exceed the 10yr ARI peak flow. As such, it may be necessary to provide an additional overflow, typically a pipe or weir, which can accommodate larger flows up to and including the 100yr ARI peak flow.

5.3.5 Safety issues

The design of a stormwater detention system needs to ensure public safety requirements are addressed through a risk based approach.

Fences or vegetation barriers to restrict access should be provided above vertical walls or steep embankments if:

- there is a risk of serious injury in the event of a fall.
- there is a high level of pedestrian or vehicular exposure (e.g. adjacent to footpaths / cycleways, playgrounds, sports fields).

Access to deep water (e.g. > 300 mm) should also be restricted through the utilisation of fences or vegetation barriers. Some stormwater detention systems are specifically designed to allow temporary ponding of stormwater on the surface. The design of safety measures should take into account this temporary ponding.

If vegetation barriers are utilised to restrict access, plant species that are tall, dense and spiky will be the most effective. A temporary fence (e.g. sediment fence) will be required until the vegetation is sufficiently established to provide a physical barrier.

Where appropriate, signs should be provided to warn of deep and / or fast flowing water.

References

Northern Rivers Local Government, (2006). *Northern Rivers Local Government Development & Design Manual*.

South East Queensland Healthy Waterways Partnership, (2006). *Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland.* Version 1 June 2006.

South East Queensland Healthy Waterways Partnership, (2009). *Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands.* Version 1 February 2009.