

## Policy 11: Land Development Guidelines

### Section 13 – Water Sensitive Urban Design (WSUD) Guidelines

#### 13.0 Introduction



#### Table of Contents

13.0	Introduction .....	1
13.0.1	Background .....	2
13.0.2	Purpose of the Guidelines.....	3
13.0.3	Structure and Use of these Guidelines .....	3
13.0.3.1	How Applicants can Use the Guidelines.....	4
13.0.3.2	How Council will Use the Guidelines .....	5
13.0.4	Summary of WSUD Elements Covered in Detailed Design .....	6
13.0.4.1	Swales (incorporating Buffer Strips) .....	6
13.0.4.2	Bioretention Swales .....	7
13.0.4.3	Sedimentation Basins .....	8
13.0.4.4	Bioretention Basins .....	8
13.0.4.5	Constructed Wetlands.....	9
13.0.4.6	Infiltration Measures.....	10
13.0.4.7	Sand Filters .....	11
13.0.4.8	Aquifer Storage and Recovery.....	11
13.0.4.9	Porous Paving.....	11
13.0.4.10	Pretreatment Devices .....	12
13.0.5	References.....	12

## 13.0.1 Background

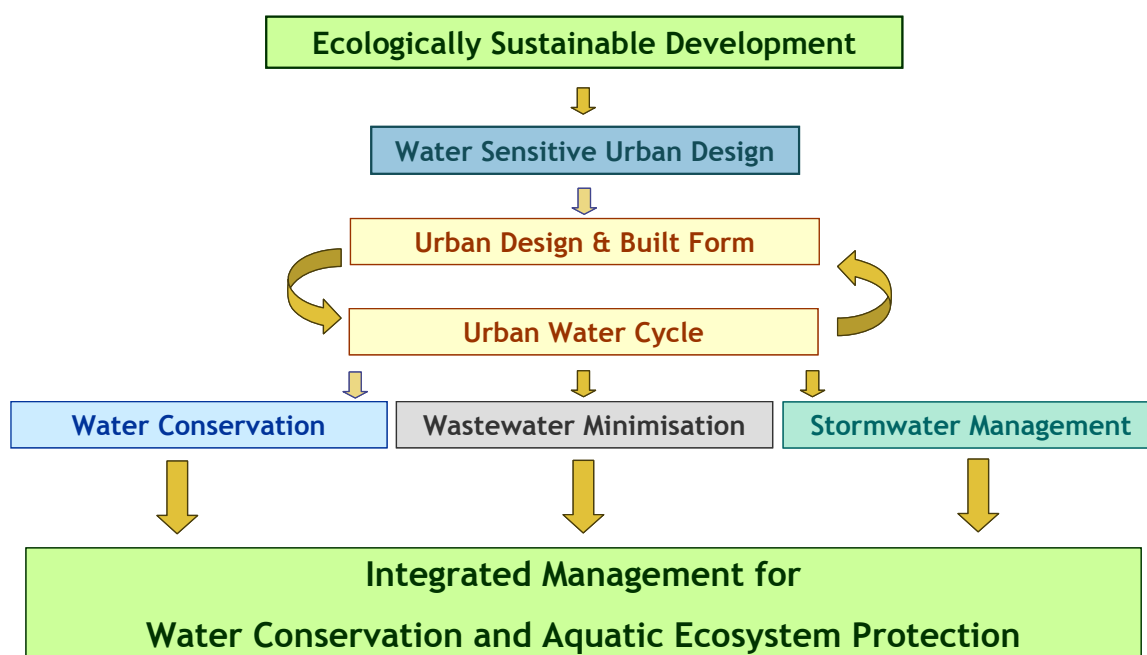
Traditional water cycle management has generally followed the principle of efficiently moving water, including stormwater and wastewater, away from urban areas directly to receiving waters including freshwater, estuarine and marine environments. Generally this involved little or no treatment or detention, resulting in significant impacts on the health of receiving environments as a result of the changes to the character of runoff and discharges in volume, velocity, physical and chemical properties.

Gold Coast City is one of South East Queensland's most rapidly growing areas. With increasing development pressure and population growth in the City, continued implementation of traditional urban water systems will result in increased pressure on natural water systems and degradation to Gold Coast waterways and beaches. Compounding these issues are drought conditions which have created issues in the delivery and assurance of a sustainable water supply.

Over the last decade, there have been an increasing number of initiatives to manage the urban water cycle in a more sustainable way. These initiatives are underpinned by sustainability principles of water conservation, waste minimisation and environmental protection. Integration of urban water cycle management with urban planning and design is known as Water Sensitive Urban Design (WSUD). WSUD is a holistic approach to the planning and design of urban development that aims to minimise negative impacts on the natural water cycle and protect the health of aquatic ecosystems. It promotes the integration of stormwater, water supply and wastewater management at the development scale (refer to **Figure 13.0-A**). This figure shows how WSUD integrates the elements of the urban water cycle with both the urban design and built form components of land developments. To this end, WSUD requires careful consideration of the urban water cycle at the land use planning stage to ensure all possible opportunities for application of best practice water cycle management solutions can be realised.

The key principles of WSUD are to:

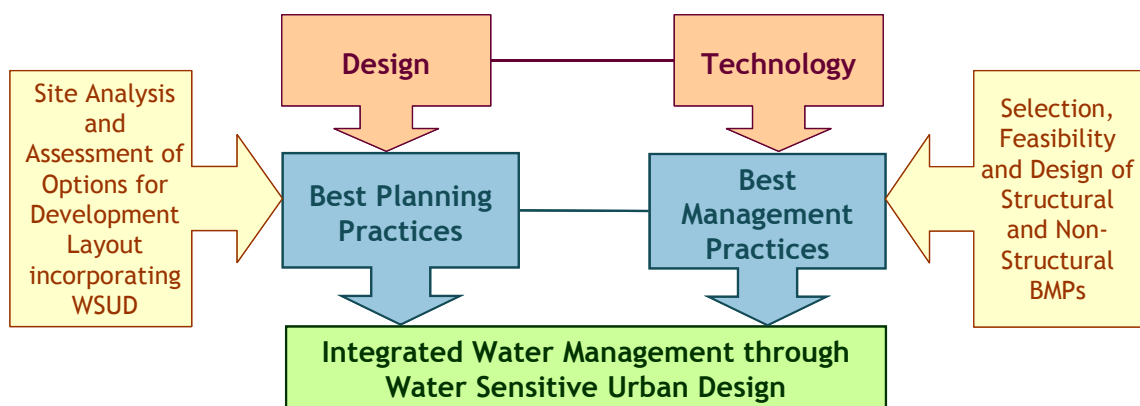
- protect existing natural features and ecological processes;
- maintain the natural hydrologic behaviour of catchments;
- protect water quality of surface and ground waters;
- minimise demand on the reticulated water supply system;
- minimise sewage discharges to the natural environment;
- integrate water into the landscape to enhance visual, social, cultural and ecological values.



Source: Adapted from Ecological Engineering 2003 in Engineers Australia 2006

**Figure 13.0-A: Links between WSUD, the Urban Water Cycle and ESD**

WSUD promotes innovative integration of urban water management technologies into an urban environment. It requires strategic planning and concept designs, underpinned by sound engineering practices in design and construction. For WSUD to be effectively incorporated into urban development, Best Planning Practices (BPP) and Best Management Practices must be applied in line with **Figure 13.0-B**.



**Figure 13.0-B: Integration of Best Planning Practices and Best Management Practices for WSUD Implementation**

### 13.0.2 Purpose of the Guidelines

Managing urban stormwater as a resource and for the protection of receiving ecosystems is a key element of WSUD, and in this first version of the guidelines urban stormwater is the key focus of the planning and design tools.

The guidelines provide a decision making guide for Best Planning Practices associated with urban development and design including selecting, integrating and locating WSUD elements within a development (ie. site feasibility). These guidelines also provide advice on Best Management Practices including the planning, conceptual and detailed design of WSUD stormwater systems. These guidelines compliment existing resources, including other GCCC guidelines and documents by other agencies, that promote WSUD.

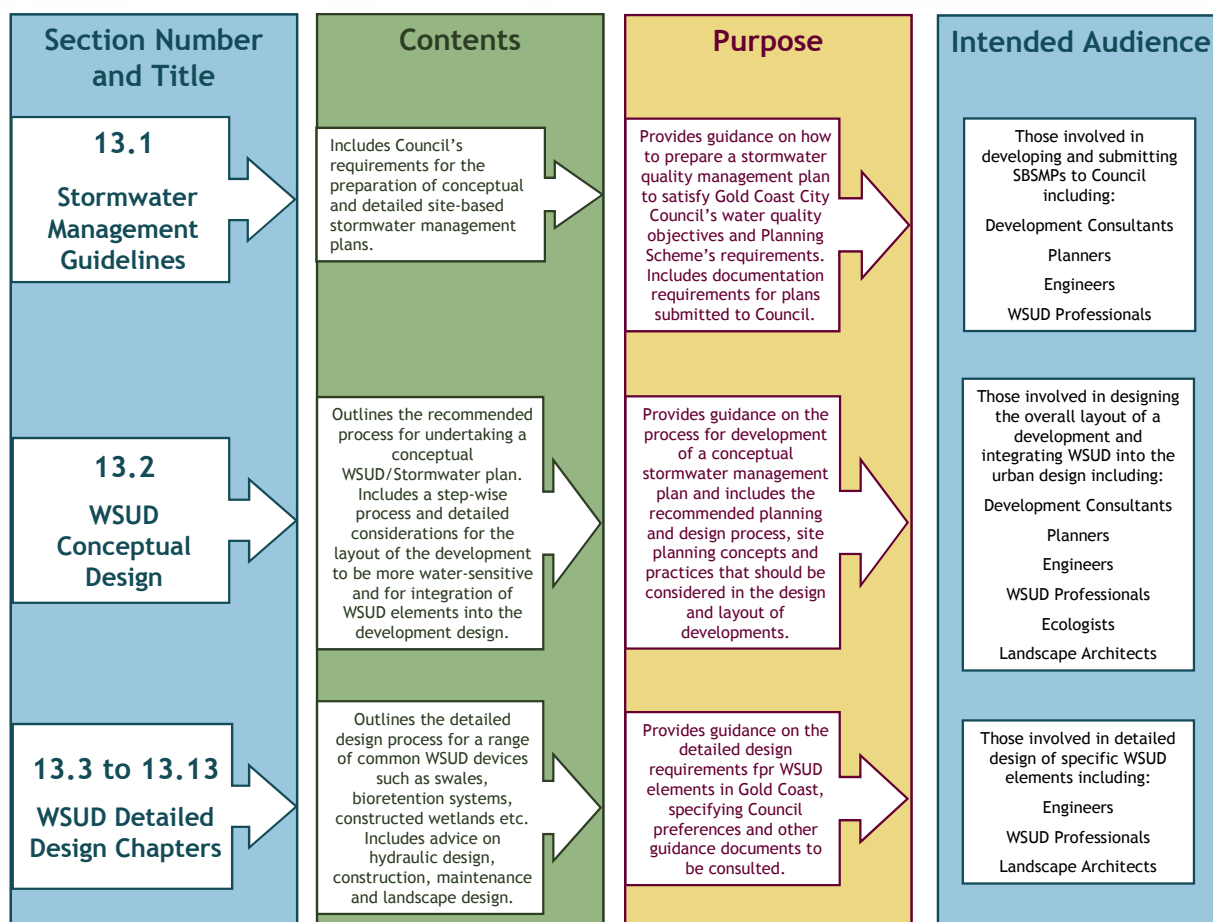
### 13.0.3 Structure and Use of these Guidelines

These guidelines have been structured to include sections covering:

- planning and documentation requirements of Council with respect to stormwater management planning (**Section 13.1**)
- planning and integration of WSUD into the development layout, selection of appropriate WSUD devices and conceptual design (**Section 13.2**)
- detailed design of a range of WSUD devices (**Sections 13.3 to 13.13**).

In covering the full planning and implementation cycle, as well as documentation requirements, WSUD applications require the involvement of a range of urban design professionals to ensure a sustainable solution is developed and properly integrated into the design and layout of a development. Typically, this would involve engineers, planners, urban designers, architects, landscape architects and environmental scientists/ ecologists.

The structure of the guidelines, a broad description of each section, its purpose and intended audience are shown in **Figure 13.0-C**.



**Figure 13.0-C: Structure of WSUD Guidelines (Section 13.0) of Land Development Guidelines**

### 13.0.3.1 How Applicants can Use the Guidelines

The purpose of the Guidelines for applicants is to:

- provide a tool for developing design responses that incorporate better water management practices and which meet defined performance standards;
- help in preparing conceptual and detailed designs for WSUD systems as part of a development proposal.

**Section 13.1** should be used to determine the requirements of Council in with respect to documentation of conceptual and detailed stormwater management plans.

**Section 13.2** should be used in the selection, location and conceptual design of WSUD elements. This section should be applied as early as possible to the development design process to ensure:

- impacts to the natural water cycle are minimised;
- WSUD is considered in the initial development design and layout;
- that suitable WSUD measures are identified to adequately address and meet applicable water quality and other objectives.

Once a WSUD strategy has been selected (typically informed by modelling using Council's **MUSIC Modelling Guidelines (GCCC 2005)**), **Sections 13.3 to 13.13** are to be used to provide advice on detailed engineering calculations required to:

- determine the physical dimensions to suit site characteristics and Council standards;
- ensure the conveyance requirements of the drainage system are maintained;
- size inlet and outlet hydraulic structures;
- provide suitable landscape characteristics to conform with treatment performance and aesthetic objectives;
- compile calculation summary sheets where basic information from the design process can be recorded and submitted as part of a development application.

### 13.0.3.2 How Council will Use the Guidelines

Council will use the Guidelines to provide:

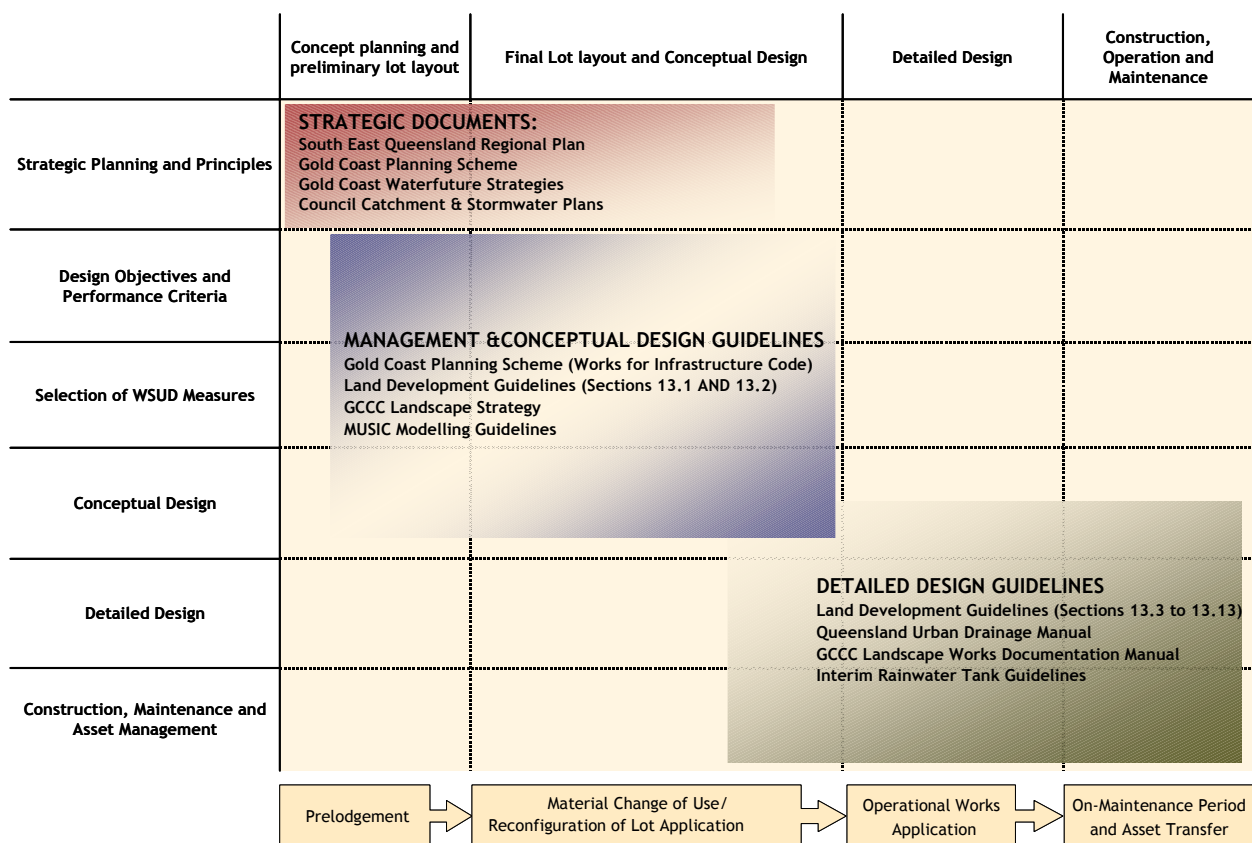
- better advice to actively guide WSUD planning, design and installation in Gold Coast;
- a clear and transparent development assessment process for construction plans for WSUD elements and promoting the achievement of catchment-based water management objectives.

Specifically, Council will use:

- Design Assessment Checklists to provide a template for checking development submissions, ensuring a sufficient level of detail is presented for assessment.
- Inspection Forms, Maintenance Schedules and Asset Transfer Checklists to help ensure WSUD elements are built as designed, are maintained and are in good operating condition prior to asset handover to Council.

The aim of the guidelines is to provide a consistent approach to the planning and design of WSUD elements for urban developments in the GCCC local government area by outlining a WSUD planning process, design procedures, simplified design tools and checklists for individual WSUD elements that can be used by designers and Council development assessment officers when checking detailed designs. They will help to ensure that treatment objectives and conveyance requirements of a stormwater system are achieved.

**Figure 13.0-D** illustrates how the Guidelines fit into GCCC’s assessment process, and what sections of these guidelines along with other guideline documents throughout the development application process.



Source: Adapted from Moreton Bay Waterways and Catchments Partnership (2006)

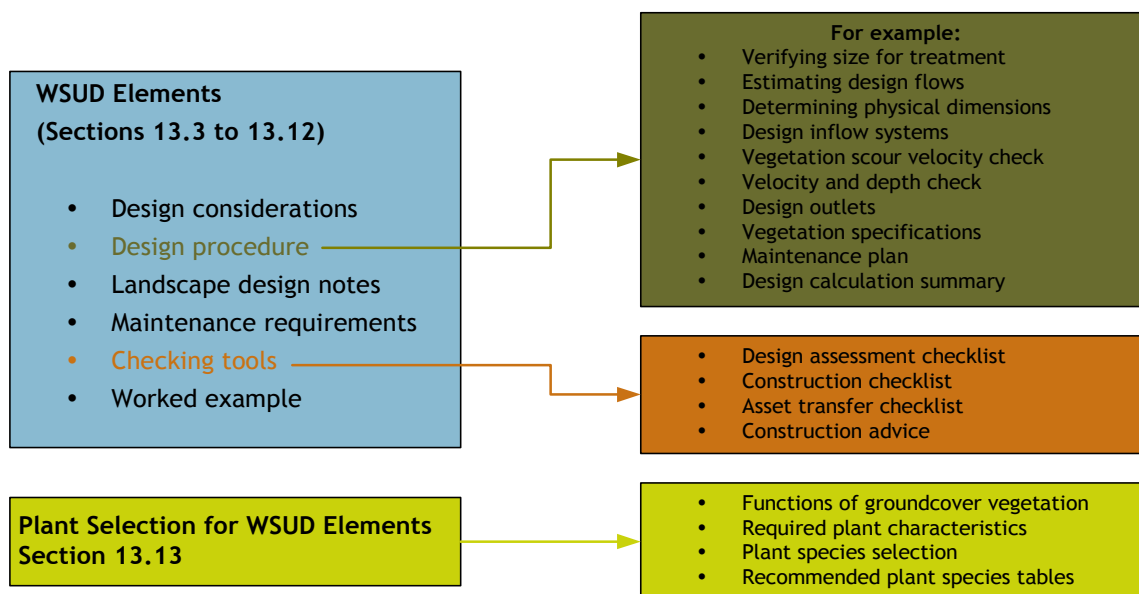
**Figure 13.0-D: Development Process**

## 13.0.4 Summary of WSUD Elements Covered in Detailed Design

This section introduces the ten WSUD elements covered in **Sections 13.3 to 13.12**, being:

Swales (incorporating Buffer Strips)	<b>Section 13.3</b>
Bioretention Swales	<b>Section 13.4</b>
Sedimentation Basins	<b>Section 13.5</b>
Bioretention Basins	<b>Section 13.6</b>
Constructed Wetlands	<b>Section 13.7</b>
Infiltration Measures	<b>Section 13.8</b>
Sand Filters	<b>Section 13.9</b>
Aquifer Storage and Recovery	<b>Section 13.10</b>
Porous Paving	<b>Section 13.11</b>
Pretreatment	<b>Section 13.12</b>

The format of these chapters follows a standard layout, as shown in **Figure 13.0-E**, to provide for consistency in the design process for each WSUD element and to assist checking of designs. Each of these chapters also includes a worked example to illustrate application of each design procedure. Checklists for design, construction and maintenance are provided to summarise key information related to the WSUD element to facilitate the design approval process.



**Figure 13.0-E: Structure of the Detailed Design Chapters**

Following is a brief description of the WSUD elements covered in **Sections 13.3 to 13.12** of these guidelines.

### 13.0.4.1 Swales (incorporating Buffer Strips)

Vegetated swales are used to convey stormwater in lieu of, or in concert with, underground pipe drainage systems and to remove coarse and medium sediment. Swales alone cannot provide sufficient treatment to meet current GCCC stormwater treatment/ water quality objectives. As such, they are commonly used as part of an overall stormwater 'treatment train' to deliver acceptable stormwater quality for discharge to aquatic ecosystems or for potential reuse applications.

Swales also disconnect impervious areas from hydraulically efficient pipe drainage systems, which is important for protecting aquatic ecosystems in receiving waterways by managing the frequency of damage to aquatic habitats by storm flows. This is achieved by slower travel times for flows along swale systems compared with efficient pipe drainage systems. This reduces the rapid response from impervious areas, particularly for frequent storm events, and resultant impact on natural receiving waterways.

The longitudinal slope of a swale is the most important consideration. They generally operate best with slopes of 1% to 4%. Milder sloped swales can tend to become waterlogged and may have stagnant ponding, although the use of subsoil drains can alleviate this problem. For slopes steeper than 5%, swales should generally not be considered. Check dams should not be used for swales in Gold Coast.

Vegetation is an integral component of swales as it promotes even distribution and retardation of flows, thus promoting settlement of coarse to medium sized sediments. Vegetation is required to cover the full width of a swale, be capable of withstanding design flows, and be of sufficient density to provide significant contact between flows and vegetation.

If runoff enters the swale as distributed flow (ie. perpendicular to the main flow direction), the swale batter receiving the inflows acts as a vegetated buffer and can provide an important pretreatment function for the swale by removing coarse sediment prior to flows concentrating along the invert of the swale.

Swales can be incorporated into urban designs along streets (within the median strip or footpaths), in parklands and between allotments where maintenance access can be preserved. In addition to their treatment function, these systems can add to the aesthetic character of an area.



**Plate 13.0-A: Swale Vegetation is selected based on required treatment performance and appearance**

### 13.0.4.2 Bioretention Swales

Bioretention swales (or biofiltration trenches) are treatment systems that are located at the downstream end of a swale cell (ie. immediately upstream of the swale overflow pit). Bioretention swales provide efficient treatment of stormwater through fine filtration, extended detention treatment and some biological uptake, and are particularly efficient at removing nitrogen and other soluble or fine particulate contaminants. They also provide a conveyance function (ie. along the swale).

Bioretention swales can form attractive streetscapes and provide landscape features in an urban development. They are commonly located in the median strip of divided roads, in carparks and in parkland areas.

Runoff is 'filtered' through a prescribed filter media as it percolates downwards under gravity. The 'filtered' runoff is then collected at the base of the filter media via perforated pipes and flows to downstream waterways or to storages for potential reuse. Unlike infiltration systems (discussed in **Section 13.0.4.6**), bioretention systems are well suited to a wide range of soil conditions, including low hydraulic conductivity 'clay' soils and areas affected by soil salinity and saline groundwater, as their operation is designed to minimise or eliminate exfiltration from the filter media to surrounding in-situ soils.

Any reductions in runoff volumes are primarily attributed to maintaining soil moisture of the filter media (which is also the growing media for the vegetation) and evapotranspiration losses. Should in-situ soil conditions be favourable, infiltration can be encouraged from the base of a bioretention system to recharge local groundwater and to reduce surface runoff volumes (refer **Section 13.8**).

Vegetation that grows in the filter media of bioretention swales is an integral component of these treatment elements. Both the vegetation and the filter media have functional roles in stormwater treatment and it is the intrinsic relationship between the two that ensures the long term functional performance of the system.



**Plate 13.0-B: Bioretention Swales are commonly located in median strips of roads and carparks**

### 13.0.4.3 Sedimentation Basins

Sediment basins are used to retain coarse sediments from runoff, are typically the first element in a 'treatment train', and are frequently used for trapping sediment in runoff from construction sites. Within a 'treatment train' they play an important role by protecting downstream elements from becoming overloaded or smothered with sediments, thus optimising treatment performance and minimising ongoing maintenance costs.

Sediment basins operate by reducing flow velocities and encouraging sediments to settle out of the water column. They rely on the creation of quiescent flow conditions and the prevention of 'short circuit' flow paths between the inlet and outlet. Sediment basins are typically constructed with sufficient depth (usually 1.5m to 2.0m) to allow for sediment accumulation and to prevent colonisation by fringing aquatic macrophytes (which is undesirable due to the requirement for regular desilting of sediment basins). They can also be designed as ephemeral systems, allowing them to drain during periods without rainfall and refill during runoff events.

Sediment basins can have various configurations including hard edges and base (eg. concrete), or a more natural form with edge vegetation creating an attractive urban element. They are, however, typically turbid and maintenance usually requires significant disturbance of the system. Further guidance on designing and constructing sediment basins is offered in **Sediment Basin Design, Construction and Maintenance Guidelines (BCC 2001)**.

Maintenance of sediment basins involves dewatering and dredging/ excavating accumulated sediments. This is required approximately every five years, but depends on the nature of the catchment. For construction sites that can produce very large loads of sediment, desilting may be required more frequently.



**Plate 13.0-C: Sedimentation Basins can be installed into hard or soft landscapes**

### 13.0.4.4 Bioretention Basins

Bioretention basins operate with the same treatment processes as bioretention swales except do not have a conveyance function. High flows are either diverted (bypassed) away from the basin or are discharged into an overflow structure.

Like bioretention swales, bioretention basins can provide efficient treatment of stormwater through fine filtration, extended detention treatment and some biological uptake, particularly for nitrogen and other soluble or fine particulate contaminants.

Bioretention basins have an advantage of being applicable at a range of scales and shapes and therefore have flexibility for locations within a development. They are equally applicable to redevelopment sites and greenfield sites. Smaller systems may take the form of 'planters' that can be located within allotments (eg. gardens) and along roadways at regular intervals (eg. in traffic calming devices) to create a boulevard aesthetic. All of these systems treat runoff near to its source and prior to entry into an underground drainage system.

Larger bioretention basins may be located at outfalls of a drainage system (eg. in the base of retarding basins) to provide 'end-of-pipe' treatment to runoff from larger subcatchments where 'at source' applications may not be feasible. Large size bioretention basins need to consider the delivery of runoff into the basin to avoid scour and to ensure even distribution over the full surface area of the filter media.



**Plate 13.0-D: Bioretention Basins are applicable at a range of scales and can be integrated into an urban landscape**

A wide range of vegetation can be used within bioretention basins, allowing them to be easily integrated into the landscape theme of an area. Vegetation that grows in the filter media of bioretention basins is an integral component of these treatment devices. Both the vegetation and the filter media have functional roles in stormwater treatment and it is the intrinsic relationship between the two that ensures the long term functional performance of the system. They are however, sensitive to any materials that may clog the filter medium or damage the vegetation and therefore vehicles, building materials and construction washdown wastes should be kept away from bioretention basins.

### 13.0.4.5 Constructed Wetlands

Constructed wetland systems are shallow, extensively vegetated water bodies that use vegetation enhanced sedimentation, fine filtration and biological pollutant uptake processes to improve stormwater quality. Water levels rise during rainfall events and outlets are configured to slowly release flows, typically over two to three days, back to a permanent pool level.

Wetlands generally consist of an inlet zone (sediment basin to remove coarse sediments), a macrophyte zone (a shallow heavily vegetated area to remove fine particulates and uptake of soluble pollutants) and a high flow bypass channel (to protect the macrophyte zone from high velocity flood flows).

Wetland processes are engaged by slowly passing runoff through heavily vegetated areas. Plants filter sediments and pollutants from the water and biofilms that grow on the plants can absorb nutrients and other associated contaminants. In addition to playing an important role in stormwater treatment, wetlands can also have significant community benefits. They provide habitat for wildlife and a focus for recreation, such as walking paths and other passive recreational pursuits. They can also improve the aesthetics of a development and be a central feature in a landscape.



**Plate 13.0-E: Wetlands can be constructed on many scales**

Wetlands can be constructed on many scales, from house block scale to large regional systems. In highly urban areas they can have a hard edge form and be part of a streetscape or used in the forecourts of buildings. In regional settings, they can be over 10 ha in size and provide significant habitat for wildlife.

### 13.0.4.6 Infiltration Measures

Infiltration measures encourage appropriately pretreated stormwater runoff to infiltrate into surrounding soils and underlying groundwater. Their purpose in a stormwater treatment train is as a conveyance measure to facilitate infiltration of surface waters to groundwater and NOT as a treatment device. They are highly dependant on local soil characteristics and are best suited to sandy soils with deep groundwater. All infiltration measures require significant pre-treatment of stormwater before infiltration to avoid clogging of the surrounding soils and to protect groundwater quality.

Infiltration measures generally consist of a shallow excavated trench or 'tank', designed to detain a certain volume of runoff and subsequently infiltrate to the surrounding soils. They reduce surface runoff volumes by providing a pathway for treated stormwater runoff to recharge local groundwater aquifers. Generally, these measures are well suited to highly permeable soils, so that water can infiltrate at a sufficient rate. Areas with lower permeability soils may still be applicable, but larger areas for infiltration and detention storage volumes are required to allow for the slow rate of exfiltration from the base of the system. In addition, infiltration measures are required to have sufficient setback distances from structures to avoid any structural damage from the wetting and drying of soils (eg. from soil shrinkage). These setback distances depend on local soil conditions.



**Plate 13.0-F: Infiltration Systems are best suited to sandy soils with deep groundwater**

Depending on the saturated hydraulic conductivity of the infiltration measure, they may also be vegetated and provide some landscape amenity to an area.

## 13.0.4.7 Sand Filters

Sand filters operate in a similar manner to bioretention systems with the exception that they have no vegetation growing on their surface. Therefore, they have a reduced stormwater treatment performance due to the absence of a biologically active soil layer typically created around the root zone of vegetation planted in bioretention systems. Sand filters lack vegetation because the filter media does not retain sufficient moisture to support vegetation growth or they are installed underground (therefore light limits vegetation growth).

Prior to entering a sand filter, flows are generally subjected to pretreatment to remove litter, debris and coarse sediments (typically via a sedimentation chamber). Following pretreatment, flows are spread over the sand filtration media and water percolates downwards to perforated pipes located at the base of the sand media. The perforated pipes collect treated water for conveyance downstream. During higher flows, water can pond on the surface of the sand filter increasing the volume of water that can be treated. Very high flows are diverted around sand filters to protect the sand media from scour.

Sand filters are particularly useful in areas where space is a premium and treatment is best achieved underground, such as in high density developments with little to no landscape areas. Due to the absence of vegetation, they require regular maintenance to ensure the surface of the sand filter media remains porous and does not become clogged with accumulated sediments. This typically involves regular routine inspections and tilling or removing any fine sediments that have formed a 'crust' on the surface.



**Plate 13.0-G: Sand Filters can be installed above or below ground**

## 13.0.4.8 Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) is a means of enhancing water recharge to underground aquifers through either pumping or gravity feed of appropriately treated stormwater runoff (or other water sources). It can be a low cost alternative to store water compared to surface storages and can minimise loss of water from evaporation. During wet periods, excess treated stormwater runoff from urbanised catchments can be stored in natural or constructed aquifers and subsequently extracted during dry periods to reduce reliance on mains water supply.

Any water source injected into a natural aquifer system must be of sufficient quality to protect the beneficial uses of the ground water. The level of treatment required is dependant on the quality of the groundwater resource and the current uses of the groundwater. In most instances, the treatment elements described in these Guidelines configured into an appropriate 'treatment train' will provide sufficient treatment prior to injection.

The viability of an ASR scheme is highly dependant on the underlying geology of an area and the presence and nature of aquifers. There are a range of aquifer types that can accommodate an ASR scheme, including fractured unconfined rock, confined sand and gravel aquifers. It is also possible to construct an aquifer if the economics of this allows. Detailed geological investigations are required to establish the feasibility of any ASR scheme. These Guidelines provide an overview of the main elements of the system and direct readers to more specific guidance documents.

## 13.0.4.9 Porous Paving

Porous pavement is a load bearing pavement structure that is permeable to water. There is a wide variety of porous pavement types, each with advantages and disadvantages for various applications. The common features porous pavements include a permeable surface layer overlying an aggregate storage layer. The surface layer of porous pavement may be either monolithic (such as porous asphalt or porous concrete) or modular (clay or concrete blocks). The reservoir storage layer consists crushed stone or gravel which is used to store water before it is infiltrated to the underlying soil or discharged towards a piped drainage system.

Porous paving can be used as an alternative to conventional paving and hardstand surfaces within urban developments to reduce stormwater runoff velocity and volume

A number of porous paving types are available including:

- porous asphalt or concrete (monolithic structures) – open graded asphalt or concrete with reduced or no fines and a special binder that allows water to pass through the pavement by flowing through voids between the aggregate;
- modular pavers – pavers may be made of porous material or where pavers themselves are not permeable, are installed with gaps between the pavers to allow stormwater to penetrate into the subsurface;
- grid or lattice systems – these are made of concrete or plastic grids filled with soil or aggregate that water can percolate through. These systems may also be vegetated (usually with grass).

Permeable paving systems should avoid areas with one or more of the following characteristics:

- high water tables;
- saline soils;
- wind blown areas;
- catchments with a high sediment load;
- high traffic volumes.

Infiltration porous paving systems are not encouraged for use in Gold Coast City, particularly where they are located adjacent to conventionally paved/ concreted areas such as roads. Water infiltration adjacent to road pavements can cause damage such as asphalt stripping and loss of strength in sub-grades. Porous paving should not be included in treatment trains where they would become Council owned or maintained assets. Porous paving systems in Gold Coast City should be privately owned and maintained.

#### 13.0.4.10 Pretreatment Devices

Pretreatment for stormwater quality improvement commonly consists of the use of Gross Pollutant Control Devices (GPT's). A GPT is any structure or facility intended to remove solid type pollutants 2 mm and larger and floatable pollutants 25mm and larger.

The use of GPT's for pre-treatment can be for either improved aesthetics in receiving waters or to maintain the integrity of further treatment devices located further downstream within integrated treatment system. There are many differing types of gross pollutant traps that are commercially available. These devices vary greatly, though in general GPT's should be designed to capture gross pollutants and coarse sediment up to a Q3-month flow.

#### 13.0.5 References

BCC 2001, **Sediment Basin Design, Construction and Maintenance Guidelines**, BCC, Brisbane.

Engineers Australia 2006, **Australian Runoff Quality**, Engineers Australia, ACT,  
[http:// www.arq.org.au/](http://www.arq.org.au/).

GCCC 2005, **Land Development Guidelines**, GCCC, Gold Coast.

GCCC 2005, **MUSIC Modelling Guidelines**, GCCC, Gold Coast.

GCCC 2005, **Stormwater Management Guidelines**, GCCC, Gold Coast.

Moreton Bay Waterways and Catchments Partnership 2006, **Water Sensitive Urban Technical Design Guidelines for South East Queensland**, prepared by WBM and Ecological Engineering.