Lake Macquarie
City Council

STORMWATER QUALITY IMPROVEMENT DEVICES GUIDELINES

December 2013

CONTENTS

1 INTRODUCTION

Urban development often results in significant modification to soils, topography, catchment imperviousness and vegetation. Surface runoff volumes and pollutant concentrations from urbanised catchments are typically elevated above natural conditions and without mitigation have the potential to convey elevated pollutant loads to receiving environments. Urban development also has the potential to significantly increase surface runoff leading to impacts on stream stability, receiving environment ecology and flooding.

Water Sensitive Urban Design (WSUD) is a philosophy that incorporates urban water cycle management into the urban design process. WSUD considers options to integrate urban water management infrastructure within the natural environment. WSUD aims to protect the health of aquatic ecosystems and minimise negative impacts on the natural water cycle. Achieving the full benefits of WSUD requires combined consideration of water supply, wastewater, stormwater, groundwater, flooding and riparian zones when planning a development. Stormwater quality and quantity management are particularly important for protecting aquatic ecosystems.

Lake Macquarie City Council (Council) has a vision to improve the management of stormwater runoff quality and quantity from new developments that drain along existing watercourses to Lake Macquarie. Stormwater Quality Improvement Devices (SQIDs) assist to manage stormwater quality and quantity from development. SQIDs function by detaining, retaining, harvesting, screening, filtering, infiltrating and/or biologically treating stormwater runoff to reduce the concentrations and loads of pollutants discharged to the receiving environments. SQIDs can also assist with reducing stormwater volumes and flow rates which assists with reducing stream erosion potential and reducing impacts on the wetting and drying cycles of natural wetlands. In addition, harvesting and infiltrating stormwater runoff can reduce runoff volumes which otherwise have the potential to generate additional pollutants through erosion and sedimentation of the receiving watercourses.

Council currently maintains approximately 700 SQIDs through the LGA with a number of other SQIDs also maintained by owner’s corporations, community associations or individual property owners. Experiences with the maintenance of these existing SQIDs has identified that efficient maintenance is a key consideration for future installations across the LGA. These SQID guidelines were prepared to assist development applicants with selecting appropriate SQIDs to incorporate into their development. These guidelines should be considered along with Council’s requirements for stormwater management that are specified in the Water Cycle Management Guidelines (WCMGs).

2 SQID GUIDELINES CONTEXT

These guidelines have been prepared to assist development applicants with identifying and arranging appropriate SQIDs within a Water Cycle Management Plan (WCMP). Preparation of a WCMP is a requirement for particular development types outlined in Council's Water Cycle Management Guidelines (WCMGs). The scope of the SQID guidelines and their context in relation to Council's existing planning instruments, guidelines and specifications is outlined in Figure 2-1 and discussed further in the following sections.

The proposed development type and scale determines whether SQIDs are required for a particular development. Development applicants should initially refer to the WCMGs which outline the type and scale of development that requires a development applicant to prepare a WCMP. The WCMGs reflect the requirements of Council's DCP 2014 and LEP 2014 that are relevant to the provision of SQIDs within development.

Subdivisions and large scale developments will typically require SQIDs to be installed within the development. Individual residential dwelling lots and other small scale developments typically may not require SQIDs to be installed. In addition to Council's DCP, State Environmental Planning Policies (SEPPs) outline further requirements for typically smaller scale developments.

Development applicants for small scale developments shall prepare a stormwater drainage plan that outlines how stormwater drainage would be managed within the site. Typically, small scale developments are required to comply with the specific requirements of SEPP BASIX (residential development), the CODES SEPP and Council's DCP. The development applicant should refer to those planning instruments, Council's guidelines and Council's WCMGs to confirm the extent of SQIDs required.

Development applicants for larger scale developments shall prepare a more comprehensive WCMP. All WCMPs shall incorporate SQIDs to demonstrate how stormwater runoff quality and quantity would be managed within the site. Development applicants should refer to the WCMGs to confirm requirements for their individual development proposal.

In addition to outlining the development scale where SQIDs are required, the WCMGs should be referred to for guidance on the following key elements:

- Environmental values of the local receiving environments;
- Water cycle management principles and their application within the local area;
- Issues to be addressed with a WCMP and associated reporting requirements;
- Runoff quality and water conservation objectives and targets;
- Guidance on how to achieve the runoff quality and water conservation objectives and targets for different developments;
- Site analysis considerations for identifying opportunities and constraints for SQIDs; and
- Guidance on the planning and conceptual design of WCM systems.

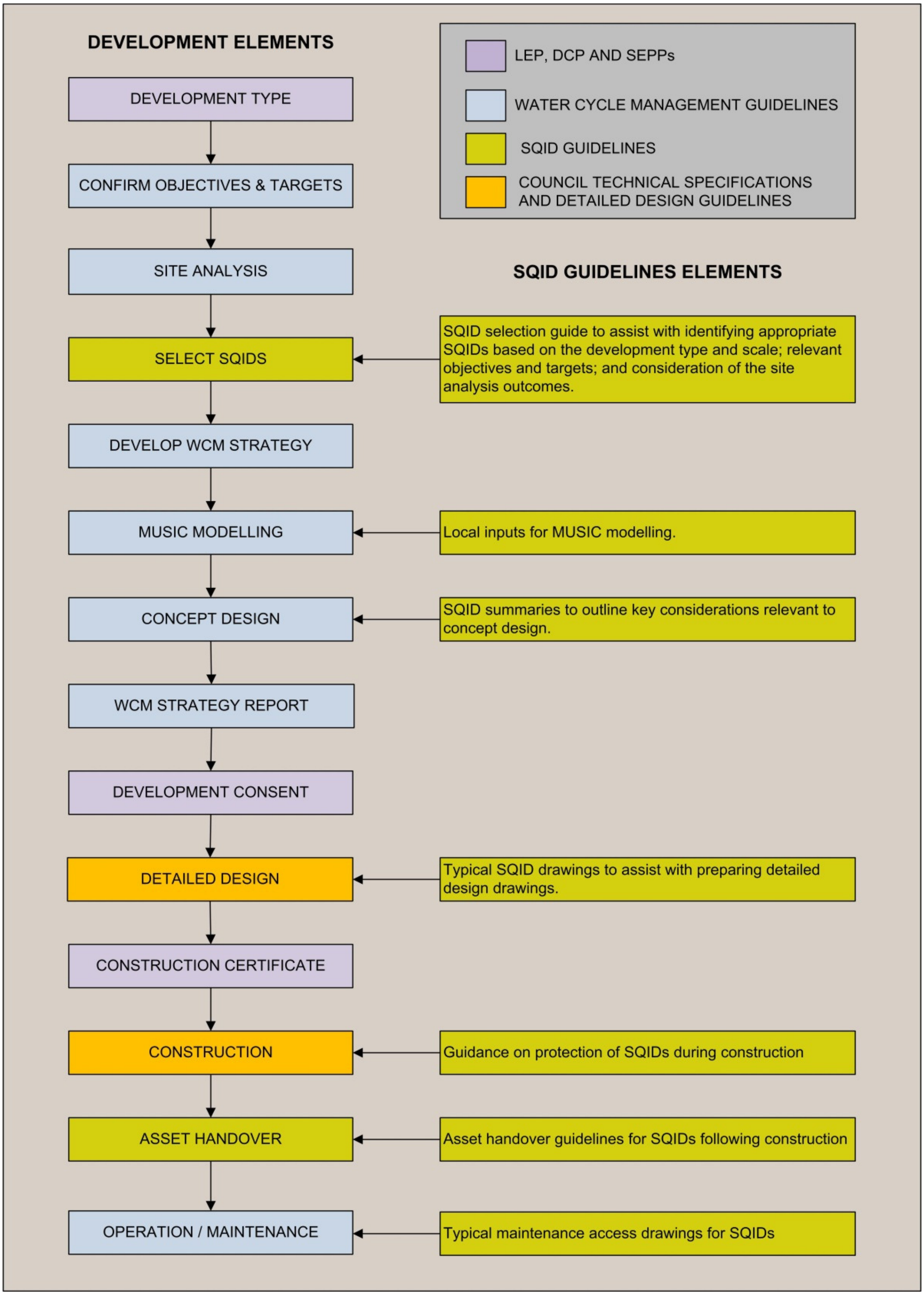


Figure 2-1 SQID Guidelines Context

The detailed design of SQIDs should be undertaken in accordance with Council's other Engineering Guidelines, namely:

- Part 1 – Design Specification;
- Part 2 – Construction Specification;
- Part 4 – Drainage Design Criteria Handbook;
- Part 5 – Batter and Fencing Guidelines for SQIDs and Detention Basins; and
- Part 6 – Engineering Standard Drawings.

Whilst no Lake Macquarie Council specific detailed design guidelines are currently available for SQIDs, a number of relevant detailed design guidelines have been prepared for other areas in Australia. Relevant resources for the detailed design of the types of SQIDs covered by this guideline are summarised in Section 10.

3 SQID SELECTION

3.1 Preferred SQIDs

Council has a preference for limiting the range of SQID types installed throughout the LGA. Council is seeking to ensure that only SQIDs that are compatible with their maintenance operational capacity are installed. A key goal of Council is to improve SQID maintenance efficiency which is a key component of sustainable implementation of Water Sensitive Urban Design (WSUD).

These SQID guidelines provide guidance on Council's preferred range of SQIDs. The preferred SQID list primarily includes measures to remove fine and dissolved pollutants from stormwater. The preferred SQIDs for the City of Lake Macquarie are:

- Permeable paving;
- Vegetated filter strips;
- Grassed swales;
- Gross pollutant traps;
- Sediment retention basins;
- Bioretention measures (tree pit filters, raingardens, bioretention swales and bioretention basins); and
- Constructed wetlands.

Infiltration measures (infiltration trenches and infiltration basins) may also be considered in specific locations where soil, groundwater and downslope development conditions are suitable. Other measures including rainwater tanks and stormwater harvesting basins are supported for reducing the consumption of potable water and achieving stormwater retention targets.

Council may approve alternative SQIDs on a case-by-case basis where it can be demonstrated that they achieve the intent of Council's current policies and will be cost effective to maintain. Nevertheless, it is recommended that developers select SQIDs from Council's preferred list.

Development applicants should consider gross pollutant traps (GPTs) to remove organic debris, litter and coarse sediment as a means of pre-treatment for other SQIDs. These SQID guidelines do not provide advice on specific proprietary and non-proprietary GPTs for which there are a number of devices available. However, these guidelines summarise key issues that need to be considered when planning a GPT installation. For the purpose of these guidelines, GPTs are deemed to also include trash racks and other debris barriers.

3.2 Site Planning

This section provides guidance on identifying appropriate SQIDs for particular development land uses and site characteristics. This section includes:

- A summary of Council's preferred SQIDs that are supported by these guidelines;
- Guidance on SQID treatment processes;

- Guidance on appropriate/preferred development scales for provision of particular SQIDs;
- Guidance on applying site analysis outcomes to the selection of SQIDs; and
- Guidance on arranging SQIDs in an appropriate treatment series.

The following sections provide a range of SQID selection tables to assist development applicants with identifying appropriate SQIDs for their particular development. These tables should only be used as a guide, as additional unusual site constraints may preclude use of some SQIDs or potentially other site constraints may be overcome through good design. Close consideration of the site characteristics is essential for confirming appropriate SQIDs. SQID selection tables are provided for the following considerations:

- Treatment scale;
- Maintenance;
- Treatment processes;
- Site constraints;
- Stormwater quality management objectives; and
- Stormwater quantity management objectives.

3.3 Treatment Scale

Depending on the scale of the development and planning agreements, SQIDs can potentially be provided at the lot, street, subdivision or precinct scales. Lot scale treatment involves positioning SQIDs in private lots to manage runoff from a specific lot. Street scale treatment involves positioning of SQIDs in the public road reserve to treat runoff from adjacent lots and road pavement. Subdivision treatment typically involves positioning SQIDs in public open spaces areas or lots dedicated to stormwater treatment. Precinct treatment typically involves positioning SQIDs at locations where stormwater will be managed from multiple subdivisions potentially owned by multiple parties. Council's preferred treatment scales for the preferred SQIDs are summarised in Table 3-1.

Table 3-1 Treatment Scales

SQID	Lot	Street	Subdivision	Precinct
Rainwater tank				
Permeable paving				
Infiltration trench				
Vegetated filter strip				
Raingarden[1]				
Grassed swale				
Bioretention swale				
Tree pit filter				
Gross pollutant trap				
Sediment basin				
Constructed wetland				
Bioretention basin				
Infiltration basin				

1. Raingardens can typically be provided at the lot or street scale. Whilst provision of raingardens in private lots is encouraged by Council, lot scale raingardens shall only be partially allowed for in preparing water quality models for the development (refer Section 6). The reason for this is that Council does not have sufficient resources to ensure SQIDs installed in private properties are adequately maintained.

3.1 Maintenance

Consideration of future maintenance requirements for SQIDs is often overlooked or given cursory attention during planning and design. As a result of not appropriately considering future maintenance during planning and design, a constructed SQID may be expensive to maintain and as a result inadequately maintained during operation. Consequently, stormwater pollutants may accumulate excessively, reducing the effectiveness of the SQID and enabling elevated loads of pollutants to discharge into the receiving environments.

It is often costly to resolve earlier oversights once a SQID is handed over to Council and becomes operational. A significant concern is the sustainability of future maintenance requirements for SQIDs. Key planning considerations for SQIDs relevant to future maintenance are summarised in Table 3-2.

Table 3-2 Maintenance Considerations

SQID	Vehicle access to inlet	Vehicle access to treatment zone	Footpath access to low level outlet	Vehicle access to high level outlet	Vegetation and weed control	Manual weed control	Additional landscaping maintenance	Skilled labour required[1]	Vegetation establishment period	Typical inspection frequency	Preferred maintenance frequency	Ephemeral or wet system	Staged construction[2]	Operation and maintenance cost
Rainwater tanks	N	N	N	NA	N	NA	N	N	N	annual	annual	W	N	L
Permeable paving	NA	N	N	NA	Y	Y	N	N	N	annual	annual	E	N	H
Raingardens	N	N	Y	NA	Y	Y	N	N	Y	3month	6month	E	Y	H
Infiltration trench	N	N	N	NA	N	NA	N	N	N	6mth	annual	E	N	H
Vegetated filter strips	NA	Y	NA	NA	Y	N	N	N	N	3month	3month	E	N	M
Grassed swale	N	Y	Y	NA	Y	N	N	N	N	3month	3month	E	N	M
Bioretention swale	N	N	Y	NA	Y	Y	N	Y	Y	3mth	6month	E	Y	H
Tree pit filter	N	N	Y	NA	Y	Y	N	N	Y	6mth	annual	E	Y	H
Gross pollutant trap	Y	Y	Y	Y	N	NA	N	Y	N	3mth	6month	E/W	Y	M
Sediment basin	Y	Y	Y	Y	Y	N	Y	Y	N	6mth	annual	E/W	N	M
Constructed wetland	Y	Y	Y	Y	Y	Y	Y	Y	Y	6mth	annual	W	Y	M
Bioretention basin	Y	Y	Y	Y	Y	Y	Y	Y	Y	6mth	annual	E	Y	M
Infiltration basin	Y	Y	Y	Y	Y	Y	Y	Y	N	6mth	annual	E	Y	H

1. Labour trained for confined spaces access, horticulture, bush regeneration, machine operators licence etc.
2. SQIDs that may be significantly damaged by building construction activities should have staged construction to protect treatment elements from being excessively loaded with sediment.

3.2 Treatment Processes

A treatment series comprises a number of SQIDs arranged in a sequence to optimise treatment performance. Configuration of SQIDs in the series will depend on the development scale and the treatment function of the SQIDs. Currently, no one particular SQID has the ability to effectively treat all stormwater pollutants from large debris to dissolved pollutants without requiring high maintenance. Therefore, typically a number of SQIDs should be arranged in series to efficiently capture the full range of targeted pollutants.

By providing SQIDs in series, it is also possible to maintain SQIDs on different maintenance cycles. Typically the initial SQIDs in the series will be maintained more regularly to remove larger pollutants, whilst the following SQIDs capturing finer pollutants can be maintained less frequently where water quality is not compromised. As the range of pollutants is separated by different SQIDs within the treatment series, cost saving opportunities may also exist for more economical disposal of captured pollutants.

SQIDs function in different ways to remove stormwater pollutants. Essentially these treatment processes can be divided into five broad categories that target particular stormwater pollutant types including:

- Screening – Coarse filtering of stormwater to separate the bulk of large organic debris, litter and some coarse sediment. Typically these SQIDs include GPTs installed with screens, racks, baskets, nets etc.
- Filtration – Vegetation and media filtering to separate organic debris, litter and coarse to medium sediment.
- Retention – Storage of stormwater for extended periods of time enabling pollutants including coarse to fine sediments and heavy metals to settle. These SQIDs can also be configured to control flow rates and volumes during frequent storm events, and for harvesting stormwater.
- Biochemical - Biochemical treatment of stormwater to reduce dissolved pollutant loads through transformation to solid or gaseous forms. Fine sediment loads can also be removed through extended retention periods and interception on vegetation. SQIDs typically also function to control flow rates and volumes through retention and/or detention of stormwater.
- Infiltration – Storages where the primary outlet for stormwater is infiltration into the insitu soils. Typically these SQIDs will have limited application except where insitu soils have high permeability and infiltration of stormwater would not result in additional seepage, excessive groundwater table rise, weakening of structural foundations or other implications for downslope properties.

The treatment series should be configured to achieve the treatment processes in the order outlined above. Typically a development applicant should select a series of SQIDs that will collectively perform all of these functions. Council's preferred SQIDs and the relevant main stormwater treatment processes are summarised in Table 3-3. Typically the treatment series should be configured to achieve the treatment processes outlined in Table 3-3 in order (i.e. screening process first with infiltration the final process wherever possible).

Table 3-3 Stormwater Treatment Processes

SQID	Stormwater Treatment Process				
	Screening	**Retention**	**Filtration**	**Biological**	**Infiltration**
Rainwater tank	■	■			
Permeable paving		■	■		
Raingarden		■	■	■	P
Infiltration trench		■	■		■
Vegetated filter strip	■		■		
Grassed swale	■		■		
Bioretention swale		■	■	■	P
Tree pit filter		■	■	■	P
Gross pollutant traps	■				
Sediment basin	P	■			
Constructed wetland		■	■	■	
Bioretention basin		■	■	■	P
Infiltration basin		■	■		■

P – Potential to achieve treatment by modification of the typical SQID configuration or where site conditions are appropriate.

3.3 Site Constraints

The Water Cycle Management Guidelines (WCMGs) outline site analysis considerations when preparing a Water Cycle Management Plan (WCMP). This section of the SQID guidelines provides guidance on how the site analysis outcomes can be applied to confirm the feasibility of particular SQIDs.

A range of common site characteristics and how they broadly constrain the application of particular SQIDs are summarised in Table 3-4. How the site characteristics typically impacts on the feasibility of particular SQIDs have been divided into three broad categories, Low (L), Medium (M) and High (H). Low constraints will typically not impact on the feasibility of a SQID for most sites. Medium constraints provide some constraint for a SQID which may be overcome through good design. High constraints may preclude use of a SQID except in exceptional circumstances where a unique design solution can be developed. Key site constraints are discussed further below.

Table 3-4 Site Analysis

SQID	Steep terrain (>4%)	Flat terrain (<1%)	Shallow bedrock	Acid sulphate soils	Clay soils	Sandy soils	High groundwater	High sediment load	Highly dispersive or erodible soils	Saline or sodic soils	Riparian land	Services or infrastructure
Rainwater tanks	L	L	L	L	L	L	L	L	L	L	L	L
Permeable paving	H	L	H	L	M	L	M	H	L	L	L	L
Raingardens	M	L	H	M	L	M	H	M	L	M	L	M
Infiltration trench	H	L	H	H	H	L	H	M	H	H	L	M
Vegetated filter strips	H	M	M	L	L	L	L	L	L	M	L	L
Grassed swale	H	M	H	M	L	L	M	L	M	M	L	M
Bioretention swale	H	L	H	M	L	M	H	M	L	M	L	M
Tree pit filter	M	L	H	M	L	M	H	M	L	M	L	L
Gross pollutant trap	M	M	M	M	L	L	M	L	L	L	H	M
Sediment basin	H	L	H	M	L	L	H	L	M	L	H	M
Constructed wetland	H	L	H	M	L	M	M	M	M	M	H	M
Bioretention basin	H	L	H	M	L	M	H	M	L	M	H	M
Infiltration basin	H	L	H	H	H	L	H	M	H	H	H	M

3.3.1 Terrain and Natural Drainage

The terrain of a site and adjacent land is typically one of the key constraints when selecting and planning SQIDs. The existing site terrain will typically control where subdivision or precinct scale SQIDs can be located. Typically these SQIDs will be positioned in the lower areas of a site adjacent to watercourses and other drainage pathways. To avoid excessive earthworks, the existing terrain will typically dictate where these SQIDs can be positioned for optimum effect. Subdivision and precinct scale SQIDs also need to give consideration to runoff from adjacent lands. Whilst it is not the responsibility of the development applicant to improve water quality from external sites, consideration of runoff from the external land is required when sizing SQIDs unless a feasible flow diversion option is available.

The location and alignment of roads within subdivisions will impact on the feasibility of positioning SQIDs within the road reserve. Where roads are aligned perpendicular to steep contours, options for providing SQIDs in the streetscape are limited due to the high potential for erosion and reduced ability for stormwater retention without extensive earthworks. Where roads can be aligned along the contours, gradients along drainage flow paths can be significantly reduced which provides conditions more amenable to a wider range of SQID types.

Lot scale provision of SQIDs is less impacted by site gradients, except in circumstances where slopes are particularly steep. An important consideration will be if lot scale SQIDs would overflow to a road reserve, adjacent private lot or into an interallotment drainage system. Where overflow from a SQID would discharge as concentrated flow onto an adjacent property, an easement would be required. Ideally, in these circumstances the roof water drainage system would be connected to a SQID that is then connected to an interallotment drainage system. Runoff from other paved surfaces not connected to a drainage system would be managed more informally through permeable paving and filter strips to avoid concentration of flows. Overflow to public road reserves would be less of a constraint in most circumstances.

Flat terrain can also pose a constraint to the provision of SQIDs. Whilst SQIDs that temporarily retain and filter runoff are well suited to flat terrain (where groundwater and soil conditions are suitable), SQIDs that function by conveying flow will typically not drain well, resulting in frequently saturated areas that remain boggy for extended periods. This can impact on the ability to effectively maintain these SQIDs. Typically where these SQIDs are installed in flat terrain, additional subsoil drainage may be required.

In addition to assessing the gradients across the site, other terrain features should also be identified that potentially will impact on the location of SQIDs including areas of slope instability susceptible to concentrated stormwater discharges and rock outcrops.

3.3.2 Soils and Groundwater

A key objective of WSUD is to minimise changes in the stormwater runoff volumes and flow duration following development. Typically this can be achieved through rainwater/stormwater harvesting and maximising the infiltration/evapotranspiration potential across the site.

SQIDs that function primarily through infiltration can have a significant impact on reducing surface runoff volumes. Whilst infiltration will considerably reduce surface runoff volumes, it is important to consider the potential impacts of increased infiltration on groundwater levels, base flow, groundwater quality, seepage and soil salinity.

Increasing groundwater levels through distributed infiltration across a site can potentially elevate the natural groundwater table. It is important that SQIDs are selected considering the potential for infiltrated runoff to impact on structures and other infrastructure that are susceptible to groundwater table rise. Modifying infiltration across the site may also result in increased seepage occurring at downslope sites where the groundwater table intersects the surface. Concentrated infiltration of stormwater at SQID locations can lead to groundwater mounding which may impact on the hydraulic function of the SQID.

Highly permeable soils often contain layers of indurated sand that vary from loose to locally hardsetting (e.g. coffee rock). It is important that identification of hardsetting layers is identified as this may influence the function of SQIDs that rely on infiltration.

Excavation within low lying coastal areas to construct SQIDs may intercept acid sulphate soils leading to increased acid runoff or expensive soil treatments to neutralise the acidic soils. Care is required to select SQIDs in these circumstances that minimise excavation or avoid acid sulphate soil layers.

Highly dispersible or erodible soils may also impose a constraint on SQIDs. Discharges from SQIDs should not be concentrated to areas where these soils exist. In addition, locating SQIDs in areas where these soils are present can ultimately reduce water quality if exposed soils are not protected from disturbance from stormwater discharging into the SQID.

Saline or sodic soils can often be highly erodible and SQIDs can provide a more efficient pathway for saline groundwater to discharge into a receiving environment. Saline groundwater can also limit the vegetation that can be established in SQIDs. Selection of appropriate plant species for vegetated SQIDs is of high importance in saline areas.

3.3.3 Riparian Land

The protection of riparian areas is important for maintaining or improving the geomorphic form and ecological functions of watercourses through a range of hydrologic conditions. Council's position is that SQIDs shall not be provided within a riparian corridor.

The Water Management Act 2000 requires a 'controlled activity approval' for development proposed within 'waterfront land'. Waterfront land (i.e. riparian land) is typically that within 40m of a water body or watercourse (highest bank). Development requiring a 'controlled activity approval' is termed 'Integrated Development' and the 'approval body' is currently the NSW Office of Water (NoW). Council cannot grant development consent if the approval body advises that it is not prepared to grant approval.

NoW provides guidance on appropriate widths and allowable controlled activities for riparian lands. Riparian corridors are defined within the *Guidelines for Controlled Activities - Riparian Corridors* (DWE, 2008). Riparian corridor zones (Core Riparian Zone and Vegetated Buffer) and adjacent Asset Protection Zone are shown in Figure 3-1.

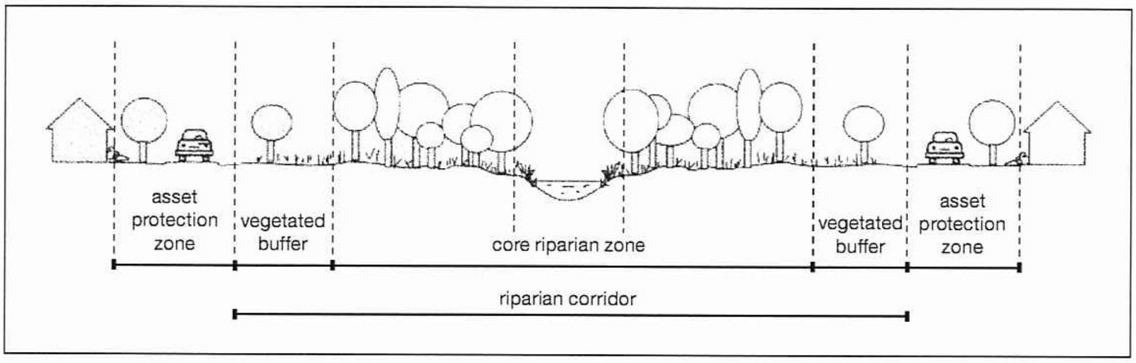


Figure 3-1 Riparian corridor zones (DWE, 2008)

The Core Riparian Zone (CRZ) is the land contained within and adjacent to the watercourse. NoW typically seeks to ensure that the CRZ remains, or becomes vegetated, with fully structured native vegetation (including groundcovers, shrubs and trees). The Vegetated Buffer (VB) protects the environmental integrity of the CRZ from weed invasion, micro-climate changes, litter, trampling and pollution. SQIDs should not be positioned within the CRZ or VB.

Asset Protection Zones (APZ) are a requirement of the NSW Rural Fire Service and are designed to protect assets (house, buildings etc) from potential bushfire damage. APZ requirements are provided in the NSW Rural Fire Service document *Planning for Bushfire Protection, 2006.* The APZ should contain cleared land which means that it cannot be part of the CRZ or VB. SQIDs can typically be located within the APZ provided the NSW Rural Fire Service requirements are met.

3.3.4 Terrestrial Flora and Fauna

In addition to flora and fauna that lie within defined riparian zones, other terrestrial habitats should be identified and mapped within the development site to ensure these are considered when SQIDs are being planned. Key flora and fauna elements to consider include:

- SEPPs and associated mapped areas;
- Endangered ecological communities;
- Threatened species and habitats;
- Migratory bird habitats;
- Ecological buffers; and
- Heritage listed trees.

3.3.5 Services and Infrastructure

Existing services and infrastructure can often constrain the location of SQIDs. The site analysis should also include investigations for any planned infrastructure and services that need to be accommodated within the development.

For greenfields development where SQIDs are planned to be positioned within the road reserve it is important that the planned service allocations within the footpath area are considered to ensure that conflicts with SQIDs are avoided. It is important that excavation to construct the SQIDs does not compromise the cover to the services or that regular maintenance of the services would not be impeded.

SQIDs provided at the subdivision or precinct scale may be positioned adjacent to riparian corridors and other low lying areas where there is potential for conflict with sewerage and other trunk infrastructure. Typically a Dial-Before-You-Dig services search enquiry is required to determine if any infrastructure (e.g. sewerage, transmission easements, oil pipelines) crosses the site.

Where SQIDs are provided in lots, consideration of roof drainage lines, water supply, sewerage, gas, electricity and telecommunications services is required to avoid conflicts.

For brownfields (i.e. re-development) development, a services search enquiry should be undertaken to identify the location of existing above and below ground infrastructure. Site based service locating surveys may also be necessary to confirm the exact plan location and depth of constructed services to ensure that planned SQIDs avoid these. Liaison with Council may be required to identify the location of stormwater drainage.

3.3.6 Other Urban Design

There are a range of other urban design elements that typically form a lower constraint to SQIDs. These include heritage, archaeology, traffic, lighting, aesthetics and crime prevention. Although they are often lower constraints, where identified, these elements should be considered when planning SQIDs.

3.4 Stormwater Quality

Objectives and targets for stormwater quality management are summarised in Council's WCMGs. The development applicant should refer to the WCMGs to confirm the relevant objectives and targets for their site. The stormwater pollutants targeted for removal by the SQIDs can cover a wide range of different sizes. The treatment series proposed should initially focus on capturing gross pollutants (litter, organic debris etc) and coarse particulates (sediment), followed by fine particulates, colloidal and dissolved pollutants. Configuring the treatment series in this manner will achieve pre-treatment for downstream treatment measures that could potentially be damaged or require frequent maintenance to remove high gross pollutant and coarse sediment loads. For example, a bioretention basin may become clogged in a short period if no upstream sediment retention basin is provided.

Individual SQIDs function most effectively across particular pollutant size ranges. As the size of the targeted pollutants reduces, the hydraulic residence time must increase to ensure that effective treatment is achieved (i.e. the storage volume in the SQID relative to the catchment size must increase). SQIDs that are appropriate for particular targeted pollutants are shaded in Table 3-5. From Table 3-5 it can be seen that to capture certain pollutants, one treatment measure may not be sufficient. For example, whilst a grassed swale can remove some particulate nutrients, it will be ineffective for the dissolved nutrients for which a raingarden or constructed wetland will provide more effective treatment.

Table 3-5 Stormwater Quality Management

SQID	Litter	Organic debris	Coarse particles	Medium particles	Suspended solids	Phosphorus (particulate)	Nitrogen (particulate)	Phosphorus (dissolved)	Nitrogen (dissolved)
Rainwater tanks									
Permeable paving									
Raingardens									
Infiltration trench									
Vegetated filter strips									
Grassed swale									
Bioretention swale									
Tree pit filter									

SQID	Litter	Organic debris	Coarse particles	Medium particles	Suspended solids	Phosphorus (particulate)	Nitrogen (particulate)	Phosphorus (dissolved)	Nitrogen (dissolved)
Gross pollutant trap									
Sediment basin									
Constructed wetland									
Bioretention basin									
Infiltration basin									

3.5 Stormwater Quantity

The development applicant should refer to the WCMGs to confirm the relevant stormwater quantity management objectives and targets for their site. Relevant stormwater quantity management objectives for SQIDs are summarised in Table 3-6.

Most SQIDs will have some influence on reducing flow rates and runoff volumes from development. Typically SQIDs with a low retention or detention storage volume (relative to the contributing catchment area) will have a lower potential for managing flows, whilst those with a relatively larger retention or detention storage may have a significant influence. SQIDs that retain and slowly release or divert stormwater volumes will typically influence the lower flow range (<3 month ARI). During higher flows (up to 100yr ARI), a large dedicated detention storage can significantly reduce flow rates.

SQIDs that are located within the road reserve or in-line are typically configured to convey higher flows (>5yr ARI) without causing flooding impacts or excessive damage to the SQIDs. SQIDs located near development or catchment outlets, can potentially be configured to manage higher flows if required, or designed with bypasses to divert high flows.

Table 3-6 Stormwater Quantity Management

SQID	Stormwater Quantity Management Objectives						
	Drainage disconnection	Stormwater retention	Frequent flow conveyance	Stream erosion protection	Stormwater detention	Minor drainage conveyance	Overland flow conveyance
Rainwater tanks					P		
Permeable paving							
Raingardens							
Infiltration trench							
Vegetated filter strips							
Grassed swale							
Bioretention swale						P	P
Tree pit filter							
Gross pollutant trap							
Sediment basin				P			
Constructed wetland					P	P	P
Bioretention basin					P	P	P
Infiltration basin							

P – Potential to achieve objective with modification of the typical SQID configuration.

4 SQID SUMMARIES

4.1 Overview

The following summaries provide information on Council's preferred SQIDs. Whilst the SQIDs outlined in the summaries are preferred by Council, alternative SQIDs may be considered based on their merits provided the development applicant consults with Council prior to submission of the Water Cycle Management Plan (WCMP). Where consultation has not occurred prior to submission of the development application, alternative SQIDs are unlikely to be supported by Council.

The primary objective of these SQID summaries is to provide sufficient guidance for a development applicant to ensure that appropriate SQIDs are identified at the development application stage. Following identification of potential SQIDs for a particular development from the SQID selection guide outlined in Section 3, development applicants should refer to individual SQID summaries for further guidance prior to preparing a WCMP and concept design. The SQID summaries outline further considerations to ensure that selected SQIDs are appropriate for the proposed development. The SQID summaries should provide sufficient guidance to assist with avoiding significant changes to the WCMP during the following detailed design, construction and operational phases of the development lifecycle.

SQID summaries for rainwater tanks, permeable paving, filter strips, grassed swales, gross pollutant traps, sediment basins, infiltration measures (trenches and basins), bioretention measures (raingardens, tree pit filters, swales and basins) and constructed wetlands are provided in the following sections. The summaries include:

- A summary of the function of each SQID;
- A description of the typical configuration of the SQID;
- A summary of typical access, inspection and maintenance requirements;
- Typical operation and maintenance costs; and
- Examples of constructed SQIDs that highlight some of the key considerations.

Resources that may assist with the detailed design of the SQIDs are provided in Section 10.

The inspection and maintenance considerations outlined in the SQID summaries are provided to assist development applicants with ensuring that proposed SQIDs have been planned with an awareness of the intended future maintenance activities. These considerations are provided to ensure that SQIDs will be acceptable for Council at handover. More detailed maintenance service standards are documented in Council's internal maintenance service specifications which are regularly updated to take account of site specific observations, new technologies, procedures, revised budgets etc.

4.2 Rainwater Tanks

4.2.1 Function

Rainwater tanks are typically installed within private lots in urban areas to capture roof runoff (rainwater) for internal and external uses. Benefits of harvesting rainwater include potable water conservation, stormwater detention and water quality improvement. Retaining and using rainwater reduces reliance on potable water supply systems in urban areas and as such can assist with deferring potable water system upgrades. The retention of roof runoff can also contribute to reducing the duration of elevated stream flows from urban catchments. Rainwater tanks will typically have limited influence on water quality concentrations, although retention and diversion of stormwater to the sewer and garden areas reduces the volume of stormwater pollutants discharging to watercourses in the catchment of the development.

Rainwater tanks are more efficient when the retained water is used to supply multiple water demands within a development. Within urban residential areas, rainwater can potentially replace potable water for water demands including toilet flushing, garden watering, laundry, hot water and pool filling. The NSW Department of Health does not expressly prohibit rainwater tanks being used as a source of drinking water, however, the guidelines recommend avoiding drinking rainwater where a reticulated potable supply is available. Typically a potable water service connection is still required for situations where the rainwater tank is empty and water is unable to be accessed from another source. Rainwater tanks are typically required for many residential developments to achieve BASIX criteria. In these circumstances, rainwater tanks will also form a part of the treatment series.

Although rainwater tanks can potentially provide a high security of supply to a site, available space may limit the size of tank that can be installed. Rainwater tanks can be relatively simple and efficient to maintain provided the tanks are initially configured appropriately and on-going attention is given to maintaining electrical equipment and tank inlets/outlets.

This SQID summary applies only to rainwater tanks to be positioned above-ground as this is Council's preferred arrangement. Other below-ground, under floor, in-slab or membrane rainwater tanks may require specialist consideration and design by a qualified consulting engineer.

4.2.2 Configuration

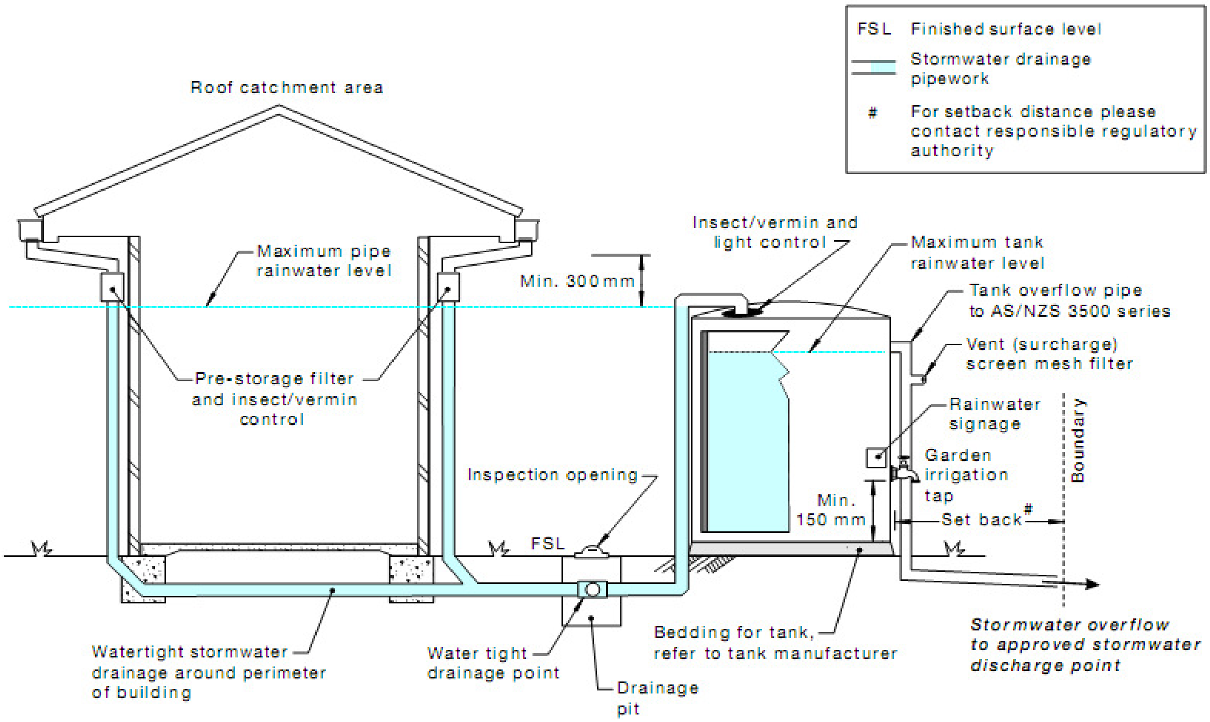


Figure 4-1 Typical Above-ground Rainwater Tank Installation (charged system) (National Water Commission, 2008)

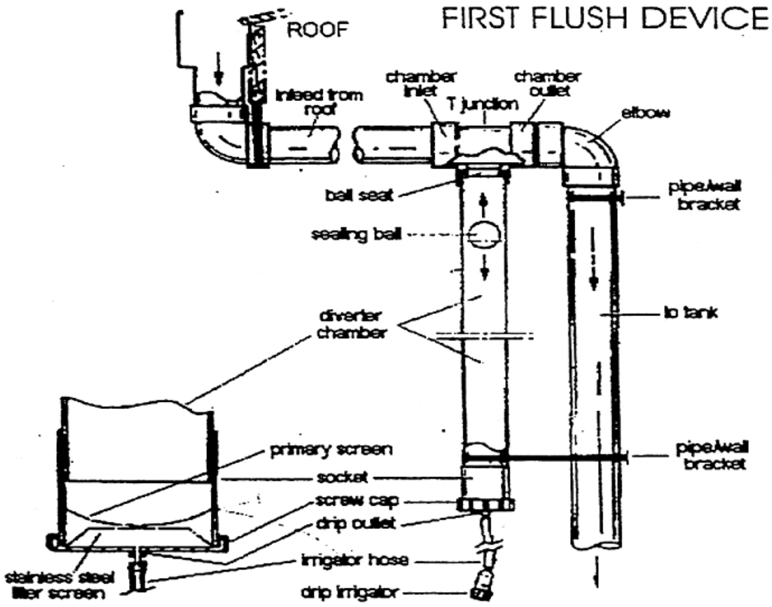


Figure 4-2 Typical First Flush Device (Gosford City Council, 2003)

Roof runoff is directed to a rainwater tank either by direct connection of downpipes or in-direct connection via a charged pipe system. Filtering devices are often installed across roof gutters and downpipe inlets to minimise the potential for leaves and other organic debris to be conveyed by roof runoff into the tanks. First flush devices are also typically installed to capture the first proportion of runoff from roofs which may contain elevated levels of sediment and other pollutants. Typically a first flush diversion pipe with a floating ball valve is installed just prior to the rainwater tank inlet. The roof water discharged into the tank is typically filtered through a mosquito proof mesh screen to remove any coarse material that bypasses the gutter filters and first flush diverter.

In order to drain a high proportion of roof area to a tank, a below ground piped system is typically constructed to collect multiple downpipes and discharge the combined runoff via a single inlet into the rainwater tank. At the conclusion of a rainfall event, the pipes remain charged (i.e. filled with water). Typically a drainage valve or slow seepage device is provided at the low point of the charged system to allow the pipes to be drained between events. An alternative to charged systems requires large capacity box gutters to convey all roof runoff to a single rainhead and downpipe located directly above the rainwater tank.

Most residential rainwater tanks are configured to pump water from a tank through a water controller/switch that alternates between mains water and rainwater tank supply depending on the level of stored water in the tank. When the tank storage level is high, a valve on the potable water service line closes and supply to the fixtures within the building will be from rainwater. As the rainwater tank level drops, the pressure on the valve reduces and the valve opens to enable mains water to flow to the fixtures. When the tank refills following rainfall, the supply source reverts to the rainwater tank. Other arrangements using internal float switches with mains water topping up of tanks are also occasionally used.

4.2.3 Access, Inspection and Maintenance Considerations

Minimum access requirements for inspections and maintenance include:

- Access to the complete perimeter of the tank;
- Access to pump, first flush device, leaf screen and control switches not impeded.

The following inspection tasks typically apply to rainwater tanks:

- Regularly check rainwater tanks during flushing of toilets, washing machine operation, garden watering, etc to ensure that the tank and pumps continue to function as designed.
- Any accesses to rainwater tanks should be checked frequently to ensure they are secure to prevent risk of entry by children.
- Check inlets and mosquito/insect prevention screens frequently to ensure they are intact and clear of debris.
- Inspect the rainwater tank internally (if possible) annually for evidence of access by animals or insects.
- Inspect pipe work and fittings annually during a storm event to ensure that connections are not leaking.
- Measure sediment level in the tank annually.

The following maintenance tasks typically apply to rainwater tanks:

- Prune trees overhanging roof areas annually.

- Clear gutters and filter screens of organic debris and sediment annually unless inspections identify additional needs.
- Flush out charged roof drainage systems (if relevant) during extended dry periods.
- First flush diverter should be checked and cleaned quarterly.
- Rainwater tank structure should be checked annually for leaks and any repairs undertaken.
- Clean pumps on an annual basis.
- Clean/replace/backwash pre and post rainwater tank storage filtration devices annually.
- Dewater the rainwater tank where inspections identify the potential for accumulated sediment to block the outlets.

4.2.4 Constructed Examples

	Rainwater tanks installed away from dwelling walls enable access to the entire tank perimeter. Roof runoff enters the tank through a charged charged roof water drainage system that relies on the difference in height between the roof gutter and tank inlet to convey roof runoff into the tank.
Roof runoff filter to remove leaf matter and sediment prior to draining to below ground rainwater tank. Any blockage of the filter simply results in overflow onto the adjacent pervious grass area.	

Provision of mesh over roof gutters will assist with reducing the quantity of organic debris and sediment discharged to a rainwater tank.
(photo source www.gumleafgutterguard.com)

Careful consideration of plumbing arrangements should reduce the complexity of the inlet and outlet configuration for a rainwater tank.

Rainwater tanks can be provided with appropriate controls to switch the water supply to a building from rainwater tank supply when the storage is low to backup potable water supply. This avoids the need to top rainwater tanks up from the potable water supply and optimises the harvesting of rainwater.

Filter canisters can be installed to provide further treatment of the rainwater prior to supplying to a building.

Rainwater tank installed with first flush diverter. First flush fills up small length of pipe that terminates at a screw cap incorporating a drip line that slowly discharges the first flush water onto the adjacent ground. The screw cap needs to be checked and cleaned frequently to remove fine sediment to avoid the drip line becoming blocked.

4.3 Permeable Paving

4.3.1 Function

Permeable paving filters stormwater during frequent runoff events to remove fine sediment and associated particulates. Detention and retention of stormwater is achieved by storage on the surface and within the granular base. During infrequent high runoff events the infiltration capacity of the voids is exceeded and the excess rainfall is converted to runoff. During these events runoff is directed to an appropriate minor or major drainage system and conveyed to the receiving environment.

Permeable paving is typically positioned close to the source of pollutant generation. Permeable paving provides an option in urban areas for disconnecting impervious surfaces from receiving environments. Typically permeable paving is provided in residential driveways, shared accesses and car parking spaces where traffic loadings are relatively low.

Permeable paving can be relatively simple and efficient to maintain provided appropriate pre-treatment of surface runoff draining onto the pavement is undertaken.

4.3.2 Configuration

Permeable paving typically comprises a semi-permeable surface layer overlaying a depth of granular material. The surface layer is typically formed from modular concrete pavers, concrete/plastic grids or porous asphalt. The surface layer incorporates voids that enable water to infiltrate into the lower granular layer. The lower granular layer functions to filter, detain and retain stormwater, and also provide structural support to transfer vehicular loads to the underlying soils.

4.3.3 Access, Inspection and Maintenance Considerations

Minimum access requirements for inspections and maintenance include:

- Ability to temporarily exclude traffic from the permeable pavement area.

The following inspection tasks typically apply to permeable paving:

- Observe pavement surface during or immediately following a high rainfall period annually to check that extended ponding of water is not occurring.
- Check surface of pavement for any areas of accumulated coarse sediment.
- Check for any evidence of silting on the pavement surface that may indicate clogging of the permeable media.
- Check for cracks, depressions and/or edge failures.
- Check that landscaping or building materials are not being stockpiled in an area where runoff would direct the materials onto the pavement.

The following maintenance tasks typically apply to permeable paving:

- Regular manual or mechanical sweeping of the pavement to remove litter, leaves, other organic debris and coarse sediment.
- Occasional vacuuming or high pressure flushing of granular infill to reduce clogging potential.

- Top up granular infill where displaced by traffic or other maintenance activities.
- Flushing of underdrains that capture filtered runoff (where these exist).
- Remove paving in areas where local settlement has occurred and reconstruct pavement to subgrade level.
- Remove and replace broken pavers.
- Mow grass infill where applicable.

4.3.4 Constructed Examples

	Permeable pavement voids will tend to accumulate sediment, small leaves, twigs and enable small vegetation species to establish. Occasional maintenance is necessary to clear out the upper gravel layers in the voids to maintain infiltration.
Limiting the catchment for the permeable paving to the immediate carparking area and surrounds can assist to limit runoff conveying sediment onto the pavement from surrounding areas. Landscaped bunding around the permeable paving area can assist with re-directing runoff away from the area.	

4.4 Filter Strips

4.4.1 Function

Filter strips are vegetated strips that are effective at intercepting litter, organic debris, coarse to medium sized sediment particles and attached pollutants. Filter strips are typically provided directly adjacent to road pavements or carparking areas for filtering of sheet flow runoff from these impervious surfaces.

Filter strips are measures that typically perform a primary treatment function and also assist with shallow infiltration of stormwater runoff. Filter strips provide pre-treatment by removing a high proportion of coarse matter to reduce the potential for blockage of downstream measures designed to manage finer and dissolved pollutants.

4.4.2 Configuration

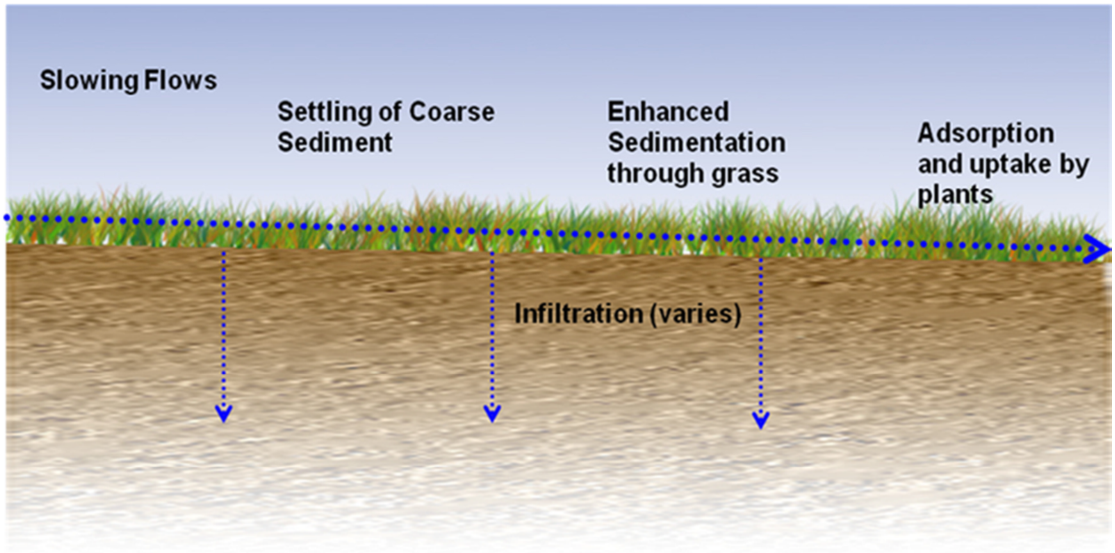


Figure 4-3 Typical Filter Strip

Filter strips typically comprise a grassed or otherwise vegetated strip of land directly adjacent to a paved area. Runoff from the paved area is typically able to flow as unconcentrated sheet flow onto the filter strip. The sheet flow is distributed across the filter strip and treatment occurs through friction with the grasses which slows the flow and enables sedimentation to occur. It is important that runoff is not concentrated into filter strips to avoid scouring. Where concentrated flows to the filter strip are unable to be avoided, flow stilling and scour protection measures are typically provided to reduce flow velocities and distribute the flow more evenly.

The raised concrete edge strips typically provide up to a 50mm vertical step between the road pavement edge and filter strip to reduce edge trimming requirements and minimise sediment accumulation on the road. Bollards or other similar traffic control devices are often provided to restrict vehicular access the filter strip.

Grass is typically maintained at around 150mm to provide effective filtration. This height may be varied as a catchment becomes more stabilised and coarse sediment loads reduce. Low growing tufted native grasses could also be planted to achieve a similar function.

Filter strips are often provided adjacent to grassed swales, raingardens or bioretention swales to provide pre-treatment of flows draining to these SQIDs.

4.4.3 Access, Inspection and Maintenance Considerations

Filter strips are relatively simple to maintain with similar mowing requirements as grassed footpaths,

The maintenance frequency will depend on a number of factors including seasonal influences, catchment area, catchment development, recent rainfall, pollutant loads/characteristics, maintenance equipment, receiving water sensitivity etc. An appropriate inspection and maintenance frequency can usually be determined after 2 years of operation when the catchment and filter strip are stabilised.

Typically during spring and summer grass cutting and weeding should occur at least on a monthly interval. During autumn and winter this frequency may be extended to a 2-3 month interval. For some sites, higher loading rates and aesthetics may require more frequent maintenance. To prevent rutting within the filter strips, mowing should only be undertaken following a period of dry weather.

Minimum access requirements for inspections and maintenance include:

- Traffic exclusion bollards are either removable or appropriately spaced to enable grass mowing equipment to access.

The following inspection tasks typically apply to filter strips:

- Check for bare patches and/or areas where weed growth exceeds 10% of the filter strip area.
- Check for accumulated deposits of sediment, litter, rocks and/or organic debris.
- Check for erosion around inlets or concentrated flow rills formed within the filter strip.
- Observe for concentrated flows within the filter strip during wet weather.
- Check for vehicle wheel ruts or other evidence of vehicle access.

The following maintenance tasks typically apply to filter strips:

- Manually remove weeds, sediment, litter and organic debris using rakes, shovels and/or hoes.
- Cut grass to the minimum design height.
- Trim edges using line or edge trimmers.
- Regrade and replant bare areas.
- Remove cut grass, weeds, litter, debris and other matter and dispose off-site.

4.4.4 Constructed Examples

Grassed filter strip provided adjacent to mulched landscaping buffer. Timber border between mulch and grass provided to restrict grass intrusion into the mulched area.

Grass currently maintained at low height for aesthetics during land sale period. Ideally, grass should be maintained higher during the dwelling construction phase to be more effective.

Filter strips can be incorporated as pre-treatment for bioretention swales.

Grassed/mulched filter strip constructed during subdivision works damaged by placing of building materials and facilities during dwelling construction phase.

	Mulched filter strip constructed on sandy soils on high slope resulting in scouring and erosion of mulch and sand during runoff events.
Mulched filter strip constructed on sandy soils on moderate slope less prone to scouring and erosion of mulch and sand during runoff events.	
	Concrete edge strips should be slightly raised above the filter strip to avoid sediment washing out. Bollards or other vehicle exclusion measures also necessary to prevent access which can destroy vegetation. Use of low growing tufted native grasses in the filter strip can reduce mowing requirements in less accessible areas.
Grassed filter strips can be combined with vegetated and mulched buffers. Drainage inlets provided within the filter strips can manage pre-treated flows.	

4.5 Grassed Swales

4.5.1 Function

Grassed swales are measures that typically perform a stormwater treatment and drainage function. Grassed swales filter stormwater during frequent runoff events to remove gross pollutants and medium to coarse sediment. During infrequent runoff events, the measures may also function as a component of the minor and major drainage systems to convey runoff to the receiving environment.

Grassed swales are typically provided close to the source of pollutant generation and provide primary (and partial secondary) treatment of stormwater runoff draining to tertiary treatment measures. Typically these measures may be provided adjacent to highly impervious areas including roads and car parks.

Grassed swales can be relatively simple to maintain with similar mowing requirements as grassed footpaths. Where low growing native grasses are provided, more manual maintenance may be required. Additional maintenance may be required to remove gross pollutants and sediment, repair scouring and clear drainage inlets. Open channels or modified watercourse that convey concentrated flood flows should not be considered as grassed swales.

4.5.2 Configuration

Figure 4-4 Typical Roadside Grassed Swale

Grassed swales are typically trapezoidal shaped grass lined measures. The swale base width should be designed considering the hydraulic capacity requirements and the width of equipment that Council would use to cut the grass. The base should be relatively level across the section to avoid concentrated flow paths forming which could lead to scouring and rills forming. For the same reason v-shaped swales should be avoided.

The swale side slopes should have an appropriate gradient for the location and for maintenance access. Typically swales located within the road reserve will be formed with shallower depths and gentle side slopes to manage potential risks for pedestrians and traffic during wet and dry periods. Gentle side slopes also assist with minimising the potential for scouring from distributed runoff that discharges laterally into the measure. Swales in less trafficked areas potentially may be deeper and have steeper side slopes where this is assessed to be an appropriate solution.

The swale gradient typically should be within the 1% to 4% range. Shallower gradients result in poorer drainage leading to frequently boggy areas which are difficult to maintain. Steeper gradients may result in increased potential for scouring.

Grassed swales can either be planted with turf species or native grass species. Where native grass species are planted, it is important that species are relatively low growing and that the drainage function of the swale would not be compromised by dense vegetation growth.

4.5.3 Access, Inspection and Maintenance Considerations

Minimum access requirements for inspections and maintenance include:

- Traffic exclusion bollards are either removable or appropriately spaced to enable grass mowing equipment to access.

The following inspection tasks typically apply to grass swales:

- Check for bare patches and/or areas where weed growth exceeds 10% of the grass swale area.
- Check for accumulated deposits of sediment, litter, rocks and/or organic debris.
- Check that sediment is not accumulating on the road pavement or driveways adjacent to the grass swale.
- Check for erosion around inlets or concentrated flow rills.
- Check for signs of concentrated flow across the grass swale cross section during wet weather.
- Check for vehicle wheel ruts or other evidence of vehicle access.
- Open inspection covers (where provided) to check if excessive silting of the subsoil drainage has occurred.

The following maintenance tasks typically apply to grass swales:

- Preferably remove weeds manually. Where weeds are particularly invasive, spot spraying with a herbicide approved for use in an aquatic environment may need to be undertaken.
- Remove accumulated sediment, litter and organic debris using rakes, shovels and/or hoes. Portable blower/vacuum units may also assist to vacuum material.
- Cut grass to the minimum design height. Only cut grass when soil is relatively dry to avoid rutting, particularly when ride-on mowers are used.
- Where native grasses are used instead of turf, line trimmers will typically be required to trim grasses.
- Tidy up swale edges using line or edge trimmers.
- Regrade and replant bare areas.
- Flush sub-soil drains using high pressure jets of hoses.
- Transport waste from site and recycle or dispose.

4.5.4 Constructed Examples

	Grassed swale and filter strip adjacent to relative steep road. Closely spaced timber guide posts provided to exclude vehicle access.
Grassed swales are an effective control for filtering organic debris and coarse sediment from runoff prior to flowing into a constructed drainage system for further treatment at a downslope measure. Traffic bollards should have been provided between the swale and road pavement to exclude vehicular access.	
	Inlet to grassed swale constructed from rock embedded in concrete to reduce energy and minimise potential for scouring. Bollards provided to restrict access. Kerb and gutter has been provided up until the inlet, and a flush concrete edge strip provided after the inlet to allow for distributed flows into the swale.

Access to grassed swale restricted by decorative timber bollards.	
	Driveway crossings over swales are an important consideration for excluding vehicular traffic.
Grass swale constructed with elevated driveway crossings. It is particularly important that the drainage function of the swale is considered in these circumstances to ensure that the potential for crossings to become blocked by debris is considered.	
	Drainage inlets with raised grates can assist with limiting the ponding of water. Flush grates will reduce gross pollutants discharging into the drainage system, but will be more prone to blockage. It is important that when raised grates are provided in footpath areas that appropriate consideration is given to potential conflicts with pedestrians and vehicles. Co-ordination with street lighting can assist with reducing potential conflicts.

Drainage inlets should be slightly depressed within swales to avoid localised ponding of water, which can kill grass leaving bare patches that are susceptible to erosion.

Traffic bollards should have been provided between the swale and road pavement to exclude vehicular access.

Where gradients are low more frequent drainage inlets may be required or sub-soil drainage provided to prevent frequently boggy areas. Frequently boggy areas limit the periods available for grass cutting.

Where gradients are reasonable, excessive accumulation of fine sediment can result in boggy conditions due to water being retained in a progressively deepening sediment layer. Maintenance should be planned to avoid excessive build up of sediment. This may require grass to be cut shorter than designed annually to enable sediment to be removed.

V-shaped grass swales should be avoided to minimise the potential for flow concentrations and scouring. Trees and shrubs should be planted outside the grassed swale to avoid entraining light mulch in flows and providing an obstruction during high flow events.

4.6 Gross Pollutant Traps

4.6.1 Function

Gross pollutant traps (GPTs) are provided to capture organic debris, litter and coarse sediment entrained in stormwater. GPTs are a pre-treatment measure for SQIDs designed to remove fine sediment, heavy metals, nutrients and other particulate or dissolved pollutants. GPTs essentially concentrate the larger visible stormwater pollutants at one location and therefore avoid the time consuming task of removing this matter when it is dispersed within a downstream measure or receiving environment. Capture of these pollutants can also assist in minimising the potential for blockage of downstream measures.

GPTs are provided to treat runoff from highly impervious commercial or industrial lot scale development where litter and sediment loads are potentially high. Gross pollutant traps may also be provided downstream of a subdivision that relies on a large subdivision scale measure to manage stormwater (e.g. constructed wetland or bioretention basin). Where stormwater quality is proposed to be managed by street scale measures in residential areas (e.g. grassed and bioretention swales) GPTs would typically not be required.

4.6.2 Configuration

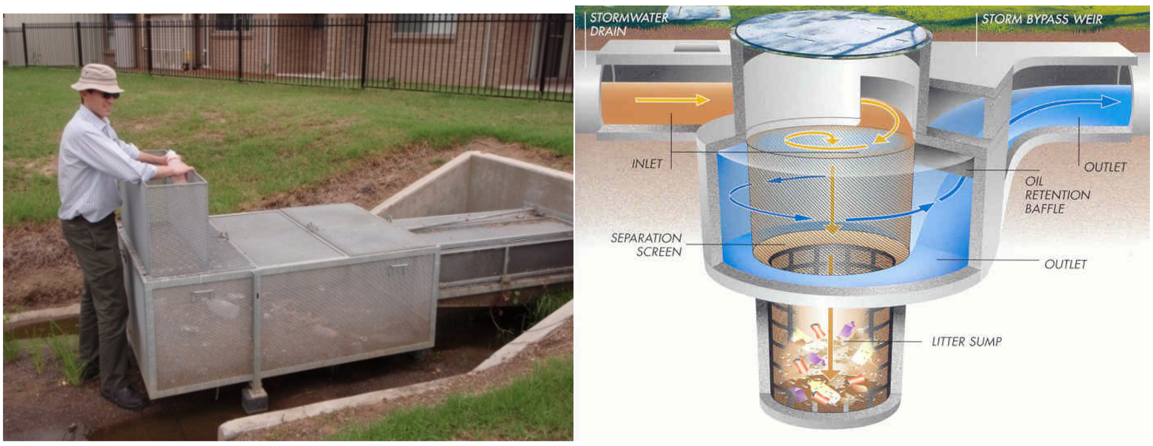


Figure 4-5 Typical Proprietary GPTs

The majority of GPTs function by filtration to separate pollutants from stormwater. The filtration mechanisms employed include vertical screens, inclined screens, circular screens, media filled cartridges, nets, racks and baskets.

The most simplistic GPTs are stormwater grates installed flush with the finished surface of a carpark. Any pollutants with a least dimension exceeding the grate opening (typically 10 to 20mm) are prevented from entering the drainage system and can then be removed from the surface of the carpark manually or by mechanical sweeping. Other simple examples include mesh screens across the inlet of rainwater tanks to trap leaves.

Pit inserts are a type of GPT typically installed near the pollutant source either within a kerb inlet pits or surface inlet pits. These GPTs function by directly filtering stormwater runoff entering a stormwater pit. Pit inserts typically comprised a mesh screen or cage which captures the gross pollutants as stormwater dropping into the pit filters through the mesh. Pit inserts are not a preferred gross pollutant trapping device within the City of Lake Macquarie and their use should be avoided.

GPTs can be provided with either an above or below-ground detention storage. Above-ground storage GPTs typically store the captured pollutants in a dry state, whilst below-ground GPTs store pollutants wet (with the exception of pit inserts). Storing gross pollutants dry is preferable for transportation and disposal costs will be lower. Although, where space is limited, a below-ground GPT may be more feasible.

In-line separator devices (i.e. oil and sediment separators) are typically installed along a drainage line near a pollutant source. These measures rely on gravity settling, variations in pollutant density, baffles and/or hydrodynamic separation processes to remove oil and sediment from stormwater. The hydraulic residence time must be long enough for either settling of sediments, or for the oils and greases to rise to the water surface and be trapped. Sediment is typically retained within the base of the storage/treatment chamber, oils and other liquids with densities less than water rise in the storage chamber and become trapped above a submerged riser outlet. These measures should only be utilised to provide pre-treatment where sediment is the key issue. Typically these measures should not be used to capture organic debris and litter.

In-line filtration GPTs are typically installed along a stormwater drainage line between inlet pits and headwall outlets to channels or watercourses. A low height weir is typically employed along the drainage line to divert flow into the GPT. The stormwater is then directly or in-directly filtered through screens, baskets, bars or racks and then directed back into the drainage line. These GPTs typically store the gross pollutants in a constantly wet condition.

Outlet filtration GPTs are typically installed immediately downstream of a stormwater drainage system headwall outlet. These measures typically include nets, screens and racks to filter the flow. These GPTs rely on direct filtration to remove stormwater pollutants and typically store the gross pollutants in a moist to dry condition.

GPTs may also be integrated within sediment basin located at the inlet to a higher level treatment measure.

4.6.3 Access, Inspection and Maintenance Considerations

Typically requirements for access to GPTs will vary between particular devices.

The following minimum access requirements apply to below ground GPTs installations:

- A heavy duty minimum 3.6m wide access driveway is available to the GPT site.
- The access driveway alignment is appropriate for access by an AUSTROADS standard 8.8m service vehicle and space is available for the vehicle to turn around (if required) and leave the site in a forward direction.
- The access driveway has appropriate strength and gradient for access and egress by a fully laden eductor truck (holding up to $10m^3$ of liquids in a tank).
- A 4m wide concrete pad is provided adjacent to the GPT for parking of an eductor truck and the pad is located not too close to the GPT for unsafe access, or too far for the reach of the eductor hose/pipe.
- Where heavy covers need to be removed, an additional concrete pad is provided adjacent to the GPT for a backhoe. The additional pad should be at an appropriate offset from the GPT for removing the cover using the backhoe bucket.
- Where the GPT has a below ground capacity exceeding $3m^3$, the GPT must be installed with two inspection lids.
- Vertical and horizontal clearances to power lines, trees, fences, roadways and other infrastructure are appropriate for the backhoe reach.

The following minimum access requirements apply to above ground GPTs installations:

- A heavy duty minimum 3.6m wide access driveway is available to the GPT site without incurring damage or deformations.
- The access driveway alignment is appropriate for access by an AUSTROADS standard 8.8m service vehicle and space is available for the vehicle to turn around (if required) and leave the site in a forward direction.
- The access driveway has appropriate strength and gradient for access and egress by a fully laden truck (holding up to $10m^3$ of solid waste).
- A ramp to the GPT with a minimum width of 3.6m and maximum gradient of 10% is available.
- The ramp has sufficient strength to support a fully laden backhoe.
- For large GPTs, a level concrete pad is available adjacent to the GPT for positioning of a backhoe and space is available for the backhoe to turn around and move up the ramp in a forward direction.
- Sufficient space is available for the backhoe bucket to access all parts of the GPT.

The following inspection tasks typically apply to GPTs:

- Remove covers (if below ground) typically using machinery.

- Estimate the volume of gross pollutants retained within the GPT to confirm if cleaning is required. The estimated volume should be compared with a pre-defined level to confirm if cleaning should be initiated (typically around 50-75% of the active storage volume).
- Visually observe water quality (for wet storage GPTs) to ascertain if system has become anaerobic (gases being released, dark water, offensive odour).
- Check access to the GPT site has not been compromised through vandalism.
- Check the inlet, outlet and any bypass mechanism for blockage.
- Check that the filtration mechanism is not more than 30% blocked where possible.
- Check the filtration mechanism for structural damage.
- Observe for detectable odours near adjacent properties.
- Confirm if any animals are trapped and arrange for their release by trained personnel.

The following maintenance tasks typically apply to GPTs:

- Check weather forecast prior to scheduling personnel and equipment to ensure that GPT can be cleaned during dry weather.
- Provide safety barricading around the GPT access (if below ground) and/or traffic exclusion measures where required prior to establishing machinery on site.
- Ensure confined spaces access equipment, qualified personnel and procedure are available for GPTs where internal access is required.
- Temporarily block inlets where possible and/or bypass base flow during cleaning where required.
- Remove covers (for below ground GPTs) using manual lifting equipment (light duty covers) or machinery (heavy duty covers).
- Trained personnel to release any trapped animals.
- Use eductor truck to remove gross pollutants and liquids from wet storage GPTs.
- Decant liquids to an appropriate treatment measure or area adjacent to the GPT; to the sewer under a trade waste agreement; discharge to the environment where approved by OEH; or transport from the site for disposal at an approved liquid waste management facility.
- Use most efficient machinery to remove the bulk of gross pollutants from dry storage GPTs.
- Use backhoe or other lifting equipment to remove baskets from the GPT;
- Manually clean filtration mechanisms by agitation, rakes, brooms, pressure hoses or other appropriate method to clear the mechanism openings.
- Use manual tools to remove gross pollutants where machinery access is not feasible for the GPT.
- Load manually cleaned waste into garbage bags or wheelie bins.
- Load waste onto appropriate vehicles for transport and recycling/disposal to an approved waste management centre.
- Check structural elements (walls, base, inlet, outlet, welds, fittings, catches, brackets etc) are functional and undamaged when GPT is clear of waste.

- Clear inlet, outlet, bypass weirs or catches of any blockages, and reset bypass catches or mechanisms if required.

4.6.4 Constructed Examples

	Ineffective gross pollutant trapping can result in large quantities of gross pollutants being distributed throughout downstream SQIDs that are designed to treat finer pollutants. Requires time consuming manual collection to remove these pollutants and may also result in high quantities of sediment smothering vegetation or filtration media.
Easy access to gross pollutant traps is an important consideration. Gradients to the measures should be appropriate for the required maintenance methods to minimise risks to maintenance personnel and ensure devices can be cleaned efficiently. Access arrangements similar to those shown in this image are unacceptable for handover to Council.	
	Gross pollutant trapping measures need to also consider the function of the drainage system during design events where the performance of the drainage system can be detrimentally impacted by blockages that could be avoided. Horizontal bars with an appropriate gap at the bottom are preferable to the mesh.

Access and ease of debris removal should be primary considerations when planning gross pollutant traps. Adequate maintenance access has not been provided for the trash rack in this image. Provision for backhoe access is preferred. Devices with pedestrian access via a footway ramp will only be considered for handover to Council under exceptional circumstances.	
	Trash racks combined with sediment trapping bays at inlets to bioretention basins can be effective at stopping the bulk of gross pollutants entering the measure. Combined with a sufficiently wide concrete access ramp, these pre-treatment measures can be efficiently cleaned using small machinery.
Trash racks with good ramped access for vehicles can be relatively quick and efficient to maintain.	
	Heavy vehicles should not be required to park on footway areas to undertaken maintenance where there are no dedicated provisions for heavy vehicle access and the potential for damage to kerbs/gutters, and concrete footways is high. Council will not accept maintenance access arrangement similar to those shown in the image.

The potential to trap aquatic fauna should be considered when planning GPTs. In addition to catchment gross pollutants, many of these traps will also capture freshwater turtles, snakes, lizards, eels, cats, dogs and other animals found in areas where urban development interacts with the natural environment.

Providing a multi-purpose sealed path assists with achieving access to a measure for maintenance. Pathways need to have sufficient strength to manage the vehicular load including consideration of the mass of materials removed from the SQID.

Maintenance of some GPTs may require large vertical clearances. Planning should ensure that appropriate clearance zones to trees, overhead power lines, awnings etc are available for cleaning.

Provision of simple GPTs such as trash racks can often be effective at capturing a high proportion of gross pollutants for most runoff events.

Provision for backhoe access is preferred. Devices with pedestrian access via a footway ramp will only be considered for handover to Council under exceptional circumstances.

Ensuring access is available to GPTs may require traffic controls to be in place prior to cleaning where appropriate design options are unable to avoid conflicts. GPTs should be designed to avoid conflicting access requirements by maintenance vehicles and other traffic. Maintenance access provisions like those shown in this image are not acceptable for new GPTs.	
	Grassed filter strips can be combined with vegetated and mulched buffers. Drainage inlets provided within the filter strips can manage drainage flows.

4.7 Sediment Retention Basins

4.7.1 Function

Sediment retention basins assist with achieving stormwater quality and quantity management objectives. Retention basins typically can function during the construction and post construction phases. During construction, a temporary sediment retention basin may be formed to manage sediment eroded from exposed surfaces during construction. After construction, temporary sediment retention basins are often modified to form a permanent sediment retention basin which provides pre-treatment for other measures designed to remove finer and dissolved pollutants during the post development phase. These guidelines focus on the role of permanent sediment retention basins in the post development stormwater quality management series. Guidance on sediment retention basins during construction is provided in the Managing Urban Stormwater: Soils and Construction handbook (the 'Blue Book') (Landcom, 2004).

During the post development phase, sediment retention basins typically target the removal of litter, organic debris and coarse sediment. Sediment retention basins function by capturing and storing stormwater runoff which is typically discharged into the basin from a piped stormwater drainage system outlet. The stormwater runoff is retained within the sediment retention basin for an extended period to promote settling of sediment and other pollutants. Sediment retention basins can be either dry or wet storage measures. Wet sediment retention basins have a permanent storage volume and often function similarly to a pond. Wet sediment retention basins may also have an additional storage above the permanent storage that functions as a temporary storage for the detention of stormwater during flooding events. Dry sediment retention basins only have a temporary retention storage that fills during an event and drains during the period immediately following the event.

The performance of the sediment retention basin is related to the residence time of the stormwater captured within the measure. Sediment retention basins are typically designed to capture coarser particles. As the residence time increases, the size of particles able to settle becomes smaller. As the size of particles captured reduces, a higher proportion of nutrients attached to fine sediment particles can also be captured. Whilst this initially would seem beneficial, if the retention pond does not incorporate significant areas of aquatic vegetation, there is a potential that eutrophication and algal blooms can occur regularly in the wet basin when climatic conditions are suitable.

4.7.2 Configuration

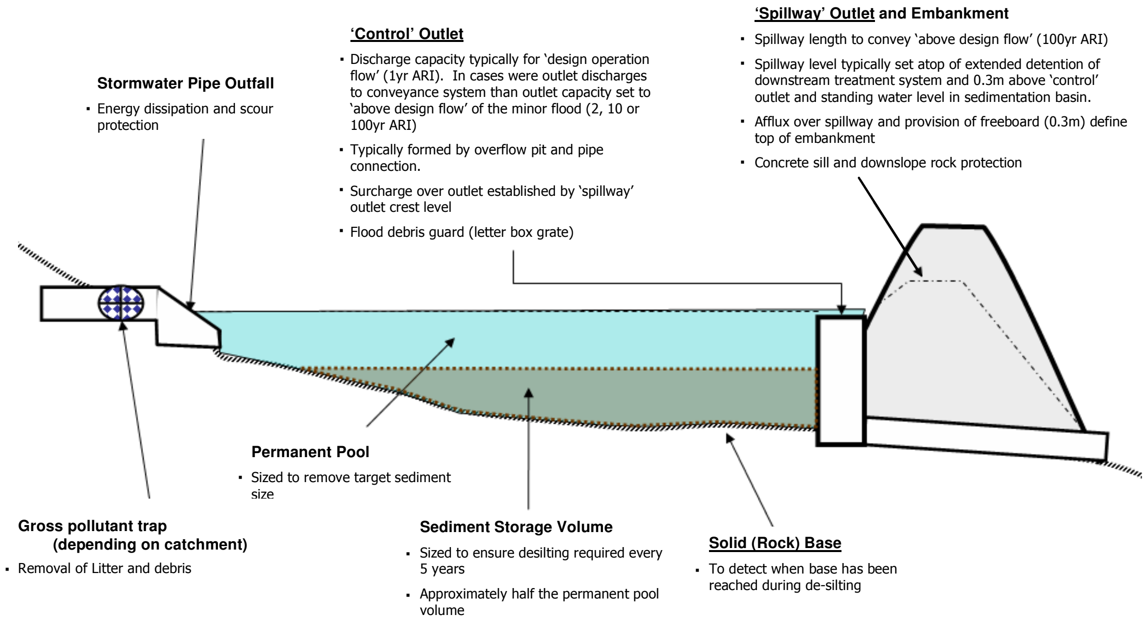


Figure 4-6 Typical Sediment Retention Basin Configuration (Gold Coast City Council, 2006).

Sediment retention basins typically include inlet and outlet structures, and a settling basin. Sediment retention basins may also incorporate a high flow weir where high flows are not initially controlled at the inlet. The settling basin includes a temporary/permanent pool settling zone and a sediment storage zone.

The inlet structure to a sediment retention basin may comprise a diversion structure that controls the maximum flow rate that can discharge into the basin with higher flows diverted around the basin. The inlet structure may also include a trash rack or other form of screening mechanism to filter out litter and organic debris before it discharges into the main settling basin to assist with efficient maintenance. Flow would then pass into the main settling basin.

Wet sediment retention basins will typically comprise a trapezoidal shaped storage with initially slightly grading benches (typically 1(v):10(h)) planted out to limit access. The internal edge of the bench then typically drops to the base at a grade of 1(v):4(h) to suit access/egress requirements. In situations where space is limited, and safety and maintenance access can be managed appropriately, near vertical sides formed from concrete or rocks could be considered. During events that exceed the available volume in the extended detention storage, excess runoff typically overflows into a minor drainage system through structures positioned within the measure.

4.7.3 Access, Inspection and Maintenance Considerations

Sediment retention basins should be inspected regularly during the first year after construction and more regular maintenance should be expected during this period to ensure that the sediment retention basin functions effectively. Following the initial year of operation, bi-annual maintenance may be appropriate to remove stored sediment. After the catchment has stabilised, less regular maintenance may be required. Additional maintenance may be required following particularly large storm events.

Following construction of a sediment retention basin, inspections during the first several significant storm events should be undertaken to confirm that the drainage system functions effectively and that bank stability is sufficient. Sediment retention basins should be inspected within 48 hours of a significant storm event.

Minimum access requirements for maintenance include:

- Ability to dewater a wet sediment basin prior to removal of sediment.
- Backhoe bucket reach access to inlet and outlet structures. Sealed pedestrian pathway (maximum gradient 1(v):6(h)) to inlets/outlets may be considered for handover to Council under exceptional circumstances.
- Backhoe bucket reach access and a smooth,, hard surface to areas adjacent to the inlet where the bulk of coarse sediment accumulates.

The following inspection tasks typically apply to sediment retention basins:

- Check any inlet structures for accumulations of litter and organic debris. Inspect inlet and outlet structures to ensure they are not blocked by debris. Any debris should be removed at the time of inspection if practical.
- Check inlets and outlets for areas of concentrated erosion.
- Check for accumulated deposits of sediment, litter, rocks and/or organic debris.
- Check that the weed coverage and algal growth within sediment retention basins is not more than 10% of the surface area.
- Check the depth and/or area of sediment annually to confirm the volume of sediment within the pond. When sediment storage exceeds 25% of the storage volume removal, the sediment retention basins should be dewatered (if required) and sediment removed.
- Check embankments and high flow spillway for erosion, cracks, seepage or other signs of instability.
- Check the health of aquatic and landscaping vegetation.
- Check for offensive odours during inspections as these can often indicate low oxygen conditions within the sediment retention basins.

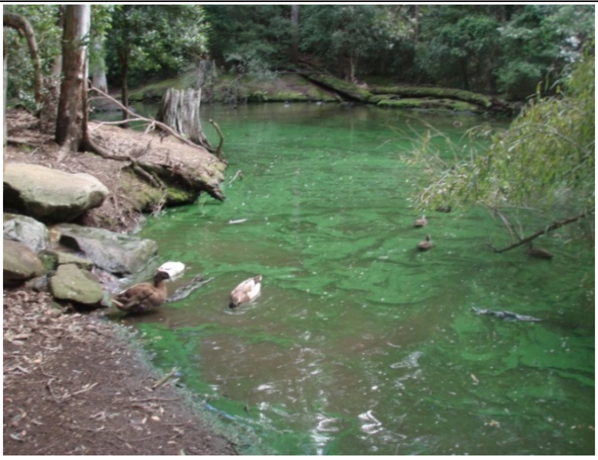
- Check the basin during wet weather to confirm that flow is evenly distributed and not concentrated along one flow path.

The following maintenance tasks typically apply to sediment retention basins:

- Check weather forecast to confirm that maintenance is scheduled during dry weather.
- Check site prior to locating maintenance equipment on site.
- Clear inlet/outlet structures of any debris causing blockage.
- Remove any accumulated litter and debris.
- Remove invasive plants species, weeds or any other unwanted vegetation from sediment retention basin and surrounding landscaped surfaces. A flat-bottomed boat or other suitable aquatic machinery may assist with removing floating and fixed aquatic weeds.
- Remove accumulated sediment from the sediment retention basin using a backhoe or other appropriate machinery. A dewatering system should be provided for wet sediment retention basins to enable the water level to be manually lowered, although water levels should only be lowered when turbidity is acceptable.
- Prune and/or remove dead branches from trees and shrubs in landscaping surrounding the basin.
- Place sediment, litter and organic debris in a designated secure area for drying (if required) prior to transport and disposal.
- Cut grass using mowers.
- Use line trimmers to trim landscaping vegetation in areas inaccessible by mower.
- Regrade and replant bare areas.
- Repair damage due to vandalism as required.
- If pests are present, implement appropriate non-toxic measures to control.
- Repair destabilised banks and areas showing signs of erosion. Identified structural bank instability areas should be inspected by a geotechnical engineer and in some circumstances may require reconstruction of the embankments.
- Repair inlet and outlet structures as necessary.

4.7.4 Constructed Examples

Sediment retention basins can be effective at treating runoff flowing to treatment measures designed to provide treatment of finer pollutants.	
	Sediment retention basins can be relatively simple structures where space and drainage system hydraulics allow. Systems incorporating retention/stilling basins with baffles can provide effective litter, debris and some sediment removal during most events and provide good access and a platform for storage of captured debris.
Small sediment retention basins can provide effective treatment in advance of larger treatment measures provided suitable access is available.	

	Provision of wet sediment retention basins that capture fine-grained soil particles, have limited aquatic vegetation, have poor circulation and are infrequently maintained are susceptible to algal blooms.
Sediment retention basins can utilise appropriate turf species resilient to frequent wetting provided grass species are selected carefully to ensure that the grass does not spread into the adjacent streams.	
	Wet sediment retention basins constructed with steep batters are a hazard for the community and are difficult to access for maintenance. Maintenance access provisions to the inlet shown in the image would be unacceptable for handover to Council.
Wet sediment retention basins typically vary from constructed wetlands due to the extent of aquatic vegetation provided and limited depth variability. Wet sediment retention basins will typically only have nominal fringing vegetation to assist with stablising the banks, restricting access and improving aesthetics.	

4.8 Constructed Wetlands

4.8.1 Function

Constructed wetlands will primarily assist with achieving stormwater quality and stormwater retention objectives. They can also be designed with additional extended detention storage to manage stream forming flows and provide flood detention. Constructed wetlands assist with disconnecting impervious areas from urban streams by retaining stormwater for an extended period.

Constructed wetlands comprise separate zones to remove stormwater pollutants of varying sizes and physical states. Larger pollutants are removed first by settling or filtration in a primary treatment zone. Stormwater is then conveyed into a variable depth open storage where finer and dissolved pollutants are removed by enhanced sedimentation, filtration through vegetation and biological uptake. A bypass channel is typically incorporated to ensure that the vegetated areas are protected from scouring during infrequent high flow periods.

In addition to managing stormwater quality and quantity, constructed wetlands provide habitat and refuge for fauna, landscape amenity, temporary storage for stormwater harvesting schemes, opportunities for positioning public art and passive recreation. Constructed wetlands are typically provided as larger catchment scale measures.

4.8.2 Configuration

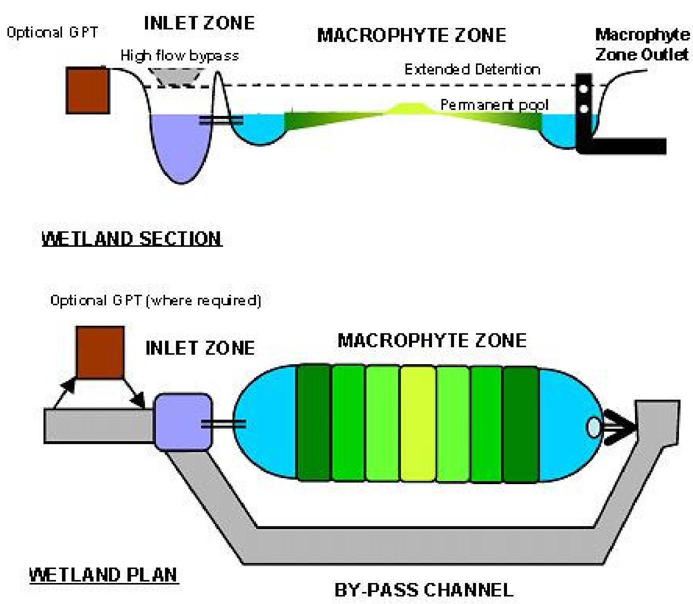


Figure 4-7 Typical Constructed Wetland Configuration (Gold Coast City Council, 2006)

Constructed wetlands typically comprise an inlet zone, a macrophyte zone, an open water zone, an extended detention zone and a high flow bypass channel.

The inlet zone typically comprises a sediment basin or GPT for trapping coarse sediment, litter and organic debris. The inlet zone when provided as a sediment basin is typically at least 1.5m deep to discourage vegetation growth and minimise the potential for re-suspension of settled sediment. The inlet zone is provided to remove a high proportion of larger pollutants that would either be too difficult to efficiently remove from the other zones or potentially will smother the vegetation. The inlet zone is also typically designed with a diversion structure to control the flow of stormwater to the macrophyte zone. For flows typically exceeding the 1yr ARI flow, the diversion structure re-directs flow to a bypass channel that conveys flow around the macrophyte zone to the downstream receiving environment. If the constructed wetland is also required to function to manage stream forming flows and flood detention, flows up to the 100yr ARI may be directed from the inlet zone into the macrophyte zone. In these circumstances it is important to ensure that the overflow from the inlet zone into the macrophyte zone is evenly distributed over a wide weir or similar arrangement to ensure that flow velocities are kept low to prevent scouring and loss of vegetation.

The macrophyte zone typically incorporates a sequence of ephemeral, shallow marsh, marsh and deep marsh areas. The macrophyte zone bathymetry typically ranges from 0.2m above, to 0.5m below, the permanent water level. Each marsh area has a depth range appropriate for particular aquatic vegetation species. The proportion of each marsh area and related vegetation is related to the targeted pollutants. A wetland targeting phosphorus removal would have a higher proportion of ephemeral marsh zone where the potential for adsorption of phosphorus to soil particles is increased. If high nitrogen removal is targeted, the macrophyte zone would typically be comprised of a higher proportion of marsh and deep marsh.

The open water zone should typically be not less than 1m deep to minimise the potential for excessive growth of emergent macrophytes in this zone. The open water zone provides a permanent storage during extended dry periods where water may not be available in the marsh areas and provides a refuge for mosquito predators including fish and aquatic insects. The open water zone may also be utilised for stormwater harvesting.

Extended detention is the depth (and related volume) of water storage available above the lowest outlet from the macrophyte zone. The extended detention depth and location of outlets will vary depending on the required function of the constructed wetland. If the constructed wetland is planned specifically for stormwater quality management, a single outlet that achieves a notional detention time of 48 to 72 hours may be appropriate. If the constructed wetland is designed to manage stream forming flows or achieve flood detention then additional higher outlets may be required. In addition to achieving the stormwater quality and hydrologic/hydraulic objectives, it is important that consideration is given to selecting appropriate vegetation for the inundation depths and potential impacts on upstream flooding levels.

The high flow bypass channel typically connects the inlet zone to the receiving waters. The purpose of the channel is to re-direct high flows away from the macrophyte zone where these high flows may otherwise scour the vegetation and bed sediment and subsequently disturb the established ecosystem. Typically the bypass channel would be sized to divert peak flows in the 1yr to 100yr ARI range around the macrophyte zone.

4.8.3 Access, Inspection and Maintenance Considerations

The following inspection tasks typically apply to constructed wetlands:

- Check that site access is not compromised by broken locks, damages access gates etc.
- Check for evidence of building waste, household dumping, littering, oil/paint spills. Where significant loads are detected, investigate to identify the source/s.

- Check for vandalism of structural elements.
- Check for presence of vermin.
- Check that any offensive odours are not detectable at adjacent properties.
- Check embankments for signs of instability (e.g. settling, cracking, erosion, seepage).
- Check any pre-treatment measures for areas of accumulated sediment or erosion.
- Check that inlets, outlets and bypass weirs are unblocked and operational. Where possible clear any blockages during the inspection.
- Check inlets and areas of concentrated flow into the measures for erosion.
- Check for accumulated deposits of sediment, litter, rocks and/or organic debris.
- Check any shallow ponded areas for evidence of mosquito breeding habitat.
- Check whether algal growth or weeds cover more than 10% of the constructed wetland surface area.
- Check if aquatic plants are healthy and are growing satisfactorily with no obvious evidence of disease.
- Check terrestrial landscaping to ensure that plants are healthy; mulch coverage is acceptable; and weed growth is limited.
- Check for vehicle wheel ruts or other evidence of vehicle access.

The following maintenance tasks typically apply to constructed wetlands:

- Check weather forecast to confirm that maintenance is scheduled during dry weather.
- Pre-treatment GPTs or sediment retention basins should be maintained in accordance with the SQID summaries for those measures.
- Repair any damage to the embankments. Where structural issues are identified from inspections, these should be repaired promptly to reduce risks to the community and particularly where deep open water areas exist.
- Remove dumped wastes.
- Repair damage due to vandalism.
- Treat diseased plants; remove and replace dead plants.
- Prune branches from trees and shrubs in landscaped areas.
- Use line trimmers to maintain grasses in landscaped areas.
- Clear inlets, outlets and bypass weirs of any blockages.
- Mow grassed embankments and landscaped areas during dry weather to prevent rutting.
- Manually remove terrestrial weeds where weed coverage is localised. Spot spraying with herbicides approved for use in aquatic environments may be required where coverage is more widespread.
- Manually remove aquatic weeds using waders where water is shallow and bed conditions allow areas to be traversed on foot. Boats may be required for deeper areas where access is possible

and the wetland size justifies their use. Where aquatic weeds are widespread, chemical treatments approved for use within aquatic environments may be required.

- If frequent algal blooms occur, initially treat the wetland with an approved algaecide appropriate for the algae species being controlled. Implement more long-term management controls to then improve water quality and reduce the occurrence of frequent algal blooms.
- Check and clear overflow and maintenance structure/drains.
- Monitor bed sediment storage depth, plant condition, algal bloom frequency and water quality to ascertain when wetland may need to be re-set through reconstruction works. This may require draining of the wetland, temporary bypass, excavation to remove a high proportion of bed sediments and replanting of aquatic vegetation.

4.9 Bioretention and Infiltration Measures

4.9.1 Bioretention Function

Bioretention measures assist with achieving stormwater quality and stormwater retention objectives. All bioretention measures comprise an extended detention storage and below ground filter media. The extended detention storage enables settling of sediment and other particles which is a function of the hydraulic residence time. The below ground filter intercepts finer particles including heavy metals. Nutrients are removed through uptake by appropriate vegetation planted within the measure. Bioretention measures assist with disconnecting impervious areas from urban streams by retaining stormwater for an extended period.

Bioretention measures include tree pit filters, raingardens, bioretention swales and bioretention basins. These measures all perform a similar function, although at different scales. Tree pit filters are typically distributed throughout large paved footpaths or malls in commercial areas. Individual tree pit filters will only treat a minor volume of stormwater sufficient to sustain tree growth, and are typically only applied in retrofit situations where highly impervious areas preclude large vegetated measures. Raingardens are often provided close to a runoff source and are typically small retention cells/basins constructed at strategic points within a development or within the streetscape. Bioretention swales are typically provided in conjunction with grassed swales to function as a combined flow and water quality management measure. Bioretention swales are commonly provided within public road reserves (footpath or central median), public open spaces and carparks. Bioretention basins are typically provided as large end-of-line measures that may be combined with other community functions (e.g. detention basins, sporting fields). Smaller bioretention basins may also be distributed throughout a development precinct.

4.9.2 Bioretention Configuration

A typical arrangement of a bioretention measure (raingarden, bioretention swale or bioretention basin) is shown in Figure 4-8 and Figure 4-9.

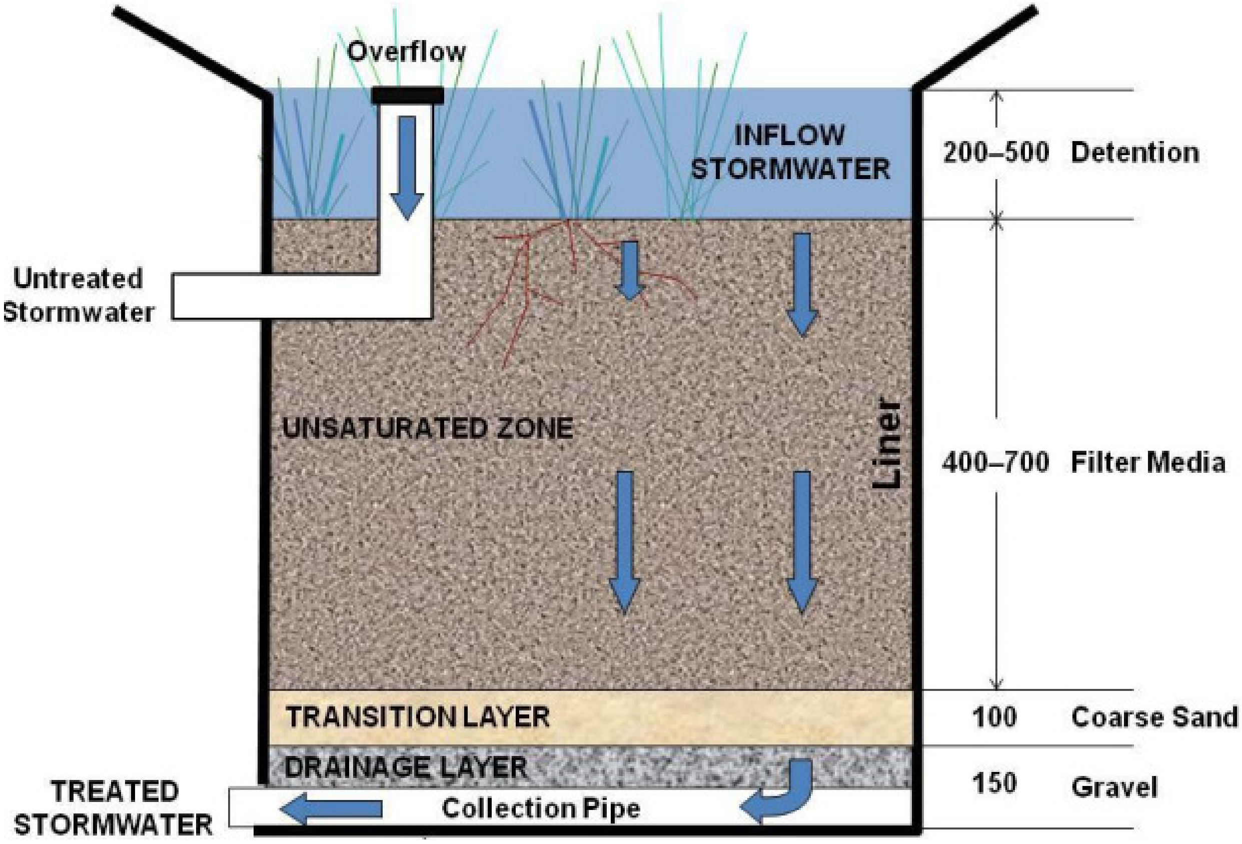


Figure 4-8 Typical Bioretention Arrangement (FAWB, 2009)

Figure 4-9 Typical Infiltration Basin

Bioretention measures typically comprise above-ground extended detention and below-ground media filter components. The extended detention is typically trapezoidal shaped with a slightly grading base and 1(v):4 to 6(h) side slopes for access. In situations where space is limited, and where safe maintenance access can be managed appropriately, near vertical sides formed from concrete or rocks may be considered. Tree pit filters typically have vertical sides with open grates covering the extended detention storage. The extended detention temporarily stores runoff prior to filtration through the media filter. During events that exceed the available volume in the extended detention storage, excess runoff typically overflows into a minor drainage system through structures positioned within the measure.

The media filter typically consists of a biofilter layer and drainage layer. The biofilter layer is the upper layer and incorporates soil that has a reasonable water holding capacity that is capable of sustaining vegetation growth. The biofilter layer must also have a reasonable saturated hydraulic conductivity to enable steady percolation of runoff when the water holding capacity is exceeded. The lower layer comprises fine gravel that typically surrounds slotted agricultural drainage pipe and captures the filtered stormwater before directing it to a constructed drainage system.

A transitional layer of coarse sand is often provided between the upper and lower layers to intercept fine to medium size soil particles that may otherwise be conveyed into the drainage layer and potentially block the underdrains. Geotextiles should not be used to perform the transitional layer function for their potential to block. In situations where the surrounding soil has a saturated hydraulic conductivity exceeding the biofilter, vertical lining of the sides of the media filter layers with a geotextile membrane may be warranted to prevent ex-filtration of untreated stormwater.

For bioretention measures to be effective it is very important that the biofilter media grading, characteristics and preparation is closely considered. Appendix C of the Facility for Advancing Water Biofiltration (FAWB) “Adoption Guidelines for Stormwater Biofiltration Systems” (FAWB, 2009) should be reviewed to assist with sourcing appropriate biofilter media.

Bioretention measures may also be constructed with a submerged zone which includes an additional depth of storage below the invert of the collection pipe. Bioretention measures may also be unlined when the saturated hydraulic conductivity of the surrounding soils are an order of magnitude less than the filter media and groundwater inflow is not a concern.

A key component of bioretention measures is vegetation which is planted into the biofilter layer. Appropriate species should be selected considering the biofilter soil characteristics and climatic conditions. Species should be capable of withstanding dry periods in addition to periods of frequent wetting.

4.9.3 Bioretention Access, Inspection and Maintenance Considerations

Bioretention measures should be inspected regularly until the vegetation is established and then typically on a monthly basis or following significant storm events.

Maintenance will be more regular during the initial vegetation establishment period. During this period regular watering, mulching, weeding, soil treatment, removal and replacement of dead/diseased vegetation may be required. An appropriate long-term maintenance frequency can usually be determined after 2 years of operation when the catchment and bioretention measure have stabilised.

The typical long-term maintenance frequency varies with aesthetics and seasonal influences. Grass cutting and weeding are typically required either fortnightly or monthly (depending on the species) during spring and summer. Less frequent grass cutting and weeding (typically every 2 to 3 months) typically occurs during autumn and winter where other factors (e.g. aesthetics, litter removal, erosion, vegetation damage) may control the maintenance frequency.

The following inspection tasks typically apply to bioretention measures:

- Check any pre-treatment measures for areas of accumulated sediment or erosion.
- Check inlets and areas of concentrated flow into the measures for erosion.
- Check for bare patches and/or areas where weed growth exceeds 10% of the biofilter area.
- Check for accumulated deposits of sediment, litter, rocks and/or organic debris.
- Check for withering, dead or otherwise unhealthy plants. If concentrated areas of dead or unhealthy plants are identified, undertake soil sampling to determine if soil improvement is required.
- Check the measures during wet weather to confirm that flow is evenly distributed and not concentrated along one flow path.
- Check that the biofilter media has a good coverage of mulch with limited gaps.
- Check for saturated areas or concentrated deposits of silt where water may be ponding excessively.
- Check underdrains through inspection covers to confirm that excessive silting of the drains has not occurred.
- Check driveway crossings and other interfaces with impervious surfaces for erosion or sediment accumulation.
- Check for vehicle wheel ruts or other evidence of vehicle access.

The following maintenance tasks typically apply to bioretention measures:

- Check weather forecast to confirm that maintenance is scheduled during dry weather.
- Pre-treatment measures should be maintained in accordance with the guidelines for those measures.
- Prune and/or remove dead branches from trees and shrubs.
- If the bioretention measure surface has become clogged from the input of elevated loads of sediment, tilling should be undertaken to break these areas up to improve permeability of the surface layer. Reasons for the elevated input of sediment should be investigated.
- Manually remove sediment, litter and organic debris using rakes, shovels and/or hoes.
- Manually remove weeds if the weed coverage is localised. If the weed coverage is more widespread, options including spot spraying of herbicides approved for use within an aquatic environments may be required.
- Cut grass filter strips adjacent to biofilter using mowers.
- Use line trimmers to trim biofilter vegetation and cut grass in areas inaccessible by mower.
- Regrade and replant bare areas.
- Spread appropriate low nutrient mulch prior to summer (ensure that type of mulch does not readily float in water) and replace mulch every 2 to 3 years during dry periods. Mulching should also be undertaken periodically to fill in gaps observed during inspections.
- Clear drainage structures of any blockages.

- Flush underdrain system using high-pressure jets or hoses.
- Repair damage due to vandalism as required.
- If pests are present, implement appropriate non-toxic measures to control.

4.9.4 Infiltration Measures

Infiltration measures are unsuited for development across the majority of the Lake Macquarie LGA due to limited coverage of appropriate soils for infiltration. In addition to soil types being inappropriate, other conditions such as impacts on groundwater levels and downslope development would need to be considered. Development applicants seeking to utilise infiltration of stormwater into the insitu soils as a treatment technique shall contact Council prior to proceeding with preparing a Water Cycle Management Plan for their development. Concept design considerations for infiltration measures are similar to bioretention measures (refer above sections).

Infiltration measures are most effectively applied as distributed source control measures across a catchment where soil conditions are amenable to infiltration. Infiltration measures are often provided close to a runoff source in the form of an infiltration trench. Typically infiltration measures can be provided to capture and infiltrate runoff from dwelling roofs in a distributed manner. When applied in this distributed, small scale source control manner, a range of soil types may be suitable for ensuring a high proportion of runoff is infiltrated prior to runoff.

Infiltration measures can also be provided to treat runoff from a larger catchment. In these circumstances, an infiltration basin may be provided. For larger catchments, infiltration measures are only likely to be effective where sandy, highly permeable soils dominate. Whilst sandy soils have the potential to infiltrate a high proportion of runoff from a particular catchment, it is important to consider the potential impacts of increased concentrated infiltration of runoff on groundwater rise and increased seepage into downstream properties. In addition, concentrated infiltration at a particular location can result in mounding of the groundwater table that impedes infiltration.

Pre-treatment of stormwater runoff is particularly important for infiltration measures to reduce the potential for litter, organic debris and coarse sediment to block the surface and soil pores within the infiltration area. If pre-treatment is not provided, there is a high potential that frequent partial or complete blockage of the surface or soil may occur.

Infiltration measures typically comprise an inlet zone for pre-treatment of stormwater and a retention storage that temporarily stores stormwater prior to infiltration to underlying highly permeable soils. Depending on the scale of the catchment being treated, the inlet zone may simply comprise a mesh screen installed within a pit upstream of a below ground retention storage, or a separate GPT or sediment retention zone for trapping of litter, organic debris and coarse sediment.

Infiltration measures can be provided with either an above or below-ground detention storage. Typically small infiltration measures adjacent to dwellings may have a below ground retention storage, whilst infiltration measures on larger catchments may have an above ground retention storage. As the size of the catchment increases, the potential for blockage of the retention storage potentially will also increase. Providing the retention storage above ground on larger catchments assists to minimise the potential risk of blockage.

4.9.5 Constructed Examples

Raised grate and drainage inlet within raingarden enables water to pond temporarily prior to filtration through the biofilter media. During high rainfall intensity events ponding depth would exceed the level of the pit inlet enabling stormwater to bypass the biofilter media and overflow into the drainage system. Sub-soil drains would connect the base of the biofilter to the base of the stormwater pit.

Provision of raingardens within private lots requires careful consideration of how the long term performance will be maintained throughout the lifecycle of the measure.

Council will typically not approve inclusion of raingardens on private property in water quality modelling for proposed developments. Exception will be where the SQID can be entirely located within a separate lot dedicated to Council.

Kerb return inlet to street scale raingarden. Cut off timber bollards and raised half island provided to restrict vehicular access. Turf filter strip and horizontal timber boards provided between road pavement and the biofilter to enable temporary ponding of water prior to overflowing into the biofilter. This arrangement can assist with pre-treating road runoff during dwelling construction phase to ensure that raingardens are not overloaded with sediment.

	Vertical monitoring pipes can be provided within raingardens to assist inspections and enable flushing of the underdrain system.
Street scale raingarden provided with river pebble mulch. Creates instant cover for the biofilter media to limit intrusion of weeds during vegetation establishment phase. Inorganic mulch is also longer lasting, protects biofilter from erosion and less susceptible to becoming suspended and entrained in flow.	
	Cascading series of raingardens formed on steep gradients can lead to scouring of the highly erodible biofilter media prior to vegetation establishing. Provision of rock check dams/weirs can reduce the flow gradient, but sufficient bed protection is required at drops to prevent scour pools forming just downslope of the check dams.
Street scale raingarden provided with lintel inlet to manage flows in excess of the capacity of the system. When the water depth exceeds the inlet level stormwater overflows into an adjacent below ground piped drainage system.	

	Drainage inlets can be screened using vegetation.
Raingardens provided between road pavement and footpath. Slots provided between kerb sections to exclude vehicles and enable flow to passively enter the raingarden. Footpath side of the raingardens is framed by a low concrete wall that also functions as seating for users of the adjacent passive recreational space.	
	Bioretention basins can be a component of multi-purpose open space areas that incorporate a range of active and passive recreation areas.
Inadequate erosion and sediment control during construction may lead to biofilter media being smothered with fine sediments prior to vegetation establishment. In addition to blocking the biofilter surface, fine sediments may also clog the biofilter substantially reducing the hydraulic conductivity and therefore future performance of the measure. In some cases, the entire biofilter media layer may need to be removed and replaced.	

	Energy dissipation structures can assist with reducing flow energy at the inlet to bioretention basins providing conditions for gross pollutants and sediment to settle or be separated from the flow. The positioning of energy dissipators in this image inhibits effective maintenance. A larger concrete apron, with rocks set further out from the pipe outlet is preferred to enable backhoe bucket access.
Rock protection can protect the bioretention basin bed and assist to dissipate flow energy prior to runoff draining to the vegetated biofilter. Weed exclusion provisions such as installation of geotextile or concrete beneath rocks, would be required for unvegetated rock protection assets to be handed over to Council.	
	Clear bordering and delineation of bioretention basin extents can assist maintenance. Provision of readily maintainable bypass swales around bioretention measures limits the magnitude of flows discharging into the basin.
Clear delineation and structural protection of high flow weirs is good design practice. High flow weirs can also be provided with a sacrificial turf covering to improve aesthetics. Weed exclusion provisions, such as installation of geotextile or concrete beneath rocks would be required for rock gabions to be handed over to Council.	

	All weather unsealed access can be formed by placing rock aggregate in appropriate locations. Gradients need to be lower than a sealed access but can be appropriate for many applications. Important to ensure that granular accesses are not located in high flow bypass or weir spill locations.
For a bioretention basin to function it is important that the filter media is of an appropriate size and grading to filter the stormwater. Planting out the biofilter is also a key element of the measure and without plants only limited treatment is possible.	
	Fencing should be provided to separate pedestrians and cyclists from steep fringing batters.
 Excavation to biofilter base	 Placement of underdrains and impermeable liner

Biofilter media placed

Biofilter media consolidated

Biofilter planting completed

Biofilter vegetation establishing

Biofilter vegetation established

Biofilter vegetation several years after construction

It is important to consider seasonal groundwater table fluctuations when planning and designing infiltration measures. Where infiltration measures are constructed too low, interception of the groundwater table may frequently occur during wet periods.

	Provision of inspection/monitoring wells can assist with monitoring groundwater levels below infiltration measures. Monitoring the water levels over time or during events can assist with confirming the presence of any blockages within the insitu soils.

5 LIFECYCLE COSTS

5.1 Summary

Council will consider whole of life costs when assessing proposals for SQIDs to be dedicated to Council. Designers should aim to minimise life cycle costs when selecting, siting and designing SQIDs.

Lifecycle costs for SQIDs include the following key components:

- Acquisition cost - cost associated with the planning, design, construction and establishment of a SQID.
- Annual maintenance cost – annual cost of frequent maintenance activities including all labour, material and operating costs associated with inspections, training, administration, landscape maintenance, waste removal, waste disposal, monitoring and reporting.
- Renewal and adaptation costs - costs associated with infrequent restoration/preventative maintenance (e.g. additional landscaping, access track repair, re-contouring and replanting a wetland's macrophyte zone, replacing filter media, replacing a GPT screen etc).
- Decommissioning cost - costs associated with removing a SQID from operation (e.g. sand filling/demolition of a GPT, filling a redundant pipe with sand, disconnection and disposal of a rainwater tank) and restoring the site at the end of the SQIDs life cycle.

There is currently only limited accessible data available on acquisition and maintenance costs for SQIDs. Where available, this data was utilised to estimate the lifecycle costs summarised in

Table 5-1, which should be read in conjunction with the following sections. Renewal and adaptation costs are highly variable, and are largely dependent on the quality of the original design and construction. No recent comprehensive data is available on renewal and adaptation costs. Values outlined in Table 5-1 should be adopted wherever possible, unless other reliable data can be identified. Where the values in Table 5-1 are not applicable, default values from MUSIC software should be used.

Decommissioning costs should be excluded from life cycle cost analysis for SQIDs to be owned by Council, as most such SQIDs remain operational.

Further guidance on lifecycle costing for SQIDs is provided within MUSIC software.

Table 5-1 Summary of Typical Lifecycle Cost Components for SQIDs

SQID	Acquisition ($)	Annual Maintenance ($/yr)	Renewal and Adaptation (% of acquisition cost/yr)	Estimated Annualised Life Cycle Cost ($/yr)
Rainwater Tank	$1,000 - $4,000/kL	$100/yr	5%	$150/kL.yr - $300/kL.yr
Permeable Paving	$100 - $170/m^2	$1/m^2/yr	2%	$3/m^2.yr - $4.50/ m^2.yr
Filter Strips	$5 - $10/m^2	$2 - $3/m^2	2%	$2/m^2.yr - $3.50/ m^2.yr
Grassed Swales	$5 - $20/m^2	$2 - $9/m^2	2%	$2/m^2.yr - $9.50/ m^2.yr
Gross Pollutant Traps	$4,000 - $9,500/ha treated	$50 - $350/ha catchment $7,000 - $11,000/device	1.25%	$100/ha treated.yr - $470/ ha treated.yr
Sediment Basins	$150 - $250/m^2	$5 - $10/m^2	1.5%	$7.50/m^2.yr - $14/ m^2.yr
Constructed Wetlands	$250/m^2	$3 - $12/m^2	1.25%	$6/m^2.yr - $15/ m^2.yr
Bioretention – Tree Pit Filter	$2,500 - $3,000/m^2 of biofilter	$5 - $12/m^2 of biofilter	2%	$55/m^2.yr - $72/ m^2.yr
Bioretention – Raingarden or	$500 - $1,500/m^2 of biofilter	$5 - $12/m^2 of biofilter	2%	$15/m^2.yr - $42/ m^2.yr
Bioretention – Basin	$350 - $650/m^2 of biofilter	$5 - $12/m^2 of biofilter	2%	$12/m^2.yr - $25/ m^2.yr

5.2 Rainwater Tanks

5.2.1 Acquisition

In addition to the material cost of a rainwater tank, the acquisition cost includes delivery, installation, fittings, pipe work, connections to gutters and overflow, first flush device, base slab/stand, plumbing connections to toilets/irrigation, supply and installation of pump and electrical work. It is assumed that rainwater tanks would be coated zinc alum and be constructed above ground. Estimated costs are applicable to tanks sizes below 10 kL only. An additional $500 planning, design and documentation cost was incorporated into the supply and installation cost to estimate the total acquisition cost. Based on the above assumptions it is estimated that a total acquisition cost of $1,000 to $4,000/kL would be appropriate, with the lower rate applying for tank sizes closer to 10 kL and the higher rate for tanks closer to 2kL.

5.2.1 Maintenance

Estimated maintenance costs for residential rainwater tanks are typically less than $100/yr.

5.3 Permeable Paving

5.3.1 Acquisition

Limited data is available on the acquisition costs for permeable paving. Costing information was sourced from Boral (2003) for 5 types of design:

- Permeable paving allowing infiltration: ~\$111/m^2.
- Permeable paving over sealed subgrade, allowing water collection: ~\$119/m^2.
- Augmentation with permeable paving (i.e. mixing permeable with normal pavers): ~\$98/m^2.
- Permeable paving with asphalt: ~\$67/m^2.
- Permeable paving with concrete slab: ~\$90/m^2.

Based on published Building Price Indices for Sydney (Rawlinsons, 2012), it is estimated that the 2012 acquisition cost for permeable paving would be approximately \$100 to \$170/m^2. Typically pedestrian traffic only paving would be in the lower range, whilst lightly vehicular loaded areas (e.g. off-street carparking spaces) would be in the higher range.

5.3.2 Maintenance

Limited data are available on the annual maintenance costs for permeable paving. Annual maintenance costs for permeable paving have been estimated to be approximately \$1/m^2 of paved area (BCC, 2011).

5.4 Filter Strips

5.4.1 Acquisition

It is estimated that acquisition costs for turfed filter strips would be similar to grassed swales and approximate \$5/m^2. In circumstances where native grasses and vehicle exclusion bollards are provided, acquisition costs may increase to around \$10/m^2.

5.4.1 Maintenance

Contracted landscape maintenance activities associated with Hornsby Shire Council's SQIDs cost approximately \$11,000/ha in 2010 – 2011. Including Council's other operation costs, it is estimated that the total cost was approximately \$20,000/ha (i.e. \$2/m^2) (HSC, 2011). Contractors were responsible for landscape maintenance at around 71 sites (approximately 7ha) covering bush regeneration activities. The activities included weeding and spot spraying of the immediate area surrounding each SQID including landscaped areas that have been mulched and planted with local native species. Some replacement planting and staking of existing tube stock was also required. It is estimated that maintenance costs for filter strips would be similar to that required for general landscaping areas.

Maintenance costs for filter strips are similar to the costs of maintaining grass median strips and other similarly vegetated areas. It is estimated that the annual maintenance cost would be \$2 to 3/m^2. Where mowing is not required, it is expected that similar costs would be incurred for manual weeding, removal of litter and replacement of grasses.

5.5 Grassed Swales

5.5.1 Acquisition

Acquisition costs for grassed swales are estimated to be approximate $5/m^2. In circumstances where site conditions are challenging or where additional costs including vehicle exclusion bollards and driveway crossing are required, acquisition costs may be considerably higher and around $20/m^2.

5.5.2 Maintenance

Annual operation and maintenance costs for swales planted with native grass species are estimated to be approximately $2/m^2 once established (BCC, 2011). During the initial 2 year vegetation establishment phase of native grassed swales, annual maintenance costs may be up to $9/m^2 (Lloyd et al, 2002). Annual operation and maintenance costs for turfed swales are primarily associated with mowing and costs are estimated to be approximately $2/m^2.

The largest component of the maintenance costs during the initial establishment period is attributed to manual removal of weeds. Over time, the cost of manual weed removal reduces significantly due to denser vegetation cover, which prevents invasive weeds from establishing. Spot spraying of weeds is typically the second largest cost and rubbish removal the least costly.

5.6 Gross Pollutant Traps

5.6.1 Acquisition

Willoughby City Council (2004) estimated $2003 equivalent capital costs for a number of dry and wet storage proprietary GPTs constructed within urban catchments varying between 4 and 260ha. The estimated median capital cost was $800/ha for dry storage GPTs, and $3,050/ha for wet storage GPTs. In $2012 this is equivalent to approximately $1,100/ha for dry storage GPTs and $4,300/ha for wet storage GPTs.

The NSW EPA gathered capital costs in 2004 (NSW EPA, 2004) for a range of proprietary GPT models installed under the former Stormwater Trust Grants program. Capital costs were provided for a number of installations on urban catchments varying from less than 5 ha to over 130 ha. Median capital cost for these installations typically varied between $800/ha of catchment to $6,500/ha depending on the device model and catchment size. Converted to $2012, the capital cost range is $1,200/ha to $9,500/ha. Generally, GPTs in the lower capital cost range will require more frequent maintenance and these devices would not be accepted by Council.

5.6.2 Maintenance Costs

Willoughby City Council (2004) estimated $2003 equivalent maintenance costs for a number of dry and wet storage proprietary GPTs constructed within urban catchments varying between 4 and 260ha. The estimated median maintenance cost was $42/ha for dry storage GPTs, and $237/ha for wet storage GPTs. In $2012 this is equivalent to approximately $60/ha for dry storage GPTs and $335/ha for wet storage GPTs. The $2012 equivalent average annual maintenance cost for each dry storage GPT was $7,050 and for each wet storage GPT was $11,650.

5.7 Sediment Basins

5.7.1 Acquisition

There is currently limited data available on the acquisition costs for pre-treatment sediment basins. Acquisition costs estimated in MUSIC are summarised in Table 5-2.

Table 5-2 Sediment Basin Acquisition Cost Estimates (MUSIC)

Surface Area	Capital Cost
100m^2	\$260/m^2
250m^2	\$215/m^2
500m^2	\$185/m^2
750m^2	\$170/m^2
1000m^2	\$160/m^2

5.7.2 Maintenance Costs

Limited data is currently available on maintenance costs for sediment basins. Maintenance costs estimated within MUSIC for sediment basins suggest an annual rate of \$5 to \$10/m^2 of basin surface area is appropriate.

5.8 Constructed Wetlands

5.8.1 Acquisition

Hornsby Shire Council has gathered cost data for 16 constructed wetlands installed throughout their LGA in the 1995 to 2006 period (HSC, 2011). The mean capital cost for these installations (unadjusted for inflation) was \$165/m^2 of wetland. Converting these capital costs to \$2012 based on published Building Price Indices (Rawlinsons, 2012), it is estimated that 2012 capital cost would be approximately \$250/m^2 of wetland treatment area. It is unclear from the published data if the capital costs also include planning and design costs.

Brisbane City Council identified capital costs for two constructed wetlands (one greenfield and one retrofit) constructed in Brisbane (Ecological Engineering, 2007) in 1999 and 2004. Converting these capital costs to \$2012 based on published Building Price Indices, it is estimated that 2012 capital costs would be approximately \$230/m^2 of wetland treatment area (i.e. total footprint excluding batters and perimeter landscaping). The capital cost estimates indicate that the planning and design cost represents approximately 15% of the capital cost. The remaining 85% of the capital cost is associated with construction costs.

5.8.2 Maintenance Costs

Hornsby Shire Council is responsible for maintaining 16 constructed wetlands. The average cost to maintain each wetland for the 2010 – 2011 financial year was approximately \$2,900/yr (median of \$1,910). Average regular maintenance cost to Council was \$2.90/m^2 of wetland treatment area and \$135/ha of treated catchment, although some maintenance activities are undertaken by volunteer bushcare organisations (HSC, 2011). The estimates include costs for weeding, spraying, sediment/debris/litter removal, mulching, replacement and reporting tasks.

Maintenance costs (including actual and estimated costs) were gathered for four constructed wetlands installed in Brisbane (Ecological Engineering, 2007). Average maintenance costs ($2012) based on these estimates are $12/m^2 of treatment area (during establishment) and $5/m^2 (following establishment).

5.9 Bioretention Measures

5.9.1 Acquisition

Knights et al (2010) reviewed construction data for more than 20 bioretention systems constructed throughout Kurring-gai, Hornsby and inner Sydney Council LGA's. Measures reviewed included a range of retrofit and greenfields installations. Broadly, the study found that the capital costs for recent bioretention measure construction in Sydney were:

- Source control bioretention measures (e.g. tree pit filters) capital costs were $2,700/m^2 of biofilter area for two sites, comprising 18 tree pit installations. The tree pit installations were primarily retrofit situations where matching to existing infrastructure was required.
- Street-scale bioretention measures (e.g. raingardens, bioretention swales) capital costs were typically $500 to $1,500/m^2 of biofilter area in the 25 to 150m^2 range. Typically street-scale measures closer to 150m^2 had a capital cost closer to $500/m^2.
- End-of-line bioretention measures (e.g. bioretention basins) with a biofilter area exceeding 150m^2 were found to have capital costs typically around $700/m^2.

Knights et al (2010) also outlined a summary of capital costs for bioretention measures in Melbourne and Brisbane including:

- The average cost for 10 tree pit filters installed in Melbourne was $6,250/m^2 of biofilter area.
- The average capital cost for 30 retrofit streetscape raingardens installed in the Kingston City Council LGA was $1,000/m^2.
- Greenfields bioretention installations in Brisbane for three sites were found to have average capital costs of $280/m^2 of biofilter area (biofilter area range of 450 to 975m^2).

Where reported, the biofilter area as a proportion of the total footprint was in the 35 to 90% range.

Knights et al (2010) plotted data for all installations and derived estimates for typical street-scale and end-of-line installations. These estimates are summarised in Table 5-3.

Table 5-3 Capital Cost Estimates for Bioretention Measures

Biofilter Area	Capital Cost
50m^2	\$1,250 to \$1,290/m^2
100m^2	\$860 to \$915/m^2
200m^2	\$585 to \$650/m^2
500m^2	\$355 to \$415/m^2

Knights et al (2010) estimated that design costs would be approximately 10 to 15% of the total capital cost.

5.9.2 Maintenance Costs

Maintenance cost estimates were derived from actual costs in 2006 for three bioretention basins installed in Brisbane (Ecological Engineering, 2007). Based on these estimates, average maintenance costs (\$2012) for bioretention basins in Lake Macquarie LGA would be approximately \$11.50 per m^2 of biofilter area during the establishment period (typically first two years) and \$5.50/m^2 following the establishment period.

5.9.3 Renewal and Adaptation Costs

It was estimated by Knights et al (2010) that renewal costs including excavation of the filter media, replacement of filter media and replanting would cost between 20 to 40% of the original capital cost depending on the depth of filter media that needed replacing (i.e. if only upper media layer required replacing, costs may be closer to 20%). Assuming media replacement would occur every 10 years, a renewal and adaptation cost of 2 to 4% / yr would be appropriate. The renewal cost could potentially increase if the media were to be classified as a contaminated waste.

6 MUSIC MODELLING

Development applicants should contact Council to obtain access to default MUSIC templates that shall be applied for modelling stormwater quality for a particular development site. For MUSIC modelling guidance, refer to the NSW MUSIC Modelling Guidelines (BMT WBM, 2010) that are available from the Sydney Metropolitan CMA web-site.

For subdivision applications where SQIDs are proposed within lots to form part of the treatment series, MUSIC modelling shall be completed assuming that a maximum of 50% of the proposed lot scale SQIDs (excluding rainwater tanks) are functional. Therefore, the modelling should be based on all the rainwater tanks and 50% of the other within-lot SQIDs functioning as designed. The development applicant shall also confirm with Council at the subdivision stage what arrangement will be in place to ensure that the modelled lot scale SQIDs will be installed as a component of future lot building works.

7 OPERATION AND MAINTENANCE PLAN

7.1 Purpose

To ensure that SQIDs will function effectively into the future it is important that operation and maintenance requirements are considered during initial planning to ensure that the SQIDs can be efficiently maintained by Council. Operation and maintenance requirements for particular SQIDs shall be summarised in an Operation and Maintenance Plan (OMP).

The OMP is a living document that is regularly reviewed and updated at various stages throughout the development lifecycle as further details of the development are confirmed or changes occur. The OMP should typically be prepared, reviewed and/or updated at the following stages:

- Development application (by development applicant);
- Construction certificate (by development applicant);
- Hand over (by development applicant); and
- Operation (by Council/asset owner).

A Draft Operation and Maintenance Plan (OMP) shall be prepared along with the WCMP and lodged with the Development Application. A summary of the elements that shall be addresses in the OMP and the development stage/s for addressing these is provided in Table 7-1.

Table 7-1 Operation and Maintenance Plan Preparation

	Development Stage to Incorporate into OMP			
Element	**Development Application**	**Construction Certificate**	**Handover**	**Operation**
Confirm maintenance responsibility	●			
Site and development description	●	○		
Site access location	●	○		
Proposed locations of SQIDs	●	○		
Concept sketches of SQIDs	●			
Maintenance access design	●	○		
Maintenance equipment and personnel	●	○	○	○
Description of maintenance methods	●	○	○	○
Estimate operation and maintenance costs	●	○	○	○
Specific performance monitoring activities	●	○	○	○
Details of SQID construction staging		●		
Landscape and weed control management		●	○	○
Inspection methods		●	○	○
Safe work method statement		●	○	○
Work-as-executed drawings			●	
Photographs of SQIDs and components			●	○
SQID co-ordinates			●	
Details of modifications to constructed SQID			●	○

● Initial consideration; ○ Review and revise if necessary

The Draft OMP shall include details on the elements outlined below.

7.2 Description of SQIDs

A description of the SQIDs shall be provided including the locations and types of SQIDs proposed. This description shall also include a summary of the land uses / surfaces draining to the SQIDs and the expected types and loads of pollutants.

7.3 Confirm Maintenance Responsibility

The development applicant typically should confirm if the future maintenance responsibility lies with Council, the private property owner or a owner's corporation/community association. Council has a preference for major SQIDs to be located within public lands formed within the development to ensure that Council has a legal right to access the measures. The maintenance responsibility for the SQIDs should be confirmed as an initial step when planning the development site.

7.4 Site and SQID Access

The provision of a well-planned and designed site access will reduce maintenance time and costs, particularly where large machinery is required for maintenance. Planning an appropriate location for a SQID should be undertaken following an inspection of the site to confirm that there are no significant factors that would impede site access. Commonly encountered issues that may impact on site access include-:

- Unavailability of a legal site access;
- All-weather site access unavailable;
- Overhead power lines and trees reduce access by machinery;
- Limited horizontal clearance to obstacles (e.g. trees, fences, parked cars);
- Steep gradients restrict access and egress for fully laden maintenance vehicles;
- Access road pavement has insufficient strength for heavy maintenance vehicles;
- Constant base flow restricts access and limits maintenance activities;
- Safety risks resulting from remote site location and configuration;
- Traffic increasing risks to maintenance personnel; and
- Parked vehicles prevent access.

These issues and other site specific constraints to efficient maintenance should be identified and considered by the development applicant when preparing a SQID design.

7.5 Pre-treatment

SQIDs can often become overloaded with large volumes of litter, organic debris and coarse sediment (gross pollutants) that reduce the performance of the measures. To minimise the volume of gross pollutants directed to SQIDs that are designed to remove fine sediments, nutrients, heavy metals and other fine pollutants, pre-treatment should be undertaken. Pre-treatment measures including GPTs and sediment retention traps should be provided in advance of all vegetated SQIDs to improve maintenance efficiency.

7.6 Maintenance Equipment and Personnel

A key consideration is that proposed SQIDs can be efficiently maintained using available Council equipment and personnel.

Machinery required to efficiently maintain a SQID should be confirmed during initial planning to assist with designing the site access and ensuring that personnel with qualifications to operate the machinery are available. Labour intensive manual maintenance methods should wherever possible be avoided, but in situations where complete access by machinery is unavailable alternative appropriate methods should be identified.

To ensure that SQIDs can be maintained efficiently during operation, a list of Council's available maintenance equipment and personnel skills (including contractors) should be confirmed by the development applicant to ensure that SQIDs are planned considering the available resources. The development applicant should confirm with Council the preferred maintenance methods and any limitations of the available equipment (e.g. maximum load, vehicle dimensions, maximum gradients for accesses, reach limitations for excavators etc). This ensures that proposed SQIDs are designed considering the practical limitations of Council's resources. Where Council utilises contractors to perform maintenance, similar details should be sourced to assist with confirming limitations of the contractors.

7.7 Operation and Maintenance Cost Estimate

The evaluation of the lifecycle costs for a SQID is a fundamental step to ensure that an appropriate level of funding is allocated for construction of the SQID and the longer-term operation and maintenance costs.

An estimate of the operation and maintenance costs for SQIDs is particularly important during early planning to ensure that Council has a good appreciation of the long-term costs. The future operation and maintenance costs for SQIDs should be estimated at the development application stage to avoid re-design of SQIDs that will ultimately be ineffective due to excessive and impractical maintenance requirements (and associated costs). Cost estimates should be provided for the operation, maintenance and replacement/decommissioning cost elements for each measure.

Experience of various Councils in NSW has shown that the total annual maintenance costs for SQIDs are on average between 2 to 5% of the capital cost of installed measures. Although, in some circumstances the annual maintenance cost has been up to 20% of the capital cost. Detailed guidance on evaluating whole of life costs is provided in a report titled 'An Introduction to Life Cycle Costing Involving Structural Stormwater Quality Management Measures' prepared by the Co-operative Research Centre for Catchment Hydrology (Taylor, 2003a).

7.8 Construction Staging

A description of any staging associated with the proposed SQIDs construction should typically be provided. SQIDs that will potentially be exposed to damage and/or excessive sediment loading during the building construction phase should be staged to ensure that the measures will be functional when building works have neared completion and the catchment is stabilised. Catchments typically stabilise after both subdivision works, and building works on individual lots are complete.

It will be important that it is demonstrated that sufficient SQIDs will be provided throughout the development and building phases to ensure that the Council's objectives and targets would be achieved from commencement to completion of all road and building construction. It is also important that measures that will subject to potential damage and/or excessive sediment loading during a building construction phase are staged to ensure that the SQIDs will be functional when the catchment is stabilised. Development applicants shall clearly demonstrate how construction of the SQIDs would be staged (e.g. temporary sacrificial vegetation or media layers during construction replaced by final layers prior to asset handover).

8 SQID DESIGN

8.1 Development Application

For the development application, concept design drawings/sketches shall be prepared showing the location, size and conceptual configuration of the SQIDs. Sufficient information shall be provided to clearly demonstrate how the SQIDs function and fit with other urban design elements of the proposed development. A key consideration is how suitable access for maintenance to the SQID would be achieved and Council's preferred methods for maintaining each SQID should be considered and addressed in the design.

A sub-catchment plan shall be provided to show all site and external catchments draining to the SQIDs. Contours should be shown at an appropriate interval that clearly indicates proposed site gradients and any distinct changes in ground levels. Where the SQIDs will intercept runoff from areas external to the development, contours and sub-catchments for the external areas shall be shown.

The location and total footprint of the SQIDs in relation to other infrastructure proposed within the development shall be shown. The total estimated footprint may be shown as a shaded area on a plan that indicates the other elements of the development. To confirm the total footprint of the SQIDs, it will be important that consideration is given to embankments, cutting, retaining walls, bypass structures, access driveways, maintenance pads, temporary stockpile area etc. This will be particularly important within steep sites where the total footprint of a SQID may substantially exceed the MUSIC modelled internal treatment area of a particular SQID.

A conceptual section/s through the SQIDs shall be provided showing the dimensions and key features of the SQID. Examples of the design elements that the concept sections should show include extended detention depths, internal and external batter slopes, retaining wall locations, embankment crest widths, filter media layer depths, filter media characteristics, drainage pit and pipe size/location, plant species, locations and densities, inlet location/configuration etc.

A conceptual section/s through the SQID shall be provided showing the dimensions and key features. Examples of the design elements that the concept sections should show include extended detention depths, internal and external batter slopes, retaining wall locations, embankment crest widths, filter media layer depths, filter media characteristics, drainage pit and pipe size/location, plant species, locations and densities, inlet location/configuration.

Locations of existing services within or external to the development site that may require adjustment to construct the SQID shall be shown along with proposed connections to external drainage systems (including the existing drainage system characteristics).

There are a number of resources available to assist in the development of concept designs for SQIDs. A number of these are publicly available, whilst others would need to be purchased from the relevant publisher/owner of the document. A summary of key resources is provided in Section 10**.**

Typical drawings to assist with preparing concept designs are shown in Part 6 of the Engineering Guidelines – Standard Drawings.

8.2 Concept Design Checklist

A summary of key concept design considerations for SQIDs is provided in Table 8-1.

Table 8-1 Concept Design Checklist

CONCEPT DESIGN CONSIDERATIONS	Y	N	N/A
DEVELOPMENT CONFIGURATION			
Site analysis has been completed and site constraints for proposed SQIDs have been evaluated.			
Water management targets and objectives relevant to the SQIDs have been confirmed.			
SQIDs are arranged in a treatment series that initially captures coarse pollutants followed by progressively finer pollutants.			
Dedicated land is provided for the SQIDs in the development layout.			
Dedicated land for the SQIDs includes allowance for batters, retaining walls, maintenance access, temporary waste stockpiles, landscaping and other ancillary development.			
SQIDs will be positioned outside defined riparian corridors.			
Concentrated discharge of stormwater into riparian corridors will be avoided or mitigated.			
SQIDs will not require clearing of habitat planned for retention.			
SQIDs have been positioned considering other urban design criteria (e.g. heritage, traffic, ecology, services, infrastructure, visual etc).			
Numerical modelling completed to confirm that the proposed SQID configuration would achieve the objectives and targets.			
SITE CONFIGURATION			
Pre-treatment SQIDs are provided to remove litter, organic debris and/or coarse sediment.			
Gradients are suitable for minimising erosion or excessive ponding of water.			
Site access to the SQIDs is not too steep for the required maintenance vehicles.			
Bedrock is at a sufficient depth for the proposed SQID configuration.			
SQIDs function would not be impacted by a seasonally rising groundwater table.			
SQIDs would not impact adversely on existing groundwater quality or flow regimes.			
SQIDs would not be located in an area where sodic, saline or reactive soils are present.			
If sodic, saline or reactive soils are present, SQIDs can be modified to address risks.			
SQIDs positioned adjacent to road pavements and structures have considered the potential for seepage from the SQIDs to impact on this infrastructure.			
SQIDs can be accessed by the maintenance equipment available to Council.			
Existing trees, overhead power lines, building awnings, parked vehicles or other infrastructure will not restrict future maintenance access.			
SQIDs positioned in public open spaces would not reduce the function of the space.			
A concept for connection of roof and/or property drainage to the SQIDs has been identified.			
A concept for drainage at intersections has been identified including consideration of ponding depths and potential pedestrian conflicts.			
Crime Prevention Through Environmental Design principles have been considered.			
Safety of pedestrians, cyclist, residents and motorists has been considered and potential conflicts can be mitigated. Trip hazards are minimised and motorist sight lines retained.			

CONCEPT DESIGN CONSIDERATIONS	Y	N	N/A
Options for excluding public vehicle access have been identified (e.g. fencing, gates, bollards, slotted kerbs, signage, dense planting and street trees.)			
SQID CONFIGURATION			
SQIDs have no permanent water storage.			
Horizontal and vertical clearances to existing services are appropriate or agreements are in place with services authorities to protect and/or relocate their infrastructure.			
SQIDs have sufficient flow capacity to convey or divert the minor event design flow without inundating adjacent roads or private property.			
SQIDs would not reduce the hydraulic capacity of, and/or significantly increase upstream water levels within the minor drainage system.			
SQIDs with extended detention have appropriate maximum depths for the proposed locations.			
Inflow to the SQIDs will be evenly distributed or energy dissipation SQIDs provided.			
SQIDs incorporate a high flow bypass or controlled overflow structure.			
Overflow from the SQIDs will be directed to a defined drainage or infiltration system.			
Filter media is available locally.			
Proposed vegetation species are available locally.			
Vegetation species are appropriate for the local soil, topography and climatic conditions.			
SQID construction can be staged to manage potentially high construction sediment loads.			
Conceptual plan and typical sections of the SQIDs provided.			

8.3 Construction Certificate

The detailed design of SQIDs will require engineering and landscaping drawings and technical specifications to be prepared. The level of detail required to prepare detailed designs is beyond the scope for the SQID guidelines and Council currently does not have specific detailed design guidelines for SQIDs. However, Council has prepared checklists to assist with preparation of the final design (refer APPENDIX A:).

The following resources should assist in preparing detailed designs, although some elements will need to be tailored to local conditions in Lake Macquarie.

- Council's Engineering Guidelines
- *Water Sensitive Urban Design Engineering Guidelines: Stormwater, (Draft),* Brisbane City Council, Brisbane (Brisbane City Council, 2005).
- *Water Sensitive Urban Design Guidelines,* Gold Coast City Council (2007)
- Melbourne Water, (2005) *WSUD Engineering Procedures: Stormwater*. CSIRO Publishing.
- Moreton Bay Waterways and Catchments Partnership 2006, *Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland,* Moreton Bay Waterways and Catchments Partnership and Brisbane City Council, Brisbane.
- Water by Design Capacity Building (http://www.healthywaterways.org/wbd_project_overview.html) – numerous publications.

9 ASSET HANDOVER

9.1 Handover Requirements for Public Land Installations

SQIDs installed by developers within the LMCC LGA are to be designed, constructed, maintained and assessed in accordance with the checklists supplied in APPENDIX A: This process has been developed to ensure SQID components are selected, designed, constructed and ready for handover once approved by Council asset inspectors. Completion of the checklists follows a logical format from design through to preparation of the SQID for a final handover inspection to be undertaken by Council. For an asset to pass into ownership of Council all checklists must be completed including a summary of works required to maintain and / or repair the device. Only when the developer is satisfied that the device is compliant with Council's requirements will Council undertake a final handover inspection at which Council will use its own criteria checklist to confirm the devices are established, and ready for operation as designed.

Where multiple SQIDs are constructed as part of a treatment series for a development, Council's preference is that all SQIDs constructed in a specific lot will be handed over together rather than as individual SQIDs. An example of this is where a GPT is provided for pre-treatment adjacent to a bioretention basin in the same lot. Where the SQIDs within a treatment series are provided in separate land parcels (e.g. GPT provided in the road reserve upslope of a bioretention basin in a separate lot) Council may consider transfer of these assets separately. Council should be contacted to confirm appropriate arrangements where SQIDs are in separate land parcels and are proposed to be transferred separately.

For community title developments where SQIDs are to be transferred into public ownerships, these shall also be provided in separate lots dedicated to Council. Private and Council owned assets shall be clearly defined on work-as-executed plans for the development and registered on the land title.

Council will typically assume responsibility for future maintenance of SQIDs installed by developers on Council land following completion of construction and a subsequent developer maintenance period, provided the following conditions are satisfied:

- Certification that the SQID was constructed in accordance with the construction certificate. In most cases it is expected that this certification will be provided by an appropriately qualified and experienced professional, such as an engineer or landscape architect who designed particular components of the SQID.
- Work-as-executed drawings and any required engineering certifications for the SQID have been provided to Council.
- Council has inspected the SQID and confirmed that it is being maintained in accordance with the draft OMP.
- The draft OMP has been reviewed and revised (if necessary) following completion of the developer maintenance period and this final OMP is approved by Council.
- A final estimate of the annual operation and maintenance costs for the SQID is provided to Council and supported by verifiable expenses incurred during the developer maintenance period.

- Any required security bonds have been received.
- Detailed records of maintenance works completed by the developer during the period between construction and handover have been provided to Council.
- Details of any incidents including, OH&S incidents, public safety, and complaints received are documented and provided to Council.
- Any water quality monitoring required has been completed and monitoring results provided to Council.

If Council determines that a SQID is not complying with the applicable development consent conditions (e.g. appropriate maintenance access has not been provided and the SQID is not being maintained in accordance with the approved OMP), Council will be under no obligation to approve handover and accept responsibility for future maintenance. Until formal written notice is provided by Council accepting responsibility for maintenance, the developer shall retain responsibility for maintaining the SQID. Where inspections identify that the SQID is not performing as designed, Council may require alterations prior to handover.

9.2 Maintenance Contributions

For subdivisions, the developer will be responsible for funding and maintaining vegetated SQIDs constructed as a component of the subdivision works until 80% of lots within the SQID catchment have occupied buildings/dwellings constructed upon them or until a period of two years from the release of the subdivision certificate has transpired (whichever is the lesser).

Large and other non-standard SQIDs that have increased maintenance requirements may require additional lump sum contributions from the developer to assist Council with future maintenance.

9.3 Security Bonds

Vegetated SQIDs will typically need to be constructed in stages to protect SQIDs constructed during subdivision works from being overloaded with sediment during the subdivision building/dwelling construction phase. For example, Council will typically require that a bioretention SQID be constructed with a sacrificial surface layer (e.g. turf) for the building stage, with the sacrificial layer only removed and the biofilter planting completed when 80% of lots within the subdivision have occupied buildings/dwellings constructed upon them or a period of two years from the release of the subdivision certificate has transpired (whichever is the lesser).

Council will require the developer to construct vegetated SQIDs to a functional stage and provide appropriate bonds to cover the final stage of construction of the SQID. Council will only allow the final stage of vegetated SQID construction to proceed when 80% of lots within the subdivision have occupied buildings/dwellings constructed upon them or after two years.

Bonds will be required under Section 109J of the EP&A Act in accordance with Council's "Subdivision Bonds and Guarantees" policy.

Requirements for maintenance contributions and bonds should be discussed with Council during the early development planning to identify a preferred arrangement for both parties.

9.4 Positive Covenants

To provide Council with legal powers to ensure SQIDs installed within private property are appropriately maintained, the developer may be required to create positive covenants and register these title encumbrances with the Land Titles Office. The title encumbrances shall be registered prior to occupation of the development.

Council appreciates that creation of positive covenants increases costs to the lot owner in the form of additional legal fees, registered surveyor fees and future inspection fees. Costs for Council also increase through additional compliance officers to inspect and address any non-compliances. For these reasons, creation of positive covenants is usually not required for individual residential lots. Typically creation of positive covenants may be required for SQIDs installed within multi-dwelling, business and industrial lots. Development types where title encumbrances are required to be registered for SQIDs are outlined in the WCMGs.

Positive covenants are created under Section 88E of the *Conveyancing Act 1919.* A Section 88E instrument shall provide appropriate restrictions and covenants to enable unhindered long term management and maintenance of the SQIDs. In particular, the instruments should-:

- Protect the SQID from being removed, constructed over or modified;
- Provide a legal right for Council to inspect the SQID and have vehicle access;
- Require an owner to carry out maintenance of the SQID in accordance with the final OMP and provide regular maintenance reports to Council;
- Give authority to Council to issue a directive to the owner to maintain a SQID if required within 14 days of notification;
- Give approval for Council to enter the property and complete maintenance if a directive to clean or repair a SQID is not complied with and recover the costs to complete this maintenance from the owner; and
- Require that the current and future owner maintains the SQIDs in perpetuity for the life of the development.

9.5 Development Consent Conditions

Where a positive covenant is not required to be registered, development consent conditions will require future owners to maintain SQIDs installed within lots. Council has the option under s.121B of the EP&A Act to instruct an owner to comply with a condition of consent to maintain a SQID. It these instructions are not complied with Council has powers to issue fines or proceed with Land and Environment Court action.

9.6 Vegetation Establishment

9.6.1 General

As a general principle, Council requires the developer to prepare their landscaping plans in accordance with the current Water by Design Guidelines, which can be downloaded from http://waterbydesign.com.au/ and the LMCC Landscaping Guidelines.

Notwithstanding, the period for establishment of plants is often dependent on the season when planting is undertaken and weather patterns in the following years. Vegetation that is planted in late autumn and winter will typically require longer to establish than planting in spring or summer.

Council requires 90% vegetation coverage within two growing seasons. The Water by Design Guidelines provides assistance as to how this coverage can be achieved. The LMCC Landscaping Guidelines provide assistance on the selection of suitable plant species for the Lake Macquarie area.

9.6.2 Maintenance Period

Developers are required to maintain vegetation within SQIDs installed in public lands until the vegetation covers 90% of the vegetated area (i.e. 90% coverage).

Where close to mature height plants are grown in a nursery off-site and transported for planting, a minimum planted period (nominally 6 months) should pass before confirming establishment.

9.6.3 Assessment Guidelines

Identification of an appropriate stage when vegetation is considered to be established typically requires a level of subjective assessment. To assist with reducing the level of subjectivity, the following elements are to be considered when assessing the establishment of vegetation in SQIDs:

- Sufficient planting coverage;
- Visually healthy plants; and
- Limited bare patches and weed growth.

Each of these establishment criteria as they apply to LMCC is discussed below.

Where bonding arrangements have been agreed between Council and the developer, alternative handover arrangements may apply.

Sufficient Planting Coverage

For ephemeral SQIDs, stake out sample $4m^2$ areas of vegetated measure (i.e. 2m x 2m) for every $100m^2$ of biofilter. Record GPS co-ordinates of sampled areas and take photographs with staked area in place to visually confirm sampled areas are representative. Count plants within the staked areas and check for planting density.

Where access is limited by permanent water or staking out of sample areas is otherwise impractical, photographs of previously measured installations should be used as a visual reference for comparison with the planted SQID to ascertain whether appropriate planting densities have been achieved. Photos should be provided for comparison with the constructed condition for typical species, plant densities and heights. Example photographs for a bioretention basin are shown in Figure 9-1. For comparison with planting densities, photographs taken 12 months after planting are likely to be most relevant.

Just planted 4 months growth 12 months growth

Figure 9-1 Example Bioretention Basin Establishment Photos

Visually Healthy Plants

Visually check that plants are healthy with no obvious signs of disease. Confirm that the vegetation colour is consistent with the season. Binoculars may be required to inspect vegetation that is inaccessible from dry land.

Limited Bare Patches and Weed Growth

For vegetated ephemeral SQIDs, traverse parallel sections through the planted vegetation to identify areas where bare patches or weed growth are present. For large measures, record locations using GPS. Otherwise, note locations of bare patches or weed presence in relation to adjacent features. Initiate re-planting or weed removal.

For vegetated SQIDs containing permanent water, broadly view the SQID from a nearby elevated location to visually identify any bare patches within the constructed wetland and areas where weeds are present. Initiate weed removal and planting/replanting in bare patches. Water levels may need to be adjusted to enable re-planting to occur.

Check planted areas adjacent to inlets to confirm that invasive weeds species are absent and initiate removal and replanting where necessary.

Where replanted areas are less than 10% of the area of the SQID, check that these areas have been successfully rehabilitated 3 months after replanting prior to confirming establishment. Where an area exceeding 10% of the surface area of the designed planting area requires replanting, these areas shall be maintained by the developer for a further 12 months (minimum) prior to re-assessing whether Council will accept handover.

9.7 Maintenance Inductions

At the end of the developer maintenance period, a SQID shall be inspected and maintained in Council's presence as a means of providing Council's maintenance personnel with an induction on the maintenance requirements of the SQID and any particular unusual characteristics of the site.

10 REFERENCES AND RESOURCES

Argue, J.R. (ed), 2004, *Water Sensitive Urban Design: Basic Procedures for Source Control of Stormwater,* Stormwater Industry Association, University of South Australia and Australian Water Association, ISBN 1 920927 18 2

BMT WBM, 2009, *Evaluating Options for Water Sensitive Urban Design – A National Guide*, Prepared by the Joint Steering Committee for Water Sensitive Cities in Delivery Clause 92(ii) of the National Water Initiative, downloaded May 2010 from www.nwc.gov.au

BMT WBM, 2010, *Draft NSW MUSIC Modelling Guidelines*. Prepared for the Sydney Metropolitan Catchment Management Authority.

Boral 2003, *Low Impact Water Management in New Developments – How Much Does WSUD Really Cost? Booklet 1: Project Cost Summaries and Workshop Information,* Proceedings of workshop in Newcastle, 1 July 2003. Lower Hunter and Central Coast Regional Environmental Management Strategy, Newcastle, New South Wales.

Brisbane City Council, 2005, *Water Sensitive Urban Design Engineering Guidelines: Stormwater, (Draft),* Brisbane City Council, Brisbane.

Brisbane City Council, 2011, *Water Sensitive Urban Design - Streetscape Planning and Design Package,* Brisbane City Council, Brisbane.

Cuncliffe, 2004 *Guidance on Use of Rainwater Tanks,* enHealth Council, Australian Government.

Department of Water and Energy, 2008, *Guidelines for Controlled Activities – Riparian Corridors*

Ecological Engineering, 2007, *Life Cycle Costs of Water Sensitive Urban Design (WSUD) Treatment Systems*, *Summary Report*, Prepared for Brisbane City Council, 5th January 2007

Engineers Australia, 2006, *Australian Runoff Quality: A Guide to Water Sensitive Urban Design*. Engineers Australia, ACT.

Facility for Advancing Biofiltration 2009, *Stormwater Biofiltration Adoption Guidelines,* Monash University.

Fletcher, T., Duncan, H., Poelsma, P. and Lloyd, S., 2005, *Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures – A Review and Gap Analysis*, Report 04/8 Cooperative Research Centre for Catchment Hydrology, Monash University, Melbourne

Gold Coast City Council, 2006, *Water Sensitive Urban Design Guidelines.*

Gosford City Council, 2003, *Guidelines for the Installation of Rainwater Tanks.*

Hatt, B.E., Deletic, A., and Fletcher, T.D., 2004, *Integrated Stormwater Treatment and Re-use Systems - Inventory of Australian Practice*, Cooperative Research Centre for Catchment Hydrology.

HCCREMS, 2007, *WaterSmart Practice Notes* Hunter & Central Coast Regional Environmental Management Strategy.

HCCREMS, 2007, *Water Smart Model Planning Provisions* Hunter & Central Coast Regional Environmental Management Strategy.

Hornsby Shire Council, 2011, *Catchment Remediation Rate Capital Works Program 2010 – 2011 Annual Report,* Water Catchments Team.

Knights, D., Beharrell, D. and Jonasson, J. 2010, *What Does it Cost to Build a Water Quality Treatment System, Conference.* Proceedings of the National Conference of the Stormwater Industry Association, 2010.

Lake Macquarie City Council, 2013 *Landscaping Guidelines to the Development Control Plan*

Landcom, 2004, *Managing Urban Stormwater: Soils and Construction, 4th Edition*, NSW Government.

Melbourne Water, 2005, *WSUD Engineering Procedures: Stormwater*. CSIRO Publishing.

Moreton Bay Waterways and Catchments Partnership 2006, *Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland,* Moreton Bay Waterways and Catchments Partnership and Brisbane City Council, Brisbane.

National Water Commission, 2008, *Rainwater Tank Design and Installation Handbook*.

NSW Department of Environment and Conservation, 2006, *Managing Urban Stormwater – Harvesting and Reuse*

Rawlinsons, 2012, *Australian Construction Handbook, 30th edition*. Rawlinsons Publishing.

Upper Parramatta River Catchment Trust, 2004, *Water Sensitive Urban Design – Technical Guidelines for Western Sydney* Stormwater Trust and Upper Parramatta River Catchment Trust.

Willoughby City Council, 2004, *Reducing the Economic and Environmental Lifecycle Costs of Stormwater Gross Pollutant Traps.* Report prepared by Willoughby City Council and North Sydney Council in partnership with the NSW Stormwater Trust.

Water by Design, 2012, *Water by Design Guidelines*. Downloaded from http://waterbydesign.com.au/

Web Sites

Water Sensitive Urban Design (WSUD) in the Sydney Region Capacity Building Program (http://www.wsud.org/index.htm).

Hunter Central Coast Regional Environmental Strategy WSUD Capacity Building Program (http://www.urbanwater.info/index.cfm).

Water by Design Capacity Building (http://www.healthywaterways.org/wbd_project_overview.html).

Clearwater Capacity Building Program (http://www.clearwater.asn.au/).

APPENDIX A: CHECKLISTS

GRASSED SWALE DESIGN CHECKLIST

Location:		
Hydrology:	Design operational flow (m^3/s):	Above design flow (m^3/s):
Area:	Catchment Area (ha):	Swale Area (ha)

Treatment	**Y**	**N**	**NA**
Treatment performance verified?			
INFLOW SYSTEMS	**Y**	**N**	**NA**
Inlet flows appropriately distributed?			
Swale/ buffer vegetation set down of at least 60 mm below kerb invert incorporated?			
Energy dissipation (rock protection) provided at inlet points to the swale?			
Swale configuration / Conveyance			
Longitudinal slope of invert >1% and <4%?			
Manning's n selected appropriate for proposed vegetation type?			
Overall flow conveyance system sufficient for design flood event?			
Overflow pits provided where flow capacity exceeded?			
Velocities within swale cells will not cause scour?			
Maximum ponding depth and velocity will not impact on public safety (V x d < 0.4 m/s)?			
Maintenance access provided to invert of conveyance channel?			
Overall shape, form, edge treatment and planting integrate well (visually) with host landscape?			
LANDSCAPE	**Y**	**N**	**NA**
Plant species selected can tolerate periodic inundation and design velocities?			
Planting design conforms with acceptable sight line and safety requirements?			
Top soils are a minimum depth of 300mm for plants and 100 mm for turf?			
Existing trees in good condition are investigated for retention?			
Swale and buffer strip landscape design integrates with surrounding natural and/ or built environment?			

COMMENTS

*The 'control' outlet structure is to consist of an outlet pit with the crest of the pit set at the permanent pool level of the sedimentation basin. The overflow pit is sized to convey the design operational flow (1 year ARI).

GRASSED SWALE CONSTRUCTION INSPECTION CHECKLIST

Location:		**Inspected By (Name and Company):**	
Constructed By:		**Date / Time:**	
Contact during visit	Eg. Council, resident, etc	**Weather:**	

Items Inspected	Checked Y	Checked N	Satisfactory Y	Satisfactory N	Items Inspected	Checked Y	Checked N	Satisfactory Y	Satisfactory N
DURING CONSTRUCTION									
A. FUNCTIONAL INSTALLATION									
Preliminary Works					Structural components cont.				
1. Erosion & Sediment Control plan implemented and adopted					21. Inlets appropriately installed				
2 Limit public access					22. Inlet erosion protection installed				
3. Location same as plans					23. Set down to correct level for flush kerbs				
4. Site protection from existing flows									
5. Critical root zones (0.5 m beyond drip line) of nominated trees are protected?									
EARTHWORKS									
6. Existing topsoil is stockpiled for reuse if suitable?									
7. Level bed of swale					VEGETATION				
8. Batter slopes as plans					24. Stabilisation immediately following earthworks				
9. Longitudinal slope in design range					25. Weed removal prior to planting				
10. Provision of sub-soil drainage for mild slopes (<1%)					26. Vegetation layout and densities as designed				
11. Compaction process as designed									
12. Appropriate topsoil on swale									
13. Check for groundwater intrusion									
14. Stabilisation of bare ground									
STRUCTURAL COMPONENTS					B. EROSION AND SEDIMENT CONTROL				
15. Location and levels of pits as designed					27. Stabilisation immediately following earthworks and planting of terrestrial landscape as designed				
16. Safety protection provided (eg. Fencing, barriers)					28. Erosion controls and traffic controls in place				
17. Location of check dams as designed					C. OPERATIONAL ESTABLISHMENT				
18. Swale crossings located/ built as designed					29. Test and ameliorate topsoil, if required				
19. Pipe joints/ connections as designed					30. Planting as designed (species/densities)				
20. Concrete and reinforcement as designed					31. Weed removal and watering as required				
FINAL CONSTRUCTION INSPECTION									
1. Confirm levels of inlets and outlets using laser levels					8. Check for uneven settling of banks and repair if required				
2. Confirm structural element sizes					9. Evidence of stagnant water, short circuiting or vegetation scouring				
3. Check batter slopes (slope/stability)					10. Evidence of litter or excessive debris				
4. Vegetation planting as designed (density, species, survival)					11. Drainage area for removed sediment provided				
5. Erosion protection measures working					12. Construction generated sediment removed				
6. Maintenance access approved									
7. Public safety adequate									

COMMENTS ON INSPECTION
Actions Required
1.
2.
3.
4.
5.
6.
7.

GRASSED SWALE /BUFFER MAINTENANCE CHECKLIST

Location			
Inspection frequency	1 to 6 monthly	Date of visit	
Location			
Description			
Site visit by			

INSPECTION ITEMS	Y	N	ACTION REQUIRED (DETAILS)
Litter accumulation?			
Sediment accumulation at inflow points?			
Erosion at inlet or other key structures (eg crossovers)?			
Traffic damage present?			
Evidence of dumping (building waste, oils etc)?			
Terrestrial vegetation condition satisfactory (density, weeds etc)?			
Littoral vegetation condition satisfactory (density, weeds etc)?			
Replanting required?			
Settling or erosion of bunds/batters present?			
Weed removal required?			
Damage/vandalism to structures present?			
Crossing structures free from damage?			
Mowing Required?			

COMMENTS

GRASSED SWALE PRE-HANDOVER INSPECTION CHECKLIST

Location	
Asset Description	
Constructed By	
'On-maintenance Period'	
Site visit by	

TREATMENT	Y	N	ASSET OWNER SIGN OFF*
System appears to be working as designed visually?			
No obvious signs of under-performance?			
MAINTENANCE			
Maintenance plans and indicative maintenance costs provided for each asset?			
Vegetation establishment period completed (2 years?)			
Inspection and maintenance undertaken as per maintenance plan			
Inspection and maintenance forms provided?			
Asset inspected for defects?			
ASSET INFORMATION			
Design Assessment Checklist provided?			
As constructed plans provided?			
Copies of all required permits (both construction and operational) submitted?			
Proprietary information provided (if applicable)?			
Digital files (e.g. drawings, survey, models) provided?			
COMMENTS			

* Asset owner before handover to LMCC.

SEDIMENT BASIN DESIGN CHECKLIST

Location:		
Hydrology:	Design operational flow (m^3/s):	Above design flow (m^3/s):
Area:	Catchment Area (ha):	Basin Area (ha)

Treatment	**Y**	**N**	**NA**
MUSIC modelling preformed?			
BASIN CONFIGURATION	**Y**	**N**	**NA**
Discharge pipe/structure to sedimentation basin sufficient for design flow?			
Concrete pad provided at inlet before scour protection to enable sediment removal?			
Scour protection provided at inlet?			
Basin located upstream of treatment system (i.e. macrophyte zone of wetland)?			
Configuration of basin (aspect, depth and flows) allows settling of particles >125 µm?			
Basin capacity sufficient for desilting period >=5 years?			
Maintenance access allowed for into base of sediment basin?			
Public access to basin prevented through dense vegetation or other means consistent with Councils batter slope treatment guidelines?			
Gross pollutant protection measures provided on inlet structures where required?			
Freeboard provided to top of embankment?			
Public safety design considerations included in design and safety audit of publicly accessible areas undertaken?			
Overall shape, form, edge treatment and planting integrate well (visually) with host landscape?			
OUTLET STRUCTURES	**Y**	**N**	**NA**
Control' outlet structure required?*			
'Control' outlet structure sized to convey the design operation flow?			
Designed to prevent clogging of outlet structures (i.e. provision of appropriate grate structures)?			
'Spillway' outlet control (weir) sufficient to convey 'above design flow'?			
'Spillway' outlet has sufficient scour protection?			
Visual impact of outlet structures has been considered?			

COMMENTS

*The ‘control’ outlet structure is to consist of an outlet pit with the crest of the pit set at the permanent pool level of the sedimentation basin. The overflow pit is sized to convey the design operational flow (1 year ARI).

SEDIMENT BASIN CONSTRUCTION INSPECTION CHECKLIST

Location:		**Inspected By (Name and Company):**	
Constructed By:		**Date / Time:**	
Contact during visit	Eg. Council, resident, etc	**Weather:**	

Items Inspected	Checked		Satisfactory		**Items Inspected**	Checked		Satisfactory	
	Y	N	Y	N		Y	N	Y	N
DURING CONSTRUCTION									
A. FUNCTIONAL INSTALLATION									
Preliminary Works					Structural components cont.				
1. Erosion & Sediment Control plan implemented and adopted					22. Check spillway is level				
2 Limit public access					23. Provision of maintenance drain(s)				
3. Location same as plans					24. Collar installed on pipes				
4. Site protection from existing flows									
5. All required permits in place									
EARTHWORKS									
6. Integrity of banks									
7. Batter slopes as plans					VEGETATION				
8. Impermeable base installed					29. Stabilisation immediately following earthworks				
9. Maintenance access to whole basin					30. Weed removal prior to planting				
10. Compaction process as designed					32. Vegetation layout and densities as designed				
11. Placement of adequate topsoil for optimal plant growth									
12. Levels as designed checked using laser level.									
13. Check for groundwater intrusion									
14. Stabilisation of bare ground									
STRUCTURAL COMPONENTS					B. EROSION AND SEDIMENT CONTROL				
15. Location and levels of outlets as designed					35. Sediment basin to be used during construction				
16. Safety protection provided (eg. Fencing, barriers)					36. Stabilisation immediately following earthworks and planting of terrestrial landscape as designed				
17. Pipe joints and connections as designed					37. Erosion controls and traffic controls in place				
18. Concrete and reinforcement as designed									
19. Inlets appropriately installed					C. OPERATIONAL ESTABLISHMENT				
20. Inlet energy dissipation installed					39. Sediment Basin desilted				
21. No seepage through banks									
FINAL CONSTRUCTION INSPECTION									
1. Confirm levels of inlets and outlets using laser levels					8. Check for uneven settling of banks and repair if required				
2. Confirm structural element sizes					9. Evidence of stagnant water, short circuiting or vegetation scouring				
3. Check batter slopes (slope/stability)					10. Evidence of litter or excessive debris				
4. Vegetation planting as designed (density, species, survival)					11. Drainage area for removed sediment provided				
5. Erosion protection measures working					12. Construction generated sediment removed				
6. Maintenance access approved									

7. Public safety adequate									
COMMENTS ON INSPECTION									
Actions Required									
1.									
2.									
3.									
4.									
5.									
6.									
7.									

SEDIMENT BASIN MAINTENANCE CHECKLIST

Location			
Inspection frequency	1 to 6 monthly	Date of visit	
Location			
Description			
Site visit by			

INSPECTION ITEMS	Y	N	ACTION REQUIRED (DETAILS)
Litter accumulation?			
Sediment accumulation at inflow points?			
Sediment requires removal (record depth, remove if >50%)?			
All structures in satisfactory condition?			
Evidence of dumping (building waste, oils etc)?			
Terrestrial vegetation condition satisfactory (density, weeds etc)?			
Littoral vegetation condition satisfactory (density, weeds etc)?			
Replanting required?			
Settling or erosion of bunds/batters present?			
Weed removal required?			
Damage/vandalism to structures present?			
Outlet structure free of debris?			

COMMENTS

SEDIMENT BASIN PRE-HANDOVER INSPECTION CHECKLIST

Location	
Asset Description	
Constructed By	
'On-maintenance Period'	
Site visit by	

TREATMENT	Y	N	ASSET OWNER SIGN OFF*
System appears to be working as designed visually?			
No obvious signs of under-performance?			
MAINTENANCE			
Maintenance plans and indicative maintenance costs provided for each asset?			
Vegetation establishment period completed (2 years?)			
Inspection and maintenance undertaken as per maintenance plan			
Inspection and maintenance forms provided?			
Asset inspected for defects?			
ASSET INFORMATION			
Design Assessment Checklist provided?			
As constructed plans provided?			
Copies of all required permits (both construction and operational) submitted?			
Proprietary information provided (if applicable)?			
Digital files (e.g. drawings, survey, models) provided?			
COMMENTS			

* Asset owner before handover to LMCC.

BIORETENTION SWALE DESIGN CHECKLIST					
BIORETENTION SWALE CONSTRUCTION INSPECTION CHECKLIST					
Hydrology:	Design operational flow (m^3/s):	Above design flow (m^3/s):			
Area:	Catchment Area (ha):	Swale Area (ha)			
Treatment			**Y**	**N**	**NA**
Treatment performance verified?					
Swale configuration / Conveyance			**Y**	**N**	**NA**
Longitudinal slope of invert >1% and <4%?					
Manning's n selected appropriate for proposed vegetation type?					
Overall flow conveyance system sufficient for design flood event?					
Overflow pits provided where flow capacity exceeded?					
Velocities within swale cells will not cause scour?					
Maximum ponding depth and velocity will not impact on public safety (V x d < 0.4 m/s)?					
Maintenance access provided to invert of conveyance channel?					
Set down of at least 60mm below kerb invert to top of vegetation incorporated?					
BIORETENTION COMPONENT			**Y**	**N**	**NA**
Design documents bioretention area and extended detention depth as defined by treatment performance requirements?					
Overflow pit crest set at top of extended detention?					
Maximum ponding depth and velocity will not impact on public safety (v x d <0.4)					
Bioretention media specification includes details of filter media, drainage layer and transition layer?					
Design saturated hydraulic conductivity included in specification?					
Transition layer provided where drainage layer consists of gravel (rather than coarse sand)?					
Perforated pipe capacity > infiltration capacity of filter media?					
Selected filter media hydraulic conductivity > 10 x hydraulic conductivity of surrounding soil?					
Maximum spacing of collection pipes <1.5m?					
Collection pipes extended to surface to allow inspection and flushing?					
Liner provided if selected filter media hydraulic conductivity > 10x hydraulic conductivity of surrounding soil?					
Maintenance access provided to invert of conveyance channel?					
LANDSCAPE AND VEGETATION					
Plant species selected can tolerate periodic inundation and design velocities?					
Bioretention swale landscape design integrates with surrounding natural and/ or built environment?					
Planting design conforms with acceptable sight line and safety requirements?					
Top soils are a minimum depth of 300 mm for plants and 100 mm for turf and detailed soil specification included in design?					
COMMENTS					

Location:		**Inspected By (Name and Company):**	
Constructed By:		**Date / Time:**	
Contact during visit	Eg. Council, resident, etc	**Weather:**	

Items Inspected	Checked Y	Checked N	Satisfactory Y	Satisfactory N	**Items Inspected**	Checked Y	Checked N	Satisfactory Y	Satisfactory N
DURING CONSTRUCTION									
A. FUNCTIONAL INSTALLATION									
Preliminary Works					Structural components cont.				
1. Erosion & Sediment Control plan implemented and adopted					21. Inlets appropriately installed				
2 Limit public access					22. Inlet erosion protection installed				
3. Location same as plans					23. Set down to correct level for flush kerb				
4. Site protection from existing flows					24. Kerb opening width as designed				
EARTHWORKS AND FILTER MEDIA									
5. Bed of swale correct shape and slope									
6. Batter slopes as plans					VEGETATION				
7. Dimensions of bioretention area as plans					24. Stabilisation immediately following earthworks				
8. Longitudinal slope in design range					25. Weed removal prior to planting				
9. Confirm surrounding soil type with Design					26. Vegetation layout and densities as designed				
10. Confirm filter media specification									
11. Provision of liner (if required)									
12. Under-drainage installed as designed									
13. Drainage layer media as designed									
14. Transition layer media as designed					**B. EROSION AND SEDIMENT CONTROL**				
STRUCTURAL COMPONENTS					27. Stabilisation immediately following earthworks and planting of terrestrial landscape as designed				
15. Location and configuration of inflow systems as designed					28. Erosion controls and traffic controls in place				
16. Location and levels of overflow pits as designed					**C. OPERATIONAL ESTABLISHMENT**				
17. Under-drainage connected to overflow pits as designed					29. Test and ameliorate topsoil, if required				
19. Pipe joints/ connections as designed					30. Planting as designed (species/densities)				
20. Concrete and reinforcement as designed					31. Weed removal and watering as required				
FINAL CONSTRUCTION INSPECTION									
1. Confirm levels of inlets and outlets using laser levels					8. Check for uneven settling of banks and repair if required				
2. Confirm structural element sizes					9. Evidence of stagnant water, short circuiting or vegetation scouring				
3. Check batter slopes (slope/stability)					10. Evidence of litter or excessive debris				
4. Vegetation planting as designed (density, species, survival)					11. Drainage area for removed sediment provided				
5. Erosion protection measures working					12. Construction generated sediment removed				
6. Maintenance access approved									
7. Public safety adequate									

COMMENTS ON INSPECTION
Actions Required
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BIORETENTION SWALE MAINTENANCE CHECKLIST

Location			
Inspection frequency	1 to 6 monthly	Date of visit	
Location			
Description			
Site visit by			

INSPECTION ITEMS	Y	N	ACTION REQUIRED (DETAILS)
Litter accumulation?			
Litter within swales?			
Erosion at inlet or other key structures (eg crossovers)?			
Traffic damage present?			
Evidence of dumping (building waste, oils etc)?			
Terrestrial vegetation condition satisfactory (density, weeds etc)?			
Littoral vegetation condition satisfactory (density, weeds etc)?			
Replanting required?			
Settling or erosion of bunds/batters present?			
Weed removal required?			
Damage/vandalism to structures present?			
Crossing structures free from damage?			
Mowing Required?			
Drainage system inspected?			

COMMENTS

BIORETENTION SWALE PRE-HANDOVER INSPECTION CHECKLIST

Location	
Asset Description	
Constructed By	
'On-maintenance Period'	
Site visit by	

TREATMENT	Y	N	ASSET OWNER SIGN OFF*
System appears to be working as designed visually?			
No obvious signs of under-performance?			
MAINTENANCE			
Maintenance plans and indicative maintenance costs provided for each asset?			
Vegetation establishment period completed (2 years?)			
Inspection and maintenance undertaken as per maintenance plan			
Inspection and maintenance forms provided?			
Asset inspected for defects?			
ASSET INFORMATION			
Design Assessment Checklist provided?			
As constructed plans provided?			
Copies of all required permits (both construction and operational) submitted?			
Proprietary information provided (if applicable)?			
Digital files (e.g. drawings, survey, models) provided?			
COMMENTS			

* Asset owner before handover to LMCC.

BIORETENTION BASIN DESIGN CHECKLIST					
BIORETENTION BASIN CONSTRUCTION INSPECTION CHECKLIST					
Hydrology:	Minor Flood (m^3/s):	Major Flood (m^3/s):			
Area:	Catchment Area (ha):	Swale Area (ha)			
Treatment			**Y**	**N**	**NA**
Treatment performance verified?					
BIORETENTION MEDIA AND UNDER_DRAINAGE			**Y**	**N**	**NA**
Design documents bioretention area and extended detention depth as defined by treatment performance requirements.					
Overall flow conveyance system sufficient for design flood event(s)?					
Where required, bypass sufficient for conveyance of design flood event?					
Where required scour protection provided at inflow point to bioretention?					
Bioretention media specification includes details of filter media, drainage layer and transition layer (if required)?					
Design saturated hydraulic conductivity included in specification?					
Transition layer provided where drainage layer consists of gravel (rather than coarse sand)?					
Perforated pipe capacity > infiltration capacity of filter media?					
Selected filter media hydraulic conductivity > 10 x hydraulic conductivity of surrounding soil?					
Liner provided if selected filter media hydraulic conductivity < 10 x hydraulic conductivity of surrounding soil?					
Overflow pit crest set at top of extended detention?					
Maximum spacing of collection pipes <1.5m?					
Collection pipes extended to surface to allow inspection and flushing?					
BASIN					
Bioretention area and extended detention depth documented to satisfy treatment requirements?					
Overflow pit crest set at top of extended detention?					
Maximum ponding depth will not impact on public safety?					
Maintenance access provided to surface of bioretention system from more than one point?					
Protection from coarse sediments provided (where required) with a sediment forebay?					
Protection from gross pollutants provided (where required)?					
LANDSCAPE AND VEGETATION					
Plant species selected can tolerate periodic inundation and design velocities?					
Bioretention swale landscape design integrates with surrounding natural and/ or built environment?					
Planting design conforms with acceptable sight line and safety requirements?					
Top soils are a minimum depth of 300 mm for plants and 100 mm for turf and detailed soil specification included in design?					
COMMENTS					

Location:		**Inspected By (Name and Company):**	
Constructed By:		**Date / Time:**	
Contact during visit	Eg. Council, resident, etc	**Weather:**	

Items Inspected	Checked		Satisfactory		**Items Inspected**	Checked		Satisfactory	
	Y	N	Y	N		Y	N	Y	N
DURING CONSTRUCTION									
A. FUNCTIONAL INSTALLATION									
Preliminary Works					Structural components cont.				
1. Erosion & Sediment Control plan implemented and adopted					21. Inlets appropriately installed				
2 Limit public access					22. Inlet erosion protection installed				
3. Location same as plans					23. Set down to correct level for flush kerb				
4. Site protection from existing flows					24. Kerb opening width as designed				
EARTHWORKS AND FILTER MEDIA									
5. Bed of swale correct shape and slope									
6. Batter slopes as plans					VEGETATION				
7. Dimensions of bioretention area as plans					24. Stabilisation immediately following earthworks				
8. Longitudinal slope in design range					25. Weed removal prior to planting				
9. Confirm surrounding soil type with Design					26. Vegetation layout and densities as designed				
10. Confirm filter media specification									
11. Provision of liner (if required)									
12. Under-drainage installed as designed									
13. Drainage layer media as designed									
14. Transition layer media as designed					**B. EROSION AND SEDIMENT CONTROL**				
STRUCTURAL COMPONENTS					27. Stabilisation immediately following earthworks and planting of terrestrial landscape as designed				
15. Location and configuration of inflow systems as designed					28. Erosion controls and traffic controls in place				
16. Location and levels of overflow pits as designed					**C. OPERATIONAL ESTABLISHMENT**				
17. Under-drainage connected to overflow pits as designed					29. Test and ameliorate topsoil, if required				
19. Pipe joints/ connections as designed					30. Planting as designed (species/densities)				
20. Concrete and reinforcement as designed					31. Weed removal and watering as required				
FINAL CONSTRUCTION INSPECTION									
1. Confirm levels of inlets and outlets using laser levels					8. Check for uneven settling of banks and repair if required				
2. Confirm structural element sizes					9. Evidence of stagnant water, short circuiting or vegetation scouring				
3. Check batter slopes (slope/stability)					10. Evidence of litter or excessive debris				
4. Vegetation planting as designed (density, species, survival)					11. Drainage area for removed sediment provided				
5. Erosion protection measures working					12. Construction generated sediment removed				
6. Maintenance access approved									
7. Public safety adequate									

COMMENTS ON INSPECTION
Actions Required
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BIORETENTION BASIN MAINTENANCE CHECKLIST			
Location			
Inspection frequency	1 to 6 monthly	Date of visit	
Location			
Description			
Site visit by			

INSPECTION ITEMS	Y	N	ACTION REQUIRED (DETAILS)
Litter accumulation?			
Litter within swales?			
Erosion at inlet or other key structures (eg crossovers)?			
Traffic damage present?			
Evidence of dumping (building waste, oils etc)?			
Terrestrial vegetation condition satisfactory (density, weeds etc)?			
Littoral vegetation condition satisfactory (density, weeds etc)?			
Replanting required?			
Settling or erosion of bunds/batters present?			
Weed removal required?			
Damage/vandalism to structures present?			
Crossing structures free from damage?			
Mowing Required?			
Drainage system inspected?			

COMMENTS

BIORETENTION BASIN PRE-HANDOVER INSPECTION CHECKLIST

Location	
Asset Description	
Constructed By	
'On-maintenance Period'	
Site visit by	

TREATMENT	Y	N	ASSET OWNER SIGN OFF*
System appears to be working as designed visually?			
No obvious signs of under-performance?			
MAINTENANCE			
Maintenance plans and indicative maintenance costs provided for each asset?			
Vegetation establishment period completed (2 years?)			
Inspection and maintenance undertaken as per maintenance plan			
Inspection and maintenance forms provided?			
Asset inspected for defects?			
ASSET INFORMATION			
Design Assessment Checklist provided?			
As constructed plans provided?			
Copies of all required permits (both construction and operational) submitted?			
Proprietary information provided (if applicable)?			
Digital files (e.g. drawings, survey, models) provided?			
COMMENTS			

* Asset owner before handover to LMCC.

CONSTRUCTED WETLAND DETAILED DESIGN CHECKLIST

Location:		
Hydrology:	Design operational flow (m^3/s):	Above design flow (m^3/s):
Area:	Catchment Area (ha):	Wetland Area (ha)

Treatment	**Y**	**N**	**NA**
MUSIC modelling preformed?			
INLET ZONE	**Y**	**N**	**NA**
Discharge pipe/structure to inlet zone sufficient for maximum design flow?			
Scour protection provided at inlet for inflow velocities?			
Bypass weir incorporated into inlet zone?			
Bypass weir length sufficient to convey 'above design flow' ?			
Bypass weir crest at macrophyte zone top of extended detention depth?			
Bypass channel has sufficient capacity to convey 'above design flow'?			
Bypass channel has sufficient scour protection for design velocities?			
Inlet zone connection to macrophyte zone overflow pit and connection pipe sized to convey the design operation flow?			
Inlet zone connection to macrophyte zone allows energy dissipation?			
Structure from inlet zone to macrophyte zone enables isolation of the macrophyte zone for maintenance?			
Inlet zone permanent pool level above macrophyte permanent pool level?			
Maintenance access allowed for into base of inlet zone?			
Public safety design considerations included in inlet zone design?			
Where required, gross pollutant protection measures provided on inlet structures (both inflows and to macrophyte zone)			
MACROPHYTE ZONE	**Y**	**N**	**NA**
Extended detention depth >0.25m and <0.5m?			
Vegetation bands perpendicular to flow path?			
Appropriate range of macrophyte vegetation (ephemeral, shallow, marsh, deep marsh)?			
Sequencing of vegetation bands provides continuous gradient to open water zones?			
Vegetation appropriate to selected band?			
Aspect ratio provides hydraulic efficiency =>0.5?			
Velocities from inlet zone <0.05 m/s or scouring protection provided?			
Public safety design considerations included in macrophyte zone (i.e. batter slopes less than 5(H):1(V)?			
Maintenance access provided into areas of the macrophyte zone (especially open water zones)?			
Safety audit of publicly accessible areas undertaken?			
Freeboard provided above extended detention depth to define embankments?			
OUTLET STRUCTURES	**Y**	**N**	**NA**
Riser outlet provided in macrophyte zone?			
Notional detention time of 48-72 hours?			
Orifice configuration allows for a linear storage-discharge relationship for full range of the extended detention depth?			
Maintenance drain provided?			
Discharge pipe has sufficient capacity to convey maximum of either the maintenance drain flows or riser pipe flows with scour protection?			
Protection against clogging of orifice provided on outlet structure?			

COMMENTS

CONSTRUCTED WETLAND CONSTRUCTION INSPECTION CHECKLIST

Location:		**Inspected By (Name and Company):**	
Constructed By:		**Date / Time:**	
Contact during visit	Eg. Council, resident, etc	**Weather:**	

Items Inspected	Checked Y	Checked N	Satisfactory Y	Satisfactory N	Items Inspected	Checked Y	Checked N	Satisfactory Y	Satisfactory N
DURING CONSTRUCTION									
A. FUNCTIONAL INSTALLATION									
Preliminary Works					Structural components cont.				
1. Erosion & Sediment Control plan implemented and adopted					22. Check spillway is level				
2 Limit public access					23. Provision of maintenance drain(s)				
3. Location same as plans					24. Collar installed on pipes				
4. Site protection from existing flows					25. Low flow channel is adequate				
5. All required permits in place					26. Protection of riser from debris				
EARTHWORKS					27. Bypass channel stabilised				
6. Integrity of banks					28. Erosion protection at macrophyte outlet.				
7. Batter slopes as plans					VEGETATION				
8. Impermeable base installed					29. Vegetation appropriate to zone (depth)				
9. Maintenance access to whole wetland					30. Weed removal prior to planting				
10. Compaction process as designed					31. Provision for water level control				
11. Placement of adequate topsoil for optimal plant growth					32. Vegetation layout and densities as designed				
12. Levels as designed checked using laser level.					33. Provision for bird protection				
13. Check for groundwater intrusion					34. By-pass channel vegetated				
14. Stabilisation of bare ground									
STRUCTURAL COMPONENTS					B. EROSION AND SEDIMENT CONTROL				
15. Location and levels of outlets as designed					35. Disconnect inlet zone from macrophyte zone (via high floe bypass)				
16. Safety protection provided (eg. Fencing, barriers)					36. Inlet zone to be used as sediment basin during construction				
17. Pipe joints and connections as designed					37. Stabilisation immediately following earthworks and planting of terrestrial landscape as designed				
18. Concrete and reinforcement as designed					37. Erosion controls and traffic controls in place				
19. Inlets appropriately installed					C. OPERATIONAL ESTABLISHMENT				
20. Inlet energy dissipation installed					39. Inlet zone cleared of sediment				
21. No seepage through banks					40. Inlet zone disconnection removed				
FINAL CONSTRUCTION INSPECTION									
1. Confirm levels of inlets and outlets using laser levels					8. Public safety adequate				
2. Confirm structural element sizes					9. Check for uneven settling of banks and repair if required				
3. Check batter slopes (slope/stability)					10. Evidence of stagnant water, short circuiting or vegetation scouring				
4. Vegetation planting as designed (density, species, survival)					11. Evidence of litter or excessive debris				
5. Erosion protection measures working					12. Drainage area for removed sediment provided				
6. Pre-treatment installed and operational (eg, GPT)					13. Evidence of debris in high floe bypass				

7. Maintenance access provided to inlets & outlets & each wetland zone					14. Macrophyte outlet free of debris				

COMMENTS ON INSPECTION
Actions Required
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CONSTRUCTED WETLAND MAINTENANCE CHECKLIST

Location			
Inspection frequency	1 to 6 monthly	Date of visit	
Location			
Description			
Site visit by			

INSPECTION ITEMS	Y	N	ACTION REQUIRED (DETAILS)
Sediment accumulation at inflow points?			
Resetting of system required?			
Sediment within inlet zone requires removal (record depth, remove if >50%)?			
Overflow structure integrity satisfactory?			
Evidence of dumping (building waste, oils etc)?			
Terrestrial vegetation condition satisfactory (density, weeds etc)?			
Aquatic vegetation condition satisfactory (density, weeds etc)?			
Replanting required?			
Settling or erosion of bunds/batters present?			
Litter within inlet or macrophyte zones?			
Evidence of isolated shallow ponding?			
Damage/vandalism to structures present?			
Outlet structure free of debris?			
Maintenance drain operational (check)?			

COMMENTS

CONSTRUCTED WETLAND PRE-HANDOVER INSPECTION CHECKLIST

Location	
Asset Description	
Constructed By	
'On-maintenance Period'	
Site visit by	

TREATMENT	Y	N	ASSET OWNER SIGN OFF*
System appears to be working as designed visually?			
No obvious signs of under-performance?			
MAINTENANCE			
Maintenance plans and indicative maintenance costs provided for each asset?			
Vegetation establishment period completed (2 years?)			
Inspection and maintenance undertaken as per maintenance plan			
Inspection and maintenance forms provided?			
Asset inspected for defects?			
ASSET INFORMATION			
Design Assessment Checklist provided?			
As constructed plans provided?			
Copies of all required permits (both construction and operational) submitted?			
Proprietary information provided (if applicable)?			
Digital files (e.g. drawings, survey, models) provided?			
COMMENTS			

* Asset owner before handover to LMCC.