GLOUCESTER
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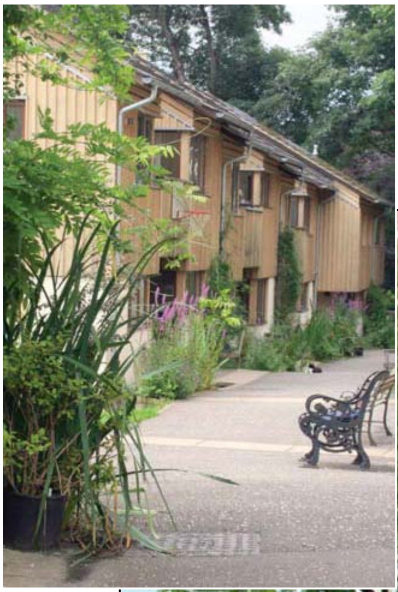
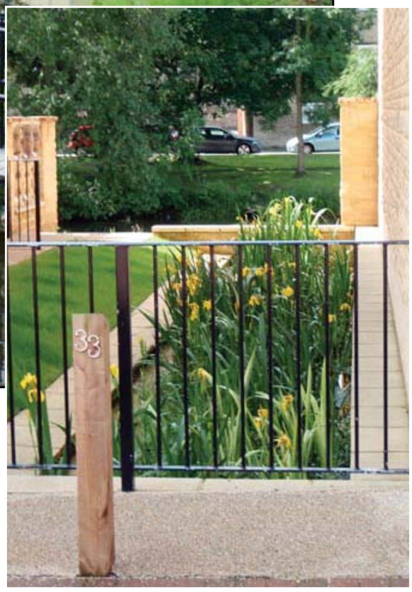


SUSTAINABLE DRAINAGE



A DESIGN AND ADOPTION GUIDE

Issue 2 – July 2013

Issue History

Issue	Change	Release Date
1	Document release	February 2013
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PREFACE

Sustainable Drainage Systems, or SUDS, is a n approach to managing rainfall that aims to control flooding, prevent pollution, and provide an attractive environment for people and wildlife.

SUDS are now the preferred way of draining development by the Environment Agency and are a key component in development to meet objectives defined in the National Planning Policy Framework (NPPF).

All development decisions must comply with local planning policy and take account of National Planning Guidance.

The SUDS approach has now been implemented on many development sites and the techniques and management of SUDS are well understood.

This more sustainable way of dealing with rainfall should now be used on all development sites which will include individual buildings and other small developments as cumulatively they will have an impact.

The primary guidance for the design and implementation of SUDS is set out in The SUDS Manual CIRIA 697 2007 and this guide generally accords with this national guidance.

There will be new guidance and legislation in the future that will reinforce the requirements set out in this guidance.

Gloucester City Council expects SUDS design to meet all the technical requirements set out in the SUDS Manual and to demonstrate amenity and biodiversity opportunities discussed in the Manual together with standards developed in this guide.

This Design and Adoption Guide sets out the requirements and design process for SUDS using examples that show how SUDS features can enhance the landscape.

This Design and Adoption Guide also develops an adoption process for SUDS features by Gloucester City Council where they meet the adoption criteria agreed by the Council.

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1.0 INTRODUCING THE GUIDE

'Water is a complex spirit. It gets everywhere – even into the soul. It takes on meanings, many of which we are only half aware of, and often causes our understanding to flow into unfamiliar areas or seep into those deep wells of stagnating thought and practice we are loath to abandon. Often we are drowned in a veritable flood of unbelief. But the water spirit renews our thirst for change, for change we must.' Professor Geoff Steeley in the Foreword to the first SUDS design manual for England and Wales 2000.

This guide provides a straightforward explanation of the need for Sustainable Drainage or SUDS, together with the principles and practice used to design the systems. It considers the detailed design and management requirements of SUDS and develops an adoption process required by Gloucester City Council to take responsibility for SUDS in open space.

The idea of Sustainable Drainage Systems evolved in the late 1990s as a response to the increasing awareness of failures in conventional drainage and new requirements for pollution control and environmental enhancement. Traditional gully and pipe drainage system cannot deliver the requirements that meet the new challenges of climate change and new legislation.

The publication of 'Sustainable urban drainage systems - a design manual for England and Wales' in 2000, and the SUDS Manual C697 by CIRIA (the Construction Industry Research and Information Association) in 2007 has given advice and support on the planning and design of these new techniques for managing rainfall on development.
(see www.CIRIA.org.uk/SUDS).

However the delivery of attractive SUDS, with benefits for the community and opportunities for wildlife, has not proved easy to achieve and this guide sets out further conditions and standards to deliver these planning aspirations.

The guidance considers the Design and Adoption of SUDS as follows:

- **The Principles of Sustainable Drainage** describes the main ideas and concepts that must be understood to deliver high quality SUDS.
- **The Design of SUDS** explains how natural drainage informs SUDS design and provides a Design Process that integrates SUDS concepts and SUDS Design Standards into the development sequence set out in The SUDS Manual.
- **SUDS Components** are the features used to control runoff as it flows through development towards an outfall and are described in detail to clarify requirements for attractive and easily maintained SUDS.
- **Landscape Design** complements the appearance and management aspects of SUDS and must be integrated at every planning stage highlighting the multidisciplinary character of SUDS design.
- **The Maintenance of SUDS** is described including waste management and practical measures to ensure SUDS are cared for now and in the future.
- **The Adoption Process** offered by Gloucester City Council is set out in the context of the Design, Construction and Maintenance standards that need to be satisfied before responsibility for sites will be considered and adoption agreed by The Council.

2.0 PRINCIPLES OF SUSTAINABLE DRAINAGE

2.1 The need for change

At present, rain from roofs, roads, car parks and other hard surfaces is collected in gullies, channels and pipes before flowing quickly to streams and rivers or through pipes to the sewer network.

Runoff washes pollutants from hard surfaces directly into gullies and pipes without treatment before discharge to watercourses or treatment works.

This results in:

• Local flooding when pipes cannot deal with rainfall.

• Surcharge of the storm sewer or combined sewer during heavy rain.

• Damage to watercourses by erosion or deposition of silt on the stream bed.

• Reduced volumes of water soaking into the ground to recharge aquifers.

• Drying of watercourses during summer as water is removed from the landscape in pipes.

• Intermittent flashy flows in watercourses when it rains.

• Pollution of streams, rivers and wetlands.

• Loss of public connection with water in the landscape.

• Loss of wetland, stream and river wildlife habitat.

Sustainable Drainage Systems or SUDS are a new approach to managing rainfall that mimic what happens in nature, and prevent many of the problems currently caused by runoff from development.

2.2 The SUDS philosophy

SUDS aim to prevent the problems caused when polluted runoff flows from development using new concepts and techniques that collect, clean and store water before releasing it slowly to the natural environment.

The SUDS philosophy is expressed in the Sustainable Drainage Triangle:

• SUDS reduce the risk of flooding by controlling flows, volumes and the frequency of runoff from development.

• SUDS protect the environment by preventing or treating pollution.

• SUDS also provide visual, play and community benefits for people along with opportunities for creating habitat for wildlife.

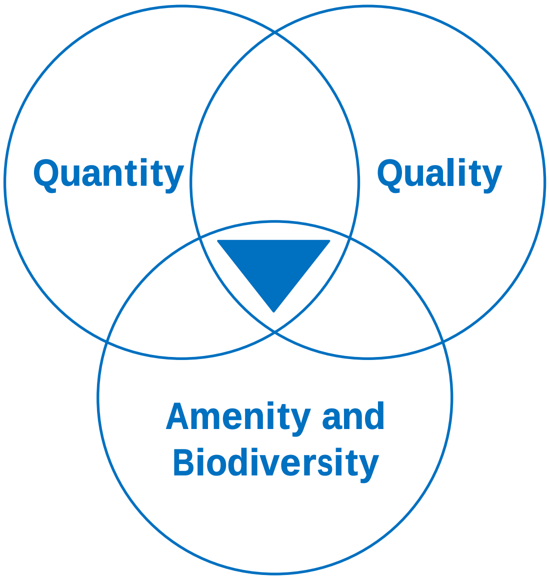


Fig 1 -The SUDS Triangle

2.3 SUDS concepts

SUDS use a number of new concepts to manage runoff from a development:

- **SUDS mimic natural drainage** – achieved by collecting rainfall in features at or near the surface to slow water and filter it as occurs in nature.
- **The Management Train** – a sequence of SUDS techniques that work together in series to control the flow, volume and frequency of runoff as well as preventing or treating pollution as water flows through the development.
- **Source Control** – rainfall is managed as close as possible to the place where it first falls as rain.
- **Sub-catchments** – development is split into a series of small drainage areas that deal with runoff locally rather than at the end of a pipe system.
- **Storage Hierarchy** – volumes of water are managed in different ways depending on the pollution of runoff and are located in different places depending on the amount of rainfall that falls on the development.

Fig 2 - Hopwood Park MSA HGV park - first 3 treatment stages - filter strip, filter drain and basin with mitred concrete headwall inlet

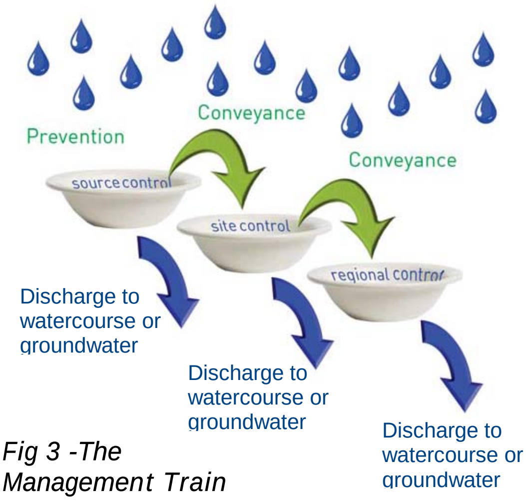


Fig 3 -The Management Train

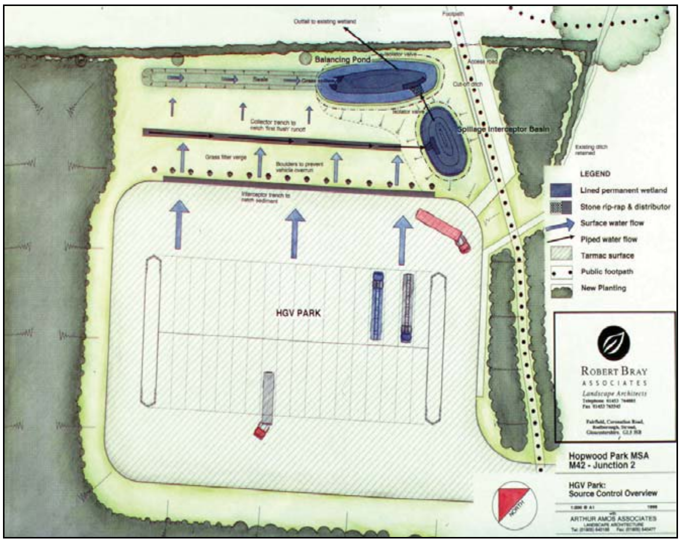


Fig 4 - Hopwood Park MSA HGV park - filter strip, filter drain (treatment trench), basin and wetland - 4 stage treatment train

2.4 SUDS Components

SUDS use landscape features to deal with runoff as it flows through the management train sequence:

- **Filter strips and swales** use vegetation to filter and control flows as runoff travels through grass or other planting.
- **Pervious surfaces**, such as filter drains (French drains) and permeable pavement allow water to percolate through the construction surface, storing and cleaning water below the surface in open crushed stone, before a controlled release to the next part of the system.
- **Green roofs and bio-retention areas**, including rain-gardens, combine vegetated surfaces together with permeable drainage layers to collect and clean rainfall before onward flow to other SUDS features.
- **Infiltration structures** store water for a short time allowing it to soak into the ground and include soakaways, infiltration trenches and basins.
- **Basins, ponds and wetlands** collect, clean and store water in depressions in the ground and provide amenity and wildlife benefits for the community.
- **Engineered storage structures** located below ground store volumes of water but do not clean runoff and require careful design and maintenance.
- **Inlets, outlets and flow control structures** manage the flow of water as it passes through the SUDS system.

Fig 5 - Filter strip and swale

Fig 6 - Permeable pavement

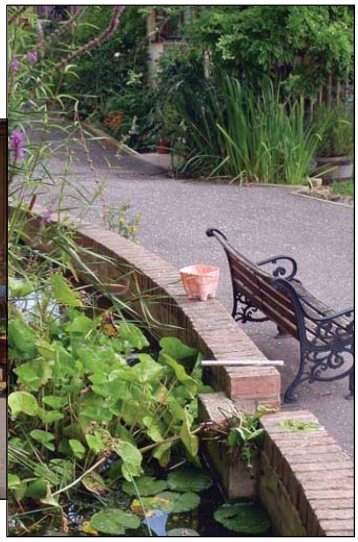


Fig 7 - Urban pool with overflow

Fig 8 - Small green roof

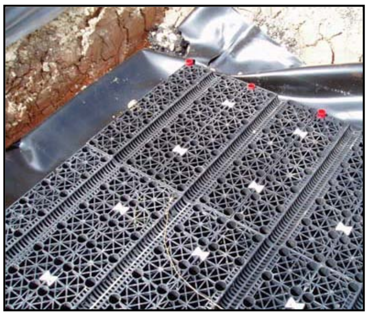


Fig 9 - Geocellular storage boxes

Fig 10 - Feature inlet

2.5 The Storage Hierarchy

SUDS deal with volumes of water in a different way to conventional piped drainage.

SUDS design divides developments into subcatchments that collect, clean and store either the whole volume of rain, as in permeable pavement, or part of the storm with additional storage elsewhere.

Therefore the storage strategy for SUDS schemes creates a cascade of small volumes of clean water rather than a single large volume of polluted runoff at the end of a pipe.

The SUDS design must clearly show how runoff is collected and cleaned before it enters the hierarchy of storage for the development and then how it flows to the outfall for the site. The storage hierarchy includes:

- **Interception storage** – the use of SUDS techniques to reduce frequency of runoff by intercepting about the first 5mm of rainfall as in natural landscapes.

- **Attenuation storage** – storage which is designed to release water at the rate before the land was developed known as greenfield rate of runoff.

- **Long term storage** – storage of exceptionally high amounts of rainfall for slow infiltration into the ground or release at 2L/sec/hectare, where possible, to protect the developed floodplain downstream.

2.6 Flow routes

A clear hierarchy of low flow routes, overflows and exceedance pathways must be demonstrated in SUDS design to show how every day flows pass through the site with predictable routes if blockage or design exceedance occurs.

- **Low flow routes** – day to day flows are conveyed by a variety of low flow channels through open space between SUDS features and onward to the outfall from the development.

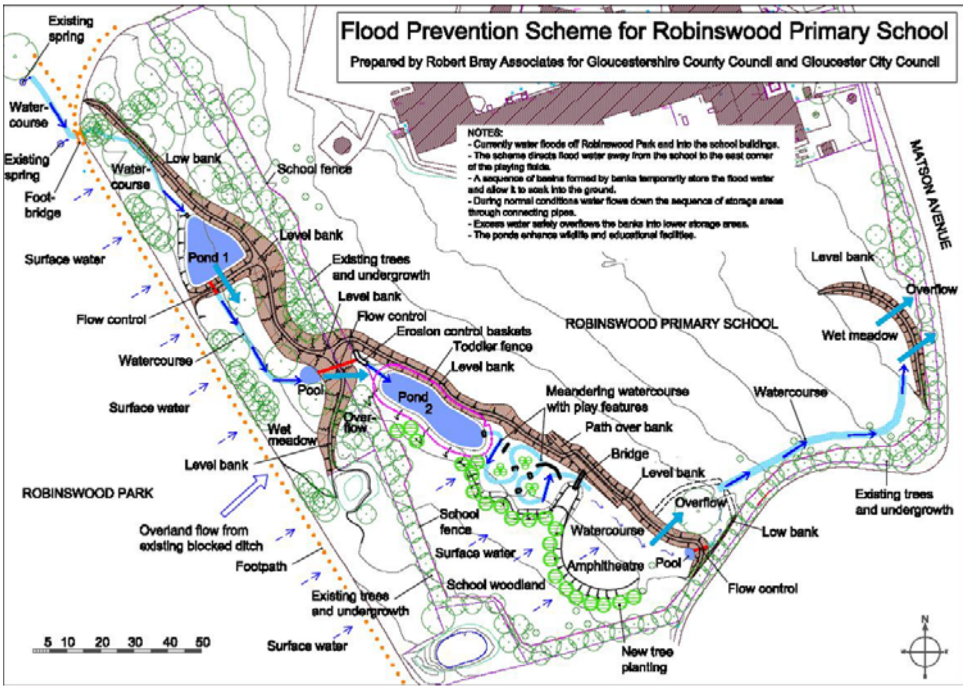


Fig 11 - SUDS techniques use a public park to protect Robinswood Primary School

• **Overflows** – overflow routes between SUDS structures are important in the event of blockage or local surcharge so that runoff can flow to the next part of the management train or the exceedance route without risk to people or property.

• **Exceedance** – when rainfall overwhelms the SUDS system then overland exceedance routes show where water will flow from development with minimum risk to people or property.

2.7 Destination of runoff

Once runoff has passed through the SUDS management train and is judged to be a controlled flow of clean water, then it should enter the natural drainage pattern in the following sequence depending on ground conditions and a suitable discharge route:

• **Soak into the ground** where ground conditions are suitable.

• **Flow to a watercourse** where water cannot soak into the ground.

• **Discharge to the sewer** system where no other option is feasible.

This hierarchy is confirmed in the Building Regulations 2000 part H.

The future planning of SUDS, including Surface Water Management Plans (SWMPs) and the requirements of adoption, will increasingly integrate SUDS with infrastructure planning so that controlled flows of clean water can leave development and contribute to public amenity before becoming part of the natural drainage system.

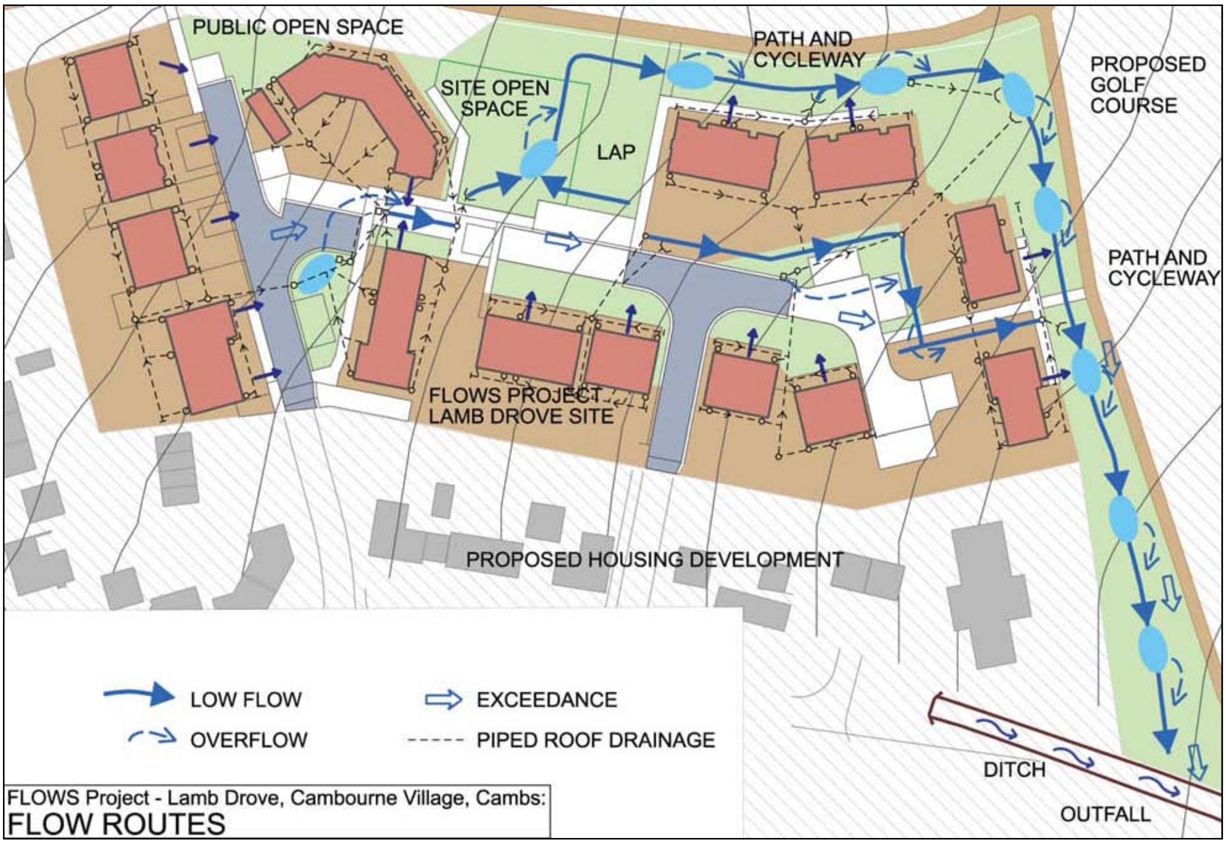


Fig 12 - The Flows Project Cambourne – FLOW ROUTE

3.0 THE DESIGN OF SUDS

3.1 A SUDS Design Approach

SUDS mimic natural drainage

Natural drainage allows rainfall to soak into the ground if the geology is suitable or creates water flows on or near the surface to a network of streams and wetlands if the ground is impermeable. Natural losses occur in vegetation, soils or back into the atmosphere as water passes through the landscape.

Where natural drainage has been disrupted or destroyed, as found in many urban areas, runoff will be discharged to the surface water sewer where one is present or enter the combined sewer resulting in rapid flow to the end of the pipe drainage system. SUDS in these situations aim to reduce the rate of flow into the sewer to protect existing drainage infrastructure as well as the normal environmental benefits expected for development.

It is important to understand the original drainage pattern for a development is largely determined by topography and geology.

Historical drainage measures, including land drainage, culverts and the sewer network have modified the original flow routes and need to be considered in SUDS design.

The SUDS design will indicate the destination of runoff after collection, cleaning and storage within the management train to infiltration, a watercourse where present or the sewer system as a last resort.

Flow routes through development

SUDS design begins with an assessment of the natural drainage pattern for the site and

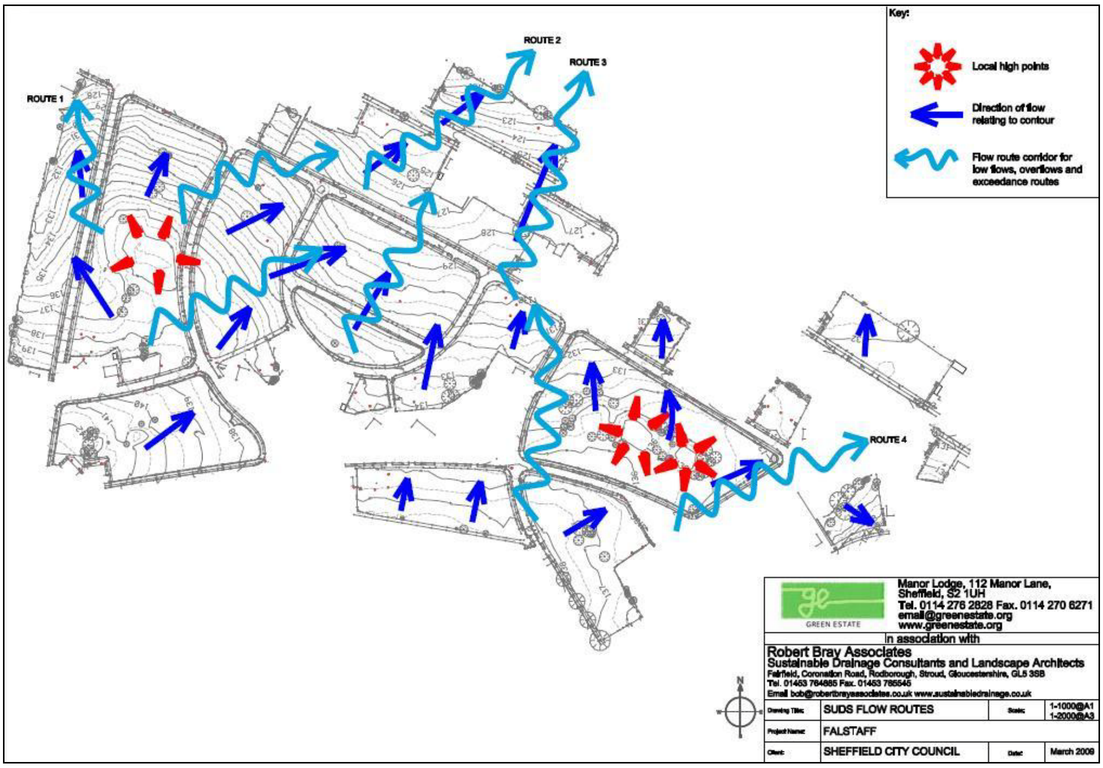


Fig 13 - SUDS Flow Route analysis - Falstaff Project, Sheffield

Section 3

how this will be modified by the development. Even where rainfall normally soaks into the ground, development will create impermeable surfaces that cause water to flow at the surface.

A flow route analysis identifies how original flow routes are modified by proposed development and creates a framework for appropriate SUDS techniques to be located to along a management train before discharge to an outfall.

Flow routes provide corridors for day to day low flows, overflows that can operate when surcharge or blockages occur and exceedance pathways when exceptional rainfall overwhelms the SUDS.

The SUDS design will demonstrate low flow, overflow and exceedance routes through the development.

Fig 14 - Rill link to feature pool – Springhill Housing, Stroud.

The Management Train

The management train concept is critical to SUDS design and comprises a sequence of best practice and SUDS techniques that improve the flow, volume and frequency characteristics of runoff and prevent or treat pollution as water moves through the SUDS system.

The sequence begins with prevention measures to reduce the impact of runoff from development and source control techniques to manage flows and pollution as close as possible to where rain falls on hard surfaces.

Source control techniques are particularly important in SUDS design as they intercept silt where it is washed from hard surfaces and provide the first level of treatment in the management train. This initial treatment often provides adequately clean water for amenity and biodiversity within the development, particularly in housing or school SUDS schemes.

Runoff usually flows to site control features within or just outside development where it is stored and undergoes polishing treatment in an amenity SUDS feature.

Sometimes runoff passes onward to a regional control in public open space, if additional storage is required, but it may discharge directly to natural drainage or the sewer network subject to meeting design requirements for quantity and pollution control.

The management train is the mechanism for meeting the requirements of the SUDS triangle: quantity and quality with amenity and biodiversity benefits.

The SUDS design will demonstrate the management train, including source control techniques, to meet the requirements of the SUDS triangle.

3.2 The Design Process and the Planning System

The new Flood and water bill will inevitably have an impact on the information required from a developer when submitting a scheme for planning approval. Even so the discussions and process should not be too different to how described below. If Gloucester becomes the SUDS approval and adoption body then hopefully matters will be more straightforward and follow the process detailed below.

The most important consideration is early discussion with the local planning authority and any other relevant stakeholder. As plans evolve the various parties will need to be kept informed and their comments where appropriate taken on board. SUDS must be considered at the outset it cannot be retro-planned in at a later date

A Pre-app consultation may well be the first opportunity to invite key players around a table for a discussion. Organizations that will want an opportunity to be involved will be Severn Trent, The Environment Agency, Highway Authority, those who will adopt any SUDS features and the Local Planning Authority. In Gloucester the latter 2 should be the City Council. When the SUDS approval body is set up, if this is not the City Council, then they will be an integral part of the process and will need to be involved in early discussions. On sites with other interests such as habitat value or archaeological remains then the applicant should ensure that the relevant organizations are represented as these sorts of constraints may well impact upon the final design.

The applicant should not turn up with a blank sheet of paper but should have mapped existing drainage patterns, topography key constraints and other matters of relevance. An outline drainage strategy should be tabled for discussion – this should be sent prior to the meeting to allow various parties to discuss the proposals.

Detailed calculations will not be required but an understanding of how surface water will be managed across the site should be clear.

The pre-app discussion should clarify the detailed design standards that will apply to the site (see next section for more detail) and any other issues that may arise such as treatment of constraints. The applicant should then be in a position to commission more detailed design work.

The later sections of this guide give details of what Gloucester City will require in terms of SUDS features as a planning authority and as a body that is likely to adopt any SUDS features. Further contact with planning authority and other players in the process is essential as the design evolves.

Outline Applications

For sites that are subject to an Outline Planning Application, a drainage master plan will need to be submitted. At this stage the broad design standards should have been agreed, calculations showing how the quantity of water will be dealt with should be submitted. Topography, existing drainage pattern and relevant constraints should have also been taken into consideration. Even at this stage a statement on adoption will be required that detail the discussions undertaken with the body responsible for adoption and Severn Trent.

Detailed Applications and reserved matters

The detailed application submission will require a significant amount of information. The guidance later on in this booklet should assist in what will be acceptable to the planning authority and if the Council is adopting the features our Neighbourhood Management Team. The amount of information submitted will depend upon the size of the site the development and its location. As a guide the following will be expected (modified from CIRIA guidance C697)

- A method statement detailing how surface water arising during construction will be dealt with.
- An examination of the current (and where appropriate) historical drainage patterns on the site and if necessary adjacent.
- A drainage plan identifying the types of SUDS to be incorporated and detailing, final discharge points and how the issues of Quantity, Quality and Amenity have been followed in accordance with the management train.
- Details of how the drainage system will be incorporated into the landscape along with information on final land use for example public open space, wildlife habitat etc.
- Soil and Geology types should be indentified and how they have influenced the design as submitted.
- Evidence of soil porosity/ permeability tests. Where infiltration is to be relied on this will be a requirement.
- Calculations showing pre and post development peak run off for the agreed critical rainfall events.
- Attenuation designed for small frequent first flush rainfall events and detail of the stages of treatment proposed.
- Calculations showing the drain down time of the various systems following an extreme event.
- Provision of drainage for larger storm events (greater than 1 in 100) including Indication of overland flow routes that show how individual properties will be protected. A viable final discharge regime will be required.
- A statement outlining broad management regimes for the various SUDS features and how they comply with the adoption standards in this guidance.
- If third party land is required for surface water treatment then a statement will be required detailing what legal arrangements will be entered into to ensure the system can be implemented and cannot be compromised in the future by any third party interests.
- If a sewer is to be used or any drain is to be adopted by Severn Trent then a letter of compliance from Severn Trent will be expected.
- On contaminated sites or where ground water pollution may be an issue the developer will need to show that the development poses no risk to ground water or will allow mobilization of existing contaminants.
- A Landscape/Habitat plan detailing proposed habitat types, habitat management plans, along with planting and sowing regimes.

- A draft management plan detailing mowing regimes, de-silting requirements and other maintenance requirements that are broadly consistent with guidance with this document and acceptable to our Neighbourhood Management team.

This list is not exhaustive and further documentation may be requested. It is likely that the SUDS approva body when set up will require a similar level of detail. If the SUDS approval body is not the City Council then 2 separate but similar submissions may well be required.

Even for small sites of a single dwelling or buildings some sort of statement detailing how drainage has been addressed following the principles of this guide will need to be submitted as part of the application.

Post development

On completion of the site if the authority is to adopt the SUDS features a number of documents will need to be submitted to our Neighbourhood Management team to ensure the features are up to the required standard to be taken on by the authority.

- As built survey/drawings. This will include any variance from previously submitted plans. Significant variation may require further information to ensure that the design standards have not been compromised.
- Details of engineering structures (head walls etc) these need to be signed off by a qualified engineer at the applicant's expense. CAD or other drawings may be requested to be transferred to the authorities GIS system.
- Details of maintenance regimes, habitat management plans and other information to be taken into consideration in the negotiation of commuted sums.

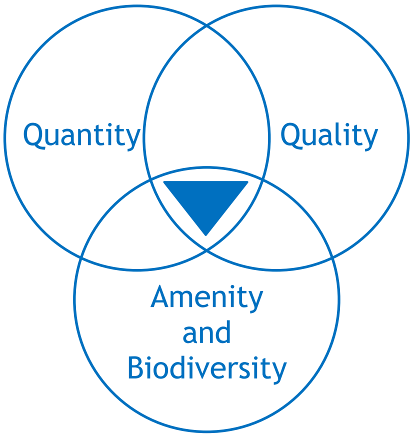
Negotiations with regard to adoption are covered later on in this guidance. In principle the City Council will adopt features as long as they are broadly in compliance with the guidance in this document. Other features not listed will be considered and a fee agreed on an individual basis.

Figure 15 Cattle grazing the Alney Island water meadows

3.3 Design Standards

Design Standards are the set of conditions set by the Planning Authority and Environment Agency, agreed with the Developer, that the proposed SUDS should satisfy.

They are considered under the elements of the SUDS drainage triangle - quantity and quality with amenity and biodiversity.



Quantity – managing the flow

Key principles for Quantity are to

- Protect people and property on the site from flooding.
- Protect areas up and downstream in the catchment from the impact of the development on flood risk.

Three key criteria should be met to protect the public from flooding, both on site and in downstream areas. These are:

- Protect against flooding from local watercourses.
- Protect against flooding from the drainage system within the development.
- Protect from overland flows coming from within or outside the site.

The rate and frequency of flow and the volumes of water leaving the development should be the same as those for an equivalent green-field site.

Controlling the rate and volume of runoff will depend on:

- The storm probability or the chance of a storm of given magnitude happening in any year – known as the storm return period.
- The storm duration or period of time during which it rains.
- The storm intensity or depth of rainfall over a period of time.

Gloucester City Council will require the developed rate of runoff to be no greater than the greenfield runoff rate for a range of annual flow rate probabilities, up to and including the 6 hour 1 per cent annual probability event (1 in 100 year return period) with a 30% allowance for climate change.

Gloucestershire County Council have published the Level 2 Strategic Flood Risk Assessment (SFRA2) which indicates soil conditions to be used in Gloucester for the calculation of Greenfield Runoff. Methods for establishing the Greenfield runoff rate are described in The Suds Manual (CIRIA C697).

Quality – controlling pollution

The key principle for Quality is to demonstrate the management train.

- **Good site management** to reduce pollution and manage spillages.
- **Source control** techniques used as close as possible to where rain falls on development to control flow and volumes, intercept silt and prevent pollution.
- **Site control** features used within or just outside the development to store and polish water volumes.

regional control where appropriate to manage volumes beyond the development boundary.

The use of **source control** techniques at the beginning of the 'management train' is critical in controlling runoff and must be used on all SUDS schemes considered for adoption by Gloucester City Council.

A **treatment stage** is a SUDS feature that cleans runoff as it flows through the management train. The number of treatment stages required is determined by the risk of pollution on a development, or part of a development, and should be determined using the following guidance from The SUDS Manual (CIRIA C697) together with judgment of site conditions.

At least one treatment stage must be provided for runoff before it is used in open landscape features, ponds or wetlands in order to protect wildlife and public amenity. The **first flush** volume is the runoff generated by a small fall of rain or the first part of a larger storm that carries most pollution from hard surfaces. It comprises the first 10-15mm of polluted water from the site. This should be collected within a SUDS structure and must be cleaned using sufficient treatment stages to manage pollution risk.

SUDS treatment stages required to clean runoff based on pollution risk		
Pollution Risk	**Development Type**	**Treatment Stages**
Low	Roofs, school playgrounds, housing areas	1
Medium	Residential roads, parking areas, commercial sites	2
High	Refuse collection and industrial areas, loading bays, lorry parks, distributor roads and other highways	3 or more

Amenity – visual and social benefits for the community

The key principle for amenity is to provide tangible benefits for the community that are attractive, robust and safe for the public and maintenance staff.

Amenity includes both use and visual quality to provide a multifunctional and pleasing landscape.

Amenity benefits include:

- Multi-functional space such as sport, education, recreational and wildlife areas.
- Visually attractive SUDS features.
- Well designed SUDS details including rills, channels, canals spouts, cascades and pools.
- Visually acceptable and safe inlets, outlets and control structures.
- Access available for all potential users. Guidance is set out in the '*Countryside Access Design Guide'* published by SNH.
- SUDS integrated into the landscape.

Although it is more difficult to evaluate amenity aspects of SUDS design, Gloucester City Council requires that amenity is incorporated and demonstrated in every SUDS scheme. (See Appendix)

Runoff must meet Quantity and Quality criteria before water enters a surface *SUDS feature to ensure a controlled flow of clean water for amenity and wildlife benefit.* Water should be at or near the surface and controlled at source before it provides amenity in the landscape.

Fig 16 - Wetland habitat in the city - Malmo, Sweden.

Adequate treatment stage must be demonstrated before water flows to amenity or wildlife features.

Information boards will be provided wherever required by Gloucester City Council.

Biodiversity – benefits for wildlife.

Key principles for ecological wellbeing are unpolluted water, close proximity to other wetland or freshwater habitat and varied structural design.

Guidance is set out in *'Ponds, pools and lochans - Guidance on good practice in the management and creation of small water bodies in Scotland'*, published by SEPA.

Good water quality is provided by meeting SUDS water quality criteria and structural diversity by following good ecological design practice. SUDS features may not connect directly with other wetlands or ponds but the design of open SUDS features and the landscape space that surrounds them should meet recognised ecological design criteria.

Fig 17 - Water sculpture with urban rill - Malmo, Swede

Summary of SUDS design criteria

Criteria	Design Event	Design Objective
Quantity		
Protection against flooding:		
Protection against flooding from watercourse.	Catchment, 100/200 year event.	Control risks to people and property. Floor levels = Max river level + appropriate freeboard.
Protection against flooding from drainage system.	Site, 10/30 year event. Site, 100/200 year event.	Flooding on site only where planned and approved. Control risks to people and property. Floor levels = Max flood storage levels + freeboard.
Protection against flooding from overland flows.	Site, 100/200 year event, short duration events.	Planned flood routing and temporary storage accommodated on site.
Protection against flooding from adjacent land.	Adjacent catchment, 100/200 year event.	Planned flood routing.
Quality		
Protection of watercourse	Site <1 year	*Interception storage* to prevent runoff from first flush, 5 –10 mm of rainfall. Treatment via SUDS components in series as a treatment train, the number of components depending on the pollution levels and environmental sensitivity.
Amenity and Biodiversity		
Managing public safety:	All	Safe maintenance access (safety bench). Fencing or vegetative barriers to constrain public access where appropriate. Aquatic bench and shallow edges to water bodies. Sign-boarding, where appropriate.
Maximising visual impact and amenity benefit:	All	Maximising aesthetic appeal. Linking systems to recreation opportunities. Appropriate maintenance. Public education programmes.
Maximising ecological value:	All	Native planting and varied habitat types. Close to diverse, natural ecosystems. Aquatic bench. Appropriate maintenance.

4.0 INTEGRATING SUDS INTO DEVELOPMENT

This section broadly summarizes the techniques available to practitioners and how they fit into the management train. It shows how developments are divided into management areas, usually spaces under private ownership, areas within the development close to buildings and then those spaces that occupy the public domain.

4.1 SUDS management areas

SUDS use a number of techniques to manage runoff as it flows through the management train sequence within development.

Firstly a number of techniques may be used within a private property boundary and will contribute to the management of rainfall on development. They include green roofs, soakaways, permeable driveways, domestic rain gardens, water butts and rain harvesting systems. These **Private SUDS** will be the responsibility of the property owner.

Source Control SUDS are usually associated with the street landscape or similar areas within development and include filter strips, swales, filter drains, permeable pavement and small detention basins. Source control techniques should be incorporated at the beginning of the management train to intercept silt and pollution and reduce the flow of runoff.

These source control features can be managed by a number of bodies depending on who takes responsibility for the SUDS and on the adoption process. The County Highways Department may take responsibility for roads and pavements, the County or Local Authority may look after green space and sometimes Management Companies will be needed where development does not meet adoption criteria.

Once runoff has passed through initial source control features it usually flows to a site control such as a detention basin, pond or wetland often located in green space within or just outside the development boundary. Regional controls, which deal with larger volumes of clean water from more than one development, may be present in public open space. These SUDS features comprise **Public Open Space SUDS** and may be considered for adoption by the Local Authority Hill.

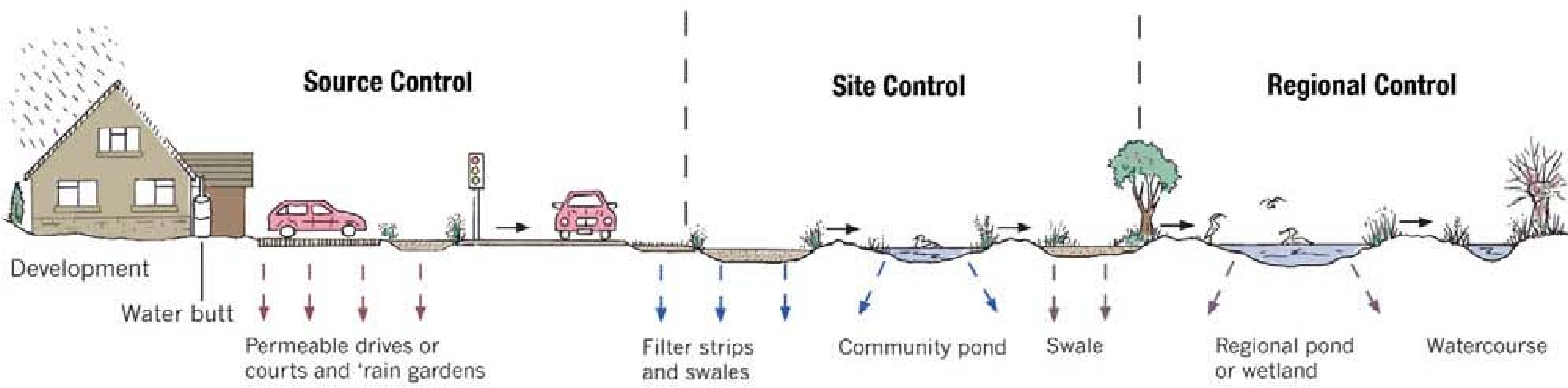


Fig 18 - A possible management train sequence. (Courtesy of Cambridge City Council)

4.2 Private SUDS – techniques used within property boundaries

Gloucester City Council will not adopt SUDS components within a private property boundary so these techniques are described only in principle. They include:

- Green roofs
- Soakaways
- Permeable driveways
- Domestic Rain-gardens
- Water butts
- Rain harvesting

Green roofs

Green roofs have a vegetated surface growing in lightweight soil over a protected drainage layer. They intercept rain, slowing the flow and remove airborne impurities before water drains from the roof. They behave like natural vegetation and reduce flow even when saturated. Up to half of the rain falling on a green roof evaporates back into the air and does not appear as surface runoff.

Fig 19 - A green roof during rain - Malmo, Sweden.

Where a green roof is located on a Local Authority building e.g. a school, sports centre or other Local Authority building then maintenance will be required at least once a year, however Gloucester City Council will not adopt green roofs on private property.

Soakaways

Soakaways are the most common type of infiltration device used in Great Britain and comprise a lined hole in the ground, filled with granular material that allows water to soak into surrounding soil. Soakaways usually collect and store runoff from a single house or building cluster allowing soakage into the ground. However, there is uncertainty over their long term performance, susceptibility to siltation and consequences of exceedance particularly as a result of climate change. Therefore there should always be an overflow from the soakaways.

Fig 20 - A shallow under-drained swale. Pershore, Worcs.

Fig 21 - A rain-garden - Malmo, Sweden.

SUDS infiltration devices such as filter trenches, under-drained swales, permeable pavements and infiltration basins can avoid many of the maintenance issues associated with individual soakaways by preventing siltation and providing simple overflows.

Conventional soakaways infiltrate water directly it is collected and often require treatment of the runoff before water soaks into the ground.

Gloucester City Council will not adopt soakaways.

Permeable driveways

Permeable pavements can be used on individual properties to collect runoff from driveways and as a route for other runoff including water from roof and other hard surfaces. The design of a permeable driveway is based on the same criteria as any other permeable surface.

Gloucester City Council will not adopt permeable driveways

Domestic Rain-gardens

A rain-garden is a depression in the garden that collects and stores water from an adjacent hard surface or roof before allowing it to soak into the ground or flow to the local drain. In this way they reduce the impact of rain and intercept silt and pollutants.

Sometimes a g ravel trench or filter drain is used in the bottom of the rain garden to increase storage and encourage soakage into the ground.

Rain-gardens can be attractive additions to the garden contributing to the landscape and providing source control for domestic runoff.

They are now being recommended as one way of reducing the effect of impermeable paving in gardens.

Gloucester City Council will not adopt domestic rain-gardens.

Water butts

Water butts are containers designed to collect and store roof runoff, usually placed under downpipes to catch roof water. Normal water butts need small modifications to provide SUDS benefits.

Maximum benefit from water butts is provided during dry periods followed by high intensity storms when a proportion of the butts will be partially or fully empty.

Volumes stored in water butts cannot be used in SUDS calculations as they do not drain down in 24 – 48 hours ready for the next storm.

While Gloucester City Council will encourage all new domestic dwellings with gardens to be fitted with water butts we will not adopt them.

Rain harvesting

Rainwater from roofs and hard surfaces can be stored for use in toilets or other functions where potable (drinking quality) water is not required. Water is collected, filtered and

Fig 22- A water butt with bypass to surface channel and rill - Springhill Housing, Stroud.

stored in various storage arrangements and delivered on demand, but with a mains override connection for when all stored rainwater has been used. Once the rain harvesting storage is full it can overflow into the SUDS system.

Volumes stored in rain harvesting systems cannot be used in SUDS calculations as they do not drain down in 24 – 48 hours ready for the next storm

Gloucester City Council will not adopt rain harvesting systems.

Fig 23 - Geocellular box rainharvesting - Red Hill Primary School, Worcs.

4.3 Source control SUDS features located outside property boundaries but generally within development before public open space

SUDS features likely to be used in this intermediate area between private property boundaries and public open space include:

- Filter strips
- Swales including under-drained swales
- Detention basins
- Bioretention areas and raingardens
- Filter drains (French drains) or treatment trenches
- Permeable pavements
- Geocellular boxes, oversized pipes and tanks (underground storage)

Gloucester City Council will not usually adopt source control features located within development unless they are surface techniques such as filter strips, swales or detention basins that integrate with other open space features.

At present the responsibility for maintenance of source control features at the beginning of the SUDS management train is often unclear. However, this part of the system is critical to ensure controlled flows of clean water to the open space SUDS features that may be adopted by Gloucester City Council.

The developer must demonstrate that a maintenance arrangement for the source control or street SUDS area has been put in place and that this arrangement is secure for the future of the development.

These features are described in Section 5.0 SUDS components.

4.4 Public Open Space SUDS

The SUDS features most commonly adopted by Gloucester City Council will be:

- Conveyance swales
- Infiltration basins
- Detention basins
- Ponds
- Wetlands

Some surface SUDS features within development, such as filter strips, collector swales including under-drained swales and detention basins may be considered for adoption by Gloucester City Council, but this will depend on site design and where they are located in the development.

4.5 The SUDS adoption break point

There should always be a convenient and clearly visible break point in the SUDS sequence where Gloucester City Council will take responsibility for maintenance. The break point must be agreed early in the design process and confirmed at Outline Drainage Proposals stage. This break point can be:

- where water leaves a storage feature eg. a pipe inlet from permeable pavement.
- where low flow channels from development enter public open space.
- where green SUDS features, like filter strips, adjoin hard surfaces.

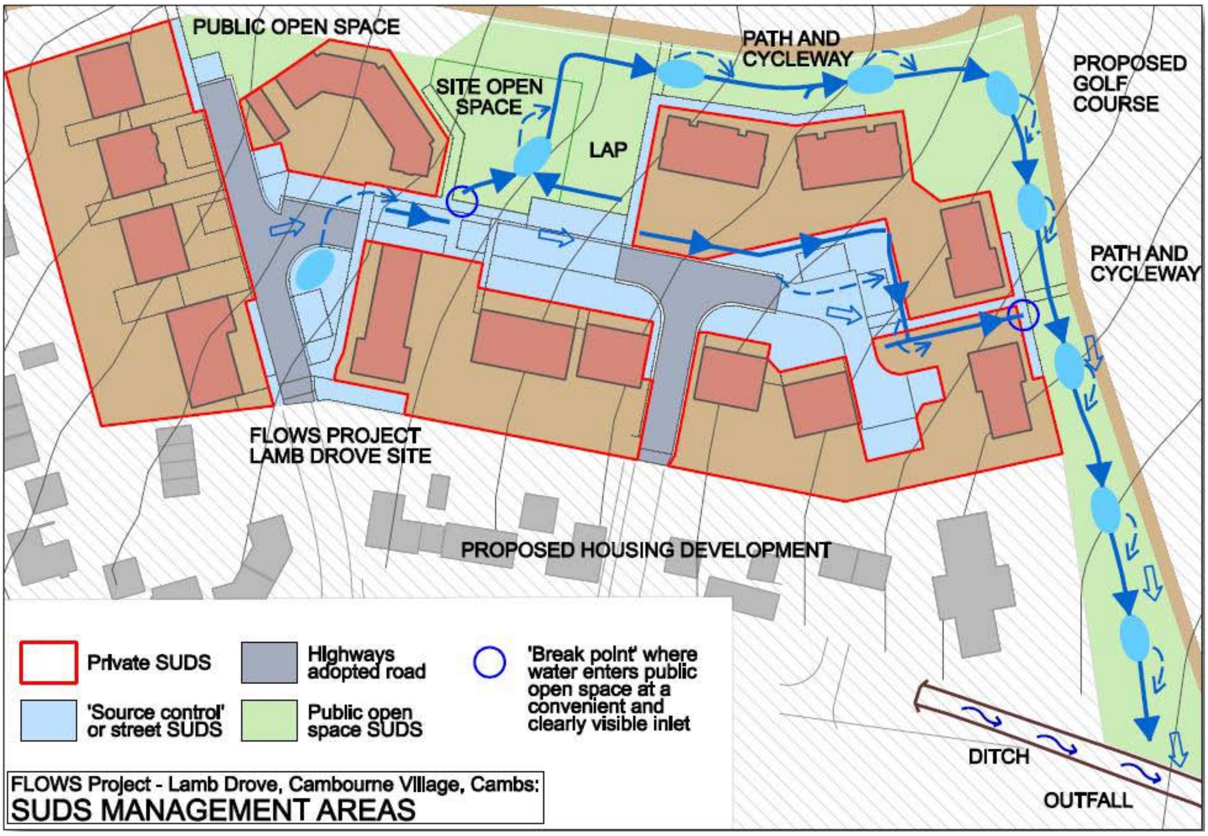


Fig 24 - The Flows Project Cambourne - SUDS management areas.

This section deals in detail with the various SUDS components that may feature in any SUDS design, large or small. It lists the critical design features for each component as well as maintenance requirements to ensure effective operation of the SUDS feature. Diagrams are used for ease of understanding.

A full range of SUDS are considered for completeness but only those likely to be adopted by Gloucester City Council are described in detail.

5.1 Filter Strips

Filter strips are grass or densely vegetated strips of land that collect runoff as sheet flow from impermeable surfaces. Runoff flows as a sheet across the filter strip which slows the flow of water, intercepts silt and pollution allowing some water to soak into the ground. Remaining flow passes onward to the next stage in the SUDS management train. They can be used to protect filter drains and other infiltration structures further down the management train and usually look like a flush grass verge at the edge of hard surfaces.

Critical design features

• Runoff must flow across a flush kerb edge onto a grass or a vegetated surface.

• The hard edge must be generally level along its length ensuring an even flow of water onto the filter strip to prevent erosion and gullying.

• The filter strip should be 20 – 25mm below the edge of the kerb giving an unobstructed flow onto the vegetated surface to avoid ponding on the adjacent hard area.

• The slope of the filter strip should be greater than the hard surface to ensure adequate flow eg. 1 in 40 road cross fall with 1 in 20 filter strip fall for at least 1m.

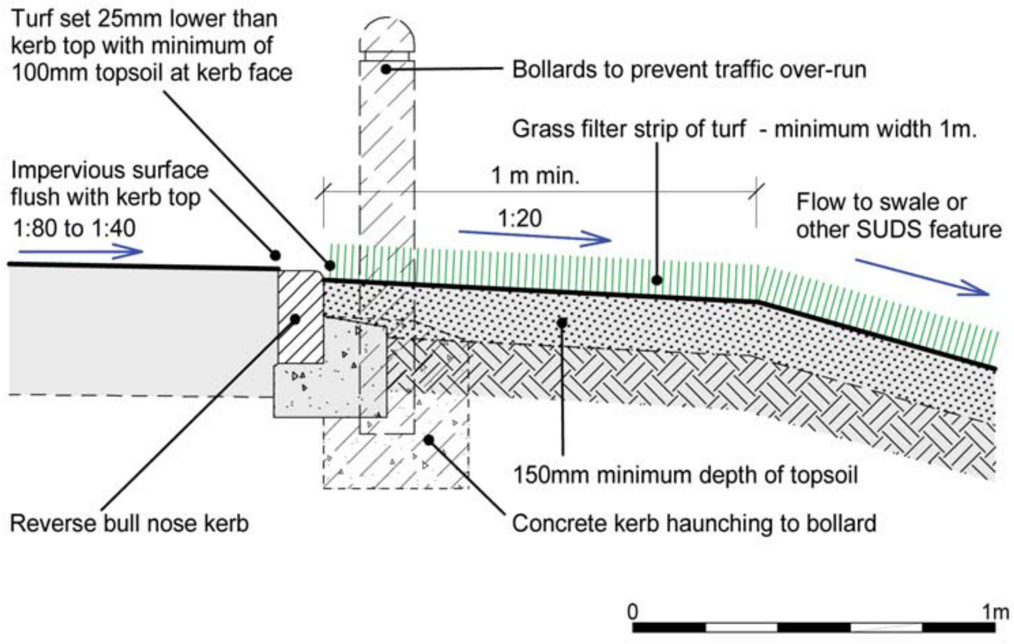


Fig 25 - Filter strip with over-edge detail - section

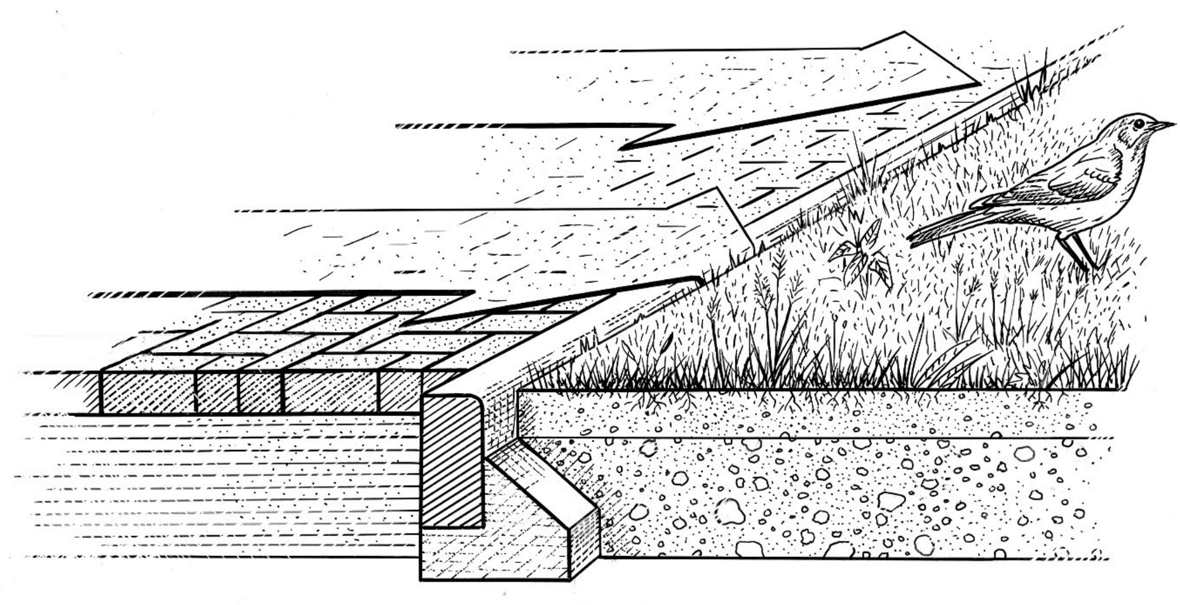


Fig 26 - Filter Strip and over edge detail – profile

Filter strip maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Grass cut to filter strip at 75-100mm not to exceed 150mm leaving cuttings in situ	Monthly or as required
Occasional tasks	Remove leaves in autumn to prevent damage to grass. Cut back overhanging branches to allow dense grass growth.	As required
Remedial work	Level uneven surfaces, repair erosion or damage by re-turfing in season	As required
	Where silt has accumulated remove an oblique divot along the hard edge to reinstate flow	As required
	Remove silt and spread locally outside design profile and reinstate surface	As required

- A minimum width of 900 – 1200mm is required to allow for mowing and an initial treatment for housing and other low risk solutions.
- Over-run by vehicles must be prevented using bollards, rails, fences or other controls to retain an even grass surface for flow.
- The kerb haunch height must allow a minimum of 100mm topsoil at the edge for acceptable grass growth to prevent erosion with 150mm topsoil generally in all other grass areas.
- A minimum of 1 in 50 and maximum of 1 in 20 fall is required to slopes.
- The filter strip should be turfed using an amenity grass seed mix. Outside the turfing season April – Sept prepare and seed the filter strip covering with a fully biodegradable coir blanket to prevent erosion during grass establishment.

Comments

- Gloucester City Council may adopt filter strips within development if they integrate with public open space SUDS.
- Maintenance of filter strips is simple and cost effective.
- Remedial work is only needed if edges are damaged by erosion or gross siltation. Experience indicates that remedial work is generally not required for at least 10 years assuming good design and competent construction unless local excavation or spillage has damaged the filter strip.

5.2 Swales

Swales are linear vegetated channels with a flat base that encourage sheet flow of water through grass or other robust vegetation.

They collect, convey and sometimes store runoff allowing water to soak into the ground where soil conditions are suitable.

Swales usually collect runoff across an edge, using grass filter strips or cross kerb edge inlets to reduce the rate of flow allowing suspended particles to settle in grass.

Runoff can also flow into swales through a point inlet but this requires erosion control and a silt collection arrangement if this has not been removed at source.

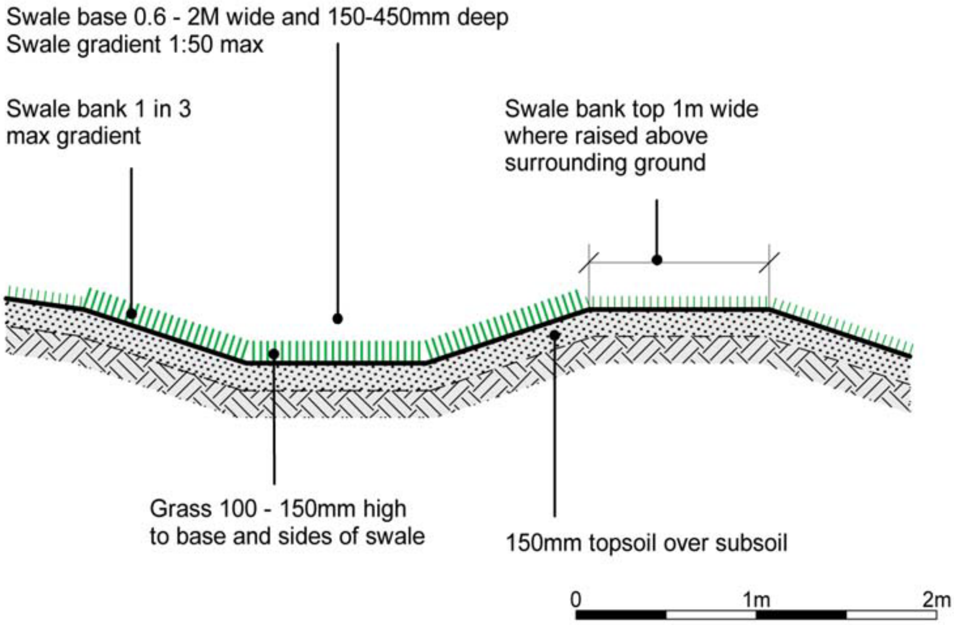
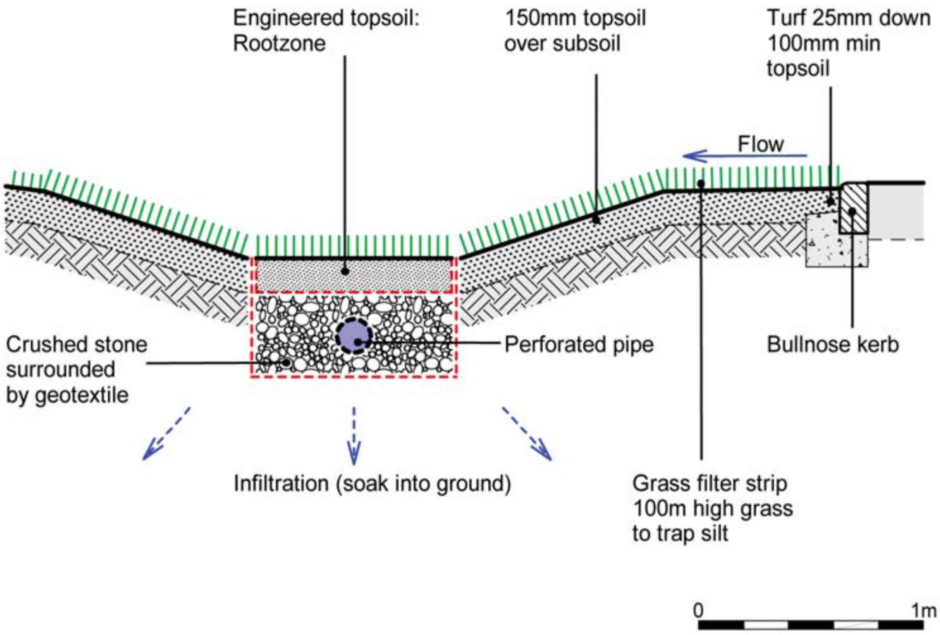


Fig 28 - Standard conveyance swale



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Shallow under-drained swales, where a filter drain is placed under the surface of the swale profile to enhance drainage, are useful in housing to collect runoff at source. They are normally dry grass channels that are visually acceptable to residents and can be used for informal play by children. They are an effective filtering treatment stage before conveyance to the next part of the management train.

Conveyance swales are not usually underdrained and can offer visual and habitat enhancement opportunities. Where swales are designed to retain water for storage or where ground conditions are suitable they

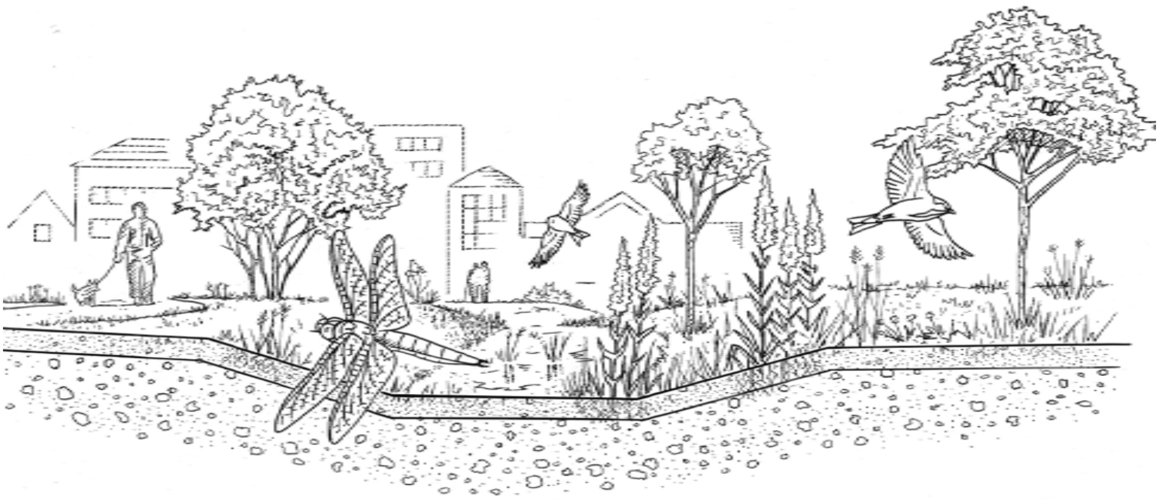

Fig 30 Swale integrated into landscape

Swale maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Grass cut to swales, access and overflows 75 100mm not to exceed 150mm leaving cuttings in situ	Monthly or as required
	Wetland or meadow vegetation cut at 50mm and remove cuttings to wildlife or compost piles	Annually or as required
	Inspect and clear inlets, outlets and overflows with 1m clear or grass cut round	Monthly
Occasional tasks	Remove leaves in autumn to prevent damage to grass Cut back overhanging branches to allow dense vegetation growth	Annual
Remedial work	Level uneven surfaces, repair erosion damage by re-turfing in season	As required
	Remove silt and spread locally outside design profile and re-instate surface	As required
	Repair inlet, outlet or check dam structures to design detail	As required

can develop wetland vegetation and become wet swales with semi-permanent water.

Critical design features

- Swales should be shallow with side slopes no more than 1 in 3 to allow flow across the edge, easy maintenance and safe access.
- Depth should not exceed 450mm particularly within housing areas.
- A 100-150mm depth is required for normal flows allowing vegetation to reduce the rate of flow and provide filtration for pollution control.
- A maximum 300mm storage depth above normal flow depth, with a shallow freeboard if necessary, provides an acceptable swale profile.
- Flow rate should be restricted to 1-2m/s or a 1 in 50 maximum slope to prevent erosion and ensure effective pollution control.
- A base width of 0.9 - 2M will allow effective maintenance and prevent gully erosion of the swale base.
- Check dams can be used to reduce the swale slope but should consider maintenance and avoid potential vandalism eg. loose stone structures.
- Unrestricted access for maintenance by mowers should be provided from one side of the swale.

Comments

- Gloucester City Council may adopt under-drained swales within development if they integrate with public open space SUDS.
    - Maintenance of swales is simple and cost effective
    - Remedial work is usually only needed immediately after construction and is then covered by defects liability in the contract.

- Normal grass swales require cutting at 75 – 100mm, not to exceed 150mm, to prevent grass falling over due to wind or water. Where meadow or wet swales develop, the vegetation is resistant to collapse and an annual or bi-annual cut will be sufficient to ensure the swale works effectively. Where long grass is cut in swales, arisings should be taken away to prevent problems further downstream.

- Gradients along the swale less than 1 in 100 can increase wetness depending on soil conditions resulting in a wet swale.
- Swales are usually mown grass but can be meadow, wetland or open woodland provided a dense ground vegetation is retained.
- Maintenance can be tailored to the desired appearance of the swale so long as the flow and filtering capacity is retained. Maintenance should always look intentional so that people know the feature is being cared for with edges and verges mown to an amenity grass standard.

Fig 31 - Habitat swale - Hamilton, Leicester.

5.3 Bio-retention areas or rain-gardens

Bio-retention areas and rain-gardens are planted areas designed to provide a drainage function as well as contribute to landscape quality. They are located where runoff flows from surrounding impermeable hard surfaces and collect the polluted first flush volume in shallow planted basins. The bio-retention planter, often with an organic mulch, intercepts silt and pollution allowing water to soak through an engineered topsoil into a drainage layer below the surface. Once the basin is full an overflow conveys relatively clean water onward to the next stage of the management train. Rain-gardens are simple planted basins that collect rainwater with an overflow when full.

Ideally runoff is collected as sheet flow over the edge of the basin but it can enter at point inlets with erosion protection and silt traps.

General plant care is like normal landscape plant beds with additional attention to silt accumulation and ensuring effective soakage into the engineered soil layer of the bio-retention planter.

Critical design features

- A bio-retention area should collect and temporarily store at least the treatment volume Vt or first flush volume (10- 15mm) from contributing hard surfaces at a usual depth of 150mm.
- A grass filter strip or silt trap for point inlets are required to prevent siltation and blockage of the basin.
- Water should drain down with 24 hours to anticipate the next storm.
- Construction must be at least 1m above the groundwater table.
- An organic mulch is recommended within the 150mm depression to trap silt and oils with protection to the permeable soil profile.
- A free draining topsoil or rootzone is required 450-900mm deep depending on the planting design.
- A drainage layer 150 – 300mm deep is required usually with a perforated pipe and overflow.

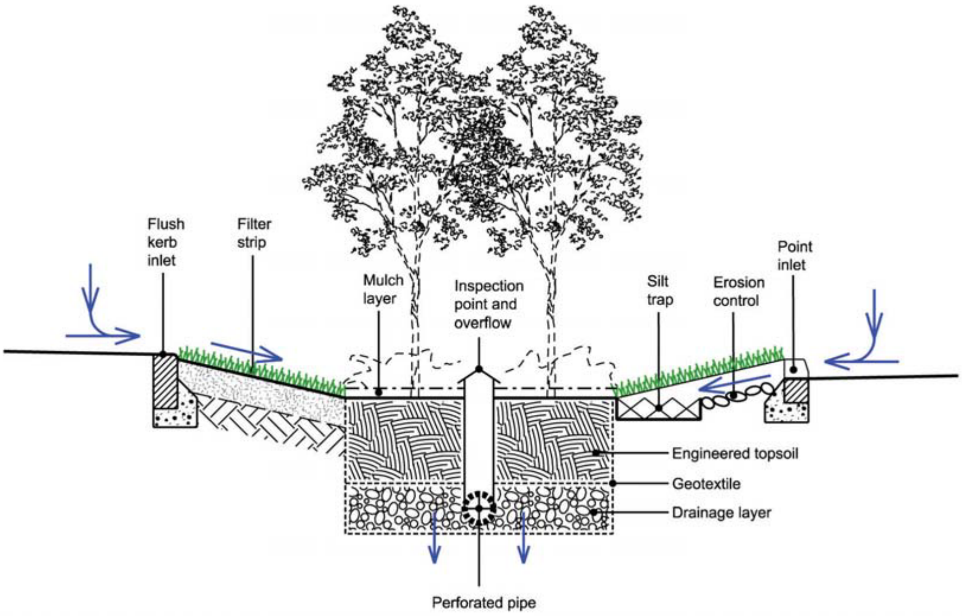

Fig 32 – Bio-retention planter - section

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- Planting must be robust to deal with intermittent flooding and designed to cover the whole surface as soon as possible.

Comments

- It is unlikely that Gloucester City Council will adopt bio-retention areas or rain gardens at present, however, each case will be dealt with on its own merits.
- The landscape character of the rain-garden will depend on the site context and may be ornamental shrub bed, woodland or meadow in appearance.
- Bio-retention areas are a relatively new design concept for Great Britain but are being increasingly used in streets and urban space planning where space is at a premium.
- Bio-retention adds another function to urban green space.

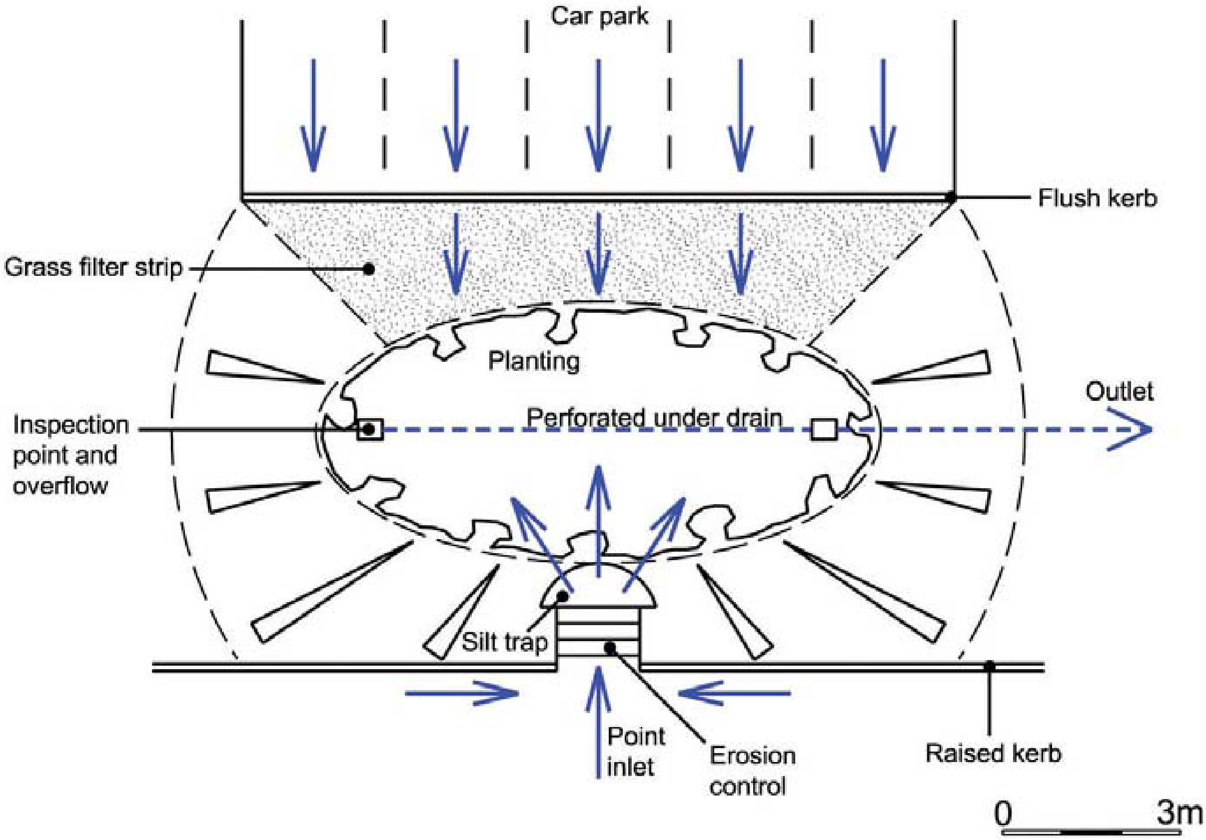

Fig 33- Bio-retention planter - plan.

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Bio-retention or rain-garden maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Grass cut to swales, access and overflows 75 100mm not to exceed 150mm leaving cuttings in situ	Monthly or as required
	Inspect and clear inlets, outlets and overflows with 1m clear or grass cut round	Annually or as required
	Pruning, trimming and general care	Monthly
Occasional tasks	Remove leaves in autumn to prevent damage to grass	As required
	Surface re-instatement by forking or scarifying	
	Replacement of mulch with shredded prunings from site or composted bark	
Remedial work	Remove silt and spread locally outside design profile and re-instate surface	
	Repair erosion, level uneven surfaces or damage by re-turfing in season or to design requirements	
	Repair inlet, outlet, check overflow structures to design detail	

5.5 Green Roofs

Green roofs combine a vegetated surface in lightweight soil over a protected drainage layer. They intercept rain, slowing the flow and removing airborne impurities before water drains from the roof.

They behave like natural vegetation and reduce flow even when saturated. Up to half of the rain falling on a green roof evaporates back into the air and does not appear as surface runoff.

Critical design features

- A green roof provides interception storage and can have a reduced runoff coefficient of 0.6 – 0.4 depending on profile depth and slope of the roof.
- A roof pitch of up to 1 in 3 is possible.
- Additional roof strength may be required to accommodate additional loading of saturated green roof elements.
- Multiple drainage outlets reduce the risk of blockage.
- The depth and profile of the roof can provide intensive or extensive character with different character and biodiversity value.

Comments

- Gloucester City Council will not adopt green roofs on private property.

Fig 34 – Green roof, permeable tarmac play area and long term storage sports pitch. Exwick Heights, Exeter.

Green roof maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly or annually
	Strim surface or other vegetation care depending on design	
	Inspect and clear inlets, outlets and overflows with 1m clear cut round	Annually or as required
Occasional tasks	Remove weeds or tree seedlings	As required
Remedial work	On sloping roofs inspect for erosion and reinstate	
	Insoect and repair or replace inlet, outlet or overflow structures	

5.6 Filter drains and trenches

Filter drains (often call French drains) and treatment trenches are linear excavations filled with single sized or crushed stone that should ideally collect runoff laterally as sheet flow from impermeable surfaces although point inlets can be used with care. The trenches filter runoff as it passes through the stone allowing water to soak into soil or flow to the next part of the management train. Some storage is provided in the voided stone, usually 30% by volume. Pipe inlets into filter drains should be avoided as they are likely to block.

Filter drains are easily clogged by silt so should be protected by upstream features or designed to deal with silt:

- A grass filter strip can protect the filter drain at source.
- A filter drain with an internal sacrificial layer of geotextile with clean stone above allows easy re-instatement.
- De-silting can be undertaken to simple trenches as practiced on major roads with special machinery and good access.

Fig 35 - Filter strip protecting filter drain - Hopwood MSA M42 J2

Critical design features

- Measures to protect from silt must be demonstrated
- A low level perforated pipe is required to convey water onward from the drain where it is used for treatment and should include access for rodding or jetting with open outfalls.
- A high level perforated pipe is required as an overflow where infiltration is proposed.

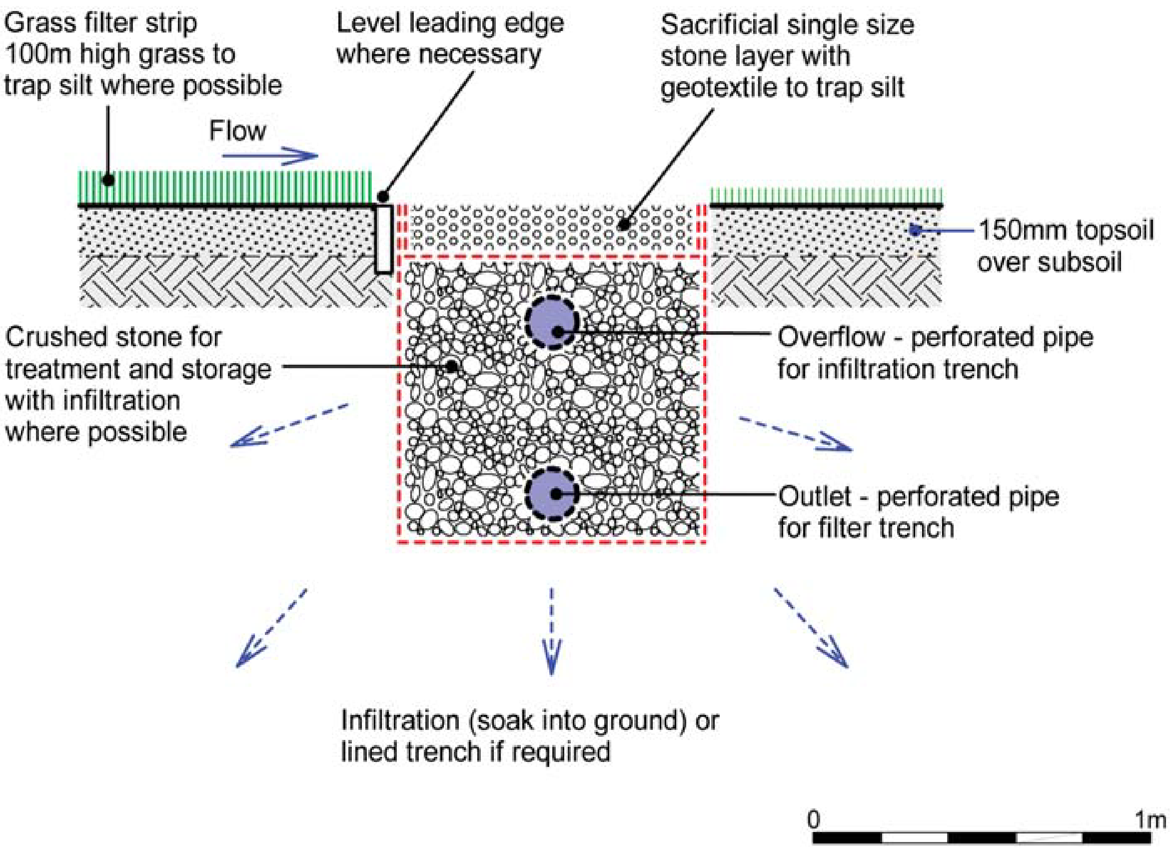

Fig 36 - Filter Drain or Infiltration Trench

Filter drain and trench maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Grass cut to swales, access and overflows 75 100mm not to exceed 150mm leaving cuttings in situ	
	Inspect and clear inlets, outlets and overflows with 1m clear cut round	
Occasional tasks	Silt removal from pre-treatment features where present spread locally outside the design profile	As required
	Inspect and remove silt from chambers and pipes by jetting	
Remedial work	Remove surface stone layer and set aside, replace clogged geotextile and re-instate as design requirements	
	De-silt stone fill using proprietary machinery as major road maintenance	
	Remove silt from filter strip	

- Treatment trenches require perforated pipes for only the last few metres of the trench to maximise filtration potential.
- The edge of the trench should be level, and with a hard edge if necessary, to encourage sheet flow and prevent localised erosion where taking flow from the side.
- Point source inlets must incorporate a silt interception feature to prevent clogging of the inlet or surface layers.

Comments

- Gloucester City Council will not adopt open filter drains or trenches at present. Gloucester City Council will not normally adopt permeable surfaces at present, however, each case will be dealt with on its own merits
- Loose stone, particularly where overrun by vehicles, can be a hazard for maintenance operations and a temptation for children to use as missiles. Therefore the use of filter drains and trenches in public space should be considered carefully.
- A filter drain or trench can be combined with a free draining swale to form an under-drained swale that overcomes the problem of loose stone but increases the cost of the structure.

5.7 Pervious or permeable pavements

Pervious or permeable pavements provide a surface that is suitable for pedestrian or vehicle traffic while allowing rainfall to percolate directly through the surface into underlying open stone construction. Water passing through permeable pavement leaves silt on or just below the surface but oils and other pollutants are trapped in geotextile or in the stone construction for bio-degradation by bacteria. Water is stored in the crushed stone construction before infiltration to the ground or controlled flow to the SUDS management train.

The design of permeable pavements comprises a structural element to support traffic and a hydraulic consideration for water storage.

Permeable pavement includes permeable block paving, porous asphalt, pervious gravel surfaces and engineered grass surfaces.

Critical design features

- Permeable pavements need to be designed structurally to meet loading and traffic requirements based on the strength of the underlying ground when it is wet.
- Storage must be sufficient for infiltration rates or to meet agreed attenuation requirements and rates of flow.
- The use of geotextile as an upper separating or treatment layer may be considered depending on design considerations.

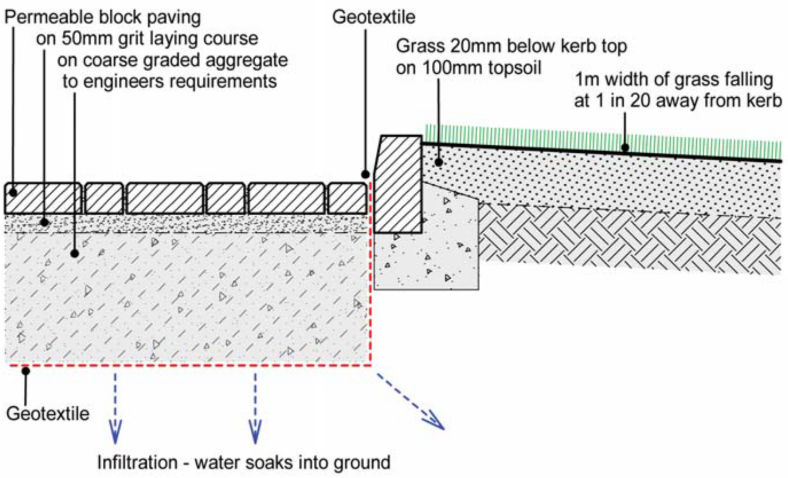

Fig 37 - Permeable Block Paving - infiltration system

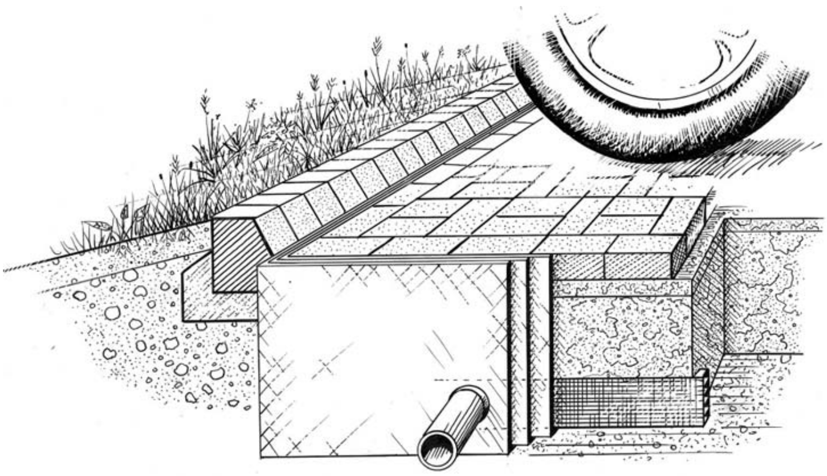

Fig 38 –Permeable Paving with fin drain outlet and reverse fall verge.

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Pervious or permeable pavements maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Surface brushing for appearance and to reduce silt accumulation	As required
	Block paving - brush and suction sweep or jet wash and suction sweep in autumn after leaf fall. Suction angle to be set to minimise loss of jointing grit. Re-gritting and vibration to lock the grit for interlock may be required.	Annually
	Mow grass edges to paving at 35-50mm leaving cuttings in-situ and remove weeds and leaves in autumn.	As required
	Check outlets and control structures with 1m clear or cut all round	Monthly
Occasional tasks	Jetting or brushing and suction where silt has accumulated in joints or voids. In permeable block paving, replace grit and vibrate surface to lock blocks together.	As required
Remedial work	Where settlement or surface damage occurs uplift blocks, remove grit bedding layer, geotextile if present and re-instate to design profile.	

- Permeable surfaces must be protected from siltation. Surrounding landscape details, slopes and management must prevent silt reaching pervious surfaces.
- Three types of system are identified in current Interpave guidance for permeable pavement:
  - total infiltration with a separating geotextile in t he base.
  - partial infiltration with an overflow outlet from the pavement.
  - no infiltration with an impermeable membrane acting as a tank with a controlled outlet.
- Sub-base storage can be augmented by geocellular box structures with the advantage that runoff is clean before it is stored below ground.
- Additional runoff from adjacent impermeable surfaces or roofs can be directed onto permeable surfaces to provide cleaning before storage.
- The structural design of all permeable pavements must be verified by a qualified structural engineer.

Comments

Gloucester City Council will not normally adopt permeable surfaces at present, however, each case will be dealt with on its own merits. The County Council may adopt them. All pervious surfaces must be protected from silt contamination. This requires site management, attention to levels and careful landscape design.
Some porous surfaces including reinforced grass or gravel cannot be easily swept and therefore silt interception is particularly important where runoff flows onto the surface from impermeable surfaces.
Siltation of the block paving occurs very slowly and silt remains in the joints between blocks rather than migrating into the grit bedding layer below.

5.8 Geocellular boxes, oversized pipes and tanks

Modular plastic geocellular box storage systems, with a high void ratio, are a new below ground storage arrangement that can replace underground pipes or concrete tanks used in the past to store water. They can also be used to convey or infiltrate runoff into the ground. It is important to recognise that all below ground storage structures only provide attenuation (storage) of runoff and not treatment. Cleaning of runoff is required before storage or release to the environment.

Underground storage features attenuate an agreed volume with a control structure to limit the discharge to an agreed flow rate.

Silt interception and a clear management arrangement is critical to long term effectiveness of these structures and this must be demonstrated at design stage and confirmed for the design life of the development.

Critical design features

There are two basic modular box arrangements.

1. A modular box system with inlet and outlet pipe work connected to the sides of the structure.

2. A honeycomb structure with perforated pipes running under or through the box.

Water is forced into the box when flows increase.

Recently shallow, load bearing boxes have been developed that can be used as sub-base replacement. In particular they can be used below permeable pavement which protects the box from silt contamination, and provides treatment before water enters the box for storage.

The structural design of any underground storage structure must be verified by a qualified Structural Engineer.

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Fig 39 - Geocellular box storage protected by geotextile and permeable block paving - Red Hill Primary School, Worcs.

Geocellular boxes, oversized pipes and tanks maintenance

Maintenance	Action	Frequency
Regular maintenance	Inspect and remove debris from inlet structures	Monthly
	Remove sediment from pre-treatment structures where present	Monthly or as required
	Check inlets, outlets, control structures and overflows	Annually or as required
Occasional tasks	Jetting and suction where silt has settled in the structure	As required
Remedial work	Full replacement of the structure if permanently silted or structural failure.	

Comments

- It is unlikely that Gloucester City Council will adopt below ground storage structures, however, each case will be dealt with on its own merits.
- Geocellular boxes can have advantages over conventional in-situ tanks or concrete pipes as they are spatially versatile and are easy to install. They can also allow infiltration through a geotextile liner in suitable soils.
- To carry out water quality treatment, these systems need to be part of a SUDS management train, with appropriate sediment management and pollution control devices installed within or before the installation.

The preferred method of runoff collection is through permeable pavement because silt is trapped on the surface and runoff passes through crushed stone and geotextile to provide cleaning before below ground storage.

The hydraulic design of on or off-line storage using pipes or tanks should be in accordance with Sewers for Adoption, 6th Edition (WRC 2006).

Infiltration systems should be designed to comply with current guidelines (BRE 365 1991 or CIRIA publication R156 Bettess 1996) and storage systems should be designed using standard routing methods set out in Chapter 4 of The SUDS Manual 2007.

The structural design of tanks and pipes should be in accordance with relevant standards eg. Sewers for Adoption, 6th Edition (WRC 2006), BSEN 1295 (BSI 1998).

Structural design for buried pipelines under various conditions of loading, Highways Agency specification for highway works (Highways Agency et al, 1998).

Design of geocellular structures should be in accordance with 'Structural design of modular geocellular drainage tanks' CIRIA Report C680.

5.9 Detention basins

Detention basins are vegetated depressions in the ground that store runoff from development with water flowing out of the basin at a controlled rate. They also allow some water to soak into the ground. Within development, these basins are usually small grassed areas, sometimes with a micro-pool or planted area at a low point where some standing water may accumulate.

They should be designed as landscape features that allow other uses when dry such as play, informal sport, social space, visual quality and habitat creation. These opportunities are enhanced when there are source control features upstream that prevent silt and pollution reaching the basin.

Source control also reduces the frequency that runoff reaches the basin and avoids the need for surface silt traps. This provides substantial flow and erosion control that allows more effective integration into the landscape with reduced maintenance.

Critical design features

- Silt should be intercepted at source wherever possible or in a silt trap where runoff enters the basin.
- Water should flow into the basin as a controlled sheet flow from source control features to reduce the risk of erosion. However, if entry is through a point inlet then an erosion control structure will be necessary to manage the flow.
- Detention basins should be 2 - 5 times as long as wide to provide maximum opportunities for settlement at the inlet and filtration in vegetation.
- The inlet should be at or above the storage level to allow an uninterrupted flow into the basin.
- There should be a gentle fall to the outlet of about 1 in 100 to encourage surface sheet flow by gravity unless a habitat space is required when falls can be reduced to encourage a wet base.

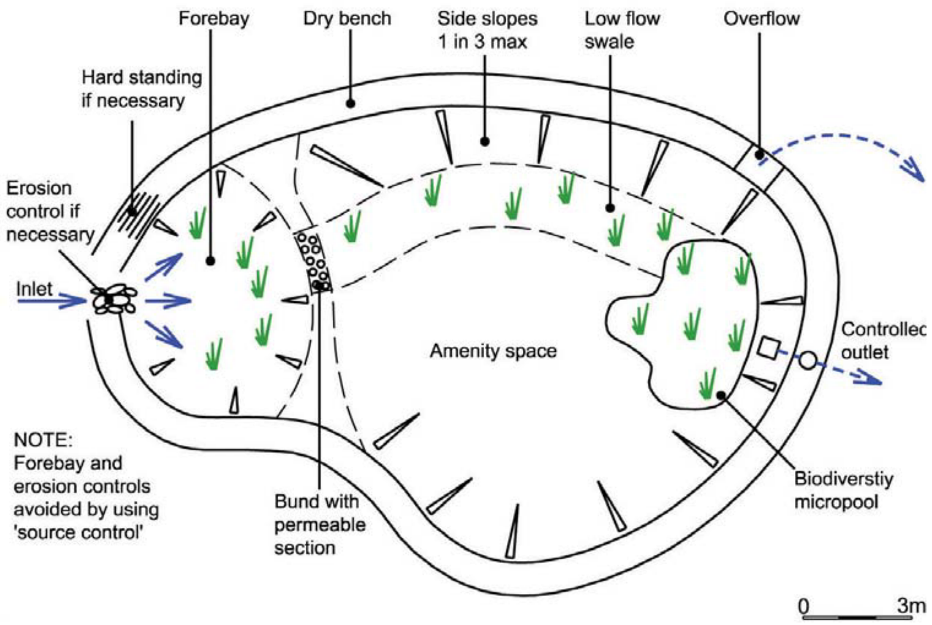

Fig 40 - Detention Basin with integral forebay where source control absent

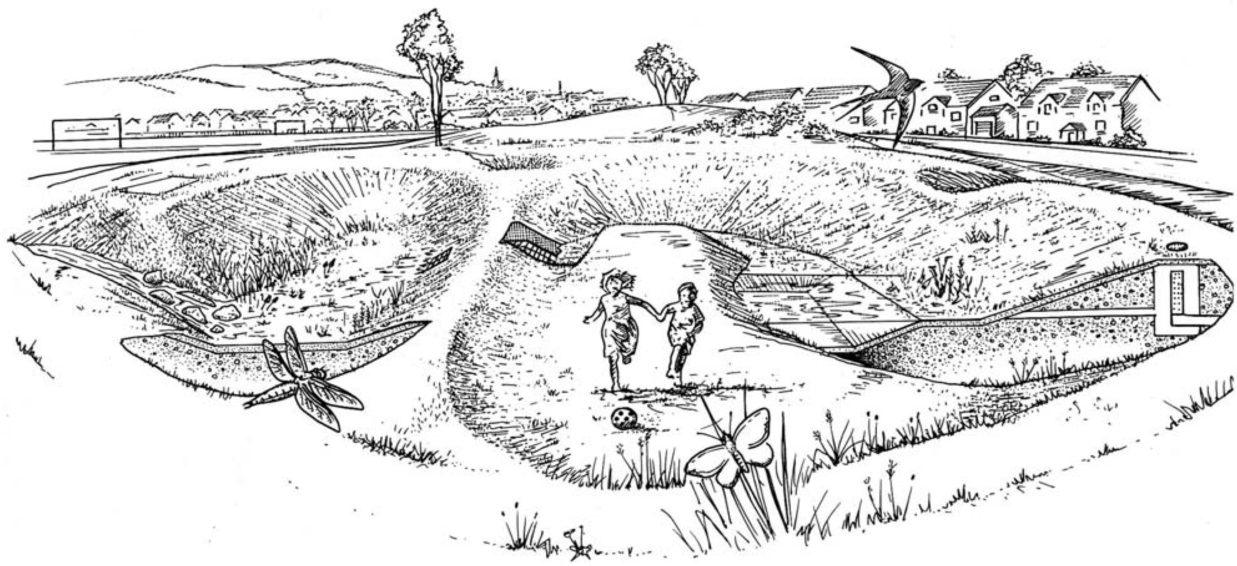

Fig 41 - Detention Basin with wet and dry areas for play and wildlife with chamber control in bank.

Detention basins maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removed from site	Monthly
	Amenity grass to edges and verges cut at 35-50mm leaving cuttings in-situ	As required
	Grass cut to basin access and overflows at 75-100mm not to exceed 150mm	Monthly or as required
	Meadow grass cut at 50mm and remove cuttings to wildlife orcompost piles, where required	Annually or as required
	Manage wetland planting in micro-pools by cutting at 50mm and remove cuttings to wildlife or compost piles	
	Inspect and clear inlets, outlets, control structures, silt traps and overflows with 1m clear or grass cut all round	Monthly
Occasional tasks	Remove leaves in autumn to prevent damage to grass	Annually or as required
	Review silt accumulation annually, remove if necessary, and site apply or take off site subject to agreement with the EA	
	Cut back overhanging branches to ensure dense vegetation growth.	As required
Remedial work	Inspect and repair damage to inlets, outlets, control structures, banks and overflows to design detail	

- A controlled outfall is required at or just below ground level to ensure water drains effectively down. This ensures a generally dry surface when it is not raining.
- A micro-pool can be used to enhance treatment and avoid a muddy area at the outlet providing bio-diversity interest with native planting.
- Side slopes to the basin should be 1:3 maximum with clear access for maintenance.
- An overflow is required to allow for design exceedance or outlet blockage.
- The design and planting of detention basins should integrate with local landscape and the basin be considered as multifunctional space.
- 75 – 100mm high grass or meadow vegetation provides enhanced treatment and a resilient surface for informal use, access and overflows.
- Amenity grass to edges and verges should be mown regularly to 35-50mm high.
- Storage depth should not be more than 600mm for safety reasons.

Comments

- Gloucester City Council may adopt detention basins within development if they integrate with adopted public open space SUDS subject to agreement and conditions in this manual.
- Detention basins should always be integrated into the design of the site to provide visual, social and bio-diversity benefits and to encourage informal policing by local people of a valued landscape space.

Fig 42 - Detention basin in housing as informal play with low flow channel - Flows Project, Cambourne.

5.10 Infiltration basins

Infiltration basins are similar to detention basins except that they are designed to allow water to soak into the ground as well as provide storage.

They generally collect runoff from small areas and are usually off-line to prevent siltation, excessive pollution and the effects of spillage. It is crucial that source control measures are in place upstream to intercept silt that cause clogging of the surface and ensure that only clean water infiltrates into the ground.

Infiltration basins are not suitable for pollution hot spots like industrial sites.

Critical design features

• The infiltration potential of the soil and sub-soil must be confirmed by geotechnical tests.

• The stability of the ground must be confirmed and an analysis of likely infiltration pathways and risk to surrounding features undertaken.

Fig 43 - Infiltration basin dry within 24 hours, showing silt delta in foreground - Lakeland Florida.

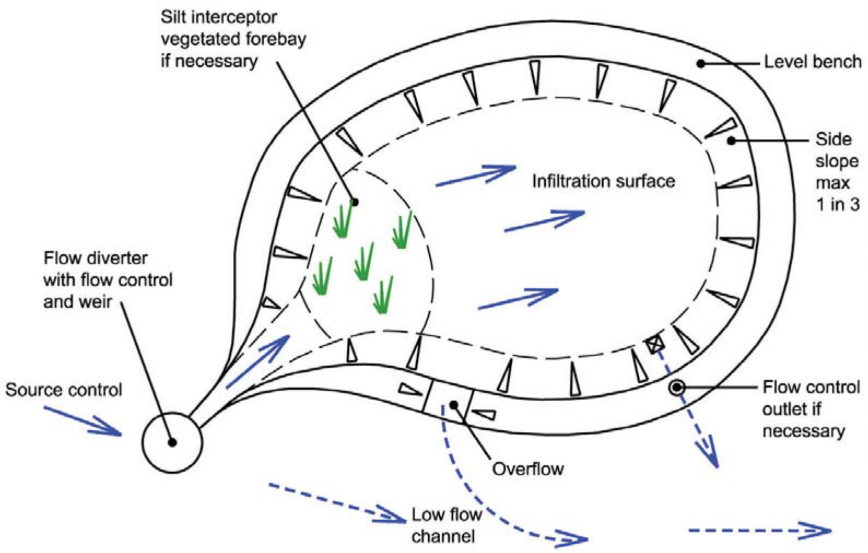

Fig 44 - Infiltration Basin Off-Line Plan

Infiltration basins maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removed from site	Monthly
	Amenity grass to edges and verges cut at 35-50mm leaving cuttings in-situ	As required
	Grass cut to basin access and overflows at 75-100mm not to exceed 150mm	Monthly or as required
	Meadow grass cut at 50mm and remove cuttings to wildlife orcompost piles, where required	Annually or as required
	Inspect and clear inlets, outlets, control structures, silt traps and overflows with 1m clear or grass cut all round	Monthly
Occasional tasks	Remove leaves in autumn to prevent damage to grass	Annually or as required
	Remove sediment from silt traps, inlets and other pre-treatment structures	
	Cut back overhanging branches to ensure dense vegetation growth.	As required
Remedial work	Inspect and repair damage to inlets, outlets, control structures, banks and overflows to design detail	
	Hollow tine and scarify surface if infiltration reduces over time	

- Silt and pollution must be removed upstream in source control features.
- An inlet flow spreader is required to distribute flows across the basin ideally using a widening grass channel inlet.
- The inlet should be at or above storage height to ensure uninterrupted flow.
- The base should be level across the basin to encourage even infiltration with a slight fall along the basin to distribute water evenly at 1 in 100 to 1 in 200.
- The water table should be at least 1m below the surface.
- Side slopes to the basin should be 1 in 3 maximum with clear access for maintenance.
- An overflow is required to allow for design exceedance.

Comments

- Gloucester City Council may adopt infiltration basins within development if they integrate with adopted public open space SUDS subject to agreement and conditions in this manual.
- Informal use of infiltration basins should take into account the risk of compaction of the basin base so vehicle access must be prevented and activities limited to low intensity impact.

- Infiltration basins should always be integrated into the design of the site to provide visual, social and bio-diversity benefits and to

5.11 Ponds

Ponds are depressions in the ground that contain a permanent or semi-permanent volume of water. Ponds can be part of a wetland system and include temporary ponds that dry out periodically during the year. Natural pond systems are described in Ponds, Pools and Lochans – a SEPA publication with reference to applications in SUDS.

SUDS ponds are usually separate structures with a storage capacity above the permanent water volume and a defined edge designed to satisfy safety concerns.

Ponds and wetlands should be designed to receive silt free runoff with only a light loading of dissolved pollution that can be processed in the water column by microorganisms.

The profile of ponds and wetlands provide cost effective storage for large volumes of clean water. Ponds and wetlands should therefore be viewed as polishing mechanisms where water quality satisfies amenity, biodiversity and management requirements.

Critical design features

- SUDS ponds should mimic natural ponds
- There should be a dry bench, minimum width 1m, to allow people to stand safely before descending towards the pond.
- Slopes down to a pond and within the pond should be no more than 1 in 3 both for ease of access, maintenance and biodiversity. Maintenance machinery should be able to access any structure

encourage informal policing by local people of a valued landscape space.

- There should be a level wet bench minimum width 1m, unless the pond is very small, to allow people to stand safely before the water edge.
- Liners may be required to retain a permanent volume of water in the pond.
- Ponds should be located towards the end of the management train to ensure a controlled flow of clean water enters the pond.
- Inlets and outlets should be located to maximise the flow path through the pond assisted by pond shape, islands and baffles where necessary.
- The outlet level should be at the permanent level of the pond.
- The storage volume above the permanent water level should be 600mm maximum depth for safety and management reasons.
- Ponds require an overflow to allow for design exceedance or outlet blockage.
- Planting of ponds and surroundings should follow guidance in this Guide and Ponds, Pools and Lochans referred to above.
- Pond edges should be planted but the design must allow for amenity and safety. See Appendix 3 - A reassessment of the role of ponds in the SUDS management train.
- The storage volume was originally determined by the treatment volume Vt. but treatment is now considered to be more appropriate within the management train.

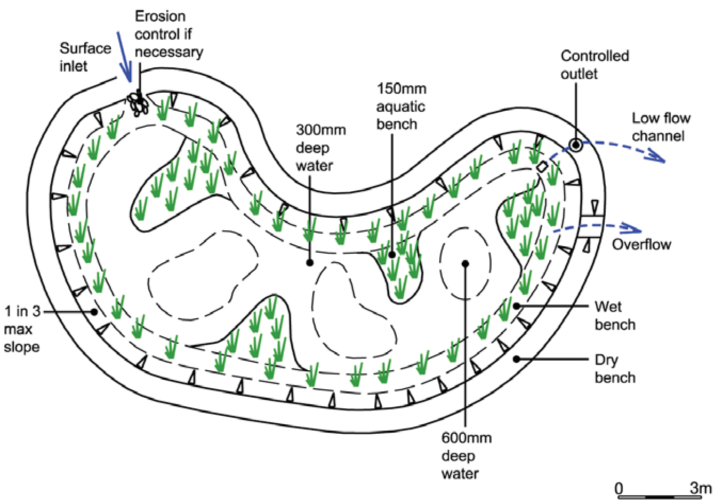

Fig 45 - Pond plan showing enhanced flow routing and biodiversity.

Comments

- A number of smaller pond features in a linked chain can often fit into development more easily than a large one and allow simple access for maintenance and benefit bio-diversity.
- Simple grass access paths with firm level dry and wet benches and management platforms normally allow adequate access for maintenance however there may be a requirement for hard access in certain situations.
- Water should flow to the pond or wetland in a controlled way, overland through a swale, low flow channel or linear wetland.
- Management of ponds involves cutting grass for access and visual amenity, cutting meadow or rough grass for visual or bio-diversity reasons, removal of small amount of aquatic vegetation to retain storage volumes, and amenity and bio-diversity and occasional bankside pruning or felling to retain a balanced surrounding to the pond or wetland. Silt removal should be largely unnecessary if inorganic silt has been removed at source and experience suggests organic silt is oxidised by shallow flows of highly oxygenated water.

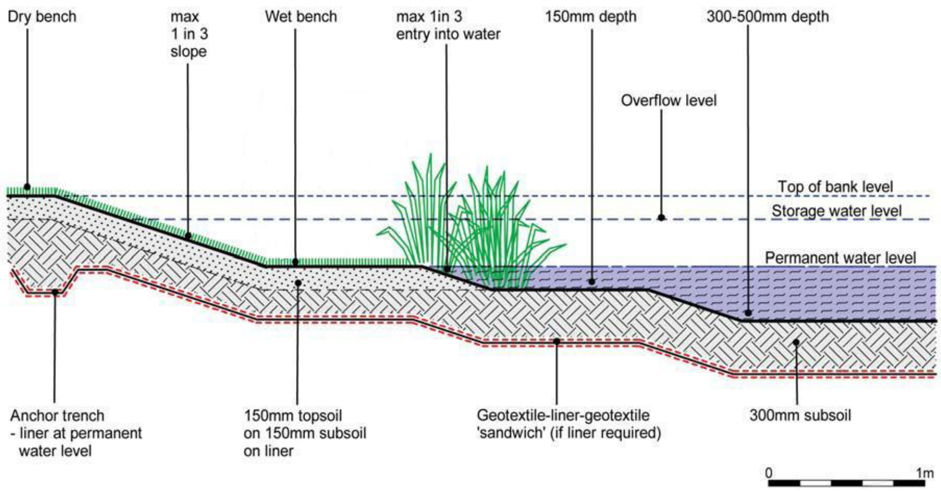

Fig 46 - Lined pond/wetland edge detail.

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Fig 47 - Pond with construction profile showing liner and anchor trench

Pond maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removed from site	Monthly
	Amenity grass to edges and verges cut at 35-50mm leaving cuttings in-situ	As required
	Grass cut to basin access and overflows at 75-100mm not to exceed 150mm	Monthly or as required
	Wetland, meadow grass cut at 50mm and remove cuttings to wildlife or compost piles	Annually or as required
	Cut pond vegetation no more than 30% at one visit, at 100mm above pond base and remove to wildlife or compost pile	Annually or 3-5 year cycle and as required
	Remove silt from silt trap structure, if present, and site spread subject to agreement with the EA	Monthly or as required
	Inspect and clear inlets, outlets, control structures, silt traps and overflows with 1m clear or grass cut all round	Monthly
Occasional tasks	Remove leaves in autumn to prevent damage to grass	As required
	Remove sediment from silt traps, inlets and other pre-treatment structures	
Remedial work	Inspect and repair damage to inlets, outlets, control structures, banks and overflows to design detail	

5.12 Wetlands

Wetlands are shallow depressions that are nearly or completely covered in marsh vegetation generally with little open water although small ponds can occur within the wetland. They naturally occur with and intergrade into ponds and basins.

SUDS wetlands can store large volumes of water and provide treatment for soluble pollutants. Silt and gross pollution should be removed at source to protect the amenity and wildlife value of the wetland.

SUDS wetlands should be at least 3 times as long as wide for treatment. Water can be directed to extended routes within the wetland by bunds and baffles to provide enhanced treatment.

In many ways wetlands behave like ponds and the two habitats often occur together.

The maintenance of wetlands is similar to ponds and for the same reasons.

Wetlands should not receive direct flows of silt laden or polluted runoff, but should be at the end of a management train, thereby creating clean, safe amenity for the community and wildlife. This also avoids costly and difficult removal of potentially toxic waste and the buildup of silt.

Critical design features

- SUDS wetlands should be linear to allow treatment and are designed to clean, store and convey runoff to the next part of the management train.
- A sediment silt trap will be required to intercept silt unless source control measures are in place.
- SUDS wetlands should mimic natural wetlands.
- There should be a dry bench, minimum width 1m, to allow people to stand safely before descending towards the wetland.
- Slopes down to a wetland and within the wetland should be no more than 1 in 3 both for ease of access, maintenance and bio-diversity.
- There should be a level wet bench minimum width 1m, unless the wetland is very small, to allow people to stand safely before the water edge.
- Liners may be required to retain a permanent volume of water in the wetland.

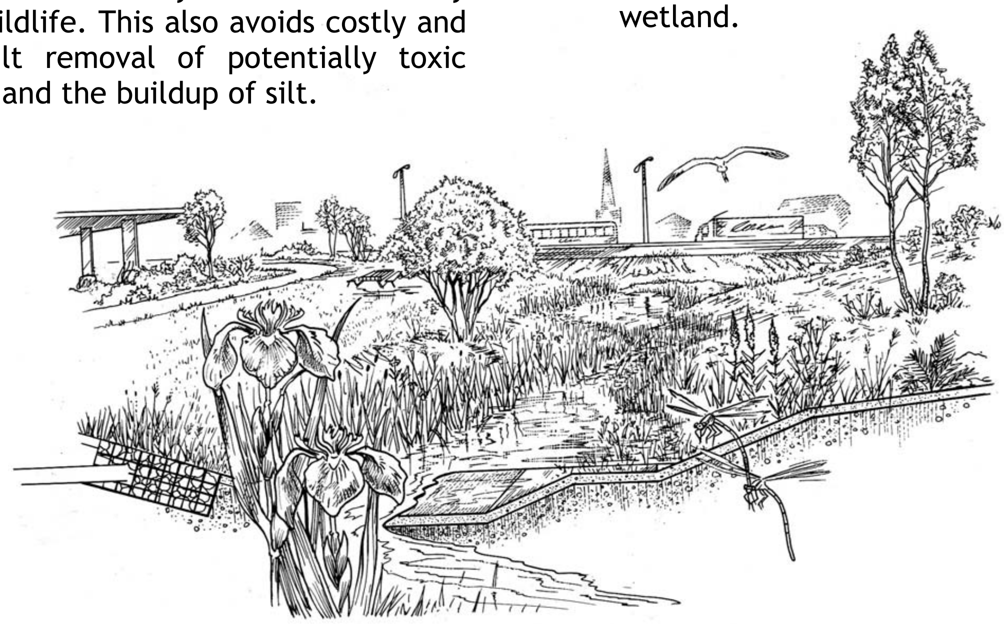

Fig 48 - Wetland with box inlet integrated into the landscape

Wetlands maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removed from site	Monthly
	Amenity grass to edges and verges cut at 35-50mm leaving cuttings in-situ	As required
	Grass cut to basin access and overflows at 75-100mm not to exceed 150mm	Monthly or as required
	Wetland, meadow grass cut at 50mm and remove cuttings to wildlife or compost piles	Annually or as required
	Cut wetland vegetation, no more than 30% at one visit, at 100mm above pond base and remove to wildlife or compost pile	Annually or 3-5 year cycle and as required
	Remove silt from silt trap structure, if present, and site spread subject to agreement with the EA	Monthly or as required
	Inspect and clear inlets, outlets, control structures, silt traps and overflows with 1m clear or grass cut all round	Monthly
Occasional tasks	Review silt accumulation annually, remove if necessary and site spread or take off site subject to agreement with EA	As required
	Remove lower branches of tree or shrub growth within 5m of wetland edge to ensure ground vegetation and access.	
Remedial work	Inspect and repair damage to inlets, outlets, control structures, banks and overflows to design detail	

- Inlets and outlets should be placed to maximise the flow path through the wetland assisted by pond shape, islands and baffles if necessary.
- The outlet should be at the permanent level of the wetland.
- The storage volume above the permanent water level should be 600mm maximum depth for safety and management reasons
- Wetlands require an overflow to allow for design exceedance or outlet blockage.
- Planting of wetlands and surroundings should follow guidance in this Guide.
- Wetland edges should be planted but the design must allow for amenity and safety.

Comments

- Gloucester City Council may adopt wetlands within development if they integrate with adopted public open space SUDS subject to agreement and conditions in this manual.
- Low flow channels that convey day to day flows through development

can take the form of linear wetlands to provide additional cleaning, infiltration and landscape value. They are preferred to pipes as they can deal with additional flows and volumes during storm conditions.

- Slopes and profiles should be generally as in pond construction.

6.0 INLETS, OUTLETS AND FLOW CONTROL STRUCTURES

This section shows how the structures that let water in or out of SUDS features together with control devices that control flows should be designed. It also deals with the need for the overflows and exceedance routes.

6.1 Controlling the flow of water in SUDS

SUDS require inlets and outlets to direct flows into and out of a SUDS feature.

- An inlet structure conveys flow into a SUDS component
- An outlet structure conveys flows out of a SUDS component
- A control structure restricts the rate of flow into or from a SUDS component

All inlets, outlets or control structures must be attractive, interesting or visually acceptable. They must not pose a risk to the public, maintenance staff or wildlife.

Rainfall is collected at the start of the management train in 3 main ways:

- Directly through pervious surfaces into the storage layers below ground.
- Laterally as sheet flow across a flush edge or through surface inlets.
- As a last resort through gullies and grating into pipes.

Gully collection should be avoided, where possible, as it is important to keep runoff as close as possible to the surface to allow entry into shallow SUDS features and surface flow routes.

Gullies with integral pots, in particular, are also a hazard to wildlife, increase maintenance costs and are expensive to install.

Storm water should be managed in small sub-catchments using source control techniques to reduce the rate of flow and volumes of runoff. This should eliminate the need for large concrete structures and allow the use of small control mechanisms appropriate for flows at low velocities.

6.2 Inlets for surface collection from impermeable hard surfaces.

The following inlets may be appropriate depending on site conditions:

- Flush kerb sheet flow inlet.

Fig 49 -Flush kerb sheet flow inlet

- Cross kerb inlet

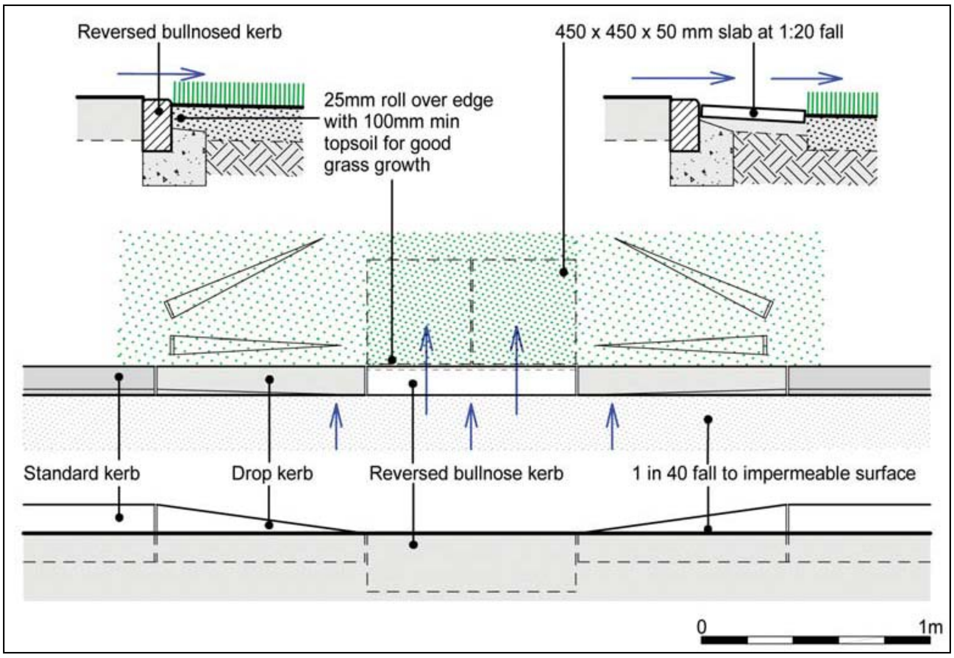

Fig 50 -Cross kerb inlet

- Bridges and causeways

Fig 51 - Simple bridge over a swale - Malmo, Sweden.

Fig 53 - Causeway kerb inlet - The Grove Primary School, Malvern.

- Kerb inlets

Fig 52 - Kerb Inlet - Hunters Hall nr. Nailsworth, Glos.

- Chute gullies

Fig 54 - Chute Gully

- Downpipe and rill

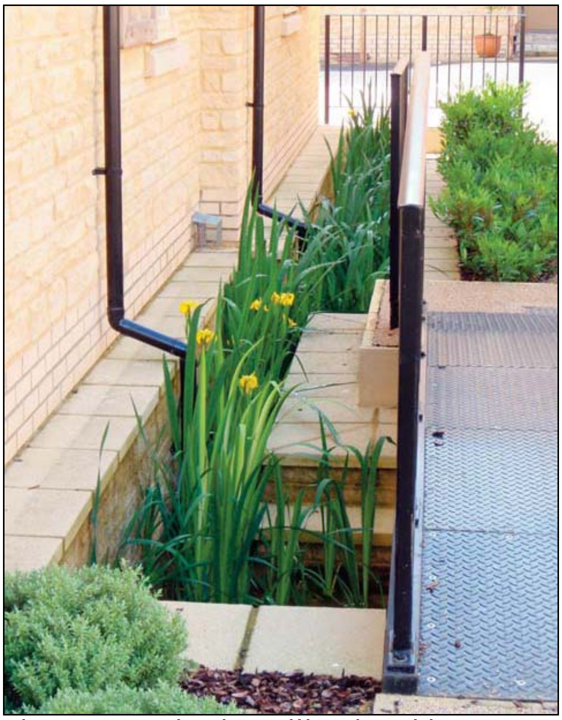

Fig 55- Downpipe into rill - Riverside Court, Stamford.

Erosion control, flow spreaders and surface silt collectors may be required to avoid localised erosion and control silt accumulation.

Inlets and outlets should be set above surrounding ground level to help prevent blockage by debris or unrestricted plant growth.

6.3 Open pipe inlets

Ideally runoff should flow on the surface into a SUDS feature but sometimes this is impossible and it must be conveyed to the SUDS through a pipe. However, pipes are prone to blockage and perform badly in heavy rainfall. The pipe length should be as short as possible before water enters the collecting SUDS feature and the inlet into the

SUDS feature should be open at the end to prevent blockage by debris flowing down the pipe and to allow simple rodding or jetting.

An effective open pipe inlet is the mitred concrete headwall. The profile of the inlet is the same as the surrounding ground and the structure requires no wing walls or other supporting elements. It presents minimal risk to people and is easily maintained.

There are many traditional types of open pipe inlet but all should be reviewed regarding, function, appearance, maintenance, safely and cost.

- Mitred concrete headwall

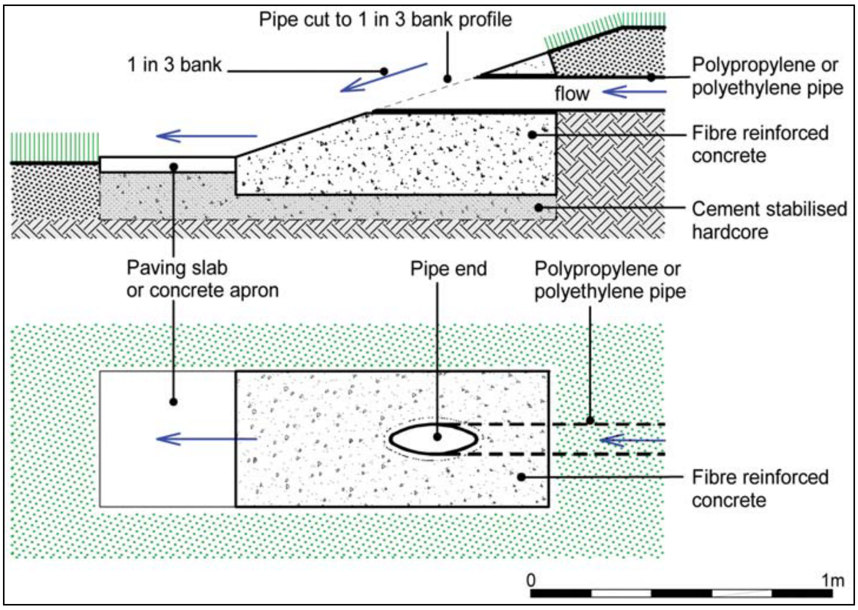

Fig 56 - Mitred concrete headwall

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Fig 57 - Mitred concrete headwall - Hopwood Park MSA M42 J2

There can be pressure to fit a grille to the opening but any size greater than 50mm mesh is considered a trip hazard to children and at this size the risk of blockage form debris in the flow of water is significant.

Open pipes are vulnerable to being blocked by children and this should be considered in the design process

6.4 Protected pipe inlets

Rainfall collected through permeable surfaces or other filtering mechanisms will not contain debris so can enter SUDS features through grilled or hidden inlets. The advantage with a covered inlet, particularly in public open space, is that they are difficult to block from the inlet end of the pipe by vandalism or maintenance operations.

The following covered inlets may be appropriate depending on site conditions.

The stainless steel mesh baskets are installed at 1 in 3 slope to reduce the risk of blockage and trip hazard to people with access for easy maintenance.

- Mitred basket inlet

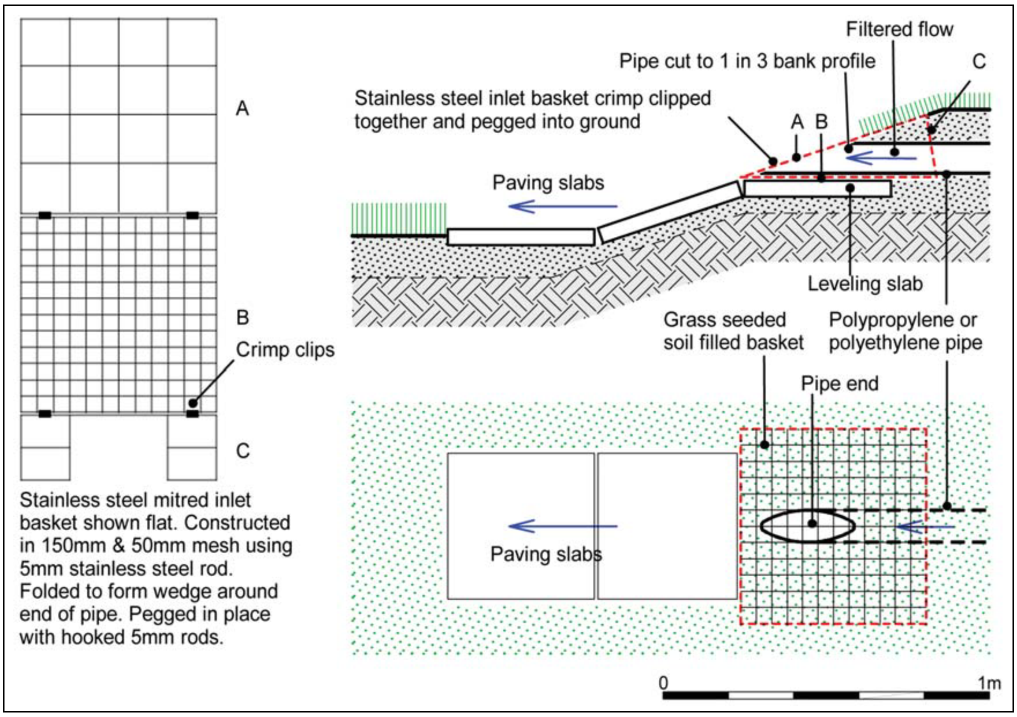

Fig 58 - Mitred basket inlet.

- Basket inlet with stone fill

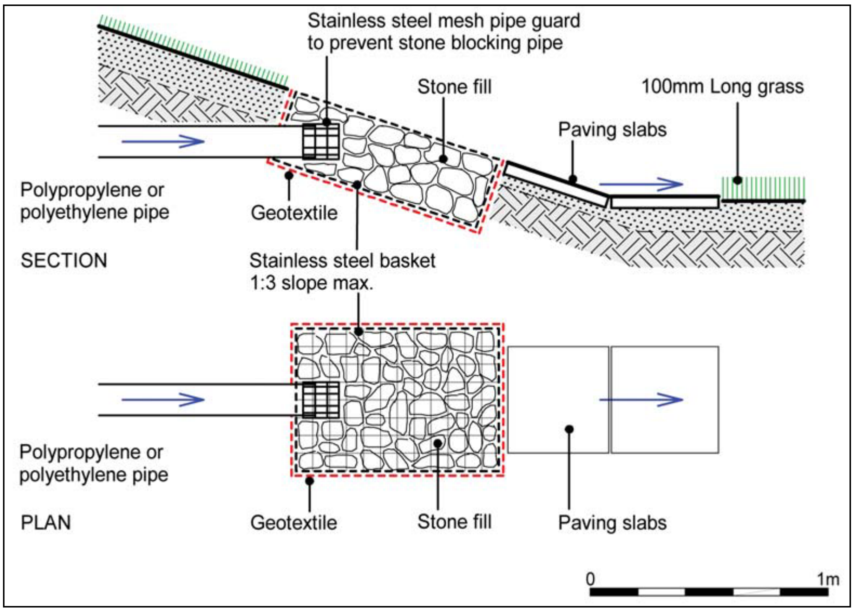

Fig 59 - Basket inlet with stone fill

Fig 60 - Basket inlet - Robinswood Hill Primary School, Glos.

6.5 Outlets from SUDS features

Once water has passed through a SUDS component it may flow onward unimpeded, as in many swale outlets, but more often it will be restricted through a flow control structure.

A hierarchy of flow control and storage is required in SUDS to meet attenuation requirements and the outlet design will depend on the location in a development.

The reduction in flow rate, as water travels through the SUDS, causes silt and debris to fall from suspension. Vegetated structures like swales, basins, ponds and wetlands intercept silt and debris through filtration and settlement that reduces the risk of blockage.

Low flows leaving an open SUDS feature usually pass through an outlet structure before flowing through a control device that further reduces the risk of blockage at the outlet opening.

Low flows leaving a permeable pavement, or other SUDS structure that filters runoff through crushed stone, will not be at risk from blockage.

Therefore the design of the outlet is generally to manage low flows effectively rather than deal with large volumes and velocities.

6.6 Protected pipe outlets

Runoff that has passed through one or more SUDS features will not contain large amounts of debris if it is flowing slowly due to a control device in the outlet and there is little risk of blockage. The outlet access structure should have a large surface area to reduce the risk of blockage with the water passing through a grille or similar screen to remove large floating debris like plastic bags. Debris that does collect on the screen can be removed at monthly inspection. Again the advantage with a covered outlet, particularly in public open space, is that they are difficult to block from the outlet end of the pipe by vandalism or maintenance operations.

The following covered outlets may be appropriate depending on site conditions.

- Basket outfall

The stainless steel mesh baskets at 1 in 3 reduce the risk of blockage and trip hazard to people.

Fig 61- Basket outlet

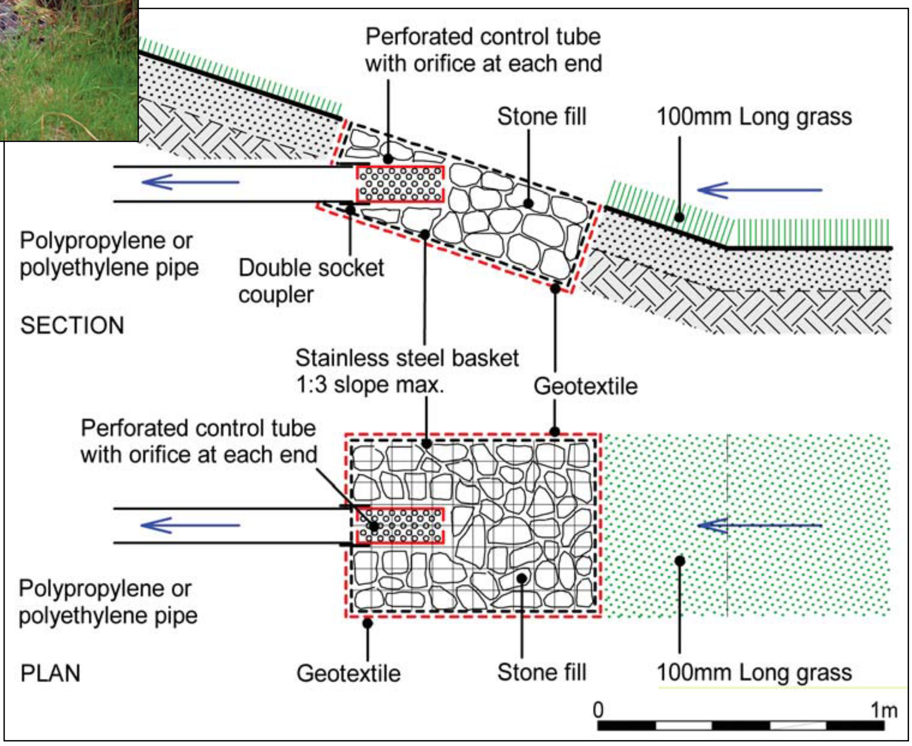

Fig 62 - Basket outlet - Hazeley School, Milton Keynes

Hidden outlets

Fig 63 - Basket inlets and overflow with geotextile to protect Great Crested Newts - Hazeley School, Milton Keynes.

6.7 Surface flow controls

- Basket outlet control
- Slot weir control

These surface controls can be integrated into landscape structures such as open jointed walls or comprise a conventional grating within a bank at 1 in 3 slope to reduce risk of blockage. Inlets and outlets offer scope for innovative design to add character to SUDS schemes.

Fig 64 - Slot Weir Control - Fort Royal School, Worcs.

6.8 Chamber controls

Outlets from pervious surfaces, such as permeable pavement where water is filtered, can discharge water directly through a chamber control structure as there is nothing to block the control.

The chambers are similar to conventional inspection chambers but with a flow control mechanism on the outlet pipe.

- Vertical control tube

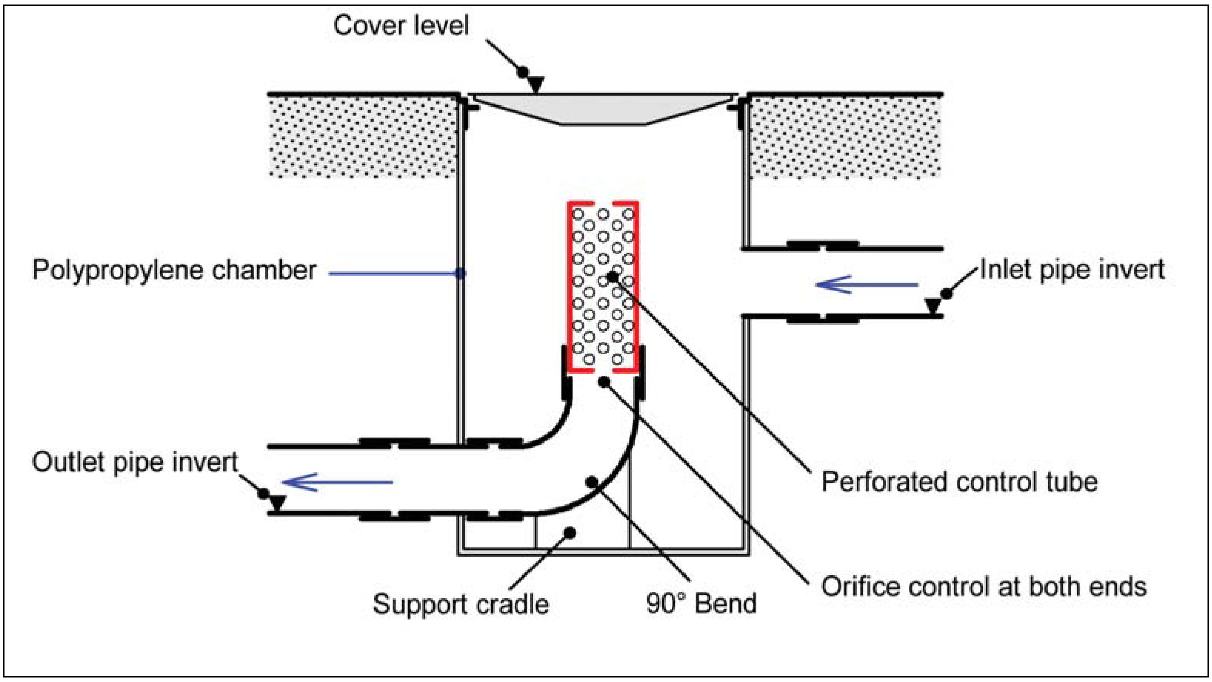

Fig 65 - Vertical control tube

Fig 66 - Vertical control tube 3 years after installation.

Fig 67 - Vertical control tube in polypropylene - orifice top and bottom of removable cylinder.

- Horizontal control tube with overflow

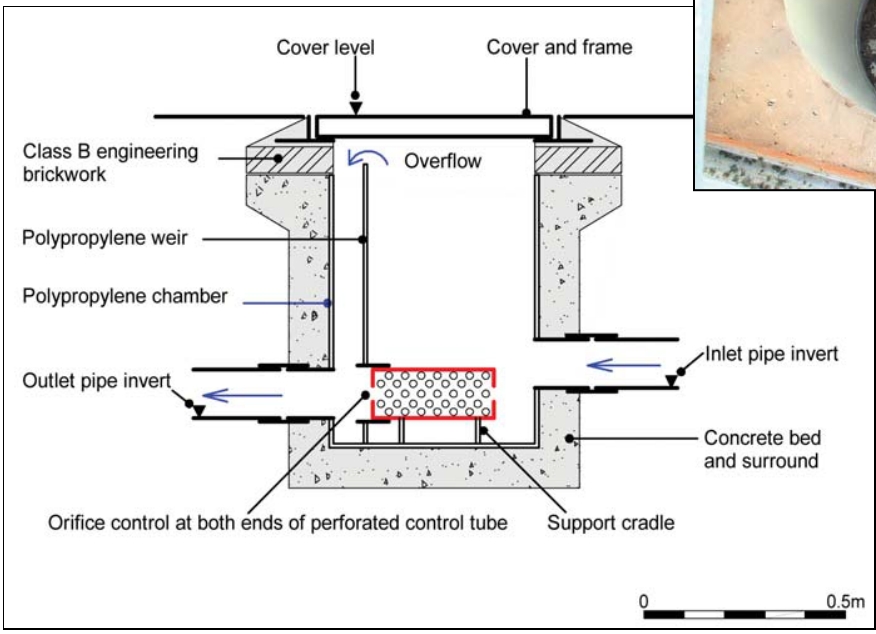

Fig 68 - Horizontal control tube with overflow.

- Horizontal control tube

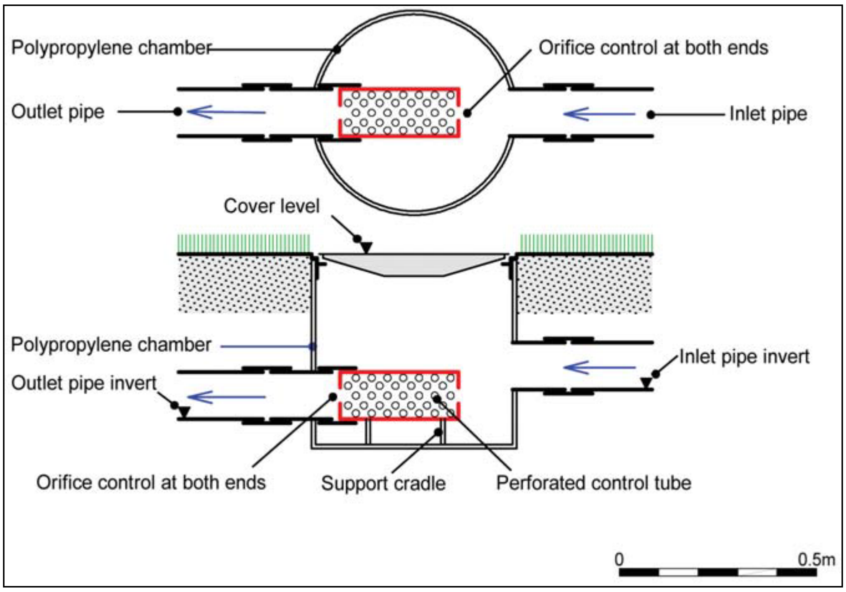

Fig 69 - Horizontal control tube for shallow installation 300-600mm

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- Reverse fall pipe outlet control

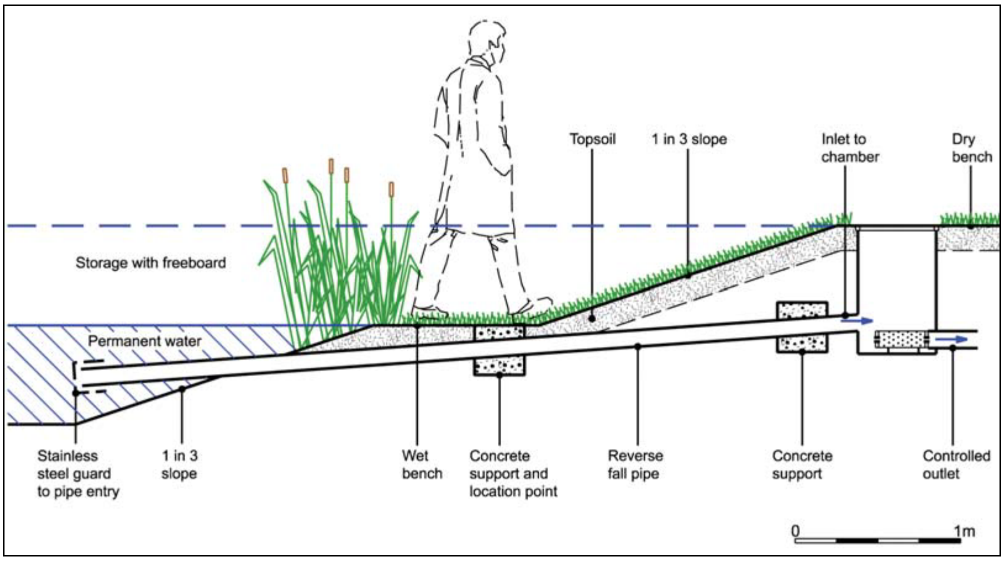

Fig 70 - Reverse fall pipe inlet control

- Vortex controls

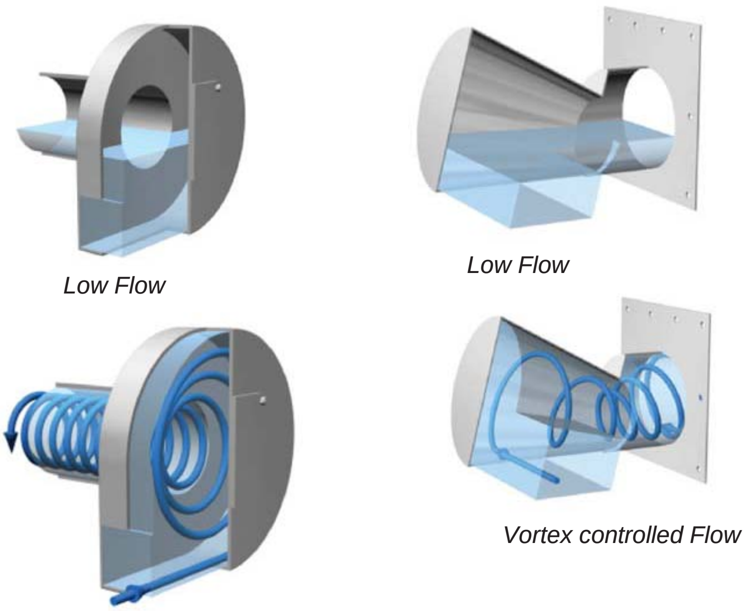

Fig 71 - Vortex controls - schematics

Chamber controls are convenient where water is controlled just below the surface or behind an outlet structure. It is important that controls are shallow, robust and easily understood for effective maintenance.

Pipe gradients from control devices should be greater than usual as there are generally no self cleaning flows in the pipe from the control mechanism.

When SUDS control structures receive more water than the anticipated design volume then surface spillways, or overflows integrated into the control structure, allow occasional large volumes of water to flow onward to the next part of the SUDS sequence.

6.9 Overflows

Overflows are needed for most SUDS features to deal with blockage or surcharge when the storage volume is exceeded. The overflow may be designed to transfer runoff to the next part of the management train until surcharge is reduced or to follow the exceedance flow route.

Off-line storage, not on the direct flow route of the water, may not need these overflows if water is diverted back through a by-pass structure from the on-line flow, and can flow back in the opposite direction. Overflows will take the form of a weir or spillway in open features, or a weir in the control structure returning runoff to the management train.

Overflow arrangements must be demonstrated for all SUDS structures.

6.10 Exceedance routes

An exceedance route is the ultimate safeguard when the SUDS, or parts of the system, are overwhelmed by exceptional rainfall.

The exceedance route protects the SUDS system, particularly low flow channels, from damage and directs water to overland routes that flow through open space in development or along roads to protect people and property.

Exceedance flow routes must be demonstrated for every development.

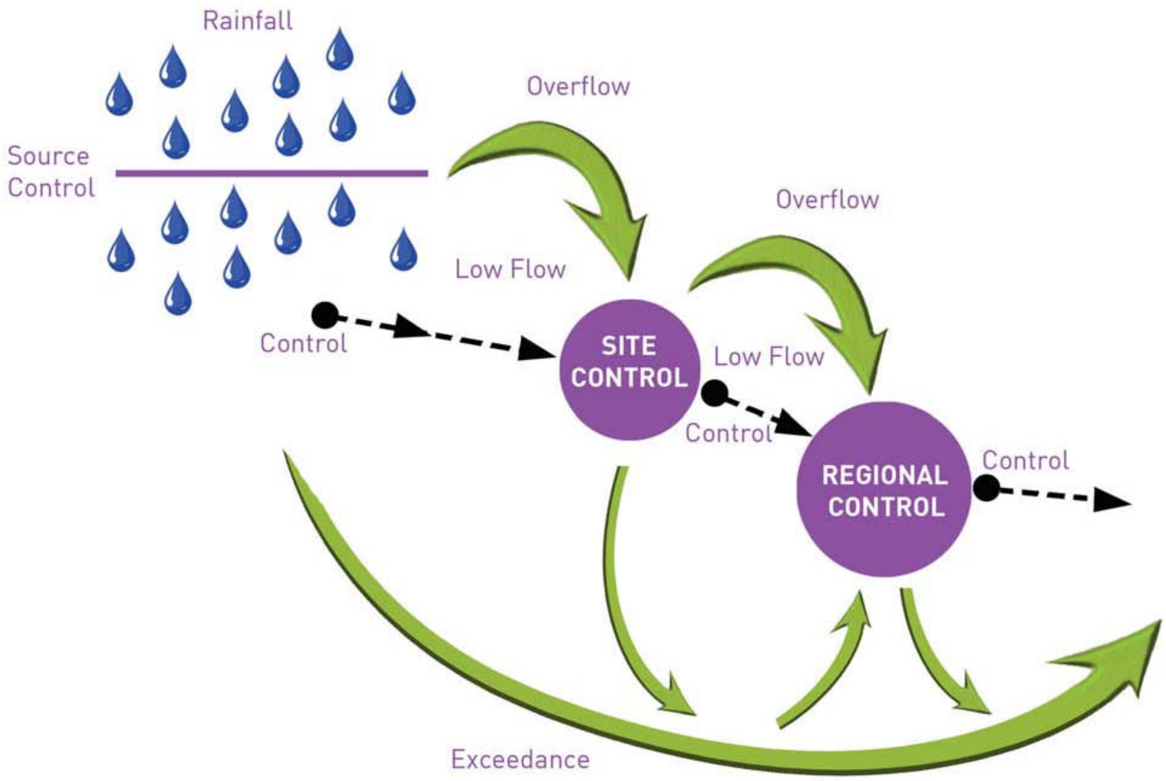

Fig 72 - Low flows, overflows and exceedance routes

7.0 LANDSCAPE DESIGN AND SUDS

This section explains how SUDS practitioners need to take account of the principles of Landscape Design so that SUDS are attractive features in the landscape and can be managed effectively during the construction process and when adopted for long term maintenance.

7.1 Design principles

SUDS features are usually visible being at or near the surface, unlike conventional drainage which is largely out of sight, and contribute to the quality of development.

Therefore the SUDS designer must understand landscape design principles to ensure the drainage system works effectively and provides environmental enhancement.

SUDS design should consider both hard and soft landscape features, integrating urban design and engineering with the planting and maintenance of soft surroundings to SUDS features.

SUDS design requires a multi-disciplinary approach to achieve acceptable outcomes.

This section considers the soft landscape requirements for SUDS:

- SUDS landscape must function effectively as soon as the drainage system becomes active and continue to do so for the design life of the development.
- Landscape design must take into account the consequence of flowing water, siltation, blockage of inlets and outlets and the design of permeable surfaces.
- Landscape specifications should avoid inorganic fertilizers, pesticides and herbicides that pollute water and mulches that can block SUDS features.

Fig 73 - Habitat swale and meadow by design and management - Hazeley School, Milton Keynes.

- Landscape maintenance should integrate with the care of SUDS features.
- Landscape design must integrate visual and landscape quality with the engineering requirements of SUDS.

7.2 Detail landscape design

Planting design around SUDS features is different to conventional landscape practice and must be designed to reduce pollution of the environment and with maintenance in mind.

Surfaces that receive direct flows of runoff

e.g. filter strips, swales, basins, inlets and outlets must be stabilised during or immediately on completion:

- grass surfaces should be turfed wherever possible.
- coir blanket (fully biodegradable) protection should be used outside the turfing season.

geo-jute mesh should be used to protect adjacent areas from surface erosion.

Grass surfaces surrounding infiltration structures, such as filter drains and permeable surfaces, should be turfed and fall away from the structure to prevent siltation.

Where water flows from a hard surface onto a grass surface the turf should be 20-25mm below the edge to ensure unobstructed flow and provide easy long term maintenance.

A 1 metre grass surround should be mown around inlets, outlets and control structures with overflow arrangements kept clear at all times during maintenance.

7.3 General planting guidelines

- All vegetation surrounding SUDS should comprise permanent ground cover with no bare areas or surface mulches to avoid silt or mulch migrating to SUDS structures.
- Planting areas should be slightly lower than the plant bed edge to prevent soil washing off during establishment.
- Consider planting in grass rather than plant beds to avoid soil disturbance.
- Planting in bio-retention areas requires dense ground cover and surface mulch at 150mm below the edge to intercept runoff silt and pollution.
- All aquatic planting to SUDS features that connect with natural wetlands must use native species from an accredited source to prevent the spread of alien species and enhance native habitat.
- Planting design should avoid the use of pre-fertiliser or inorganic slow release fertilisers to prevent nutrient enrichment that can migrate to open water features but consider organic soil conditioners as a replacement.
- Planting design should avoid the need for herbicides, pesticides and fungicides that are pollutants of the environment.
- All planting must be accessible and easily maintained using standard landscape techniques.
- Maintenance of vegetation should generally consist of grass cutting and simple shrub pruning and not disturbance of the soil profile.

7.4 Planting to ponds and wetland features

Wetland vegetation in open SUDS features plays a number of roles in managing runoff.

- Prevent erosion of soil surfaces.
- Trap silt and prevent re-suspension during storms.
- Filter and treat pollution.
- Provide wildlife habitat.
- Provide attractive surroundings.

Good practice will:

- Protect soil surfaces as soon as possible following construction.
- Establish cover quickly to prevent erosion.
- Use readily available plants and seed mixes.
- Use native species where connecting to natural habitat.
- Use plants and seed from an accredited source to prevent the spread of alien species.
- Ensure all planting can be easily maintained.

Topsoil should be used wherever vigorous vegetation cover is needed to ensure a robust surface that is resistant to erosion with good self-repair characteristics in the event of local damage. However topsoil should not be used below permanent water levels in ponds and wetlands. Topsoil depth for grass areas within SUDS features should generally be 150mm.

A normal purpose grown, amenity turf is acceptable for most SUDS situations including wet benches, filter strips and swales unless permanent inundation is expected. Amenity turf is always available and will develop local habitat character over time with natural colonisation.

There is a c ompromise between a robust surface vegetation resistant to flow of water and biodiversity criteria recommended for ecological planting. Specially seeded turf may be appropriate in sensitive habitat areas or where the surface is permanently wet.

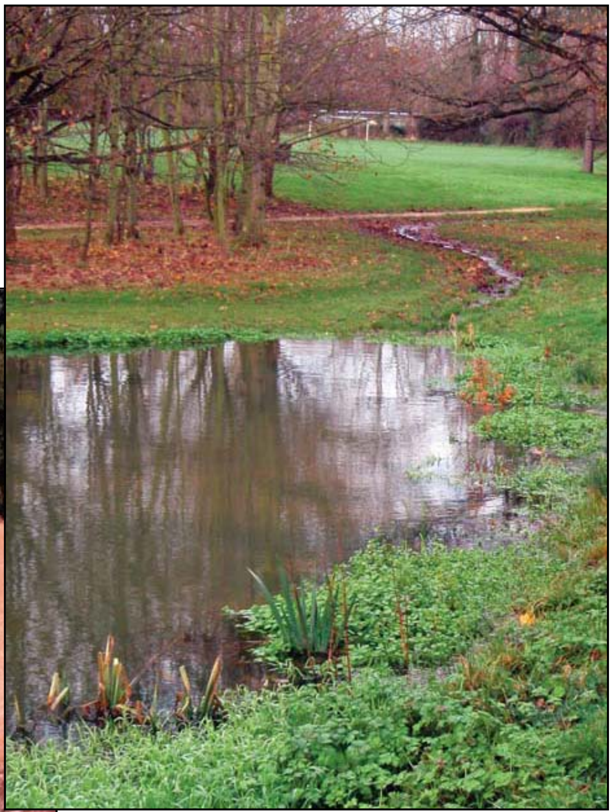

Fig 75 - Realigned spring fed channel and pondcreation, Matson Park, Robinswood Hill, Glos.

Fig 77 - Basin with dry bench, 1 in 3 slope, wet Bench and planted edge to 450mm deep water - Health and safety protocol at Hopwood Park MSA M42 J2

Fig 79 - Retrofit SUDS in Augustenborg, Malmo, Sweden

7.5 Plant selection

SUDS are often located in public areas and initial planting should take this into account by selecting native plants with visual interest. Local native plants will soon colonise wetland habitat and provide additional biodiversity interest.

All native planting must be obtained from an accredited source to ensure plants are true to name and avoid contamination by alien species

Planting density for ponds and wetlands is a minimum of 5 plants per m2 or 3 per linear meter depending on location. Planting should be in groups of 3 – 5 or multiples to create discreet plant groups.

ERECT MARGINAL PLANTS	LOW GROWING MARGINAL PLANTS	AGGRESSIVE PLANTS TO BE AVOIDED
Attractive native plants that can be used as an initial planting mix before natural colonisation occurs. **Yellow iris** (Iris pseudacorus) provides good foliage, flowers and seed pods and can be used as the dominant plant in many aquatic planting schemes. **Marsh woundwort** (Stachys palustris) **Purple loosestrife** (Lythrum salicaria) **Great water dock** (Rumex hydrolapathum) **Flowering rush** (Butomus umbellatus) **Hemp agrimony** (Eupatorium cannabinum) **Lesser pond sedge** (Carex acutiformis) **Lesser reed mace** (Typha angustifolia) **Meadowsweet** (Filipendula vulgaris) **Pendulous sedge** (Carex pendula)	**Amphibious bistort** (Persicaria amphibia) Watercress (Nasturtium officinale) **Marsh marigold** (Caltha palustris) **Water forget-me-not** (Myosotis scorpiodes) **Water mint** (Mentha aquatica) **Fine leaved water dropwort** (Oenanthe aquatica) **Floating sweet grass** (Glyceria fluitans) **Fool's water-cress** (Apium nodiflorum) **Brooklime** (Veronica beccabunga)	Native plants characteristic of high nutrient habitat can become dominant before levels fall to normal levels. **Great pond-sedge** (Carex riparia) **Reed canary-grass** (Phalaris arundinacea) **Reed sweet-grass** (Glyceria maxima) **Branched bur-reed** (Sparganium erectum) **Bulrush** (Typha latifolia)

STANDARD SEED MIXES

Grass surfaces for filter strips, swales, basins, dry or wet benches to wetlands and ponds can receive purpose grown (cultivated) amenity grade turf or an amenity seed as below or similar specification all on

150mm topsoil:

- 25% Perennial rye grass – Lolium perenne
- 15% Crested dogstail – Cynosurus cristatus
- 30% Slender creeping red fescue – Festuca rubra ssp litoralis
- 20% chewings fescue – Festuca rubra ssp commutata
- 10% browntop bent – Agrostis tenuis

include 10% creeping bent Agrostis stolonifera if possible include 2.5% white clover on poor soils if required

British provenance wildflower seed can be included in the grass mix

FLOWER MEADOW MIX

Grass areas adjacent to SUDS features can be attractive and biodiverse habitat.

Wildflowers: Mix composed of 20% wildflower seed and 80% grass seed. A specific mix may be

appropriate for special habitat creation.

%	Common Name	Species
5	Birdsfoot trefoil	Lotus corniculatus
8	Black knapweed	Centaurea nigra
5	Black medick	Medicago lupiuna
5	Common vetch	Vicia sativa
7	Meadow buttercup	Ranunculus acris
4	Musk mallow	Malva moschata
12	Ox Eye daisy	Leucanthemum vulgare
12	Ribwort plantain	Plantago lanceolata
8	Red campion	Silene dioica
13	Self heal	Prunella vulgaris
15	White campion	Silene alba
6	Yarrow	Achillea millifolium
Grasses: 80%		
7	Browntop bentgrass	Agrostis castellana
18.5	Red Fescue	Festuca rubra
21	Crested dogstail	Cynosurus cristatus
28.5	Meadow fescue	Festuca pratensis
25	Smooth stalk meadow grass	Poa pratensis

WETLAND AND POND EDGE MIX

Areas adjacent to unlined ponds where the soil remains permanently moist can become species rich wetland. Wild flowers: Mix composed of 20% wildflower seed and 80% grass seed.

%	Common Name	Species
2	Common fleabane	Pulicaria dysenterica
6	Gipsywort	Lycopus europaeus
6	Greater birdsfoot trefoil	Lotus uliginosus
4	Hemp agrimony	Eupatorium cannabinum
2	Marsh marigold	Caltha palustris
9	Marsh woundwort	Stachys palustris
8	Meadow rue	Thalictrum flavum
15	Meadowsweet	Filipendula ulmaria
5	Purple loosestrife	Lythrum salicaria
9	Ragged robin	Lychnis flos-cuculi
7	Sneezewort	Achillea ptarmica
6	Square stemmed St. John's wort	Hypericum tetrapterum
3	Water avens	Geum rivale
18	Yellow flag iris	Iris pseudacorus
Grasses: 80%		
5	Browntop bentgrass	Agrostis castellana
0.5	Common sedge	Carex nigra
20	Crested dogstail	Cynosurus cristatus
10	Meadow foxtail	Alopecurus pratensis
0.5	Pendulus sedge	Carex pendula
7	Rough meadow grass	Poa trivialis
38	Sheeps fescue	Festuca ovina
4	Sweet vernal grass	Anthoxanthum odoratum
15	Tufted hairgrass	Deschampsia caespitosa

ALIEN PLANTS TO AVOID AT ALL COSTS:

There are a few exotic plants that cause problems in native planting by outcompeting local species and in the worst case with

Crassula helmsii the habitat is overwhelmed by the newcomer.

Canadian pondweed (Elodea canadensis)

Nuttall's pondweed (Elodea nuttallii)

Curly waterweed (Lagarosiphon major)

Parrot's-feather (Myriophyllum aquaticum)

Water fern (Azolla filiculoides)

New Zealand swampstonecrop (Crassula helmsii)

Floating pennywort (Hydrocotyle ranunculoides) - this is often supplied as

Marsh pennywort (Hydrocotyle vulgaris)

Landscape Do's and Don't Checklist

DO

- Do use turf (or a coir blanket outside the turfing season) wherever water may flow on the surface.
- Do set turf or topsoil for seeded areas next to SUDS features 25mm below adjacent hard edges.
- Do dish planted areas near permeable surfaces (min. 50mm) and plant permanent ground cover.
- Do slope all topsoil away from permeable surfaces at a minimum 1 in 20 for at least 1m.
- Do use native wetland plants from accredited sources to avoid problem plants.
- Do use tree and specimen shrubs carefully to enhance swales, basins and wetlands.
- Do design planting to be managed by mowing and pruning but not to expose or disturb the soil profile.

DON'T

- Don't use fertilizers in planting or grass areas as they cause nutrient pollution to wetlands.
- Don't use herbicides near SUDS schemes as they pollute water and are unnecessary where design is considered.
- Don't cut grass too short as it must filter and control water flow.
- Don't use mulches as they block permeable surfaces, inlets, outlets and control structures.
- Don't use shrub beds with bare soil profile in grass or natural areas as they can generate silt.
- Don't worry if vegetation develops in unexpected ways as management will control future growth.
- Don't over-maintain SUDS vegetation as this reduces effectiveness and costs money.

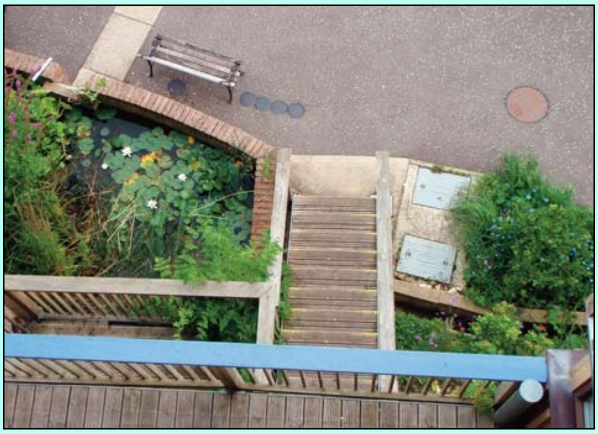

Fig 80 - Amenity pond as flow control device with T-piece pipe throttle and overflow to detention basin - Springhill Housing, Stroud.

8.1 Key Principles

Unlike conventional drainage, SUDS use landscape features to manage rainfall.

SUDS should be on or near the surface.

SUDS should be managed using landscape maintenance techniques rather than gully and pipe cleaning methods.

SUDS features should be simple, robust and easily maintained by landscape maintenance staff as part of normal site care activities.

Inlets, outlets, control structures or other below ground features should be shallow to allow easy access for maintenance and to reduce safety risks.

Site waste should be minimised by using source control techniques.

8.2 A SUDS management plan

A SUDS management plan must be provided at Detailed Design stage.

The document should comprise:

A SUDS overview – to provide a framework for the maintenance of the site setting out how the site will change with time and the operations required to achieve the management aims for the site.

The SUDS overview should explain:

- The function of SUDS.
- How and why it works on the site.
- Impacts on amenity and wildlife indicating how they can be enhanced.
- Health and safety issues.
- Long term expectations for the SUDS on site.

In many cases a simple Management Statement comprising a single page of explanation will be sufficient for this purpose.

A Specification – describes the materials to be used, how work is to be carried out with clauses that give instruction to the contractor. Again this may be a single page of notes for small schemes.

The Schedule of Work – sets out the tasks required to maintain the site and the frequency necessary to achieve an acceptable standard of work.

The Schedule of Work will often form the basis of a pricing mechanism, and can also act as a checklist to ensure the work as been carried out satisfactorily.

A SUDS Maintenance Schedule Summary may be sufficient for small sites and provides a convenient checklist for the contractor and site inspection and is shown below in section 8.3.

A Site Plan (Drawing) – showing maintenance areas, inlet, outlet and control structure positions, location of any other chambers, grating, overflows and exceedance routes.

Supporting documents - where these are appropriate e.g. details of wildlife piles, contact list, and spillage control procedure.

Fig 81 - Tracked vehicle with extending arm for pond vegetation and silt management - Hopwood Park MSA M42

8.3 SUDS MAINTENANCE SCHEDULE - SUMMARY

		Frequency	Unit Rate	Total
1.1	LITTER MANAGEMENT			
	Collect all litter in SUDS areas and remove from site	12 visits		
1.2	GRASS MAINTENANCE – all cuttings to compost or wildlife piles			
1.2.1	Amenity grass. Mow all grass verges, paths and amenity grass at 35-50mm with 75mm max.	16 visits or as reqd		
1.2.2	Mow all filter strips, swales, dry SUDS basins and margins to SUDS features at 100mm with 150mm max.	6 visits or as reqd		
1.2.3	Strim all wet swale, pond edges at 50mm in Sept- Oct annually or 3 year rotation for wildlife value	1 visit		
1.2.4	Wildflower areas strimmed to 50mm in Sept-Oct or Wildflower areas strimmed to 50mm July and Sept or Wildflower areas strimmed to 50mm on 3 year rotation 30% each year	1 visit 2 visits 1 visit		
1.2.5	All edges to hard surfaces strimmed	1 visit		
1.3	WETLAND AND POND VEGETATION – if necessary			
1.3.1	Wetland vegetation to be cut at 100mm in Sept - Oct in any one year or	1 visit		
1.3.2	Wetland vegetation to be cut at 100mm, on a 3 year rotation and 30% each year	1 visit		
1.4	WETLAND AND POND SILT - if necessary			
1.4.1	Excavate 30% of silt with vegetation to waste piles, stack and dry within 10M of the SUDS, spread, rake and overseed.	1 visit		
1.5	PLANTING			
1.5.1	Remove overhanging branches or growth in SUDS features	As reqd		
1.6	HARD SURFACES – including permeable paving			
	Sweep all paving regularly Sweep and suction brush permeable paving in autumn	As reqd 2 visits		
1.7	INLETS, OUTLETS AND GRATINGS			
1.7.1	Inspect monthly, remove silt and debris, strim 1m round	12 visits		
1.8	INSPECTION AND CONTROL CHAMBERS			
1.8.1	Annual inspection, remove silt and check free flow	1 visit		
1.9	SILT TRAP – surface and underground structures			
1.9.1	Monthly inspection and remove silt as necessary	12 visits		
1.10	LOW FLOW CHANNELS			
1.10.1	Inspect monthly, remove silt/debris and maintain edge	12 visits		
1.11	OVERFLOWS AND EXCEEDANCE ROUTES Confirm all flow routes are free from obstruction	12 visits		

8.4 Management programme

SUDS should be designed with maintenance in mind using both the hard and soft landscape to manage runoff from development. SUDS design should be visible, simple and robust to allow landscape contractors and site staff to understand how the SUDS work and care for the drainage on a day to day basis.

SUDS maintenance comprises:

Regular maintenance – for day to day care of the SUDS:

- **Litter collection.**
- **Grass cutting.**
- **Inspection** of inlets, outlets and control structures.

These activities are normally carried out monthly to coincide with regular landscape maintenance visits:

Occasional tasks – to manage silt and wetland vegetation accumulation:

- **Silt control** on hard surfaces, in silt traps and in SUDS features.
- **Vegetation management** in micro-pools, ponds and wetlands.

The activities are undertaken on a frequency determined by regular site inspection:

Remedial work – to repair unforeseen defects that occur during the design life of the system due to damage or vandalism.

Remedial action due to failure or damage will be required on an as necessary basis.

8.5 Performance and Frequency

SUDS maintenance is a combination of performance and frequency:

- **Performance** – a descriptive requirement for action such as cutting grass to a certain height irrespective of site visit frequency.
- **Frequency** – a regular activity such as litter collection or inspecting inlets, outlets and control structures, for example at monthly visits, deemed sufficient for the site.

Cost effective SUDS maintenance will depend on activities being integrated with general site care and full day visits for a maintenance team. This should be considered when management plans are being drawn up for a site.

8.6 Maintenance activities

Litter

Collection and removal of litter is a critical part of SUDS maintenance and is often included in general site maintenance to:

- Prevent inlet, outlet and control structure blockage.
- Allow grass maintenance.
- Control pollution.
- Ensure amenity value.

Litter should be removed from all sites at monthly site visits but more frequently for high profile development recognising that windblown litter will naturally collect in depressions such as swales, basins, wetlands and pond edges. This provides a convenient collection mechanism by concentrating litter in one place rather than occurring throughout the site. All litter, inorganic debris, rubbish and fly tipping should be removed from site to a designated refuse site.

Grass

Grass or other low dense vegetation has a number of SUDS functions including:

- Filtering runoff.
- Reducing the rate of runoff.
- Silt and sediment control.
- Protection of soil surfaces.
- Enhancing bio-remediation of pollutants in soil profiles.

It is therefore necessary to keep a dense cover of vegetation in SUDS features to ensure these functions can occur through the life of the development.

Amenity grass maintenance is often included in general site maintenance and it is important that verges, paths and amenity areas are mown regularly at 35-50mm to give

a cared for appearance and provide usable space for recreation.

Grass in SUDS features requires cutting at 75-100mm with a maximum height of 150mm to prevent grass falling over, or lodging as it is called, whilst allowing water to travel through the vegetation.

Although this management requirement is important when filter strips, swales and detention basins are first constructed, swales and basins can often develop robust natural vegetation that will not lodge and may therefore require only annual or mosaic maintenance. This approach offers a more visually interesting and ecologically rich habitat at reduced maintenance cost.

Grass around ponds and wetlands should be managed in a similar way to SUDS features to enhance biodiversity providing habitat and cover for wildlife. Where possible these biodiversity features should link to wildlife areas such as woodland, scrub or meadows to provide corridors for animal and plant dispersal.

All inlets, outlets, control structures should have a 1m mown surround, cut monthly at 35- 50mm, or hard apron to allow access and prevent blockage by vegetation.

All overflow routes and access routes should be mown regularly at 75-100mm with a maximum height of 150mm to allow surface flows and vehicle access at all times.

All cuttings and pruning can be managed on site in wildlife or compost piles to avoid green waste removal from site or be removed from site if necessary.

Log Pile 1

- Wildlife piles are a sustainable way of managing green waste on development sites.
- Wildlife piles provide a natural and cost effective wildlife resource.
- Wildlife piles offer educational opportunities in construction, monitoring and after use.

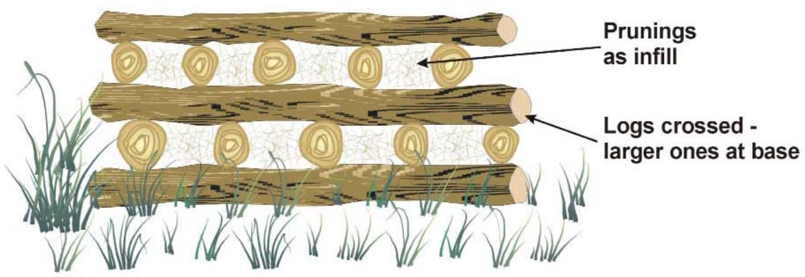

Fig 82 - Log pile - hibernation site.

- Select a sheltered corner either with some sun or in shade for varied wildlife needs.
- Pile logs and other woody material in a criss cross pattern up to about 1m high.
- The pile creates different micro habitats for wildlife and can be left as a permanent feature.

Log Pile 2

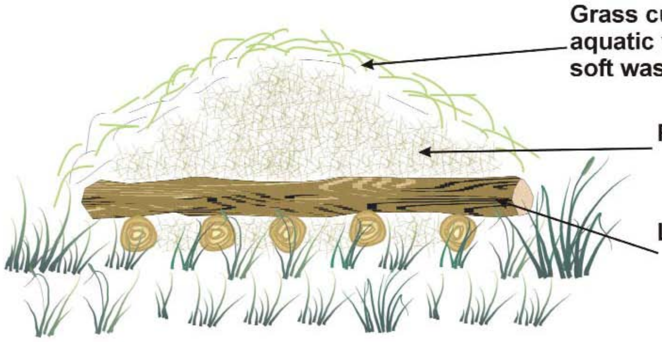

Fig 83 - Hibernation - grass snake egg laying site

- Select a sheltered corner with sun for at least half the day to allow basking sites for reptiles.
- Pile logs prunings and grass (or other soft vegetation) in sequence to 1-1.5m high.
- The pile will heat up during summer and attract many animals including slow worms and grass snakes that need heat to incubate their young and eggs.
- After 5 years the first pile can be used as compost and the process can be repeated.

Weed and invasive plant control

Normal maintenance of SUDS features and surrounding landscape will usually control undesirable weed species. SUDS features should generally use native planting of known provenance to avoid alien invasive plants becoming established.

However there are a few plants that require special control measures:

- Reedmace or bulrush (Typha latifolia) often colonises SUDS features in the early stages of wetland establishment and should be removed to allow a diverse plant community to develop. It is shallow rooting and can easily be removed by hand when young or removed mechanically if established.
- Willows (Salix spp.) can establish quickly in wetlands or pond edges and should be removed when young where necessary being careful to protect any waterproof liner.
- Alien species should be removed and prevented from establishing in SUDS systems. These include:
    - Himalayan Balsam
    - Giant Hogweed
    - Japanese Knotweed
    - Parrots-feather – Myriophyllum aquaticum
    - Canadian pondweed – Elodea canadensis
    - Nuttall's Pondweed - Elodea nuttallii
    - Curly pondweed – Lagerosiphon major
    - Water Fern – Azolla filiculoides
    - Floating Pennywort – Hydrocotyle ranunculoides
    - New Zealand Swamp Stonecrop – Crassula helmsii

New Zealand Swamp Stonecrop, in particular, is very difficult to remove once established and can have serious effects on wildlife habitats by smothering native vegetation and infilling ponds. It is resistant to herbicides and will spread from tiny pieces of the plant.

It is important to ensure that all planting is guaranteed native species of UK provenance or that habitat creation is through native seeding or natural colonisation. Therefore all native plants and seeds must be from an accredited source

Tree and shrub management

Normal landscape maintenance practice should be used to manage tree and shrub planting around SUDS features.

Wherever possible, native tree and shrub planting with native ground flora should be used to create a robust framework for SUDS.

This avoids the need for chemical treatment, herbicides or fertilizer and allows dense ground vegetation to develop so avoiding bare ground and the risk of silt movement.

It is important to cut back or remove any overhanging branches or self seeded trees and shrubs from vegetated SUDS to ensure a dense ground vegetation.

This work should be undertaken outside the bird nesting season and all prunings removed to wildlife or compost piles where these are present or removed from site.

Aquatic vegetation

Little maintenance is usually required for aquatic vegetation in the first 1 – 3 years of establishment apart from the control of undesirable weed species such as Typha latifolia (Reedmace).

Once established it will be necessary to remove dead vegetation and in some instances organic matter from wetlands and ponds. Recent experience suggests this is less frequently required than once thought, and shallow ponds with a flow of oxygenated water through the SUDS feature and interception of inorganic silt at source will reduce this to a minimum.

Work should be undertaken between September and November to avoid disturbance of nesting birds and protected species like the Water Vole and Great Crested Newt.

Wetland vegetation should be managed to create a mosaic effect removing no more than 25% - 30% at any one time. This practice ensures:

- The filtering capacity of the wetland is retained.
- The storage capacity of the wetland is retained.
- Biodiversity is conserved.
- Appearance is conserved.
- Costs are reduced.

Harvested vegetation should be allowed to de-water on the wetland or pond edge before removal to wildlife / compost piles or from site.

Appearance

A key requirement of maintenance is to provide a visually acceptable appearance to the public and a mown verge to SUDS features with clearly defined paths and access routes helps provide a cared for impression.

8.7 Waste management

Landscape and SUDS systems generate waste. SUDS are designed to intercept silt and allow natural breakdown of organic pollutants.

Regular maintenance of SUDS, including occasional removal of silt and vegetation that gathers in SUDS, is required to ensure long term performance of the system.

Management of waste will be agreed between Gloucester City Council and the Environment Agency.

The procedure for dealing with waste from SUDS must be simple to understand and allow straightforward maintenance on sites with low risk of pollution to people and the environment.

Waste evaluation for SUDS management

1. Where the site is Runoff catchment characteristic 1 or 2 as defined in the SUDS Manual then the risk of pollution is low to medium so silt and wetland vegetation can be managed on site without costly analysis. This category will include most day to day SUDS management areas including housing, schools, light commercial and car parking area.
2. Where the site is Runoff catchment characteristic 3 then the risk of significant pollution is high and analysis of silt should be undertaken where it is collected in a SUDS feature. This category will include industrial sites, HGV lorry parks and major roads. This may influence the design of the SUDS so that silt can be collected in discreet areas for evaluation and offsite disposal.
3. Where runoff is managed using source control elements and it can be demonstrated to intercept the majority of silt then additional SUDS features in the management train can be considered to be protected from significant pollution. Inorganic silt will be intercepted at source with organic silt and vegetation managed separately on site.
4. The SUDS evaluation at design stage will therefore determine the silt and wetland vegetation management approach for the site. The risk assessment undertaken to design appropriate treatment stages, as described in the SUDS Manual, will provide evidence for the management strategy.
5. The procedure identifies low to medium risk development where SUDS features will treat organic pollution in-situ with small amount of inorganic silt pollution retained on site. The landscape maintenance team can look after this type of development in a simple and efficient manner.
6. Sites are identified with special requirements that need measures in place to manage high pollution risk at appropriate locations in the management train. A requirement for silt analysis and disposal from site can be evaluated at the design stage to inform site management.

The Environment Agency has published a Regulatory Position Statement, entitled The Deposit and Dewatering of Non-Hazardous Silts from Sustainable Drainage Systems (SUDS) on Land, based on the principle of risk assessment of the SUDS type from which silt is removed.

Waste generated by SUDS

The types of waste generated by SUDS comprise:

- **Litter** from human activity.
- **Silt intercepted** at source in SUDS techniques close to where rain falls on hard surfaces.
- **Silt accumulation** where runoff is conveyed directly to SUDS features and settles at inlets, outlets or in control structures.
- **Silt** in wetlands or ponds that include both inorganic silt, if not trapped at source, and organic silt that develops in anaerobic conditions.
- **Grass** cuttings and prunings generated by regular maintenance.
- **Pond and wetland vegetation** removed by occasional maintenance.
- **Spillage** of materials or liquids likely to cause pollution effects.

Litter and other physical debris will be removed from site at regular site visits.

Organic pollution, like oils, milk or animal faeces, is broken down naturally by bacteria within the SUDS system.

Inorganic pollution like phosphorus is stored in the SUDS or in the case of nitrates broken down naturally by bacterial action.

Heavy metals should be trapped in the soil or construction profile of permeable surfaces or where silt is intercepted at source as runoff leaves hard surfaces rather than in wetland systems.

The management of waste from sites should be considered on the basis of risk to the public, maintenance personnel and the environment and be agreed with the Environment Agency before adoption and maintenance by Gloucester City Council.

Waste management based on risk assessment

Pollution risk is considered in Section 3.3 of the SUDS Manual and uses the management train concept to control pollution on development sites.

The number of treatment stages required to treat contaminants is based on pollution risk:

1. Roofs are considered low risk with only one treatment stage required in the management train.
2. Residential roads, parking areas and commercial zones are considered medium risk with two treatment stages required in the management train
3. Refuse collection, industrial areas, loading bays, lorry parks and highways are considered high risk with three or more treatment stages required in the management train

Where runoff is managed in small collection features at source then a major proportion of risk is managed at the beginning of the management train and pollution does not migrate down to SUDS features such as ponds and wetlands.

Fig 84 - Education in the swale maze, Red Hill Primary School, Worcs.

9.0 ADOPTION - DESIGN, CONSTRUCTION AND MAINTENANCE

9.1 Key Principles

Adoption is different to maintenance. Adoption is concerned with who takes responsibility for management, and maintenance is the activity of caring for the development.

Where SUDS are implemented within private property the landowner retains responsibility for the maintenance and effectiveness of the system.

Where SUDS are implemented in areas of multiple ownership, such as private housing, or where runoff flows from development into public open space then responsibility for the SUDS is transferred to another management body.

This transfer of responsibility is called the adoption process.

- **Adoption** : who takes responsibility
- **Maintenance** : who undertakes site care Gloucester City Council will consider adoption and maintenance of sustainable drainage systems (SUDS) in public open space subject to verification of design, construction and maintenance requirements set out in this document.

Gloucester City Council may consider adoption and maintenance of SUDS in development where surface features integrate with public open space subject to verification of design, construction and maintenance set out in this document.

9.2 SUDS in housing - SUDS management areas

Where SUDS are totally within a private property boundary then the whole system is the responsibility of the site owner. However housing landscapes, in particular, have distinct SUDS character areas that fall into 3 distinct types of maintenance based on the position of the techniques in the management train and site ownership patterns.

- **Private Property SUDS** – SUDS located within property boundaries are the responsibility of the property owner and may include green roofs, permeable driveways, water butts, garden soakaways and rain harvesting.
- **Source Control or Street SUDS** – SUDS located within development that provide a source control function and include filter strips, normal and under-drained swales, bio-retention areas and rain-gardens, filter drains, permeable pavement and other local infiltration systems. Underground storage structures such as oversized pipes and geo-cellular boxes are usually located in this area of management.
- **Public Open Space SUDS** – SUDS located in open green space, either owned by Local Authorities or with full public access provide conveyance and open storage of clean water that flows from development and include basins, ponds and wetlands linked by swales, linear wetlands and other open channels.

9.3 The Adoption Process

9.4 Design approval

Design approval of SUDS comprises three design stages:

- Conceptual Drainage Proposals
- Outline Drainage Proposals
- Details Drainage Design

Confirmation of critical features at each design stage is required to ensure adoption of a SUDS scheme

Conceptual Drainage Design

This preliminary design stage provides an opportunity for the developer to register an interest in adoption for a scheme and indicate the nature of the proposals and discharge location for development runoff.

Information required by the adopting body:

- Expression of intention to seek adoption
- A description and indicative plan of the development
- Preliminary flow routes, SUDS features and storage locations and discharge route

Outline Drainage Proposals

Outline drainage proposal requirements are defined in the SUDS Manual as follows:

The proposal should describe ideas for integrating the drainage system into the landscape or required public open space and the methods that will be used for linking systems together and managing flows in excess of the design event. At this stage there should be no need to submit initial calculations, but they should be carried out to roughly size any significant drainage structures.

1. Information required by the adopting body:
2. The proposed location and extent of SUDS techniques on the site shown on an Outline Drainage Proposals drawing.
3. An estimate of storage required for the development and where it is to be located.

4. The proposed location of a break point where adoption of the SUDS will begin and an outfall where runoff will enter the natural drainage system or the sewer system.

A Preliminary SUDS design statement to explain the proposals.

Detailed Design Proposals

Detail design proposals submitted for planning purposes and required by the adopting body will include will include:

1. Final layout drawing with levels.
2. Detail drawing of all SUDS elements for the scheme.
3. Appropriate calculations to show how storage volumes have been determined with location and volume of storage.
4. Location and details of inlets, outlets and control structures.
5. Details of low flow pathways, overflow arrangements and exceedance routes.
6. Copies of all relevant permissions or agreements.
7. A Management Plan.

9.5 Construction, inspection and verification

The construction phase of a SUDS scheme must demonstrate competent installation of SUDS features and verify that the correct materials have been used during the contract.

Confirmation of con struction competence at critical construction points is required to ensure adoption of a SUDS scheme.

The construction approval of SUDS requires three agreed stages:

- A Pre-contract meeting.
- An Adoption File during the contract.
- Post Contract Maintenance.

Pre-contract meeting

A pre-contract meeting with Gloucester City Council is necessary to inform the contractor, site agent and any supervising agent what documentary evidence is required at the end of the contract period to ensure adoption.

The critical site inspection points in the contract will be agreed at this meeting.

Adoption file

- Pre-contract adoption checklist.
- Critical construction stages for inspection and sign off. Signed and dated.
- Photographic record of SUDS installation. Signed and dated.
- Specification sheets for materials used in construction.
- As built level survey.
- As built drawings.
- Copy of Practical Completion Certificate.
- Copy of Final Completion Certificate.

The Council reserves the right to require opening of construction where agreed inspection points that have not been verified by an agreed party and at the Contractor's expense.

There is normally a 12 month period between Practical Completion and Final Completion to identify latent defects and carry out remedial work.

Post contract maintenance

The adoption process requires the contractor to maintain the site for an specified periond after Final Completion to ensure any remedial work is effective, the SUDS work properly and all vegetation is fully established.

Final Inspection

A final inspection is required to check that all surface SUDS features, all inlets, outlets and control structures are performing as required and to confirm that all pipe runs have been jetted and debris removed from all SUDS structures.

Severn Trent (ST)

ST may adopt structures if they connect to their existing system. Developers will need to contact the utility direct for more information in this

9.6 Maintenance

A Management Plan will be provided as part of Detail Design Proposals and include:

- A SUDS overview.
- Specification notes.
- A Schedule of work (including a summary for pricing and day to day inspection).
- A site plan.

Supporting documents.

The management plan will be the basis for the additional 5 years maintenance and any changes required to the plan will be made at Final Handover of the SUDS scheme.

Responsibility for the management of the SUDS scheme, from the break point in the development where adoption begins to the final infiltration feature, outfall to a watercourse or discharge point to the sewer, will be confirmed subject to all the above conditions being met and agreed with Gloucester City Council.

APPENDIX 1 - GLOSSARY

Amenity The quality of being pleasant or attractive; agreeableness

Aquatic bench A horizontal strip lying just beneath the water surface on which aquatic planting is established.

Aquifer A sub-surface zone or formation of rock or soil containing a body of groundwater.

Attenuation Reduction of peak flow and increased duration of a flow event.

Balancing pond A pond designed to attenuate flows by storing runoff during the storm and releasing it at a controlled rate during and after the storm. The pond always contains water.

Base flow The sustained flow in a channel or drainage system.

Basin A ground depression acting as a flow control or water treatment structure that is normally dry and has a proper outfall, but is designed to detain stormwater temporarily.

Binder course European standard description of the second layer of an asphalt pavement currently known in the UK as basecourse.

(BOD) Biodegradable Capable of being decomposed by bacteria or other living organisms.

Biodiversity The diversity of plant and animal life in a particular habitat.

Bioretention area A depressed landscaping area that is allowed to collect runoff so it percolates through the soil below the area into an underdrain, thereby promoting pollutant removal.

Brownfield site A site that has been previously developed.

Bund A barrier, dam or mound usually formed from earthworks material and used to contain or exclude water (or other liquids) from an area of the site.

Catchment The area contributing surface water flow to a point on a drainage or river system. Can be divided into sub-catchments.

Catchpit A small chamber incorporating a sediment collection sump which the runoff flows through.

Combined sewer A sewer designed to carry foul sewage and surface runoff in the same pipe.

Construction (Design and Management) Regulations 1994 Emphasises the importance of addressing construction management health and safety issues at the design phase of a construction project.

Control structure Structure to control the volume or rate of flow of water through or over it.

Conventional drainage The traditional method of drainage surface water using subsurface pipes and storage tanks.

Conveyance Movement or water from one location to another.

Critical duration event The duration of rainfall event likely to cause the highest peak flows at a particular location, for a specified return period event.

Cross-contamination Pipes carrying mains water connected to pipes carrying non-potable water.

Curtilage Land area within property boundaries.

Design standards A set of standards agreed by the developer, planners, and regulators that the proposed system should satisfy.

Detention basin A vegetated depression that is normally dry except following storm events.Constructed to store water temporarily to attenuate flows. May allow infiltration of water to the ground.

Detention pond A pond that has a lower outflow than inflow. Often used to prevent flooding.

Diffuse pollution Pollution arising from landuse activities (urban and rural) that are dispersed across a catchment, or sub-catchment, and do not arise as a process effluent, municipal sewage effluent, or an effluent discharge from farm buildings.

Discharge consent Permission to discharge effluent, subject to conditions laid down in the consent, issued by the relevant environment regulator.

Dissolved Oxygen The amount of oxygen dissolved in water. Oxygen is vital for (DO) aquatic life, so this measurement is a test of the health of a river. Used as a water quality indicator.

Ecology All living things, such as trees, flowering plants, insects, birds and mammals, and the habitats in which they live.

Ecosystem A biological community of nteracting organisms and their physical environment.

Eutrophication Water pollution caused by excessive plant nutrients that results in reduced oxygen levels. The nutrients are powerful stimulants to algal growth which in turn use up oxygen in water.

Filter drain A linear drain consisting of a trench filled with a permeable material, often with a perforated pipe in the base of the trench to assist drainage.

Filter strip A vegetated area of gently sloping ground designed to drain water evenly off impermeable areas and to filter out silt and other particulates.

Filtration The act of removing sediment or other particles from a fluid by passing it through a filter.

First flush The initial runoff from a site or catchment following the start of a rainfall event. As runoff travels over a catchment it will collect or dissolve pollutants, and the first flush portion of the flow may be the most contaminated as aresult.

Flood frequency The probability of a flow rate being exceeded in any year.

Flood plain Land adjacent to a watercourse that would be subject to repeated flooding under natural conditions. For planning purposes this is defined as having a 1 in 100 year or greater annual probability of flooding (rivers)

Flood routing Design and consideration of above-ground areas that act as pathways permitting water to run safely over land to minimise the adverse effect of flooding. This is required when the design capacity of the drainage system has been exceeded.

Flow control device A device used for the control of surface water from an attenuation facility, eg. a weir.

Forebay A small basin or pond upstream of the main drainage component with the function of trapping sediment.

Freeboard Distance between the design water level and the top of a structure, provided as a precautionary safety measure against early system failure.

Foul drainage The infrastructure that drains the water and sewage that is discharged from within houses.

Geocellular Structure A plastic box structure used in the ground, often to attenuate runoff.

Geomembrane An impermeable plastic sheet, typically manufactured from polypropylene, high density polyethylene or other geosynthetic material.

Geotextile A plastic fabric that is permeable.

Green roof A roof with plants growing on its surface, which contributes to local biodiversity. The vegetated surface provides a degree of retention, attenuation and treatment of rainwater, and promotes evapotranspiration.

Greenfield runoff The surface water runoff regime from a site before development, or the existing site conditions for brownfield **redevelopment sites.**

Groundwater Water that is below the surface of ground in the saturation zone.

Groundwater zone Areas that influence water supply boreholes must be protected from pollution. These are defined by reference to travel times of pollutants within the groundwater. See the Environment Agency's Policy and Practice for the protection of groundwater for specific details.

Gully Opening in the road pavement, usually covered by metal grates, which allows water to enter conventional drainage systems.

Habitat The area or environment where an organism or ecological community normally lives or occurs.

Heavy metal Loosely, metals with a high atomic mass, often used in discussion of metal toxicity. No definitive list of heavy metals exists, but they generally include cadmium, zinc, mercury, chromium, lead, nickel, thallium, and silver.

Highways Agency The government agency responsible for strategic highways in England, ie. motorways and trunk roads.

Highways Authority A local authority with responsibility for the maintenance and drainage of highways maintainable at public expense.

Highway Drain A conduit draining the highway, maintainable at the public expense and vested in the highway authority.

Hydraulics Hydraulics is another term for fluid mechanics used in the context of water engineering, and is the study of flows. In the context of this report, hydraulics covers the storage, conveyance and control of flows within the proposed drainage network.

Impermeable Will not allow water to pass through it.

Infiltration The passage of surface water Into the ground.

Infiltration basin A dry basin designed to promote infiltration of surface water into the ground.

Infiltration device A device specifically designed to aid infiltration of surface water into the ground.

Infiltration trench A trench, usually filled with permeable granular material, designed to promote infiltration of surface water to the ground.

Interception storage The capture and infiltration of small rainfall events up to about 5mm

Interflow Shallow infiltration to the soil, from where it may infiltrate vertically to an aquifer, move horizontally to a watercourse, or be stored and subsequently evaporated.

Long-term storage Control of volumes during extreme rainfall events by discharging additional water very slowly during and after the storm event.

Management train The management of runoff in stages as it drains from a site.

Micropool Pool at the outlet to a pond or wetland that is permanently wet and improves the pollutant removal of the system.

Model agreement A legal document that can be completed to form the basis of an agreement between two or more parties regarding the maintenance and operation of sustainable water management systems.

Nutrient A substance providing nourishment for living organisms (such as nitrogen and phosphorus).

Off-line Dry weather flow bypasses the storage area.

On-line Dry weather flow passes through the storage area.

Orifice control Structure with a fixed aperture to control the flow of water.

Percentage runoff The proportion of rainfall that runs off a surface.

Percolation The passing of water (or other liquid) through a porous substance or small holes (eg. soil or geotextile fabric).

Permeability A measure of the ease with which a fluid can flow through a porous medium. It depends on the physical properties of the medium, for example grain size, porosity, and pore shape.

Permeable A permeable surface that is paved and drains through voids pavement between solid parts of the pavement.

Permeable surface A surface that is formed of material that is itself impervious to water but, by virtue of voids formed through the surface, allows infiltration of water to the sub-base through the pattern of voids, for example concrete block paving.

Pervious surface A surface that allows inflow of rainwater into the underlying construction or soil.

Point source pollution Pollution that arises from an easily identifiable source, usually an effluent discharge pipe.

Pollution A change in the physical, chemical, radiological or biological quality of a resource (air, water or land) caused by man or man's activities that are injurious to existing, intended or potential uses of the resource.

Pond Permanently wet depression designed to retain stormwater above the permanent pool and permit settlement of suspended solids and biological removal of pollutants.

Porous asphalt An asphalt material used to make pavement layers pervious, with open voids to allow water to pass through (previously known as pervious macadam).

Porous surface A surface that infiltrates water to the sub-base across the entire surface of the material forming the surface, for example grass and gravel surfaces, porous concrete and porous asphalt.

Porous paving A permeable surface that drains through voids that are integral to the pavement.

Potable/mains water Water company, utility, authority drinking water supply.

Proper outfall An outfall to a watercourse, public sewer and in some instances, an adopted highway drain. Under current legislation and case law, having a proper outfall is a prerequisite in defining a sewer.

Public sewer A sewer that is vested and maintained by the sewerage undertaker.

Rainfall event A single occurrence of rainfall before and after which there is a dry period that is sufficient to allow its effect on the drainage system to be defined.

Rainwater butt Small scale garden water storage device which collects rainwater from the roof via the drainpipe.

Rainwater harvesting A system that collects rainwater from where it falls rather than allowing it to drain away.

Recharge The addition of water to the groundwater system by natural or artificial processes.

Retention pond A pond where runoff is detained for a sufficient time to allow settlement and biological treatment of some pollutants.

Return period Refers to how often an event occurs. A 100-year storm refers to the storm that occurs on average once every hundred years. In other words, its annual probability of exceedance is 1% (1/100).

Risk The chance of an adverse event. The impact of a risk is the combination of the probability of that potential hazard being realised, the severity of the outcome if it is, and the numbers of people exposed to the hazard.

Risk assessment “A carefully considered judgement” requiring an evaluation of the consequences that may arise from the hazards identified, combining the various factors contributing to the risk and then evaluating their significance.

Runoff Water flow over the ground surface to the drainage system. This occurs if the ground is impermeable, is saturated or rainfall is particularly intense.

Runoff co-efficient A measure of the amount of rainfall that is converted to runoff.

Section 38 An agreement entered into pursuant to Section 38 Highways Act 1980 whereby a way that has been constructed or that is to be constructed becomes a highway maintainable at the public expense.

Sediments The layers of particles that cover the bottom of water-bodies such as lakes, ponds, rivers and reservoirs.

Separate sewer system A sewer for surface water or foul sewage, but not a combination of both.

Sewer A pipe or channel taking domestic foul and/or surface water from buildings and associated paths and hard-standings from two or more cartilages and having a proper outfall.

Sewerage undertaker This is a collective term relating to the statutory undertaking of water companies that are responsible for sewerage and sewage disposal including surface water from roofs and yards of premises.

Sewers for Adoption A guide agreed between sewerage undertakers and developers (through the House Builders Federation) specifying the standards to which private sewers need to be constructed to facilitate adoption.

Silt The generic term for waterborne particles with a grain size of 4-63mm, ie. between clay and sand.

Soakaway A sub-surface structure into which surface water is conveyed, designed to promote infiltration.

Source control The control of runoff at or near its source.

Sub-base A layer of material on the sub grade that provides a foundation for a pavement surface.

Sub-catchment A division of a catchment, to allow runoff to be managed as near to the source as is reasonable.

Sub-grade Material, usually natural in-situ, but may include capping layer, below formation level of a pavement.

SUDS Sustainable drainage systems: an approach to surface water management that combines a sequence of management practices and control structures designed to drain surface water in a more sustainable fashion than conventional techniques.

Sump A pit that may be lined or unlined and is used to collect water and sediments before being pumped out.

Surface course European standard description of the top layer of an asphalt pavement currently known in the UK as wearing course.

Surface water Water that appears on the land surface ie. lakes, rivers, streams, standing water, and ponds.

Suspended solids General term describing suspended material. Used as a water quality indicator.

Swale A shallow vegetated channel designed to conduct and retain water, but may also permit infiltration. The vegetation filters particulate matter.

Time of entry Time taken for rainwater to reach an inlet into the drainage system after hitting the ground.

Treatment Improving the quality of water by physical, chemical and/or biological means.

Void ratio The ratio of open air space to solid particles in a soil or aggregate.

Watercourse A term including all rivers, streams, ditches, drains, cuts, culverts, dykes, sluices, and passages through which water flows.

Water quality The proportion of total runoff from impermeable areas that is treatment volume captured and treated to remove pollutants.

Water table The point where the surface of groundwater can be detected. The water table may change with the seasons and the annual rainfall.

Weir Horizontal structure of predetermined height to control flow.

Wetland Flooded area in which the water is shallow enough to enable the growth of bottom-rooted plants.

Whole life cost The present day value of total costs of a structure throughout its likely operating life.

The SUDS proposal must demonstrate (page 1 of 3)

1	The SUDS philosophy objectives have been met in the overall design: • control of flooding • prevention of pollution • benefits for the community • wildlife opportunities	☐
2	How the original drainage pattern for the site has been considered in the design	☐
3	How existing flow patterns aremodified to provide low flow routes, overflows and exceedance pathways	☐
4	The use of the management train concept in the drainage design	☐
5	How source control measures have been used at the beginning of the SUDS	☐
6	The division of the development into sub-catchments to manage runoff	☐

The SUDS proposal must demonstrate (page 2 of 3)

7	How the storage hierarchy manages flows and volumes of runoff	☐
8	The destination of runoff – to infiltration, watercourses or the sewer as a last resort	☐
9	The SUDS Design Process • SUDS infrastructure planning where possible • Conceptual Drainage Design where appropriate • Outline Drainage Proposals to allow full consultation • Detail Design for final planning review	☐
10	Design Criteria meet the requirements of the SUDS philosophy and guidance set out in the SUDS Manual • Quantity or control of flooding • Quality or prevention of pollution • Amenity or benefits for the community • Biodiversity or wildlife opportunities	☐
11	Hydraulic criteria set out in the SUDS manual and agreed with the Environment Agency – generally flow rates and storage volumes	☐
12	Sufficient treatment stages are provided for each sub catchment to manage pollution	☐
13	First flush volumes are intercepted and treated at source	☐

The SUDS proposal must demonstrate (page 3 of 3)

14	Appropriate SUDS components have been used to manage runoff	☐
15	Inlets, outlets and control structures are safe, robust, easily maintained and visually acceptable inspection and provide an attractive and multifunctional landscape	☐
16	The SUDS design is understandable to site managers on visual	☐
17	The Landscape proposals take into account the requirements of SUDS	☐
18	That Health and Safety measures meet the requirements of this Guide and the requirements of Gloucester City Council	☐
19	That the maintenance of the SUDS is simple, cost effective and confirmed in a management plan	☐
20	The Adoption arrangements are acceptable to Gloucester City Council	☐

APPENDIX 3 - SUDS AMENITY AND BIODIVERSITY CRITERIA REVIEW

Amenity and Biodiversity Criteria are not well developed in current guidance. This appendix illustrates an approach to SUDS amenity and biodiversity criteria and evaluation based on landscape character and wildlife potential for SUDS.

AMENITY

- Definition – amenity provides a 'useful or pleasant facility' (Collins Dictionary)
- Visibility – SUDS should be at or near the surface and are therefore subject to the same cultural judgement as any other visual environmental discipline.
- Visibility requires evaluation of SUDS design for both amenity and biodiversity.
- A pre-condition for both Amenity and Biodiversity is a controlled flow of clean water that meets Quality and Quantity Criteria set out in current guidance
- Source control is required to provide clean water within development and allow Amenity & Biodiversity close to where people live.

Amenity criterion 1:

Legibility: telling the water story along the SUDS 'management train' – visibility and understanding.

Amenity criterion 2:

Elemental water: a controlled flow of clean water before public access or use. Source control must be provided within development.

Amenity criterion 3:

Conveyance and containment: each component of the SUDS sequence must contribute to landscape quality.

Amenity criterion 4:

Usefulness and SUDS: each SUDS component must be considered for other uses or as multi-functional space.

Amenity criterion 5:

Inlets, outlets and control devices: all visible SUDS structures must be attractive, interesting or visually neutral but not ugly.

Amenity criterion 6:

Health and safety: assess and manage risk for open water, gratings and sumps, slip and trip hazards, flow control structures, and other risks in the landscape.

Amenity criterion 7:

Management: public acceptance and enjoyment of SUDS requires a clear maintenance strategy to demonstrate the SUDS are cared for and will function for the life of the development

BIODIVERSITY

- Definition – Biodiversity: the diversity of plant and animal life in a particular habitat (The SUDS Manual C 697 2007)
- SUDS landscape comprises both wetland and surrounding terrestrial habitat
- Ecological value is affected by existing habitat, environmental design of the development and management
- There are 3 key factors for high biodiversity in ponds
  - unpolluted water
  - close proximity to wetland habitat
  - varied design
- Source: Ponds, pools and lochans – Guide on good practice in the management of small water bodies in Scotland - SEPA and Ponds Conservation Trust

Biodiversity criterion 1:

Clean water: A management train with source control ensures a controlled flow of clean water for biodiversity within development before water enters wetland SUDS features

Biodiversity criterion 2

Connectivity: links between existing and proposed wetland and ponds enhance natural colonisation and habitat resilience for wildlife

Biodiversity criterion 3

Structural diversity: varied profiles both vertically and horizontally provide maximum habitat potential

Biodiversity criterion 4:

Terrestrial habitat: opportunities for wildlife enhancement extend beyond wetlands and ponds to provide connectivity and integrated ecological design

Biodiversity criterion 5:

Nutrient control: low fertility measures generally promote habitat diversity and reduce maintenance costs (except where needed for a SUDS function)

Biodiversity criterion 6:

Native planting: local or national provenance seed and planting ensure habitat integrity with guarantees that recognised alien weeds are absent

Biodiversity criterion 7:

Management: mosaic habitat management with mown access paths and edges ensure wildlife friendly SUDS and public acceptance.

APPENDIX 4 - HEALTH AND SAFETY CONSIDERATIONS

Health and Safety issues are an important consideration for all SUDS design.

A Health and Safety review of SUDS features involves both a consideration of cultural acceptance as well as a practical assessment of risk and consequence. Society generally accepts the benefits and desirability of clean, attractive and safe water features in public open space.

All open water features should be assessed for risk, particularly regarding small children, and will demonstrate that all reasonable measures have been taken to minimise the risk of drowning or harm in any other way.

All structures, such as headwalls and concrete details, associated with SUDS will be evaluated for risk to the public, maintenance staff and wildlife.

The SUDS designer will demonstrate measures taken to reduce the possibility of harm to the public or maintenance staff and will be agreed with Gloucester City Council during the design process.

SAFETY MEASURES THAT REDUCE RISK INCLUDE:

- Where toddlers under 5 may have unsupervised access to open SUDS features, a toddler proof fence 600 – 750mm high will be required.
- High fences can create their own hazards, prevent rescue and become visually unacceptable. Unless required for toddlers or other vulnerable groups then fences should not be required for SUDS features that meet the criteria agreed in this Guide.
- Where a person could fall more than 2m, a fence should be considered (this situation should be designed out of a scheme wherever possible).
- A level dry bench at the top of all open
- structures, 1m minimum wide, allows stationary rest for a person and safe access.
- Slopes of 1 in 3 or less allow people and grass cutting machinery to enter and leave SUDS features easily and safely.
- A wet bench, 1m minimum wide, to all water features allows stationary rest for a person and safe access to water.
- Slopes of 1 in 3 or less into shallow water allow people to enter and leave wetland edges easily and safely.
- A maximum permanent depth of 600mm for wetlands and ponds is acceptable for SUDS and wildlife needs unless the feature is designed as an amenity lake.
- A maximum storage depth of 450mm is acceptable for swales.
- A maximum storage depth of 600mm is acceptable for ponds and wetlands.
- Unrestricted visibility is required to all accessible water features.
- Dense marginal planting to water is advised to reduce the risk of falling into water accidentally but should not to obscure visibility
- Headwalls, manholes, inlets, outlets, control structures and hard vertical surfaces that can be a trip hazard or create a hard surface near open water should re-designed and be located a safe distance from the water's edge.
- Gullies, silt trap pits, catchpits and other sumps should be avoided wherever possible to reduce risk to wildlife and pedestrians.

- All structures in the SUDS landscape should be assessed for Health and Safety during the design process.

The Construction, Design and Management (CDM) Regulations (DETR 1994) must be applied to the planning, design, construction and long-term maintenance of SUDS (see The SUDS Manual 2.5.10). For example:

- All SUDS features must provide safe and secure access for maintenance.
- Access points for vehicles should be level, secure and stable.
- Access may be available to all parts of a SUDS feature and at least from one side for machine work.

Danger signs and life saving equipment to SUDS features should not be necessary where the conditions set out above are followed as SUDS should be considered inherently safe features in the landscape.

Information about SUDS

Education and information boards should be provided wherever required by Gloucester City Council to ensure residents and visitors understand SUDS design and the SUDSfeatures used on the site.

APPENDIX 5 - THE ROLE OF PONDS AND WETLANDS IN THE SUDS MANAGEMENT TRAIN

The role of SUDS ponds and wetlands is under review due to new research on pollution breakdown, entry into the wildlife food chain and a reappraisal of the value of amenity and biodiversity features in the SUDS landscape.

Pollution

In the past ponds have been considered as treatment mechanisms for polluted runoff but now it appears that these valuable amenity features cannot treat many oils effectively, which remain for long periods in anaerobic sediments. Pollutants that include heavy metals and long lasting hydrocarbons may be re-circulated in wildlife through natural food chains.

Surface SUDS features further up the management train, that allow alternate wetting and drying of sediments with access to UV light, have been found to provide better treatment of organic pollutants and offer protection for downstream wetland systems.

SUDS ponds can deal with dissolved pollutants such as nitrates and phosphorus and are effective storage structures,

The SUDS management train should be designed to deliver silt and pollution free runoff to ponds and wetlands, with possible light loading of dissolved pollution that can be processed in the water column by micro-organisms. Ponds and wetlands should be viewed as polishing features where poor water quality does not compromise amenity, biodiversity and management requirements.

Treatment volume Vt

The concept of the treatment volume or Vt. was used for sizing ponds before the development of the management train concept and before research into the fate of pollutants and risk to wildlife became evident.

The treatment volume Vt, usually the first 10 – 15mm of runoff from hard surfaces, should be collected at source, and directed through an appropriate series of treatment stages to remove silt and pollution before water reaches ponds and wetlands.

Ponds and wetland features should not be considered primary treatment stages but final components in the SUDS systems with storage, amenity and bio-diversity value to the community.

Site and regional controls, usually basins, ponds and wetlands, with inter-linking conveyance swales should therefore be free of inorganic silt and pollution to ensure the public can have confidence in a safe, attractive and bio-diverse environment.

Health and Safety

Some SUDS guidance recommends dense planting at the pond edge to prevent public access but many natural ponds have a mosaic of vegetation types at the margins.

Recent research suggests that people like to see the water and wildlife in their local pond with direct access to the water's edge. A high stand of Reed (Phragmites australis) will prevent this connection and may not be appropriate for amenity water features.

A depth of 500-600mm is the usual depth of natural ponds in Britain and the shallow margin is the most biodiverse area of the pond. The work of the Pond Conservation Trust has demonstrated that the traditional pond profile with depths of 1-2M is unnecessary for habitat ponds and can be a health and safety issue.

A pond profile with a dry bench at the top to allow people to stand and assess the pond, gently sloping sides to provide easy access for the public and maintenance staff with a wet bench before a further gentle slope enters the water is considered safe in most situations as it allows adults and young children to stand up and walk safely out of a pond.

Full visual access to ponds and wetlands gives confidence for assessment and action.

A fence, other than for toddlers, can be considered a significant risk to young people and prevent access for rescue.

This approach ensures a more attractive, interactive and natural environment that can be enjoyed by the public.

Waste

Control of inorganic silt at source ensures minimal build up of silt in ponds or wetland structures. Shallow ponds accumulate organic silt slowly due to regular flushing through by oxygenated flows of water that breakdown organic matter.

If silt removal is required then, subject to Environment Agency approval, remove no more than 30% of accumulated silt and excess vegetation to protect bio-diversity and filtration potential of the pond. Allow dewatering to occur before spreading the silt on adjacent land outside the SUDS design profile with vegetation to wildlife or compost piles on site.

The local Environment Agency should be consulted to confirm a sustainable, cost effective and practical route for waste management that meets the requirements of current legislation.

APPENDIX 6 - SUDS GUIDANCE

There are an increasing number of documents available to assist planners, designers and assessors of SUDS.

- The main SUDS guidance document is the SUDS manual:- CIRIA Report 687 2007
- Ponds, pools and wetlands – Guidance on good practice in the management and creation of small waterbodies in Scotland. SEPA - Scottish Environment Protection Agency. This provides the best available information on creating ponds and wetlands in Britain.
- Building Regulations Part H, Drainage and Waste Disposal states that infiltration should be considered as the first disposal route for rainfall followed by watercourses and finally the sewer as a last resort.
- Interpave - Guide to the Design, Construction and Maintenance of Concrete Block Permeable Pavements www.paving.org - a resource for frequently asked questions about permeable block paving.
- The Flood and Water Management Bill 2010 together with the National Standard for Sustainable Drainage Systems (SUDS) will be key new guidance.
- Consult the CIRIA website for further guidance www.ciria.org/SUDS

MAINTENANCE COSTS DECEMBER 2008

These costs have been derived from a review of 2 sets of prices provided by two Landscape Contractors with some experience of SUDS.

These costs assume:

- 2 men on site for 1 day – cost between £400-600 depending on equipment costs
- 25 mile maximum travel distance to site
- 100m^2 minimum area for maintenance activity

The number of visits indicated is for any one year unless otherwise stated

Activity	Frequency	Unit	Cost/Unit	Check
1.0 Litter All litter, debris and rubbish removed from site at monthly visits.				
1.1 Grass Areas	Monthly	m^2	0.20	
1.2 Wetland or Pond Areas	Monthly	m^2	0.25	
Comments: • Litter quantity and characteristics are dependent on the site • Litter collects in swales, basins and wetland features which allows simple collection • Litter collection is part of landscape maintenance • Litter collection should be undertaken at each site visit and the beginning of any maintenance task, particularly grass cutting • All litter must be removed from site				

Activity	Frequency	Unit	Cost/Unit	Check
2.0 GRASS CUTTING				
2.1 Amenity Grass – verges and surrounding amenity areas may require fortnightly visits in wet summers and at least 12 visits to keep grass at 35-50mm				
Pedestrian	Monthly	m^2	As schedule	
Vehicle	Monthly	m^2	As schedule	
2.2 Swales, filter strips, basins, other surfaces receiving water flow and habitat edges 100 – 150mm				
Pedestrian	6 visits/yr	m^2	£0.08	
Vehicle	6 visits/yr	m^2	£0.075	
2.3 Meadow grass habitat – cut, rake andstack to on site piles				
Pedestrian	1 visit/yr	m^2	£0.20	
Vehicle	1 visit/yr	m^2	£0.80	
2.4 Mosaic grass – cut, rake and stack one third of area cut in any year to on site piles				
Pedestrian	1 visit/yr	m^2	£0.30	
Vehicle	1 visit/yr	m^2	£0.25	
Comments: • Amenity grass managed for visual reasons may be considered landscape maintenance • All grass cuttings normally disposed of in wildlife or compost piles. Add additional cost factor if removed from site • Swale and filter strip grass provides filtering of runoff 100mm deep subject to vegetation type • Where wet grassland with rushes develops then cutting can be reduced to annual or mosaic maintenance • Habitat or wetland swales can be managed as 2.3 or 2.4 above				

Activity	Frequency	Unit	Cost/Unit	Check
3.0 SCARIFYING In the event of grass areas becoming compacted where infiltration is required then scarifying or the use of a hollow spring tine will restore the surface. Undertake as required.				
3.1 Hollow spring tine				
Pedestrian	1 visit/yr	m^2	£0.04	
Vehicle	1 visit/yr	m^2	£0.03	
Chain harrow	1 visit/yr	m^2	£0.025	
Comments: • Grass permeability normally improves with time unless compacted during construction. and therefore design controlled access to prevent compaction • Allow item in construction for ripping sub-soil 300 deep at 600 centres in 2 directions				
4.0 SCRUB CLEARANCE				
4.1 Remove encroaching scrub growth	1 visit/yr	m^2	£1.80	
Comments: • Overhanging branches and encroaching growth will normally be undertaken as part of landscape maintenance				
5.0 SHRUB BED- BIO-RETENTION AREA OR RAIN-GARDEN Planted basins, with or without an underdrain, require landscape care. Where an overflow or underdrain is present an annual rodding or jetting is needed to ensure free flow in the pipe.				
5.1 Shrub bed maintenance	Monthly	m^2	£1.75	
5.2 Supply and spread bark mulch site generated	1 visit/yr	m^2	£2.20	
5.3 Supply and spread bark mulch imported	1 visit/yr	m^2	£4.50	
5.4 Jet wash underdrain	1 visit/yr	m	£1.00	
Comments: • Shrub bed care usually part of landscape maintenance • Remove silt from pre-treatment trap or accumulation in surface of mulch if necessary • Supply and spread 75mm composted bark mulch annually or after silt removal				

Activity	Frequency	Unit	Cost/Unit	Check
6.0 TREE MAINTENANCE A dense foliage canopy can shade out grass and other low vegetation so crown lifting may be required to ensure light reaches the ground. Undertake as required.				
6.1 Raise crown to encourage ground flora in swales etc	1 visit/yr	m^2	£1.05	
6.2 Raise crown to encourage ground flora in swales etc	1 visit/yr	tree	£24.00	
Comments • Tree care is usually part of landscape maintenance				
7.0 WETLANDS Wetlands are permanently wet basins with the surface largely covered with water dependant planting although some areas of open water often occur in natural wetlands. SUDS wetlands are usually longer than wide to provide a longer pathway for treatment but are managed in a similar way to ponds				
7.1 Cut wetland vegetation and remove to site wildlife piles	1 visit/yr	m^2	£3.30	
7.2 Habitat mosaic wetland 30% cut and removed to wildlife piles	1 visit/yr	m^2	£3.55	
7.3 Remove planting and silt to site wildlife or compost piles	1 visit/yr	m^3	£1.00	
7.4 Remove planting and silt to site wildlife or compost piles	1 visit/yr	day	£460.00	
7.5 Bankside vegetation (as 4.1 above)	1 visit/yr	m^3	£1.80	
Comments • Landscape contractors are familiar with the management of wetlands • Silt accumulation is slow if source control features are located upstream in the management train and may not be necessary as a regular task				

Activity	Frequency	Unit	Cost/Unit	Check
8.0 PONDS Ponds are basins with a permanent area of water that exceeds the area of wetland vegetation although the one often merges with the other in natural habitats.				
8.1 Cut pond edge vegetation and remove to site wildlife piles	1 visit/yr	m^2	£1.37	
8.2 Habitat edge cut 30% vegetation and remove to site piles	1 visit/yr	m^2	£1.625	
8.3 Remove 25-30% aquatic vegetation including silt to site piles	1 visit/yr	m^2	£10.00	
8.3 Remove 25-30% aquatic vegetation including silt to site piles	1 visit/yr	day	£414.00	
8.5 Remove 25-30% silt from pond base	1 visit/yr	m^3	£12.00	
8.6 Remove 25-30% silt from pond base	1 visit/yr	day	£460.00	
Comments • Landscape contractors are usually familiar with the management of ponds. • Silt accumulation is slow if source control features are located upstream in the management train and may not be necessary as a regular task. • Day rates will vary depending on the cost of equipment hire.				
9.0 PERMEABLE PAVEMENT – usually concrete blocks in a herringbone pattern Recent experience suggests permeable block paving does not allow silt to migrate through the joints unless grit is missing. Accumulated silt can therefore be removed without lifting the blocks and replacing underlying construction layers. Assuming silt cannot easily contaminate the surface of the blocks only an annual sweeping visit may be necessary.				
9.1 Brush and suction sweep	1 visit/yr	m^2	£15.00	
9.2 Brush and suction sweep	1 visit/yr	day	£500.00	
9.2 Jet wash and suction sweep	1 visit/yr	m^2	£25.00	
Comments • Subject to appropriate construction the main issue with permeable pavement is accumulation of silt in the joints • Following suction cleaning it may be necessary to refill joints with 2-6mmm grit to adequate hardness spec., and vibrate the surface to provide adequate interlock of the blocks. • Permeable grass or gravel surfaces in plastic or other modules only requires litter collection and grass mowing during their design life.				

Activity	Frequency	Unit	Cost/Unit	Check
10.0 WEED TREATMENT - minimum use as spot treatment to hard surfaces SUDS schemes should be designed so that the landscape needs minimum weedkiller application to avoid contamination of water and damage to bioremediation processes. Spot treatment should be the only weedkill treatment necessary.				
10.1 Visit site, identify weed location and treat using Glyphosate	1 visit/yr	m^2	£0.04	
Comments • Wherever possible the need for weed treatment should be designed out of the landscape to reduce chemical pollution of runoff.				
11.0 INLETS AND OUTLETS Inlet and outlet structures allow runoff to enter and leave SUDS features. Surface structures will normally require only a visual inspection at monthly site visits. Underground structures should be as shallow as possible to allow inspection by one or at most two people and without the need for entering the chamber. Chambers should not normally be deeper than 1.2M with inlets and outlets no deeper than 900mm. Silt accumulation at inlets and outlets must be removed at monthly site visits.				
11.1 Inspect surface structures	Monthly	each	£4.50	
11.2 Inspect below ground structures	Monthly	each	£8.00	
Comments • Inlets and outlets will be based on simplified headwall design requiring inspection, removal of silt at the inlet and outlet apron and any debris obstructing the flow • Below ground structures will normally be a chamber with a lockable cover • Monthly visits can be reduced to 6 monthly or annual visits once it can be confirmed that silt or other blockage is not occurring during use.				

<table>
<tr><th>Activity</th><th>Frequency</th><th>Unit</th><th>Cost/Unit</th><th>Check</th></tr>
<tr><td colspan="5">12.0 CONTROL STRUCTURES Control structures control the rate at which water flows through the SUDS. Surface structures will normally require only a visual inspection at monthly site visits. Underground structures should be as shallow as possible to allow inspection by one or at most two people and without the need for entering the chamber. Chambers should not normally be deeper than 1.2M with inlets and outlets no deeper than 900mm. Silt accumulation at inlets and outlets must be removed at monthly site visits.</td></tr>
<tr><td>12 .1 Inspect surface control structures</td><td>Monthly</td><td>each</td><td>£5.50</td><td></td></tr>
<tr><td>12.2 Inspect orifice control chambers</td><td>Monthly</td><td>each</td><td>£8.00</td><td></td></tr>
<tr><td>12.3 Hydrobrake inspection</td><td>Monthly</td><td>each</td><td>£10.50</td><td></td></tr>
<tr><td colspan="5">Comments
Surface control structures can be slot weirs, V-notch or gabion baskets with control in the stone fill. They can be inspected without removing covers or the need for special keys
Control chambers should be shallow with an orifice or similar control device and a lockable cover
Hydrobrake controls are a proprietary device with special maintenance. They are located in a chamber and are inspected as recommended by the manufacturer but may require staff with special training as the way they work is not obvious.
Monthly visits can be reduced to 6 monthly or annual visits once it can be confirmed that silt or other blockage is not occurring during use.</td></tr>
<tr><td colspan="5">13.0 SILT AND OIL TRAPS These structures are usually used in conventional drainage schemes but may occur in hybrid systems and require regular maintenance.</td></tr>
<tr><td>13.1 Catchpit silt traps empty, dispose off site</td><td>Monthly</td><td>each</td><td>£17.50</td><td></td></tr>
<tr><td>13.2 Gully pot empty, dispose off site</td><td>Monthly</td><td>each</td><td>£37.50</td><td></td></tr>
<tr><td>13.3 Oil Interceptor</td><td>Monthly</td><td>each</td><td>£600.00</td><td></td></tr>
<tr><td colspan="5">Comments
Conventional silt traps usually have a cover that needs to be removed with accumulated silt removed and disposed off site as special waste.
Gully pot cleaning requires suction cleaning and disposal of waste off site to special waste standards
These features should be designed out of SUDS wherever possible
All waste disposal routes should be agreed with the Environment Agency</td></tr>
</table>

Activity	Frequency	Unit	Cost/Unit	Check
14.0 PIPE RUNS Pipe runs in SUDS should be short and without complex bends and inspection chambers wherever possible. Self cleaning velocities may be difficult to achieve following flow control structures requiring increased falls in the pipe.				
14.1 Jet wash, collect and dispose of washings on site or remove from site depending on source of silt	Annually	m	£2.25	
Comments • All pipe runs should be jetted annually to anticipate blockage that will cause flooding in exceptional rainfall • All waste disposal routes should be agreed with the Environment Agency				