Sustainable drainage systems (SUDS) adoption manual

November 2023

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About this manual

This guide details our local practices and working examples. Your drainage system should refer to guidance as set out in SSG Appendix C – Design and Construction Guidance within Sewerage Sector Guidance – approved documents

This is your guide to the design, construction and adoption of sustainable drainage systems (SUDS). It sets out to explain:

- the concept underpinning SUDS;
- the joint engagement process to agree adoption;
- how SUDS schemes should work in practice; and
- design and construction guidelines for integrated system and component features.

Sustainable drainage systems – at a glance

SUDS are used as an alternative to conventional ways of managing surface water. In built environments they aim to mimic the way rainfall drains in natural systems, avoiding many of the problems typically caused by surface water runoff from developments.

As we all work to find sustainable solutions to the challenges of growth and climate change, SUDS play a critical role in flood and pollution prevention by freeing up capacity in our sewers. Importantly too, SUDS add considerable aesthetic and environmental value, offering attractive natural amenities for the local community and protecting and enhancing biodiversity.

Part 1 – General SUDS information

1.0 Sustainable drainage systems (SUDS) – concepts and techniques

1.1 Why SUDS?

SUDS manage rainfall by replicating what happens in nature. They prevent many of the problems caused by surface water runoff from development by reducing the impact of excessive quantities of water flow.

At present, rain from roofs, roads, car parks and other hard surfaces is collected in gullies, channels and pipes before being released directly to streams, rivers and soakage, or, in urban areas, to the sewer system.

This can cause:

- Flooding and erosion because surface water runoff is piped directly to watercourses before it has a chance to soak into the ground and enter the natural drainage system.
- Silt, oils, and other pollutants to be carried straight to the natural environment before they can be trapped, removed or broken down naturally.

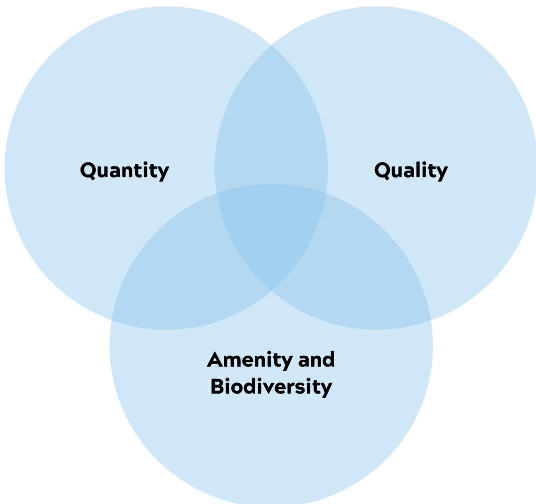
In addition, wetlands, watercourses and other habitats are lost or damaged as a result of current drainage practice. Consequently, communities may feel little pride in, or positive connection to, the water environment.

1.2 The SUDS drainage philosophy

SUDS manage the flooding and pollution aspects of drainage and ensure that the community and wildlife are considered in SUDS design.

SUDS deliver efficiently and effectively across four key criteria:

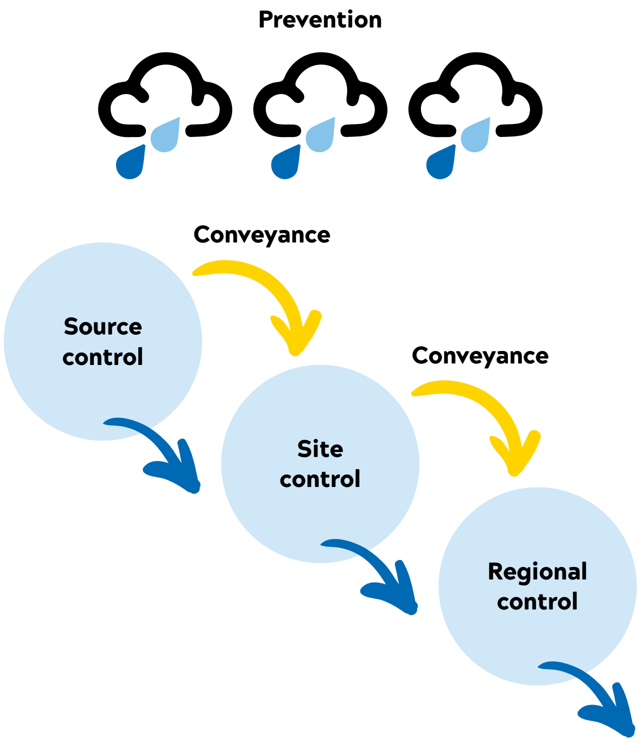
- **Quantity** – SUDS reduce the risk of flooding and erosion by controlling flow volumes and the frequency of surface water runoff.
- **Quality** – SUDS prevent and treat pollution in surface water runoff to protect the environment.
- **Amenity** – SUDS provide visual and community benefits for people.
- **Biodiversity** – SUDS enhance and create habitats for wildlife.



1.3 SUDS concepts

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

- **The management train** employs drainage techniques in series to reduce pollution, and control flow rates and volumes as water flows along the SUDS. Each part of the SUDS management train reduces the impact of the quantity of water leaving a development and improves the quality of water before release to the wider environment.



- **Source control** deals with surface water runoff as close as possible to where it falls as rain.
- **Sub-catchments** manage surface water runoff locally in small SUDS drainage areas.
- **Storage hierarchy** stores water throughout the site in SUDS features.
- **SUDS maintenance** manages SUDS by using landscape maintenance techniques.

1.4 SUDS techniques

SUDS use a number of techniques generally based on natural drainage features to collect, treat, store and then release storm water slowly to the environment:

- Filter strips and swales use vegetation to filter and control flows.
- Filter drains, permeable surfaces, green roofs, bioretention areas and other permeable structures allow water to percolate through a pervious surface into voided construction below to allow cleaning, storage and controlled release.
- Infiltration devices are specific design features that allow soakage into the ground and include soakaways and infiltration basins, although most SUDS features can also provide infiltration depending on design and ground conditions.
- Basins, ponds and wetlands are open depressions in the landscape that collect, clean and store water in a natural way and can provide amenity and wildlife benefits for the community.
- Engineered below-ground storage structures, including geocellular boxes, tanks and oversized pipes can augment the attenuation capacity of a SUDS design but do not clean surface water runoff.
- Inlets, outlets and control structures manage the flow of water through the SUDS.

2.0 Managing SUDS

2.1 Designing for maintenance

Sustainable drainage systems use landscape features to manage surface water runoff that is at or near the surface.

The design of each SUDS feature must take into account the day-to-day maintenance requirements, occasional tasks and long-term design life elements of each structure.

They should be simple, robust and easy to manage. The maintenance requirements must be within the Management Plan as set out in section 4.5.

SUDS techniques are usually landscape features and therefore should be managed using established landscape maintenance practices. An understanding of landscape care should inform how the SUDS features are designed.

2.2 Landscape maintenance practice

Landscape maintenance ensures the SUDS features continue to drain the development effectively and that the SUDS and surrounding landscape look attractive at all times. SUDS maintenance comprises:

- Regular site attendance for litter collection, grass cutting and checking of inlets, outlets and control structures.
- Occasional visits to brush permeable pavement, remove silt from source control features and manage wetland vegetation.
- Remedial work that may be required due to damage or vandalism, though this should be minimal if the design of the SUDS has taken these possibilities into account.

2.3 The SUDS management plan

SUDS maintenance requirements for a development should be set out in a SUDS Management Plan that includes:

- A SUDS overview.
- A management statement to describe the SUDS scheme and set out the management aims for the site. It should consider how the SUDS will perform and develop over time anticipating any additional maintenance tasks to ensure the system continues to perform as designed.
- Specification notes that describe how work is to be undertaken and the materials to be used.
- A maintenance schedule describes what work is to be done and when it is to be done using frequency and performance requirements as appropriate. This can be based on the schedule included in this manual in section 14.0.
- A site plan showing maintenance areas, control points and outfalls.
- Supporting documents.

2.4 The SUDS outfall route

Each part of the SUDS management train reduces the impact of the quantity of water leaving the development and improves the quality of water before release to the wider environment.

Once surface water runoff has been cleaned using the SUDS, then, as confirmed in Building Regulations 2000: approved document H: Drainage and waste disposal, water will either flow to natural drainage or discharge to the sewer in the following sequence of preference:

- An adequate soakaway or some other adequate infiltration system; or, where that is not reasonably practicable.
- A watercourse; or where that is not reasonably practicable.
- A surface water sewer.

SUDS maintenance will be undertaken from the end of the intermediate SUDS management area, where the adoption break point is identified and agreed with Anglian Water. It will continue up to the point where flows infiltrate into the ground, flow into a watercourse or enter the sewer network. In some situations this may be a diffuse outfall like an infiltration basin, a natural outfall through a wetland channel mimicking nature, or a conventional outfall where water enters the sewer network.

The outfall arrangements for each SUDS will need to be agreed with Anglian Water prior to adoption. The Environment Agency, Internal Drainage Board or Riparian Owner should be consulted at each design stage as necessary.

3.0 The Anglian Water SUDS adoption process

The Flood and Water Management Act 2010 currently gives the role of the SUDS Approval Body to the lead local flood authority. Until the Act is fully in force and procedures are set out in more detailed regulations, this manual sets out our current best-practice guidelines.

3.1 Adoption criteria – overview

We will consider the adoption and maintenance of features in public open space where developers can demonstrate:

- Effective upstream source control measures.
- Effective outfall, i.e. to ground, watercourse or surface water sewer.
- Effective exceedance design; and
- Effective maintenance schedule.

Where we agree to adopt a structure, the land surrounding the structure must be transferred to Anglian Water and have reasonable access to allow for maintenance. We will also require discharge easements, and protection of exceedance routes from future changes in land use.

3.2 SUDS in housing – SUDS management areas

Where SUDS are totally within a property boundary then the whole system is the responsibility of the site owner. However, on housing landscapes in particular, where there may be multiple SUDS elements, each element is assigned to one of three maintenance areas based on its position in the management train sequence and on 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.
- **Intermediate SUDS** - SUDS located within a development that control surface water runoff at or near source include: filter strips, normal and under-drained swales, bioretention raingardens, filter drains, permeable pavement and other local infiltration systems.
- **Public open space SUDS** - SUDS located in public open space, either owned by local authorities or with full public access, which provide conveyance and open storage of surface water runoff from the development and include: basins, ponds and wetlands linked by swales, linear wetlands and other open channels.

Who does what and when?

Developer		Anglian Water
Consult with Environment Agency, Planning Authority, Internal Drainage Board and other relevant bodies on SUDS requirements.	→	Contact Number: **03456 60 66087** email: **drainage@anglianwater.co.uk**
↓		
Discuss Conceptual Design Proposals with Anglian Water Developer Services team.	→	Contact Number: **03456 60 66087** email: **drainage@anglianwater.co.uk**
Submit Conceptual Design Proposals **Purpose:** set out drainage strategy and proposed adoption arrangements. **Format:** conceptual Design Layout and Preliminary Design Statement.	→	Guidance in Anglian Water SUDS for adoption manual. Conceptual Design Proposal requirements.
	←	Review Conceptual Design Proposals and agree adoption principle.
Submit Outline Design Proposals **Purpose:** Confirm outline design, standards (criteria), flow routes, approximate storage requirements and adoption arrangements. **Format:** Outline Design layout and outline SUDS design statement.	→	Guidance in Anglian Water SUDS for adoption manual. Conceptual Design Proposal requirements.
	→	Review Outline Design Proposal and agree conditional approval to adopt SUDS features subject to detailed design.
Submit Detailed Design Statement sign agreement and pay adoption fees **Purpose:** Provide construction specifications and evidence of compliance with Anglian Water design standards. **Format:** Detailed design layout, levels, details and specifications.	←	
	→	Review Detailed Design Statement and the agreement and process adoption fees. Grant adoption approval subject to construction assurance and inspection process.
Follow Construction and Inspection Process **Purpose:** Construction assurance. **Format:** Inspection and adoption portfolio.	←	
	→	Anglian Water Vesting Document.
Submit Vesting Document **Purpose:** To finalise transfer of SUDS features to Anglian Water. **Format:** The document as prescribed.	←	
		SUDS features adopted.

- SUDS located within private property boundaries are usually the responsibility of the property owner.
- Maintenance of the intermediate SUDS area is critical. Anglian Water must be satisfied that this part of the management train is maintained effectively before it will adopt any part of the SUDS.
- Anglian Water will consider adopting SUDS features that are located in public open space and can be shown to receive treated surface water runoff from a development.
- Depending on the design and characteristics of a development, this will tend to be downstream of a break point where the intermediate source control area becomes part of accessible public open space.

3.3 SUDS on private property

The first SUDS management area is within private property and therefore the responsibility of the property owner. It is important that the overall SUDS design takes into account the consequences of failure to maintain these SUDS features or possible loss due to redevelopment. This can be achieved by the protection of exceedance routes.

3.4 Intermediate SUDS

The intermediate area between private SUDS and public open space features is important because source control and pre-treatment is provided in this location, particularly for roads that contribute the major pollution loads to surface water runoff.

The responsibility for maintenance of SUDS techniques within development has been a major barrier to adoption of SUDS. Historically surface water runoff has been collected in gullies, usually the responsibility of the County Highways Engineers Department, which is then conveyed away in pipes that are often the responsibility of Anglian Water. Surface water runoff is then conveyed either to a receiving watercourse, or, where entering the combined sewer, to a treatment works.

The maintenance of the intermediate SUDS area is critical in ensuring that a controlled flow of treated surface water runoff is delivered to open SUDS features in public open space. Anglian Water must be satisfied that this part of the management train is maintained effectively before the third part of the SUDS management sequence can be adopted and maintained as set out in this adoption manual.

3.5 SUDS in public open space

Public open space SUDS are generally located outside the envelope of individual developments, but in some instances public green space can penetrate into the development and be part of accessible open space.

Public open space SUDS are characterised by being located within green space or other clearly defined public areas that can manage the storage and conveyance of surface water runoff. Therefore it is important that runoff has been intercepted and cleaned before it reaches these open SUDS features. Depending on the design and characteristics of the site there will be a convenient location where the intermediate source control area becomes part of accessible public open space.

Anglian Water will consider adoption and maintenance of this break point. Anglian Water will consider adopting SUDS features that are located in public open space and can be shown to receive treated surface water runoff from development. These features may receive large volumes of water when heavy storms occur but in normal rainfall will offer a discharge route for low flows of treated surface water runoff from the development.

Part 2 – SUDs design

4.0 Adoption – design, construction and maintenance

Well-designed SUDS are competently constructed and easy to maintain into the future.

Anglian Water will consider the 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 adoption manual. Anglian Water may consider the 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 adoption manual.

4.1 The adoption process: Developers' responsibilities within the adoption process

Pre-development consultation

- Pre-development and ongoing consultation with the Planning Authority, Environment Agency, Anglian Water Internal Drainage Board and other relevant bodies.

Conceptual drainage design

- Show site evaluation, flow routes, storage and treatment locations and discharge location with preliminary SUDS Design Statement.
- Consider management plan with Anglian Water.

Outline drainage proposals

- Demonstrate SUDS features and how they integrate with the landscape, approximate storage volumes, conveyance and control points with an Outline SUDS Design Statement.
- Seek agreement to adoption in principle.

Detailed drainage design

- Provide detailed design, specifications, calculations, levels and details with final SUDS Design Statement and Management Plan.
- Section 104 agreements to be in place subject to construction assurance and inspection.
- Fees to be paid.

Construction

- Provide adoption portfolio, material specification assurance and agreed construction inspection profile.
- Agree adoption portfolio at the final construction stage.

Maintenance

- Provide evidence of 12-month post-construction maintenance and that all parts of SUDS are effective and robust.

4.2 Design approval

The design approval of SUDS requires three agreed stages based on the design process set out in The SUDS Manual p2-13:

1. Conceptual Drainage Proposals.

2. Outline Drainage Proposals.

3. Detailed Drainage Design.

Anglian Water requires confirmation that the criteria at each design stage have been met to ensure the 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 the discharge location for surface water runoff from development. The developer should also engage with the Environment Agency on the aspects of water quality. Information required:

- 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.
- Design for exceedance. Further information can be found in section 5.3.

Outline drainage proposals

Outline drainage proposal requirements are defined in The SUDS Manual p2-14 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.

The developer should confirm the basic design at this stage with SUDS techniques and the proposed break point for adoption. The developer should also confirm that the necessary permits and agreements for a discharge to the watercourse have been obtained from the Environment Agency, the Internal Drainage Board or the riparian owners as appropriate. Information required:

- The proposed character, location and extent of SUDS techniques on the site must be shown on an Outline Drainage Proposals drawing.
- An estimate of storage required for the development and where it is to be located within or outside the site.
- The proposed location of a break point where adoption of the SUDS will begin and an outfall location to infiltration, a watercourse or sewer.
- Outline SUDS design statement to explain the proposals.
- Design for exceedance.

Detailed design proposals

The full design should be assessed to meet the quantity, quality, amenity and biodiversity criteria as detailed in section 5.6. The intent to agree to adopt, subject to satisfactory construction of the SUDS will be confirmed at this stage. Detailed design proposals submitted for our approval will include:

- Final Layout drawing with levels.
- Detail drawing of all SUDS elements for the scheme.
- Appropriate calculations to show how storage volumes have been determined with location and volume of storage.
- Location of inlets, outlets, control structures and outfalls.
- Details of low flow pathways, overflow arrangements and exceedance routes.
- Copies of all relevant permissions or agreements including those relating to easements, planning permissions and access agreements.
- A Management Plan which details clear identification of ownership and responsibility for the maintenance of each element as detailed in section 4.4.

4.3 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.

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

The construction approval of SUDS requires agreement at three stages:

1. A pre-construction meeting.
2. An Adoption file and inspection sequence for use during construction.
3. Post-construction maintenance.

Pre-construction meeting

A pre-construction meeting with Anglian Water is necessary to inform the contractor, site agent and a supervising representative what documentary evidence is required at the end of construction to ensure adoption. The critical site inspection points in the contract will be agreed at this meeting.

Adoption file

- Pre-construction adoption checklist.
- Critical construction stages for inspection and sign off.
- Photographic record of SUDS installation.
- Specification sheets for materials used in construction.
- As built level survey.
- As built drawings.
- Copy of Provisional Certificate.
- Copy of Final Inspection Certificate.
- Copy of Certificate of Vesting.

Anglian Water reserves the right to require the opening of construction where inspection points have not been verified by inspection.

Post-construction maintenance

The adoption process requires the developer to maintain the site for a minimum of an additional year after the issue of a Provisional Certificate to ensure any remedial work is effective, the SUDS work properly, and all vegetation is fully established.

A final inspection is required to check all surface SUDS features, all inlets, outlets and control structures and outfalls and to confirm that all pipe runs have been jetted and debris removed from all SUDS structures. After a satisfactory result at this inspection, a Final Inspection Certificate will be issued. Subsequently a Certificate of Vesting will be issued and the adopted features will become the responsibility of Anglian Water.

4.4 Management plan

A Management Plan will be provided as part of the Detailed Design Proposals which include:

- A SUDS overview.
- A management statement to describe the SUDS scheme and set out the management aims for the site. It should consider how the SUDS will perform and develop over time anticipating any additional maintenance tasks to ensure the system continues to perform as designed.
- Specification notes that describe how work is to be undertaken and the materials to be used.
- A maintenance schedule describes what work is to be done and when it is to be done using frequency and performance requirements as appropriate. This can be based on the schedule included in this manual in section 14.0.
- A site plan showing maintenance areas, control points and outfalls.

The Management Plan will be the basis for the additional one year of maintenance, and any changes required to the plan will be made at final inspection of the SUDS scheme.

Responsibility for the management and maintenance of each element of the SUDS scheme will also need to be detailed within the Management Plan.

5.0 Design approach

5.1 Mimicking natural drainage

SUDS mimic natural drainage and therefore water should flow at or near the surface with as many opportunities to soak into the ground as possible.

Although there are special infiltration structures, like soakaways and infiltration basins designed to encourage water to soak into the ground, most SUDS features will allow water to percolate into soil layers, particularly in dry weather, as long as it is held for sufficient time in the system.

Surface water runoff must be clean before it is allowed to infiltrate naturally so an evaluation of pollution risk must be made and treatment provided before this occurs. It should be noted that roof water is generally clean and therefore doesn't require additional cleaning. Where ground is impermeable, surface water runoff must be collected, cleaned and stored as it flows through the management train sequence and before it travels onward to a watercourse.

In many urban areas the natural drainage system has been removed and a piped system or sewer may be required to reach a suitable watercourse. Surface water runoff from development should always be controlled and treated as early in the management train as possible using source control measures.

5.2 The design process

Early stakeholder engagement is essential as part of the design process, so call us on 08456 60 66087 or email us at drainage@anglianwater.co.uk

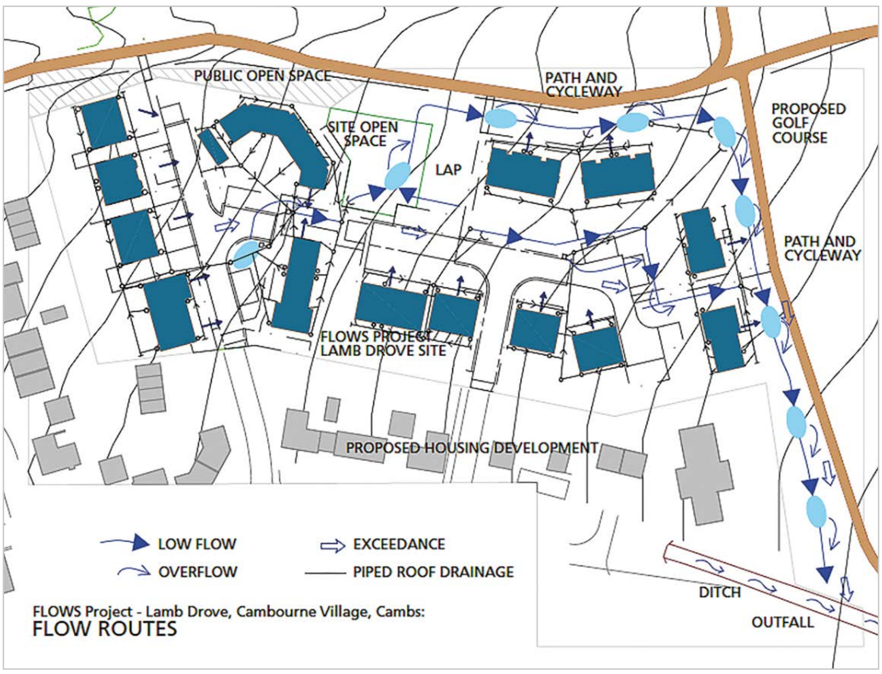
5.3 Flow routes and exceedance routes

Flow routes through the development must be demonstrated as a first stage in the design process, demonstrating how water will travel at or near the surface for three types of flow:

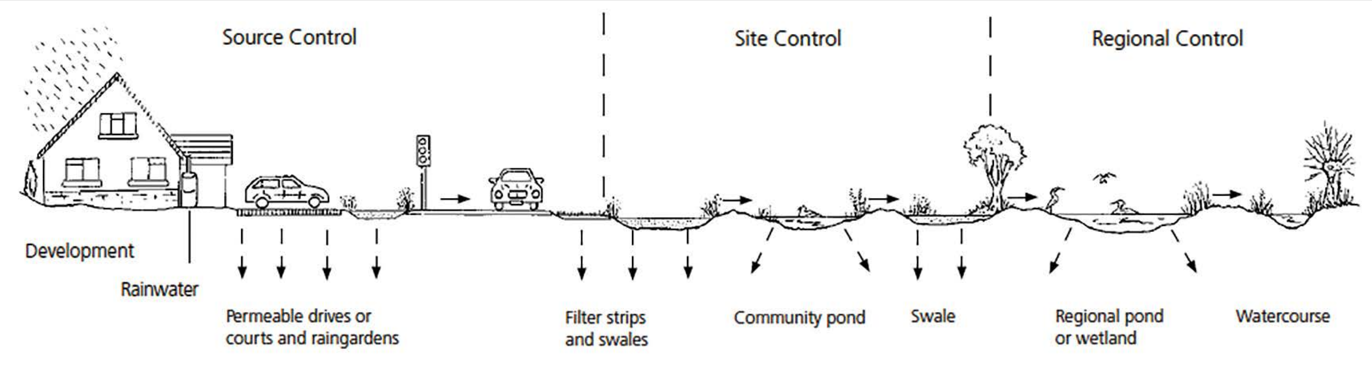
- Low flow routes.
- Overflows.
- Exceedance routes.

Low flow routes

Once surface water runoff has been collected, cleaned and controlled in source control features it will either be stored where it fell as rain in permeable pavement, or flow onward to local storage structures. The day-to-day flows from these features should travel in low flow channels through the development in a controlled way contributing to landscape quality.



SUDS management train



Overflows

In the event of local blockages or surcharge a simple overflow arrangement should allow water to bypass the obstruction and return to the management train sequence until conditions return to normal.

Exceedance routes

When SUDS are overwhelmed by exceptional rainfall then exceedance routes protect people and property by providing unobstructed overland flow routes from the development and should be considered for all drainage schemes.

The SUDS design must demonstrate that flow routes have been considered at each design stage to take into account the effect of proposed development on the natural flow pattern for the site. Exceedance routes should also be protected from future changes in land use.

5.4 The management train

Once the flow routes have been established, then the selection of SUDS techniques and the building of a management train to manage surface water runoff can proceed for the site. SUDS techniques are selected to provide the most appropriate solution for dealing with surface water runoff from the development.

The design must show how source control techniques have been incorporated at the beginning of the SUDS and a management train is in place to control the flow of water to an agreed outfall arrangement.

Where volumes of surface water runoff cannot be dealt with at source, site controls must be provided to manage flows. The design must demonstrate that all surface water runoff has been treated at source, for example in permeable pavement, or that the first flush volume from hard surfaces has been intercepted and treated using sufficient treatment stages with additional clean volumes diverted to site controls for on-site storage.

Volumes of surface water runoff that cannot be stored within the development will flow to regional controls as detailed in point 4 within section 7.3.

The management train concept must be demonstrated at each design stage.

5.5 The storage hierarchy

SUDS deal with volumes of water in a different way to conventional drainage. When surface water runoff is collected in a conventional piped system the water is conveyed to the end of the catchment. The collected runoff includes both polluted first flush volumes and any additional volumes depending on the intensity and duration of the storm. Storage is usually underground in oversized pipes, tanks or geocellular structures, but where land is available, in open balancing ponds.

SUDS design divides development into subcatchments where each collection system collects, cleans and stores 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 is different from conventional drainage and creates a cascade of smaller stored volumes of treated surface water runoff.

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

- **Interception storage** – SUDS techniques are selected to encourage infiltration, evaporation and temporary storage to reduce the frequency of surface water runoff. 5mm over the developed area is usually allowed if the correct source control measures are used.
- **Attenuation storage** – storage for release at greenfield rate of surface water runoff, usually between 3 and 8 litres per second per hectare, can be accommodated in sub-surface features like permeable pavement or open structures including swales, basins and ponds.
- **Long-term storage** – storage of exceptional rainfall for slow infiltration to protect flood plains, where the final part of the selected return period volume is directed to adjacent open landscape such as playing fields, informal car parks and green space. Where infiltration is impossible, the rate of surface water runoff is reduced to 2 litres per second per hectare, or as advised by Anglian Water, the Environment Agency or the Internal Drainage Board.

5.6 SUDS design criteria

Design criteria are a set of conditions that need to be met by the SUDS design, and comprise requirements for the four elements of the SUDS philosophy: Quantity and Quality with Amenity and Biodiversity.

- **Quantity – controlling flows, volumes and frequencies of runoff.** The SUDS design will demonstrate that the Hydraulic Criteria set out in The SUDS Manual section 3.2 and the requirements of the Environment Agency and the Internal Drainage Board have been considered and incorporated in the SUDS design.
- **Quality – controlling and treating pollution.** The SUDS design will demonstrate that the Water Quality Criteria set out in The SUDS Manual section 3.3 p3-10 and the requirements of the Environment Agency or Internal Drainage Board have been considered and incorporated in the SUDS design.
- **Amenity – visual and social benefits for the community.** The SUDS design will demonstrate that the Amenity Criteria set out in The SUDS Manual section 3.4 p3-13, this SUDS Adoption Manual and any requirements of the Local Authority have been considered and incorporated in the SUDS design.
- **Biodiversity – providing ecological diversity and wildlife interest.** The SUDS design will demonstrate that the Ecology Criteria set out in The SUDS Manual section 3.5, this SUDS Adoption Manual and any requirements of the Local Authority have been considered and incorporated in the SUDS design.

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The SUDS design should generally provide a robust drainage solution that fully integrates with the surrounding landscape for the development. The SUDS design will incorporate Health and Safety requirements at every stage and provide a system that is easy to maintain. Each element of the SUDS design will be assessed to ensure that it meets both the technical and amenity elements set out in the design criteria together with any additional requirements included within this manual.

6.0 Controlling flows, volumes and frequencies – water quantity

6.1 Key principles

- Ensure that people and property on the site are protected against flooding.
- Ensure that the impact of the development does not exacerbate flood risk at any other point (either upstream or downstream) in the catchment of a receiving watercourse.

6.2 On-site flood protection

There are three key criteria:

- Protection against flooding from the watercourse.
- Protection against flooding from the drainage system.
- Protection against flooding from overland flows (from sources within or external to the site).

6.2.1 Protection against flooding from the watercourse

The drainage designer will demonstrate that the development, including the SUDS system, is outside the functional floodplain and, wherever possible, outside the 1 in 100 (or 1 in 200) year flood risk zone.

6.2.2 Protection against flooding from the drainage system

The drainage designer will demonstrate that the SUDS will cater for the design storm (1 in 100 year storm event) with an allowance for climate change, as detailed in section 6.4.3, without causing any significant unplanned flooding. This is subject to agreement with the Environment Agency or the Internal Drainage Board, as appropriate. The drainage designer will demonstrate that water levels in the receiving watercourse at times of extreme rainfall will not affect the outfall or performance of the drainage system.

The drainage designer will demonstrate that any blockage in the drainage system will be accommodated by overflows, and exceptional rainfall by exceedance flood routing.

Although storage features should normally be formed within the landscape profile, the drainage designer will demonstrate the consequences of failure of any embanked storage facility.

6.2.3 Protection against flooding from overland flows

The drainage designer will demonstrate how exceptional flows generated within or from outside the site will be managed, including:

- Overland flood routes.
- Protection of buildings to prevent entry of water.
- Protection of major access routes and access to institutional buildings.

6.3 Protection of the receiving watercourse or sewer

Two key principles:

- Ensure that the frequency and rate of discharge from the new development is, wherever possible, equal to the frequency and rate of discharge that would be discharged under equivalent greenfield conditions.
- Ensure that the frequency and volume of surface water runoff from the new development is, wherever possible, equal to or less than the frequency and volume that would be discharged under equivalent greenfield conditions.

6.3.1 Surface water runoff rate

The drainage designer will confirm the agreed greenfield surface water runoff rate. This is usually 3-8 litres per second, or a rate negotiated with Anglian Water, the Environment Agency or the Internal Drainage Board, and will take into account, where appropriate, the difference between the 1 in 1 year event, the 1 in 30 year event and the 1 in 100 year event with an allowance for climate change.

Where the watercourse is reached via an existing sewer, improvements may need to be included as part of the design, or the surface water runoff rate will need to be further restricted.

6.3.2 Surface water runoff volume

The drainage designer will confirm the storage volumes required for the site, taking into account:

- **Interception storage** – using appropriate selection of source control and site control techniques to infiltrate or evaporate the first 5-10mm of surface water runoff.
- **Attenuation storage** – using an appropriate return period to store surface water runoff with a greenfield surface water runoff rate of 3-8 litres per second.
- **Long-term storage** – using, where possible, landscape areas to store volumes up to 1 in 100 with an allowance for climate change and a discharge of 2 litres per second per hectare, or as advised by Anglian Water, the Environment Agency or the Internal Drainage Board.

6.4 Good drainage practice – hydraulics

6.4.1 Drain-down time

The drainage designer will confirm that storage features empty within 48 hours to receive surface water runoff from subsequent storms.

6.4.2 Hydraulic performance during periods of high groundwater levels

The drainage designer will confirm that groundwater levels have been considered in the design of the SUDS scheme.

6.4.3 Climate change

An allowance for climate change is now being applied to the design storm (usually 1 in 100 or 1 in 200 year return storm). These figures can vary but are currently 20%-30% in rainfall intensity for design horizons after 2055, and may result in storage volumes that are 50% greater than present day rainfall. This may change in the future as new research takes place.

6.4.4 Pipe sizes and hydraulic controls

The minimum pipe or throttle diameter acceptable for adoption by Anglian Water is normally 100mm, as required by the latest edition of Sewers for Adoption. However, orifice controls of much smaller diameter are required to control flows from many sub-catchments within development. The design of control devices and size of controls must be agreed with Anglian Water.

6.4.5 Whole Life design considerations

- The SUDS solution must operate effectively for the design life of the development.
- The SUDS solution must operate efficiently for reasonable periods of time between significant maintenance activities, e.g. major silt removal (1-5 years).
- Regular operating and maintenance needs are easy to understand and implement .
- Natural resources are recycled wherever possible.
- Implementation is energy efficient in terms of constituent products, construction processes and operation and maintenance activities.
- There is adequate access for maintenance activities.

7.0 Preventing and treating pollution – water quantity

7.1 Key principle

- An appropriate management train of SUDS components should be implemented to effectively mitigate the pollution risks associated with different site users/activities.

7.2 Protection of the groundwater or receiving watercourse

To remove the major proportion of pollution from surface water runoff, it is necessary to:

- Capture and treat the surface water runoff from frequent, small events.
- Capture and treat a proportion of the initial surface water runoff (the first flush) from larger and rarer events.

There are a range of water quality treatment options.

1. Treatment of surface water runoff using infiltration (interception storage)

Good site design does not allow surface water runoff from impermeable surfaces to pass directly to watercourses for the range of smaller, polluting events (at least 5mm, preferably 10mm). This is likely to be achieved through the use of infiltration techniques that treat smaller events by infiltration through the soil and discharge to groundwater. Rainwater harvesting can also be used. Care must be taken not to infiltrate polluted surface water runoff directly into permeable soils. An appropriate number of treatment stages must be demonstrated before infiltration of polluted surface water runoff.

2. Treatment of surface water runoff using filtration

Improvements to surface water runoff quality can be achieved by filtering (particularly for small, frequent events) using a variety of filtration media, for example: sands, gravels (e.g. permeable pavements, filter drains), soils (e.g. bioretention), grasses and other surface vegetation (e.g. swales, detention basins) or aquatic vegetation (e.g. wetlands). The travel time or flow velocity through the system must be assessed to maximize treatment benefits. Polluted surface water runoff must not flow directly to ponds or wetlands in order to protect amenity and biodiversity. Source control measures at the beginning of the system and an appropriate number of treatment stages will be required before surface water runoff can flow to open water features.

3. Treatment of surface water runoff using detention

Storing surface water runoff volumes in detention basins, by using outflow controls, meets hydraulic criteria but also allows filtering and sedimentation to take place, which contributes to water quality improvement.

4. Treatment of surface water runoff using permanent pond volumes

In the past, ponds were used for primary treatment of polluted surface water runoff and sized so that the permanent pond volume was equal to the treatment volume or Vt Recent evidence indicates that hydrocarbons remain in pond sediments for extended periods and should be intercepted in structures that allow alternate drying and wetting with access to UV light to enhance breakdown, e.g. filter strips and swales. Secondly, inorganic silt with associated heavy metal contamination in ponds eventually adds to maintenance problems both physically and chemically due to the build up of toxic sediments. Thirdly, ponds and wetlands provide amenity and biodiversity value and should not receive silt, oil or other major pollution loadings. There should always be at least one treatment stage before a pond or wetland. However, ponds and wetlands are useful for polishing surface water runoff at the end of a management train and can be used to store large volumes of clean water. The treatment volume or Vt can be reduced for pond sizing design where upstream treatment components are part of the management train.

7.3 The Management Train

In order to mimic natural catchment processes as closely as possible, a management train is required. This concept is fundamental to designing a successful SUDS scheme and uses drainage techniques in series to incrementally reduce pollution, flow rates and volumes.

The hierarchy of techniques that should be considered in developing the management train are as follows:

1. **Prevention** – the use of good site design and site housekeeping measures to prevent surface water runoff and pollution (e.g. sweeping to remove surface dust and detritus from car parks). Prevention policies should generally be included within the site Management Plan.

2. **Source control** – control of surface water runoff at or very near its source (e.g. soakaways, other infiltration methods, green roofs, permeable pavements).

3. **Site control** – management of water in a local area or site (e.g. routing water from building roofs and car parks to a large soakaway, infiltration or detention basin).

4. **Regional control** – management of surface water runoff from a site or several sites, typically in a balancing pond or wetland.

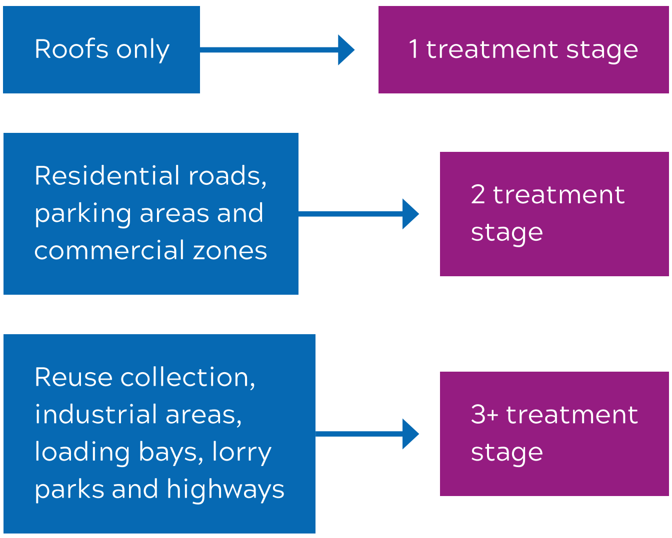
The techniques that are higher in the hierarchy are preferred to those further down so that prevention and control of water at source should always be considered before site or regional controls. However, where upstream control opportunities are restricted, an equivalent number of treatment stages should be used in series to control and treat pollution. Water should be conveyed elsewhere only if it cannot be dealt with on site. The passage of water between individual parts of the management train should be considered through the use of natural conveyance systems, e.g. swales and open low flow channels, wherever possible, although pipework and sub-surface structures may be required, especially where space is limited. Pre-treatment (the removal of gross silt or sediment loads) and maintenance is vital to ensure the long-term effectiveness of SUDS. In general, the greater the number of techniques used in series, the better the performance is likely to be, and the lower the risk of overall system failure.

7.4 Sub-catchments

Surface water runoff should be managed in small, cost-effective landscape features located within small sub-catchments rather than being conveyed to, and managed in, large systems at the bottom of drainage areas in end of pipe solutions.

7.5 Treatment stages

Where risks posed to the environment are likely to be high, then a larger number of components should be included within the management train. Where risks are low, then provided hydraulic criteria are met, a reduced number of components may be adequate. The number of treatment stage components required (assuming effective pre-treatment is in place) is based on Table 3.3 p3-12 in The SUDS Manual. These are the minimum numbers of components required and each site should be reviewed on a risk assessment basis. An increased number of components will generally be required for larger sites up to 2 hectares to meet all design criteria. Sites greater than 2 hectares should not drain to a single location, but should be split into sub-catchments and several smaller features, including those that drain to a final site control. A SUDS approach to drainage can be implemented for all development sites. The drainage designer will demonstrate the use of the management train concept, including an appropriate number of treatment stages for the cleaning of surface water runoff with catchments in excess of 2 hectares split into sub-catchments for local control of surface water runoff.



7.6 Good drainage practice – quality

7.6.1 Good site design

- Reduce the amount of silt and pollutants generated on site.
- Provide natural on-site treatment for polluted surface water runoff.
- Select and locate SUDS features to optimise pollution control.

7.6.2 Construction erosion and sediment control

- Reduce total area of the site to be disturbed.
- Protect SUDS features by physical protection or construction programme.
- Protect receiving watercourse or groundwater during construction by design and site operations.

7.6.3 Operation and maintenance

- Design for ease of maintenance using a simple, robust and easily understood design.
- Design to ensure the health and safety of maintenance staff and public.
- Design the SUDS for a long life and at least for the life of the development.
- Design an appropriate provision for waste management.

8.0 Providing value, visual interest and useful spaces for the community – amenity

8.1 Key principles

- Amenity benefits.
- Visual quality.
- Health and safety.

The key principles are to provide tangible benefits for the community that demonstrate high visual quality and robust design that is safe for the public and maintenance staff, with maximum opportunities for wildlife.

Amenity benefits are provided by keeping water at or near the surface and consider the design of surface SUDS features as an extension of landscape or urban design. Social benefits derive from multi-functional use and integration of SUDS features into the landscape.

Visual and aesthetic quality is achieved by good design and effective maintenance. Value to the community comes from education, understanding and realising that the SUDS provides better drainage, attractive surroundings and enhanced value to property and the local neighbourhood.

8.2 Amenity benefits

- Multi-functional space such as sports and recreational areas.
- Visually attractive SUDS features such as ponds and wetlands.
- Well designed surface details such as channels and canals or features like spouts, cascades and other water design details.
- Visually acceptable inlets, outlets and control structures such as headwalls.
- Integrating SUDS with the development landscape design.

All amenity elements of SUDS will be simple, robust and easily maintained.

Health and safety is 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 regarding 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 and details associated with SUDS should be evaluated for risk to the public, maintenance staff and wildlife.

Although it is generally accepted that water in the landscape is valuable for its visual interest, recreational value and benefit for wildlife, it is prudent to provide information, education and, where necessary, reassurance to people who are unfamiliar with open water and the associated risks.

8.3 Health and safety concerns

- The risk of drowning.
- Waterborne disease.
- The risk of wildfowl strikes to aircraft near airports.

Design practice that reduces risk includes:

- Where toddlers under 5 may have unsupervised access to open SUDS features, a toddler-proof fence 600-750mm high will be appropriate. However, fences generally can create their own hazards, prevent rescue and become visually unacceptable.
- A level dry bench at the top of all open structures, minimum of 1m wide, allows stationary rest and safe access.
- Slopes of 1 in 3 or less allow people to enter and leave SUDS features easily and safely.
- Safe maintenance access is required for appropriate machinery.

- A wet bench, minimum of 1m wide, to all water features allows a stationary rest and safe access at the water's edge.
- A maximum permanent depth of 600mm for wetlands and ponds is considered acceptable for SUDS and wildlife needs, unless the feature is designed as an amenity lake.
- A maximum storage depth of 600mm is considered acceptable for all open SUDS.
- Unrestricted visibility is required to all accessible water features.
- Dense marginal planting is advised to reduce accidental access to water but should not obscure visibility.
- Headwalls, manholes, inlets, outlets, control structures and other sumps or hard vertical surfaces that can be a trip hazard or create a hard surface near open water should generally be located a safe distance from the water's edge.
- All structures in the SUDS landscape should be assessed for health and safety during the design process.

Wherever possible, surface water runoff from roads and hardstanding should pass through a filtering structure like under-drained swales, bioretention and permeable pavement to enhance trapping of potential contamination.

Where ponds and other habitat associated with SUDS are located within eight miles of an airport, guidance provided by the Civil Aviation Authority (CAA) should be followed which minimises the risk of aircraft bird strike. Further information can be found in The SUDS Manual 20.3.5.

There is a potential risk of waterborne infection of Weil's disease, which is transmitted through open cuts through the vector of rat urine, and should be considered in the management of open water features. It is important to recognise that the risk of infection is low.

Concerns have been expressed about the possibility of the introduction of malaria into Britain. Although this is considered unlikely at present, it is prudent to design wetlands to reduce the breeding potential of mosquitoes by avoiding small temporary pools that are unconnected to open water. Mosquitoes breed in small, temporary water features where normal pond predators are absent, e.g. rainwater butts, large puddles and water features without natural habitat, such as marginal vegetation. This can be avoided through design.

Where ponds fall under the Reservoirs Act 1975 or the Flood and Water Management Act 2010, then additional requirements may be needed.

The Construction (Design and Management) Regulations 2007 (CDM) must be applied to the planning, design, construction and longterm maintenance of SUDS (see The SUDS Manual 2.5.10), for example:

- All SUDS features must provide safe access for maintenance.
- All SUDS features must provide a safe environment for the general public.
- Access points for vehicles should be level, secure and stable.

The developer should produce a communications plan, and educational information boards should be provided wherever required by Anglian Water to ensure residents and visitors understand SUDS design and the SUDS features used on the site.

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

The drainage designer will demonstrate that amenity has been provided in the SUDS design and that all components conform with recognised health and safety best practice as required by the local authority and as detailed within this manual.

9.0 Creating opportunities for wildlife – biodiversity (ecology)

9.1 Key principles

- Good water quality.
- Structural diversity.
- Locate near to existing habitat where possible.

Good water quality is key to ensuring ecological benefits and is provided by using the SUDS quality concepts of the management train, source control, treatment stages and by intercepting silt and pollution in pre-treatment techniques.

Surface water runoff must pass through source control features before passing onward to conveyance techniques, ideally on the surface in swales or other filtering techniques, before reaching ponds, wetlands or other biodiversity features.

Biodiversity will develop naturally in conveyance structures such as swales, or in open storage structures like basins, ponds and wetlands, providing water quality is good. The design of open landscape structures and the landscape that surrounds SUDS features should be designed and maintained for biodiversity.

Ecological design must take into account that SUDS need to meet drainage functions as a priority. Therefore:

- The management train must remain unobstructed in use at all times.
- All open soft surfaces that receive flows must be protected and remain well vegetated during the lifetime of the system.
- All landscape areas adjacent to SUDS must develop a robust ground vegetation to prevent silt migration.
- Swale, basin, pond and wetland vegetation will be necessary to retain the drainage function but this can easily be compatible with ecological objectives.
- Tree and shrub selection and subsequent care must take into account the requirement of a permanent and robust ground vegetation cover.
- Planting must not compromise future access.

Typha angustifolia wetland in housing, Malmo, Sweden

9.2 Good ecological practice includes:

- Creating ecologically designed corridors between habitat areas.
- Avoiding the use of pesticides, herbicides and fertilizers.
- Using accredited suppliers of native plants to ensure UK or local provenance and avoid alien species.
- Using local plant material and allowing natural colonization of SUDS features.
- Reduced maintenance intensity with 25-30% maximum vegetation removal at any one time.
- Retaining and enhancing natural drainage features.
- Including shallow aquatic edges to 450mm max depth and 1m minimum width to ponds and wetlands.
- Increasing vertical and horizontal structural diversity in open SUDS features.

9.3 Accreditation of plant sources

Where seeding and planting is considered necessary or beneficial then the source and provenance of seed and plants should be from accredited sources. It is important to ensure fully accredited plant sources to avoid alien species particularly Swamp stonecrop (*Crassula helmsii*), which can cover ponds completely and prevent the development of natural wetland communities. Confirmation of all plant sources will be required by Anglian Water before adoption is agreed. The removal of any alien species will be at the expense of the developer before the site is considered for adoption. The SEPA (Scottish Environmental Protection Agency) publication 'Ponds, pools and lochans' is available on the SEPA website at sepa.org.uk and provides a complete guide to pond and wetland design with guidance on planting and management of wetlands.

9.4 Native planting design strategy

All planting in public open space SUDS features including swales, basins, ponds and wetlands should be native to Great Britain, ideally of local provenance, and from an accredited source to avoid the introduction of alien species.

The planting objective for SUDS is to establish a robust native vegetation cover as soon as possible that will assist the drainage function and develop into a biodiversity asset.

Invasive plants

It is important not to plant invasive and vigorous colonising species that will prevent later establishment of a biodiverse wetland community. These include:

- Bulrush (*Typha latifolia*)
- Great pond sedge (*Carex riparia*)
- Reed canary grass (*Phalaris arundinacea*)
- Reed sweet-grass (*Glyceria maxima*)
- Branched bur-reed (*Sparganium erectum*)
- Common Reed (*Phagmites australis*)

Planting proposals should comprise common generalist species that are robust, easily established and give visual interest to local people. Later colonisation by locally occurring species will stabilise the habitat in a few years and contribute to local biodiversity.

Alien species

Alien species can out-compete and dominate native species and should not be planted where there is any contact with native planting. In particular the following species should not be planted under any circumstances due to their invasive character and recognised damage to natural habitat. These include:

- Canadian pondweed (*Elodea Canadensis*)
- Nuttall's pondweed (*Elodea nuttallii*)
- Curly waterweed (*Lagarosiphon major*)
- Parrot's feather (*Myriophyllum aquaticum*)
- Water fern (*Azolla filiculoides*)
- New Zealand Swamp stonecrop (*Crassula helmsii*)
- Floating pennywort (*Hydrocotyle ranunculoides*)

10.0 SUDS components

Anglian Water will consider the adoption of open SUDS features in public open space and the conveyance mechanisms that link them together and convey surface water runoff to an effective outfall.

Anglian Water will not adopt SUDS within the boundary of private property or the source control and other SUDS features located within development. Anglian Water will only consider adoption of SUDS which accept any highway drainage at the request of the Highway Authority.

10.1 Filter strips

Filter strips are grass or other densely vegetated strips of land that collect surface water runoff as sheet flow from impermeable surfaces.

Surface water runoff flows as a sheet across the filter strip which slows the flow of water and intercepts silt and pollution allowing some water to soak into the ground. 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.

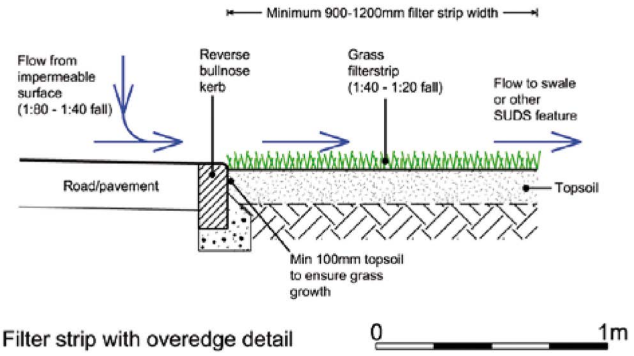
Key design standards

- Surface water runoff must flow across a flush kerb edge onto a grass or a vegetated surface.
- The hard edge must be generally level to ensure an even flow and prevent erosion and gullying.

Filter strip maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Grass cut 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	Monthly
	Cut back overhanging branches to allow dense grass growth	Monthly or as required
Remedial work	Repair erosion, level uneven surfaces or damage by re-turfing or seeding	As required
	Remove an oblique divot along the hard edge where silt has accumulated to reinstate flow over the edge	
	Remove silt and spread locally outside design profile and reinstate surface	

Filter strip with overedge detail



Filter strip with overedge detail

Filter strip and swale, Witney, Oxon

- The filter strip should be 20-25mm below the edge of the kerb to allow an unobstructed flow onto the vegetated surface and avoid ponding.
- The slope of the filter strip increases to ensure adequate flow e.g. 1 in 40 road cross fall to 1 in 20 filter strip for a minimum of 1m.
- A minimum width of 900-1200mm.
- Over-run by vehicles must be prevented by bollards, rails, fences or other controls to retain even surface flow.
- The kerb haunch must allow a minimum of 100mm topsoil for acceptable grass growth with generally 150mm topsoil over subsoil.
- A minimum of 1 in 50 and maximum of 1 in 20 slope is recommended.

Maintenance is simple and cost effective. Remedial work is only needed if an edge is damaged or gross siltation has occurred due to local excavation or spillage. Experience indicates that remedial work is generally not required for at least 10 years with good design and competent construction.

10.2 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 surface water runoff allowing water to soak into the ground where soil conditions are suitable. Swales usually collect surface water runoff laterally across grass filter strips or over kerb edge inlets that reduce the rate of flow and allow suspended particles to settle in grass kept at a minimum height of 100mm. Surface water runoff can flow into swales through a point inlet but then requires erosion control and needs a silt collection arrangement if this has not been removed at source.

Shallow under-drained swales are useful in housing to collect surface water runoff at source and are normally dry grass channels that are visually acceptable to residents and can be used for informal play by children. They can be the first treatment stage before conveyance to the next part of the management train.

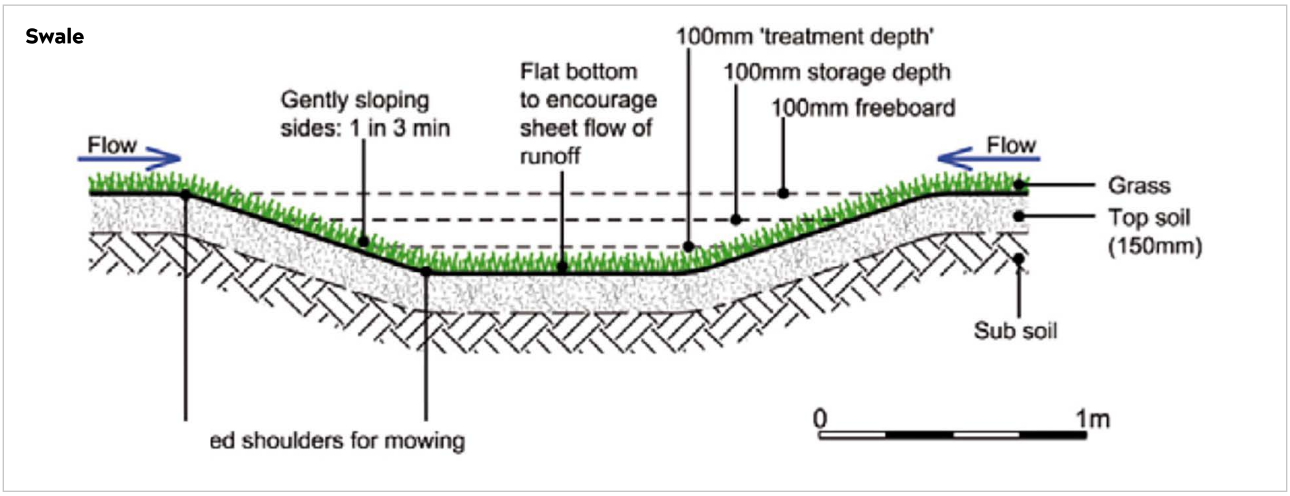
Conveyance swales are not usually underdrained and although normally dry can offer visual and habitat enhancement opportunities. Where swales are designed to retain water for storage or ground conditions and slopes are suitable they can develop a wetland vegetation and become wet swales with permanent water.

Key design standards

- Swales should be shallow with side slopes no more than 1 in 3 to allow flow across the edge, easy maintenance and for safe access.
- Swale depth should not exceed 450mm wherever possible.
- A 100-150mm depth for normal flows uses the vegetation to reduce flow and allow filtration.
- A maximum 300mm storage above normal flow depth, to include freeboard if necessary, provides an acceptable swale profile.
- Flow rate should be restricted to 1-2m/s or 1 in 50 maximum slopes to prevent erosion and ensure effective pollution control.

Swale maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Amenity grass cutting at 35-50mm	As required
	Grass cut to swales, access and overflows 75-100mm not to exceed 150mm	Monthly or as required
	Wetland or meadow vegetation cut at 50mm and remove to wildlife or compost piles	Monthly or as required
	Inspect and clear inlets, outlets and overflows	Monthly
Occasional tasks	Remove lead accumulation	As required
	Cut back overhanging branches to allow dense grass growth	
Remedial work	Repair erosion, level uneven surfaces or damage by re-turfing or seeding	As required
	Remove silt and spread locally outside design profile and reinstate surface	
	Repair inlets, outlets or check dam structures to design detail	



- Slopes along the swale less than 1 in 100 can increase permanent wetness depending on soil conditions.
- Base width is normally 0.6m to 2m to allow effective maintenance and prevent gullying of the base.
- Swales are usually grass but can be meadow, wetland or open woodland provided a dense ground vegetation is retained.
- Check dams and other flow restrictions. Consider maintenance and avoid potential vandalism, e.g. loose stone structures.
- Reasonable access for maintenance by mowers should be provided.
- Consider inlets, outlets and overflow design to reduce the risk of blockage.

Best practice

Maintenance is simple and cost effective. Remedial work is usually only needed immediately after construction and is covered by the S104 agreement. Normal grass swales require cutting at 75-100mm, and must not exceed 150mm, to prevent grass lodging or falling over due to wind or water.

Where meadow or wet swales develop with vegetation that is resistant to collapse, then an annual or bi-annual cut will be sufficient to ensure the swale works effectively.

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 amenity grass standard.

10.3 Bioretention areas and raingardens

Bioretention areas and raingardens are planted areas that are designed to provide a drainage function as well as contribute to the soft landscape. Bioretention areas normally receive surface water runoff from roads or other similar hard surfaces whereas raingardens are designed to take relatively clean roofwater. They are located where surface water runoff flows from surrounding impermeable hard surfaces and collect the polluted first flush volume in shallow planted basins. The raingarden, often with organic mulch, intercepts silt and pollution allowing water to soak through 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.

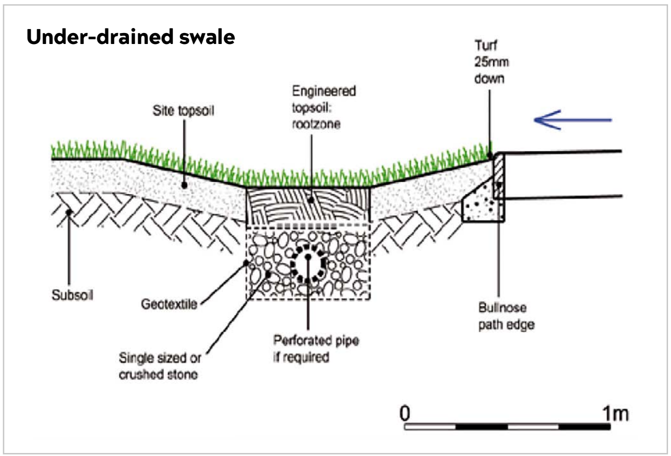
Ideally surface water runoff is collected as sheet flow over the edge, but it can enter at point inlets with erosion protection and silt traps. General plant care is like normal plant beds with additional attention to silt accumulation and ensuring effective soakage into the engineered soil layer.

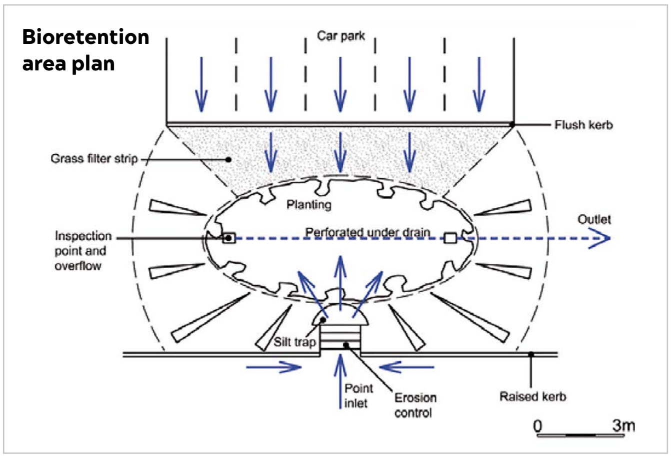
Key design standards

- A bioretention area should collect and temporarily store the treatment volume or Vt or first flush volume (10-15mm from contributing hard surfaces) at a usual depth of 150mm.
- A grass filter strip or silt forebay for point inlets is required to control siltation and blockage of the basin.
- The water should drain down within 24 hours to anticipate the next storm.
- They should be constructed at least 1m above the groundwater table.
- They usually require a forebay or filter strip to intercept silt.
- An organic mulch is recommended within the 150mm depression.
- They require a free draining topsoil or rootzone 450-900mm deep depending on the planting design.
- They usually require a drainage layer with perforated pipe and overflow.
- Planting must be robust to deal with intermittent flooding and designed to cover the whole surface as soon as possible.

Best practice

The landscape character of the raingarden will depend on the design of the space and may be ornamental shrub bed, woodland or meadow in appearance.





Biorention and raingarden maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site Mow filter strip 75-100mm not to exceed 150mm leaving cuttings in situ Inspect and clear inlets, outlets, and overflows Pruning, trimming and general landscape care	Monthly
Occasional tasks	Removal of silt from pre-treatment structure Surface reinstatement by forking or scarifying Replacement of mulch with shredded prunings from site or composted bark	As required
Remedial work	Level reinstatement due to erosion or damage Repair or replace inlets, outlets or overflow structures	As required

10.4 Filter drains and trenches

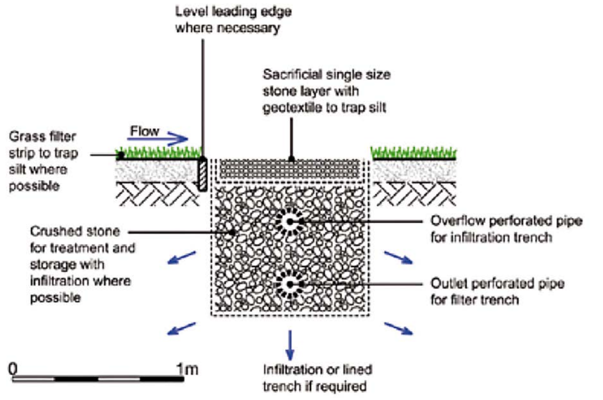
Filter drains and trenches (often called French drains) are linear excavations filled with stone that ideally collect surface water runoff laterally as sheet flow from impermeable surfaces, although point inlets can be used with care to prevent damage to the structure. They filter surface water runoff as it passes through the stone allowing water to infiltrate into soil or flow to the next part of the management train. Some storage is provided in the voids, usually 30% by volume.

Filter drains are easily clogged by silt so should be protected by upstream features like a grass filter strip.

Key design standards

- Measures are required to protect or manage siltation.
- A perforated pipe may be appropriate to convey water onward from the drain and should include access for rodding or jetting with open outfalls.
- Where infiltration is proposed then a high level overflow pipe may be appropriate.

Filter drain or infiltration trench



Filter drain and trench maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site Grass cutting around the trench where appropriate at 75-100mm and not to exceed 150mm Inspect and clear inlets, outlets and inspection points	Monthly
Occasional tasks	Silt removal from pre-treatment features Inspect and remove silt from chambers and pipes	As required
Remedial work	Remove surface stone layer and set aside, replace clogged geotextile and reinstate De-silt stone fill using proprietary machinery as trunk road maintenance Remove and replace filter drain stone	As required

- Perforated pipes should normally be provided for the last few metres of the trench to maximise filtration.
- The edge of the drain should be level to encourage sheet flow and prevent gully erosion where taking a lateral flow.
- Point source inlets should incorporate a silt pre-treatment feature to prevent clogging of the inlets or surface layers.

Best practice

Loose stone, sometimes due to overrun by vehicles, can be a hazard for maintenance operations and a temptation for children as missiles. Therefore the siting of filter drains and trenches is important.

10.5 Permeable pavements

Permeable pavements provide a surface that is suitable for pedestrian or vehicle traffic while allowing surface water runoff to percolate directly through the surface into underlying open stone construction. Surface water runoff passing through permeable pavement leaves silt on or just below the surface but oils and other pollutants are trapped on geotextiles or in the stone construction for biodegradation by bacteria. Surface water runoff is stored in the construction before infiltration or controlled discharge to the management train.

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

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

Permeable pavement maintenance

Maintenance	Action	Frequency
Regular maintenance	Surface brushing for appearance and to reduce silt accumulation	Monthly
	Brushing and suction sweep or jet wash and suction sweep particularly for block pavement in autumn after leaf fall	Annually
	Mow grass edges to paving at 35-50mm and remove weeds and leaves	As required
	Check outlets and control structures	Monthly depending on detail
Occasional tasks	Jetting and suction where silt has accumulated in joints or voids. Replace grit and vibrate surface to lock for permeable block paving	As required
Remedial work	Where sinkage or surface damage occurs uplift blocks, remove grit bedding layer, geotextile if present and reinstate to design profile	As required

Key design standards

- Permeable pavements need to be designed structurally to meet loading and traffic requirements.
- Storage must be sufficient for infiltration rates or to meet attenuation requirements.
- The use of a geotextile as an upper separating or treatment layer may be considered as an option depending on site constraints.
- Pervious surfaces are susceptible to silt blockage and surrounding landscape details, slopes and management must take this into account.
- Three types are currently identified:
  - Total infiltration with a lower separating geotextile.
  - Partial infiltration with an overflow outlet from the pavement.
  - No infiltration usually with an impermeable separating membrane and controlled outlet onward to the management train or discharge point.
- Sub-bases can be augmented with geocellular structures with the advantage that surface water runoff is clean before it enters underground storage.
- Additional surface water runoff from adjacent impermeable surfaces or roofs can be directed onto permeable surfaces to provide cleaning before underground storage.

Best practice

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 if surface water runoff flows onto the surface from impermeable surfaces.

Recent experience with permeable block paving indicates that siltation of the blocks occurs very slowly and silt remains in the joints between blocks rather than migrating into the grit bedding layer.

See the landscape design section 11.0 for managing silt from adjacent surfaces.

10.6 Geocellular structures, oversized pipes and tanks

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

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

Structural design must be provided to ensure integrity of the box, pipe or tank under loading.

Silt interception and 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.

Key design standards

There are two basic modular box arrangements:

1. A modular box system with inlet and outlet pipework 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.

There are now shallow, load bearing boxes which can be used under pavements and in particular below permeable pavement which protects the box from silt contamination and provides treatment with enhanced storage.

Best practice

The advantage of geocellular structures over conventional in-situ tanks or concrete pipes is the spatial versatility and ease of installation. They can also allow infiltration through a geotextile liner in suitable soils.

To achieve 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 hydraulic design of on or off-line storage using pipes or tanks should be in accordance with the latest edition of Sewers for Adoption.

Infiltration systems should be designed to comply with current guidelines, Soakaway Design BRE 365 1991 or CIRIA publication R156 Bettess 1996. Storage systems should be designed using standard routing methods set out in Chapter 4 of The SUDS Manual.

The structural design of tanks and pipes should be in accordance with relevant standards, e.g. the latest edition of Sewers for Adoption, Structural design of buried pipelines under various conditions of loading BSEN 1295 (BSI 1998) and the Highways Agency specification for highway works (Highways Agency et al, 1998).

Although specifications for geocellular units and other underground storage will be provided by manufacturers, each system will need an assessment in terms of structural integrity and operating efficiency.

The preferred method of collection is through permeable pavement because silt is trapped on the surface and surface water runoff passes through stone and geotextile that provide cleaning before entering storage. This arrangement provides clean surface water runoff for attenuation.

Further information can be found within the Structural Design of Modular Geocellular Tanks CIRIA C680 guide.

Geocellular structure, Red Hill School, Worcester

Geocellular boxes, oversized pipes and tanks maintenance

Maintenance		Action		Frequency
Regular maintenance	→	Check inlets, outlets, control structures and overflows	→	Monthly or annually are required
Occasional tasks	→	Jetting and suction where silt has settled	→	As required
Remedial work	→	Reinstate	→	As required

10.7 Detention basins

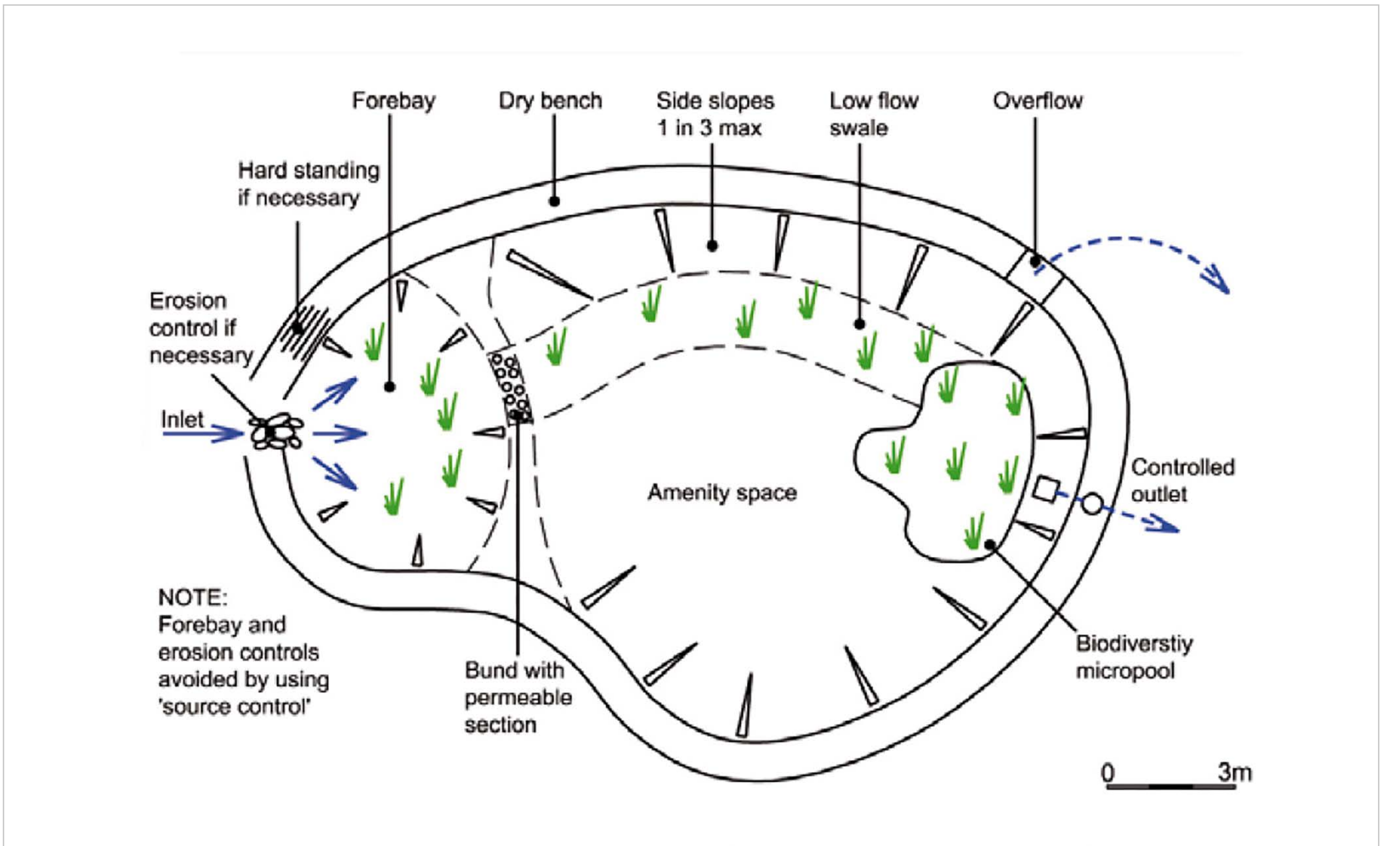
Detention basins are vegetated depressions in the ground designed to store surface water runoff and either allow it to soak into the ground or flow out at a controlled rate. Within development, these basins are usually small grassed areas, sometimes with a micropool or planted area at a low point where some standing water can accumulate.

They should be designed as landscape features that allow other uses when dry including play, informal sport, social space, visual enhancement and habitat creation. These opportunities are enhanced when there are source control features upstream that prevent silt and pollution reaching the basin and reduce the frequency at which surface water runoff reaches the basin. The use of source control avoids the need for forebays and substantial erosion control allowing more effective integration into the landscape and reduced maintenance.

Key design standards

- Silt should be intercepted at source wherever possible or be intercepted in a forebay where surface water runoff enters the basin.
- Surface water runoff should flow into the basin as controlled sheet flow from source control features to reduce the risk of erosion but if entry is uncontrolled through a point inlet then an erosion control structure will be necessary to manage the flow.
- Detention basins should have a 2:1 to 5:1 length to width ratio to provide maximum opportunities for settlement at the inlet and filtration of surface water runoff.
- There should be a gentle fall to the outlet of about 1 in 100 to encourage surface sheet flow by gravity. Falls can be reduced where a habitat space is required or where wetland is to develop.
- Part of the basin can be lowered to keep other areas dry for recreation, retaining sheet flow across a significant surface area for low flow treatment.
- A controlled outfall at or just below ground level is usual to ensure drain down unless preceded by a micro-pool. This ensures a generally dry surface when it is not raining. A micro-pool enhances treatment, avoids a muddy area at the outlet and provides biodiversity interest.

Detention basin with integrall forebay



- Side slopes to the basin should be 1 in 3 maximum, with clear access for maintenance.
- Basins require an overflow to allow for design exceedance or outlet blockage.
- The design and planting of infiltration and detention basins should integrate with local landscape and be considered as multifunctional space.
- 75-100mm amenity grass or meadow vegetation provides enhanced treatment and a resilient surface for informal use.
- Access points, paths and verges should be mown regularly to 75-100mm.
- Detention basins can be on-line or off-line when a flow diverter will be needed to store large volumes of surface water runoff.
- Storage depth should not be more than 600mm for safety reasons.

Best practice
Detention basins should always be integrated into the design of the site to provide visual, social and biodiversity benefits, and to encourage informal policing by local people of a valued landscape space.

Detention basin maintenance

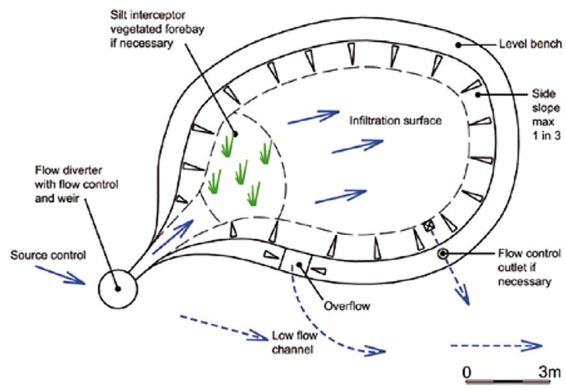
Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Amenity grass cutting at 35-50mm	As required
	Grass cutting to access routes, overflows and basin where required at 75-100mm not to exceed 150mm	As required
	Meadow grass, where appropriate, cut at 50mm and remove to wildlife or compost piles	Annually
	Manage wetland planting in micropools by cutting and remove to wildlife or compost piles	As required
	Inspect and clear inlets, outlets, control structures and overflows	Monthly
Occasional tasks	Remove leaf accumulation	As required
	Cut back overhanging branches to allow dense vegetation growth	
	Remove sediments from forebay, inlets and pre-treatment structures	
Remedial work	Inspect and repair damage to inlets, outlets, banks and overflows	As required

10.8 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 surface water runoff from small areas and are usually off-line to prevent siltation, excessive pollution and effects of spillage.

It is crucial that source control measures intercept silt and pollution to prevent clogging of the surface and ensure that only clean surface water runoff infiltrates into the ground. Infiltration basins are not suitable for pollution hot spots like industrial sites.

Infiltration basin off-line plan



Infiltration basin maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Amenity grass cutting at 35-50mm	As required
	Grass cutting to access routes, overflows and basin where required at 75-100mm not to exceed 150mm	As required
	Meadow grass, where appropriate, cut at 50mm and remove to wildlife or compost piles	Annually
	Check and clear inlets and overflow structures	Monthly
Occasional tasks	Remove leaf accumulation	As required
	Cut back overhanging branches to allow dense vegetation growth	
	Remove sediments from forebay, inlets and pre-treatment structures	
Remedial work	Inspect and repair damage to inlets, outlets, banks and overflows	As required
	Hollow tine and scarifying of surface if infiltration reduces over time	

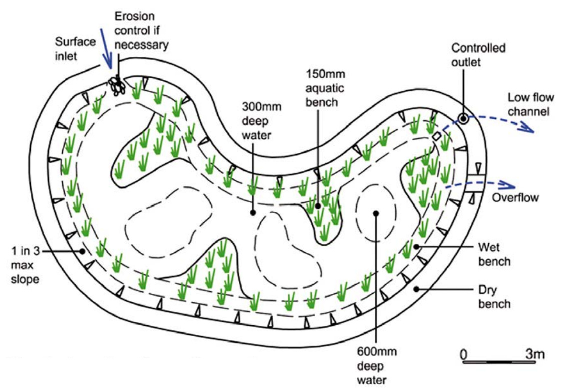
Key design standards

- The infiltration potential of the soil and subsoil must be confirmed by geo-technical tests.
- The stability of the ground must be confirmed and an analysis of likely infiltration pathways and risk to surrounding features undertaken.
- 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 base should be level across the basin to encourage even infiltration with a slight fall of between 1 in 100 and 1 in 200 along the basin to distribute water evenly.
- 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.
- Basins require an overflow to allow for design exceedance or outlet blockage.
- Informal use of infiltration basins should take into account the risk of compaction of the base, so vehicle access must be prevented.

10.9 Ponds

Ponds are depressions in the ground that contain a permanent or semi-permanent volume of water. Ponds can include wetland elements, be part of a wetland system, or be temporary ponds and basins that dry out periodically.

Pond plan showing enhanced flow routing and biodiversity



SUDS ponds are usually separate structures with a storage capacity above the permanent water volume and a defined edge design to satisfy safety concerns. In all other characteristics they should mimic natural pond systems.

Ponds and wetlands should be designed to receive silt-free surface water runoff with light loading of dissolved pollution that can be processed in the water column by micro-organisms. 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 does not compromise amenity, biodiversity and management requirements.

Key design standards

SUDS ponds should mimic natural ponds wherever possible:

- There should be a dry bench minimum width of 1m, to allow people to stand safely before descending towards the pond.
- Slopes down to the ponds and within them should be no more than 1 in 3, both for ease of access and maintenance.
- There should be a level wet bench minimum width of 1m, unless the pond is very small, to allow people to stand safely before the water's edge.
- Slopes within the ponds should also be gentle to a normal maximum depth of 500-600mm.
- Liners may be required to retain a permanent volume of water in the pond.
- Ponds should be located at the end of the management train to ensure that clean water and controlled flows enter the pond.
- Forebays are unnecessary if source control features are in place upstream of the pond.
- Inlets and outlets should be placed to maximise the flow path through the pond, assisted by pond shape, islands and baffles, if necessary.
- The outlet invert will be at the permanent water level of the pond.

- The storage volume above permanent water level should be 450-600mm deep for safety and management reasons with an infiltration option at the pond edge.
- A number of smaller pond features in a linked chain can often fit into development more easily, allow simple access for maintenance and benefit biodiversity.
- 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 where possible.
- A robust, simple and easily maintained control structure will be necessary to limit flows from the pond unless all flows have been controlled further up the management train.
- Basins require an overflow to allow for design exceedance or outlet blockage.
- Planting of ponds should follow guidance set out in 'Pond, pools and lochans' published by SEPA and landscape guidance in this manual.
- Management involves: cutting grass for access and visual amenity; cutting meadow or rough grass for visual or biodiversity reasons; removal of small amounts of aquatic vegetation to retain storage volumes, amenity and biodiversity; and occasional bankside pruning or felling to retain a balanced surrounding to the pond or wetland.

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

Ponds and wetlands should therefore be viewed as polishing mechanisms where water quality does not compromise amenity, biodiversity and management requirements.

Treatment volume or 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. The treatment volume or Vt, usually the first 10-15mm of surface water runoff from hard surfaces, collected at source and directed through an appropriate series of treatment stages removes most silt and pollution before water reaches the pond.

Current research on pollution control favours the interception of silts and oils in soils, such as filter strips and swales or permeable pavements, where alternate wetting and drying of the silts and exposure to UV light offers a better treatment mechanism for oils and entrapment of heavy metals at source.

Site and regional controls, usually basins, ponds and wetlands, with interlinking swale conveyance, should therefore be free of inorganic silt and pollution to ensure the public can have confidence in a safe, attractive and biodiverse environment.

Health and safety

Some guidance recommends a dense planted edge to prevent access but many natural ponds have a mosaic of vegetation at the margins and recent research suggests people like to see the pond and have direct access to the water's edge.

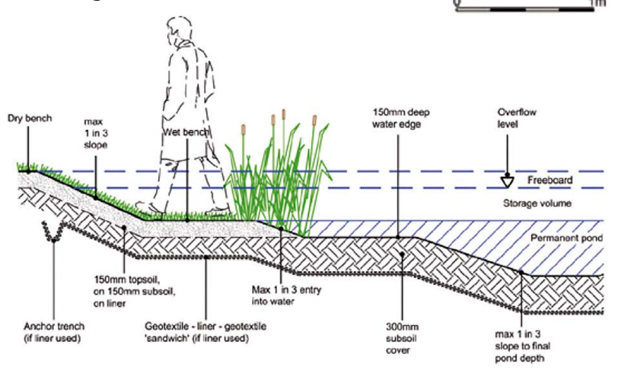
A depth of 500-600mm is the usual depth of natural ponds in Britain and the shallow margin is the most biodiverse area of the pond. A gently sloping aquatic shelf following entry to the pond is particularly important for safety reasons as it allows adults and young children to stand up and walk safely out of a pond.

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 that break down organic matter.

If silt removal is required then it may be necessary to provide a sample from the inlet to the Environment Agency for testing to ensure the silt is not toxic waste. Remove accumulated silt and no more than 30% of excess vegetation to protect biodiversity and filtration potential of the pond.

Pond edge profile



Pond maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Amenity grass 35-50mm for access, paths and visual requirements	As required
	Grass cut to pond edges, access and overflows 75-100mm and not to exceed 150mm	Monthly or as required
	Wetland, meadow or rough grass cut at 50mm and remove to wildlife or compost piles	Annually or as required
	Cut pond vegetation if required and no more than 30% 100mm above pond base and remove to wildlife or compost piles	Annually or as required
	Inspect and clear inlets, outlets and control structures	Monthly
	Remove sediment from forebay structures if present and site apply subject to agreement with the EA	Annually
Occasional tasks	Review silt accumulation remove and site apply or take off site if necessary subject to agreement with the EA	As required
	Removal of tree or shrub growth within 5m of pond edge	
Remedial work	Repair or replace inlets, outlets or control structures to design detail	As required

10.10 Wetlands

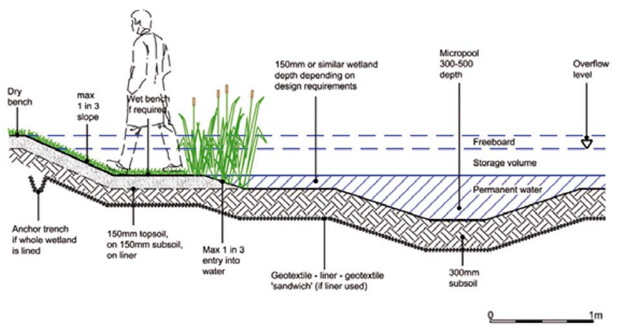
Wetlands are shallow depressions that are nearly or completely covered in marsh vegetation, generally with little open water, although small ponds can occur within the wetland. Wetlands naturally occur with ponds and basins becoming a wetland complex in many natural situations. This condition can be replicated in SUDS to provide efficient storage in open space.

Wetlands can store large volumes of surface water runoff 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 longer than wide, with a ratio greater than 3:1. Surface water runoff can be directed through extended routes within the wetland 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 surface water 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 build up of silt levels.

Wetland edge profile

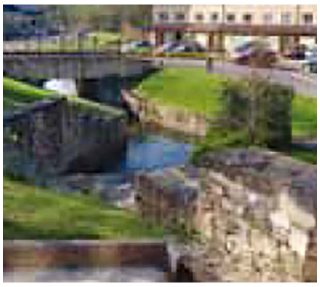


Key Design Standards

- SUDS wetlands are generally linear and designed to clean, store and convey surface water runoff to the next part of the management train.
- They are often designed to retain the treatment volume for a defined area of impermeable hard surface.
- A sediment forebay is often recommended to intercept silt but is unnecessary if source control measures are in place higher up the management train.
- A continuous baseflow in the wetland is recommended but this cannot be guaranteed in practice and is not always the case in natural wetlands.

Bridges and causeways

Kerb inlets



Chute gullies

Kerb channels

Flush kerb, Exwick School, Exeter

- A variation in depth is recommended for treatment and ecological reasons but water depths in excess of 600mm are not required for habitat reasons and can affect safety assessments and maintenance operations.
- Slopes and profiles should be generally as in pond construction.
- Basins require an overflow to allow for design exceedance or outlet blockage.

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

Wetland maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal from site	Monthly
	Amenity grass cutting at 35-50mm for verges, paths and visual requirements	As required
	Grass cutting to access routes, wetland edges and overflows	Monthly
	Meadow or rough grass cut at 50mm and remove to wildlife or compost piles	Annually or as required
	Cut pond vegetation if required and no more than 30% 100mm above pond base and remove to wildlife or compost piles	Annually or as required
	Remove silt from forebays or other inlet structures if present	Annually or as required
	Inspect and clear, inlets, outlets, control structures and overflows	Monthly or as requested
Occasional tasks	Review silt accumulation remove and site apply or take off site if necessary subject to agreement with the EA	As required
	Removal of encroaching pond vegetation if required to meet design objectives	
	Removal of tree or shrub growth within 5m of pond edge	
Remedial work	Repair or replace inlets, outlets or control structures to design detail	As required

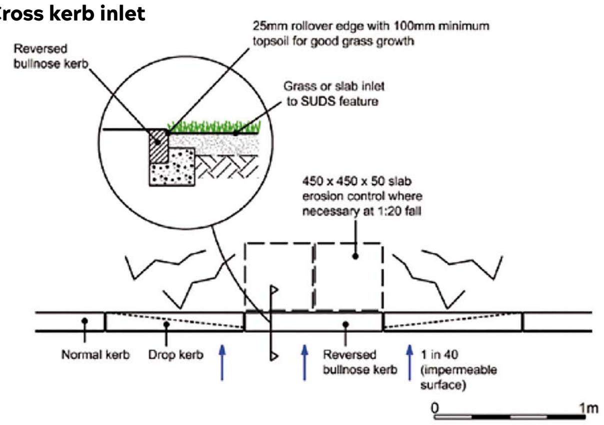
10.11 Inlets, outlets and flow control structures

SUDS require inlets, outlets and control structures to direct flows into and out of a SUDS feature and control the rate at which flows pass to the next part of the system.

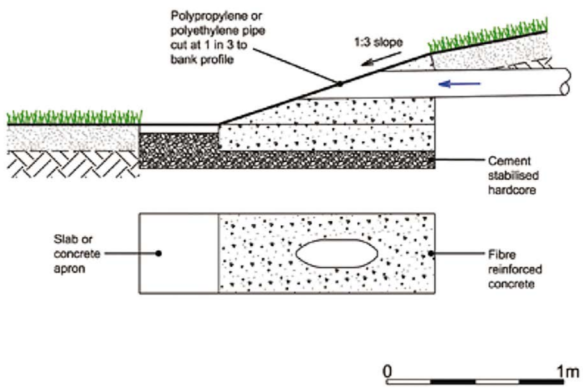
- **An inlet structure** conveys flow into a SUDS component.
- **An outlet structure** conveys flow out of a SUDS component.
- **A control structure** restricts the rate of flow into or from an outlet structure.

Unlike conventional drainage systems that concentrate surface water runoff and increase the rate of flow within ever larger pipes as surface water runoff travels to the discharge point, SUDS reduce the flow rate as surface water runoff travels through the management train. Therefore the most unpredictable and variable flows should occur as surface water runoff flows from impermeable surfaces into source control structures.

Cross kerb inlet



Mitred concrete headwall



It is important to keep surface water runoff as close as possible to the surface to allow entry into shallow SUDS features and surface flow routes.

Surface water runoff from impermeable surfaces flows laterally and can leave as sheet flow across a flush edge, channelled through point inlets, or, as a last resort, through gullies and gratings.

Where rain falls directly onto pervious surfaces the whole construction profile acts as a collector and surface water runoff percolates into the storage layer below the surface.

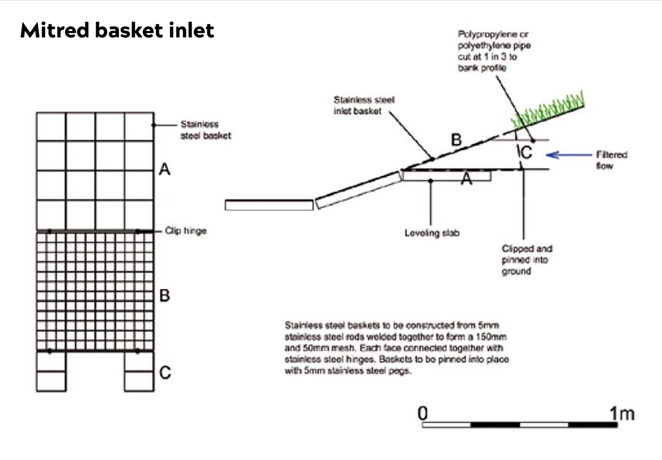
Small sub-catchments use source control techniques to reduce the rate of flow and volumes of surface water runoff. The small collection areas, together with the reduction in flow rate and volume, eliminate the need for large concrete structures and allow the use of small control mechanisms appropriate for low flows and velocities.

Collection of surface water runoff from hard surfaces can be achieved in a number of ways.

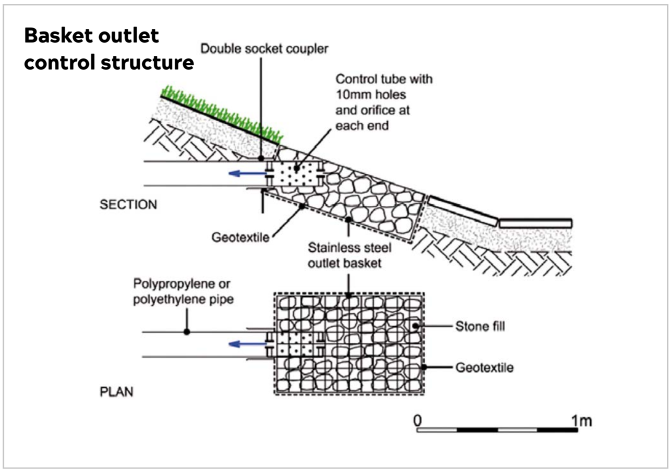
Inlets from impermeable hard surfaces

The following inlets may be appropriate depending on site conditions. They must provide unrestricted flow from hard surfaces that are unlikely to block. Surface water runoff flows directly into the SUDS feature or through a short pipe connection with open pipe inlet.

Erosion control, flow spreaders and silt traps may be required where surface water runoff enters the source control feature to avoid gullying and control silt accumulation. Wherever possible, inlets should be raised above surrounding ground level to prevent obstruction to flow where surface water runoff slows as it enters the SUDS feature.



Mitred basket inlet



Basket outlet control structure

Mitred concrete headwall with grille

Open pipe inlets

Surface water runoff should flow directly across the surface into a SUDS feature but sometimes it is necessary to collect it into a pipe from a grating, channel or chute gully. The collector should not include a silt trap or pot, as in gully pots, as they add to the risk of blockage and maintenance costs. Silt and pollution control is managed within the source control SUDS feature.

Where a pipe inlet is used, the pipe length with grille should be as short as possible before surface water runoff enters the collecting SUDS feature. The inlet into the SUDS feature will need to be open at the end to prevent blockage by debris flowing down the pipe.

An effective open pipe inlet solution, commonly used in the USA, is the concrete headwall. The profile of the structure is the same as the surrounding ground and 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, safety and cost. They should be considered against the mitred headwall as a standard inlet structure.

Protected pipe inlets

Surface water runoff collected through permeable surfaces or other filter mechanism, such as an under-drained swale, will not contain debris so can enter SUDS features through grille 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.

A convenient mesh size is 50mm usually made from stainless steel to prevent rusting or zinc leakage to the environment.

The following protected inlets may be appropriate depending on site conditions. Where flows are generated from permeable pavements, under-drained swales or bioretention areas, the flows may be controlled or attenuated by the structure and require small pipe diameters with increased falls to accommodate a self-cleaning function. Pipes should be polypropylene or polyethylene to reduce brittleness due to UV light.

Outlets from SUDS features

Once surface water runoff has passed through a SUDS feature it can either flow onward unimpeded, as in a conveyance swale, but often will pass through an outlet and be controlled through a flow control structure. A hierarchy of flow control and storage is required in SUDS to provide a sequence of attenuation. The control design will depend on the technique being used and the location in the development.

Once surface water runoff enters a SUDS feature, the flow rate reduces as water travels through the structure causing silts and debris to fall from suspension. Vegetated structures like swales, basins, ponds and wetlands intercept silts and debris by filtration through planting. This further reduces the risk of blockage at the outlet. Permeable surfaces, underdrained swales and bioretention areas filter surface water runoff through the construction profile.

The low flows leaving an open SUDS feature pass through an outlet before flowing through a control structure. Surface water runoff collected from pervious surfaces, where water is filtered through stone or engineered topsoil, can discharge water directly through a control structure as there is nothing to block the control structure. Therefore the design of the outlet is generally to manage low flows effectively rather than deal with large volumes and velocities.

The gradients on pipes connecting control features should be greater than usual as there will be no self-cleaning flows through the pipe.

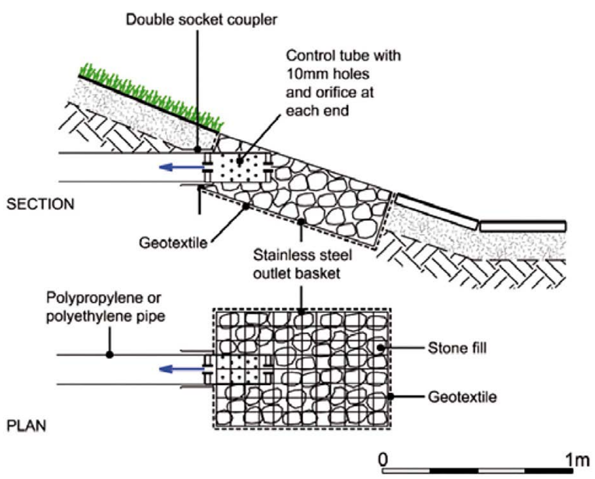
Surface spillway overflows or overflows integrated into the control structure accommodate occasional large volumes of surface water runoff.

All inlets, outlets and control structures must be simple, robust and easy to maintain. The design of the structure will be dependent on site conditions and be agreed with Anglian Water.

All SUDS drainage must demonstrate a clear means for surface water runoff to overflow from individual SUDS features and an exceedance route for surface water runoff to follow when the design volumes are exceeded during exceptional rainfall.

Surface controls

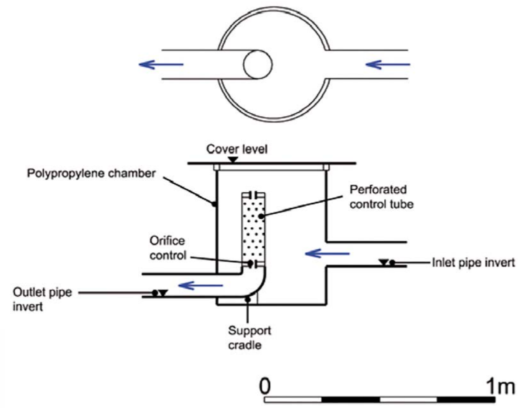
Basket outlet control structure



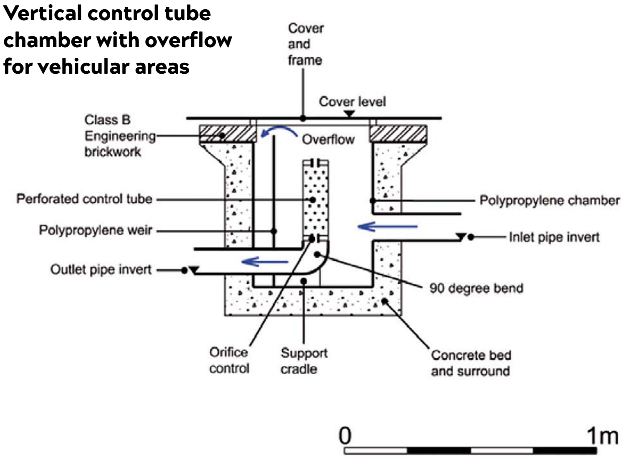
Box weir control

Chamber controls

Vertical control tube chamber for soft landscape areas



Vertical control tube chamber with overflow for vehicular areas



Overflows

SUDS features generally require an overflow to deal with blockage or surcharge when the storage volume is full. In many situations this will be designed to transfer surface water runoff to the next part of the management train until a local blockage is cleared or rainfall eases.

However sometimes overflows may flow directly to an exceedance flow route.

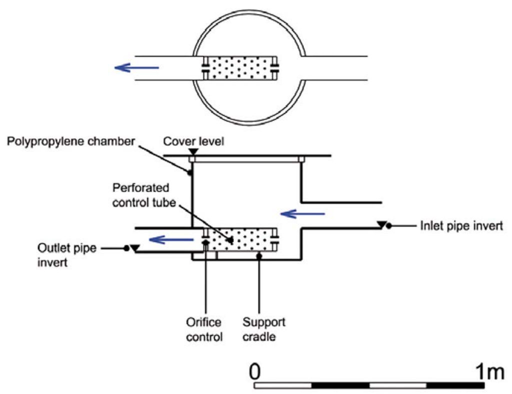
Off-line storage may not need these devices if flow is diverted through a bypass structure from the on-line flow.

In open structures the overflow will take the form of a weir or spillway returning surface water runoff to open features in the management train, with overflow weirs in underground control structures.

Overflow structures and flow routes must be demonstrated for all SUDS structures.

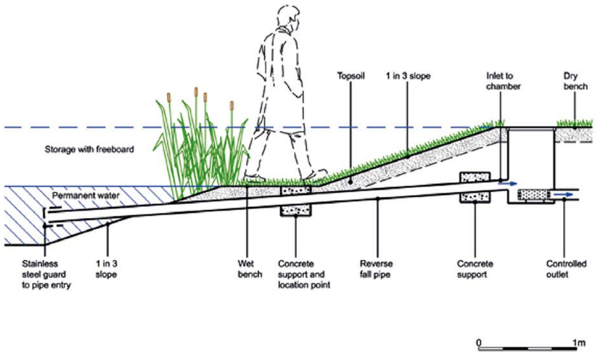
Horizontal control tube

Horizontal control tube chamber for soft landscape areas

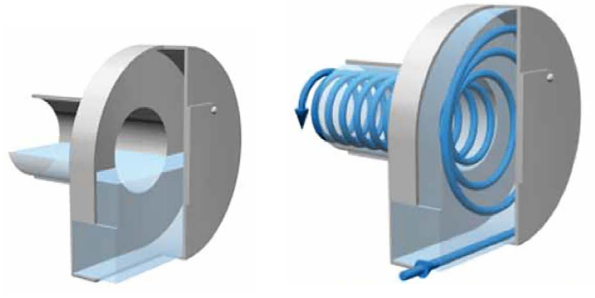


Reverse fall pipe inlet control

Reverse fall pipe pond outlet and flow control



Vortex control



Exceedance routes

The exceedance route is an ultimate safeguard when the system, or parts of the system, is overwhelmed by exceptional rainfall.

The exceedance route protects the SUDS, particularly low flow channels, from damage, and directs water away from property to overland pathways where it poses minimum risk to people or buildings. These routes may combine with SUDS structure overflows, often over a shallow grass weir, through development open space or road pathways avoiding people and property.

Exceedance flow routes must be demonstrated for every development, and the Management Plan must demonstrate how these exceedance routes will be protected.

Key design standards for adoption inlets, outlets and control structures maintenance

Maintenance	Action	Frequency
Regular maintenance	Litter and debris removal	Monthly
	Grass cut around structure 1m at 50mm where necessary	Monthly
	Remove silt from forebays, aprons or other structures if present	Monthly or as required
	Inspect and clear inlets, outlets, control structures and overflows	Monthly or as specified
Occasional tasks	Removal of tree or shrub growth within 5m of pond edge	As required
Remedial work	Repair or replace inlets, outlets or control structure to design detail	As required

11.0 Landscape Design and SUDS

11.1 Design principles

SUDS uses landscape features at or near the surface and unlike conventional drainage, which is largely out of sight, SUDS are often visible and contribute to the quality of development. Therefore the SUDS designer must understand landscape design as well as engineering principles to ensure the drainage system works effectively and provides environmental enhancement.

The design of SUDS should consider both hard and soft landscape features, thereby integrating urban design issues and engineering with the planting and maintenance of planted surroundings to SUDS features. SUDS design therefore requires a multi-disciplinary approach to achieve acceptable outcomes.

This section considers primarily the soft landscape requirements for SUDS and their immediate surroundings.

- The 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 consequences of flowing water, siltation, blockage of inlets and outlets and the design of permeable surfaces.
- Landscape specification should avoid inorganic fertilizers, pesticides, herbicides and mulches that impact upon the SUDS.
- Landscape maintenance should integrate with the care of all SUDS features.
- Landscape designers must integrate visual and landscape quality with the engineering requirements of SUDS.

11.2 Detailed design guidance

Surfaces that receive direct flows, e.g. filter strips, swales, basins, pond and wetland edges, together with inlets and outlets, should be stabilised before surface water runoff is allowed to enter the SUDS.

Where possible use turf if the ground is adequately prepared and soil retains sufficient moisture between September to April, subject to weather conditions.

When turf cannot be laid then use a fully biodegradable coir blanket (without plastic reinforcement) where regular flows occur, and either seed the underlying ground or use a pre-seeded blanket.

Slopes adjacent to SUDS features, where there is no direct flow but a risk of erosion, should have a geo-jute mesh placed over the seeded surface to protect adjacent areas from surface washout and gullying.

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

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 to provide easy long-term maintenance. This can be achieved using good detail design and is demonstrated in section 10.0 SUDS components within this manual.

Planting design around SUDS features is different from conventional landscape practice and must be designed with maintenance in mind, minimal risk of silt mobilisation and reduced pollution to the environment.

Design Checklist

- All vegetation surrounding SUDS should comprise permanent ground cover with no bare soil areas or surface mulches to avoid blockage and prevent silt and surface debris migrating to SUDS structures.
- Planting areas should be slightly lower than the turf or hard edge to prevent soil wash off during establishment and maintenance.
- Planting should be in grass or surrounded by grass rather than plant beds, where possible, to avoid soil disturbance.
- Planting in bioretention areas requires dense ground cover and surface mulch to intercept surface water runoff and associated pollution but the level should be 150mm below surrounding areas.
- All planting to SUDS features that connect directly to natural wetlands must use native species from an accredited source to prevent the spread of alien species and protect 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 an alternative.
- 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 without the need for herbicides.
- Maintenance of vegetation should generally consist of grass cutting and simple shrub pruning without disturbance of the soil profile.
- Inlets, outlets, control structures and overflow arrangements must be kept clear at all times during maintenance.

11.3 Planting strategy to SUDS features

Vegetation in open SUDS features plays a number of roles in managing surface water runoff and must provide an attractive, robust and easily established vegetation that will develop naturally over time.

Where planting, turfing or seeding cannot be undertaken immediately, then a coir blanket (fully biodegradable and seeded) or geo-jute mesh must be used to protect soil surfaces.

Topsoil should be used wherever vigorous vegetation cover is needed to ensure a robust surface and good self-repair in the event of local damage. However topsoil should not be used below permanent water levels. Topsoil depth 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. Specially seeded turf may be appropriate in sensitive habitat areas.

Planting strategy to SUDS ponds and wetland

Vegetation characteristics: →

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

Planting must: →

- 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
- Be from an accredited source to prevent the spread of alien species
- Be easily maintained

Part 3 – SUDS maintenance

12.0 Designing for maintenance

12.1 Key principles

Unlike conventional drainage, SUDS use surface landscape features to manage surface water runoff, and therefore usually require landscape and watercourse management rather than gully and pipe maintenance.

- SUDS should be on or near the surface to mimic natural drainage.
- SUDS should be managed using landscape and watercourse maintenance techniques rather than gully and pipe cleaning methods.
- SUDS features should be simple, robust and easily maintained by landscape and watercourse 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.

12.2 The SUDS Management Plan

A SUDS Management Plan must be provided at Detailed Design stage. The document should comprise:

A SUDS plan overview – to provide a framework for the maintenance of the site, describing the SUDS, how the site will change with time, and the operations required to achieve the management aims for the site. The SUDS plan 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 general instruction to the contractor.

The Schedule of Work – sets out the tasks required to maintain the site and the frequency necessary to achieve an acceptable standard of work. An example of a Schedule of Work is included in Section 14.

A SUDS Maintenance Schedule Summary – provides a convenient checklist for the contractor and site inspection and is shown in this section.

A Site Plan (Drawing) – showing maintenance areas, access routes, inlets, outlets and control structure positions, location of any other chambers, gratings, overflows and exceedance routes.

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

12.3 Model SUDS maintenance schedule – summary

1.0	Litter Management	Frequency	Unit rate	Total
1.1	Collect all litter in SUDS areas and remove from site	Monthly		
1.2	Grass maintenance – all cutting to compost, wildlife piles or removed from site			
1.3	Amenity grass. Mow all grass verges, paths and amenity grass at 35-500mm with 75mm maximum height	As required		
1.4	Mow all filter strips, swales, dry SUDS basins and margins to SUDS feature at 100mm with 150mm maximum height	As required		
1.5	Strim all wet swale, pond edges at 50mm in Sep-Oct annually or 3 year rotation for wildlife value	Annually or as required		
1.6	Wildflower areas strimmed to 100mm in Sept-Oct or Wildflower areas strimmed to 100mm July and Sept or Wildflower areas strimmed to 100mm on 3 year rotation 30% each year	Annually or as required		
2.0	**Wetland and pond vegetation**			
2.1	Wetland vegetation to be cut at 100mm in Sept-Oct in any one year up to 30% as instructed	As required		
2.2	Wetland vegetation to be cut at 100mm, on a 3 year rotation and 30% each year	Annually or as required		
3.0	**Wetland and pond silt**			
3.1	Excavate 30% of silt with vegetation to waste piles, stack and dry within 10m of the SUDS, spread, rake and overseed	Annually or as required		
4.0	**Planting**			
4.1	Remove overhanging branches or growth in SUDS features	As required		
5.0	**Hard surfaces**			
5.1	Hard surfaces – including permeable paving	As required		
5.2	Sweep all paving regularly sweep (or jet wash) and suction brush permeable paving in autumn after leaf fall	As required annually		
6.0	**Inlets, outlets and gratings**			
6.1	Inspect monthly, remove silt and debris, strim or sweep 1m around structure	As required annually		
7.0	**Control chambers**			
7.1	Inspect, remove silt and check free flow	Monthly or annually as required		
8.0	**Silt trap**			
8.1	Monthly inspection and remove silt as necessary	Monthly		
9.0	**Low flow channels**			
9.1	Inspect monthly, remove silt or debris and maintain clean edges	Monthly or as required		

12.4 Maintenance programme

SUDS should be designed with maintenance in mind using both the hard and soft landscape to manage surface water 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 or forebays, and in general SUDS features.
- Vegetation management in micro-pools, ponds and wetlands.

The occasional task activities are undertaken on a frequency determined by regular site inspection or specification.

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 but should be minimal with good design, maintenance and the control of water flows through the development.

12.5 Performance and Frequency

SUDS maintenance is a combination of performance and frequency:

- **Performance** - a descriptive requirement or specification for action such as cutting grass to a certain height during maintenance.
- **Frequency** - a regular activity such as litter collection or monthly inspection of inlets, outlets and control structures.

Cost-effective SUDS maintenance will depend on activities being integrated with general site care and full day visits for a maintenance team. The responsibilities for maintenance should be defined within the Management Plan.

12.6 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 inlets, outlets 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 surface water runoff.
- Reducing the rate of surface water runoff.
- Silt and sediment control.
- Protection of soil surfaces.
- Enhancing bioretention soil profiles.

It is therefore necessary to keep a dense cover of vegetation in SUDS features to ensure these functions are retained.

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 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 a robust natural vegetation that will not lodge and may therefore require only annual or mosaic maintenance. This approach offers a more visually interesting and biodiverse rich habitat at reduced maintenance cost.

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

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

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. Where necessary, green waste can be removed from site as part of site waste management, though this is not good practice.

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 species 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 as necessary being careful to protect any waterproof liner.
- Alien species should be removed and prevented from establishing in SUDS.

These include:

- Himalayan Balsam (*Impatiens glandulifera*)
- Giant Hogweed (*Heracleum mantegazzianum*)
- Japanese Knotweed (*Fallopia japonica*)
- Parrot's 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 a robust 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.

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 Reedmace (*Typha latifolia*).

Once planting is established it will be necessary to remove dead vegetation, and in some instances organic matter, from wetlands and ponds. Recent experience suggests that removal of dead vegetation is required less frequently than once thought, and shallow ponds with a flow of oxygenated water through the structure with 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 isretained.
- 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 or compost piles.

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.

13.0 Waste management

13.1 SUDS generate waste

All landscape and drainage systems generate waste, although with careful design this can be reduced to a minimum.

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

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.

13.2 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 surface water runoff is conveyed directly to SUDS features as it settles in silt traps, forebays and at inlets, outlets or in control structures.
- Silt build up in wetlands or ponds that includes 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 generated by occasional maintenance.
- Spillage of materials or liquids likely to cause pollution effects.

Litter and other physical debris is removed from site at regular site maintenance visits.

Local organic pollution in small quantities such as oils, milk or animal faeces, is bio-remediated within the SUDS.

Inorganic pollution like phosphorus and nitrates are stored, controlled or broken down by nitrification.

Heavy metals are stored where silt is intercepted, ideally at source as surface water 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 should be agreed with the Environment Agency before adoption.

There is an exemption agreed with the Environment Agency for all silt and vegetation on sites with 1-2 treatment stages, i.e. housing, schools or commercial sites. Guidance can be found on the Environment Agency's website within document MWRP RPS 055 titled 'The deposit and dewatering of non-hazardous silts from Sustainable Drainage Systems (SUDS) on land'.

13.3 Waste management based on risk assessment

Pollution risk is considered in The SUDS Manual p 3-10 section 3.3 and uses the management train concept to control pollution on development sites. The number of required treatment train components identifies the pollution risk, based on the surface water runoff catchment characteristic. There are three categories:

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

A waste management evaluation model can therefore be proposed that considers the risk of pollution during the SUDS design for a particular site.

The proposal assumes that for development in the 1 and 2 treatment stage categories, which includes the majority of development, pollution control is managed on site with low levels of heavy metal accumulation at source.

Development in category 3 will require evaluation of pollution load and location within the development for management to be agreed with the Environment Agency.

Waste evaluation for SUDS management

- Where the site is in the 1 and 2 treatment stage categories, the risk of significant pollution is low to medium, so silt and wetland vegetation can be managed on-site without further analysis. These categories will include most day-to-day SUDS management areas including housing, schools, light commercial and car parking areas.

- Where the site is in the 3 treatment stage categories, the risk of significant pollution is higher 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 discrete areas for off-site disposal.

- Where surface water 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 effects. Inorganic silt will be intercepted at source with organic silt and vegetation managed separately on site.

- The SUDS evaluation of risk at design stage will therefore determine the silt and wetland vegetation management approach for the site. Similarly, the risk assessment undertaken at the design stage which determines the appropriate treatment stages will provide evidence for the management strategy.

- This risk-based proposal identifies low to medium risk development, where SUDS will treat organic pollution with small amounts of inorganic pollution retained on site. The landscape maintenance team can look after this type of development in a simple and efficient manner.

- The proposal also identifies those sites with special requirements that need measures in place to manage high pollution risk at appropriate locations in the management train. Silt analysis and disposal from site can be evaluated at the design stage to inform site management.

14.0 Maintenance Schedule

A maintenance schedule shows what work is to be done and the frequency of operations. The maintenance schedule (or the summary) may be used as a base sheet for site inspection or pricing the works.

1.0	General	Frequency	Unit rate	Total
1.1	All maintenance items to be priced.			
1.2	Maintenance will be for 3 years (36 months) to be reviewed at each 12 month period.			
1.3	All items to be priced for 12 month period with prices for further 2 years at end of Schedule.			
2.0	**Litter management**			
2.1	Allow to pick up all litter in SUDS and Landscape areas, including wetlands and ponds or any debris lodged in planting at monthly site visits.	Monthly		
3.0	**Litter management**			
3.1	All grass verges, paths and access to SUDS features. All cuts at 35-50mm with 75mm max. All cuttings collected at first and last cut annually removed to wildlife or compost piles otherwise left in-situ.	16 visits as required		
3.2	All filter strips, swales, detention basins and margins to low flow channels and other source control features. All cut at 75-100mm with 150mm max. All cuttings collected at first and last cut annually removed to wildlife or compost piles otherwise left in-situ.	12 visits as required		
3.3	All wet swales and pond edges to be strimmed at 100mm during September-October annually or on a 3 year rotation and cuttings removed to wildlife or compost piles.			
3.4	All wildflower areas to be strimmed to 100mm during September-October annually and all cuttings removed to wildlife or compost piles. Or All wildflower areas to be strimmed to 100mm during July and September and all cuttings removed to wildlife or compost piles at each visit. Or All wildflower areas to be managed as a mosaic and one third (30%) of the areas to be strimmed to 100mm during September on a 3 year rotation and all cuttings removed to wildlife or compost piles. Areas to be agreed.	1 visit 2 visits 1 visit		
4.0	**Wetland maintenance – Vegetation**	**Frequency**	**Unit rate**	**Total**
4.1	An agreed area of wetland vegetation to be cut annually at 100mm above base using a scythe or shearing action (not by strimming). All cuttings to be raked off and stacked in piles to allow dewatering for 48 hours. Remove cuttings to wildlife or compost piles on site. Work to be undertaken September - October or as this Schedule to avoid damage to protected wildlife. Or Wetland vegetation to be maintained as a mosaic. Cut 30% of wetland vegetation as directed on site at 100mm above base using a scythe or shearing action (not by strimming). All cuttings to be raked off and stacked in piles to allow dewatering for 48 hours. Remove cuttings to wildlife or compost piles on site. Work to be undertaken September - October or as this Schedule to avoid damage to protected wildlife.	1 visit 1 visit or 1 visit 1 visit		

5.0	**Wetland and pond maintenance – Silt**			
5.1	Allow to erect temporary fence protection to prevent access by children to potentially polluted silt if and where necessary.	1 visit		
	Excavate and remove 30% of accumulated silt using an agreed methodology retaining a fully representative plant assemblage in the SUDS feature.	1 visit		
	Stack silt within 10m of the SUDS feature and allow to dewater (48 hours minimum to 1 month maximum)	1 visit		
	Remove plant remains to wildlife piles on site. Roughly spread remaining silt to allow air to begin breakdown of hydrocarbons and other organic matter. After 1 month check silt piles, spread on raised areas to design levels, rake to grade and overseed as necessary.	1 visit		
6.0	**Ornamental planting – see section 11.0 Landscape Design and SUDS**			
7.0	**Native planting – see section 11.0 Landscape Design and SUDS**			
8.0	**Hard surfaces**			
8.1	Brush permeable paving regularly and prevent silt washing onto the surface.	As required		
8.2	Brush and suction clean permeable surface after leaf fall in autumn to remove embedded silt and ensure permeable surface integrity.	As required		
9.0	**Inlets, outlets and gratings**	**Frequency**	**Unit rate**	**Total**
9.1	**Inlets and outlets** Inspect monthly to check for damage, blockages and silt accumulation. Remove all debris and silt from apron where present. Strim 1m area around structure where in grass or sweep to ensure unrestricted access.	Monthly		
9.2	**Gratings** Inspect monthly to check for damage, blockages and silt accumulation. Remove all debris and silt from apron below grating where present. Evaluate requirement to rod or jet pipe run at each inspection and annually after leaf fall. Strim 1m area around structure where in grass.	Monthly		
10.0	**Inspection and control chambers**			
10.1	Inspect monthly during year 1 to check for damage and blockages. Annual inspection after leaf fall thereafter removing all accumulated debris and silt. Check control tubes flow freely.	1 visit annually		
11.0	**Silt traps**			
11.1	**Surface silt traps** Inspect monthly to check for damage and blockages removing silt as required. **Below ground silt traps** Inspect monthly, removing chamber covers to check for damage and blockages removing silt as required.	Monthly		
12.0	**Low flow channels**			
12.1	**Surface low flow channel** Inspect monthly to check for damage, blockages and silt accumulation removing all debris and silt as required. **Pipe low flow channels** Inspect monthly and evaluate requirement to rod any pipe. Rod or jet pipe runs annually after leaf fall. Remove silt and debris from site.	Monthly		

Appendix - glossary and abbreviations

A

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

Attenuation storage Volume used to store surface water runoff during extreme rainfall events. Comes into use once the inflow is greater than the controlled flow.

B

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

Baseflow 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 surface water runoff temporarily.

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 surface water 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.

C

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

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

Construction (Design and Management) Regulations 2007 (CDM) Construction (Design and Management) Regulations 2007, which emphasise the importance of addressing construction health and safety issues at the design phase of a construction project.

Contaminated ground Ground that has the presence of such substances which, when present in sufficient quantities or concentrations, are likely to have detrimental effects on potential targets.

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

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

Conveyance Movement of water from one location to another.

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

D

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

Designing for exceedance An approach that aims to manage exceedance flows during rainfall events, e.g. the use of car parks during extreme events.

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

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

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

E

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 interacting organisms and their physical environment.

Exceedance Routes When SUDS are overwhelmed by exceptional rainfall, exceedance routes protect people and property by providing unobstructed overland flow routes from the development.

F

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 surface water runoff 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 surface water runoff from a site or catchment following the start of a rainfall event. As surface water 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 a result.

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.

Flood routing Design and consideration of aboveground areas that act as pathways permitting surface water runoff 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 water from an attenuation facility, e.g. 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 water and sewage.

G

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

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.

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

H

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, i.e. motorways and trunk roads.

Highway 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 manual, hydraulics covers the storage, conveyance and control of flows within the proposed drainage network.

I

Impermeable Will not allow water to pass through.

Impermeable surface An artificial non-porous surface that generates surface water runoff after rainfall.

Infiltration The passage of surface water runoff into the ground.

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

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

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

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

L

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

M

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

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

N

Non-return valve A pipe fitting that limits flow to one direction only.

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

O

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.

P

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

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 pavement A permeable surface that is paved and drains through voids 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 surface water runoff 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.

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.

R

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.

Retention pond A pond where surface water 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.

S

Section 104 A section within the Water Industry Act 1991 permitting the adoption of a sewer, lateral drain or sewage disposal works by a sewerage undertaker.

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

Sewer A pipe or channel taking domestic foul and/or surface water from buildings and associated paths and hardstandings from two or more curtilages and having a proper outfall.

Sewerage undertaker A company 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, i.e. between clay and sand.

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

Source control The control of surface water 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 surface water 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 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.

Surcharge When water can no longer be contained within the above and below ground SUDS design profile.

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

Surface water sewer A sewer taking surface water from roofs and yards of premises.

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

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

T

Time of entry Time taken for surface water runoff 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.

Treatment volume or Vt The proportion of total surface water runoff from impermeable areas that is captured and treated to remove pollutants.

V

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

W

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

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 bottomrooted plants.

Useful links

[SSG Appendix C - Design and Construction Guidance v2-2.pdf (water.org.uk)]

[Sewerage Sector Guidance - approved documents | Water UK]

[SuDS Manual (susdrain.org)]

[Item Detail (ciria.org)]

Contact details

Visit our website to download additional copies of this manual and our Easy guide to sustainable drainage systems: **anglianwater.co.uk/developers sewerconnection/suds**

Contact our specialist SUDS team:

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Anglian Water provides water and wastewater services to 6.1 million customers across the largest of the UK's water regions, stretching north/south from Grimsby to Milton Keynes, and east/west from Lowestoft to Daventry.

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