Designing Effective Practical SuDS

Contents

Why Consider Maintenance in the Design Process?

Considering the practicalities of maintenance and inspection of SuDS at the design stage can extend the useful lifetime of assets and ensure they are effective and maintainable and reduce long term costs.

It is possible to design a drainage scheme that can deliver both hydraulically, limiting risk of flood, and from a treatment perspective but yet the system (or parts thereof) can fail well before the expected operational life. Design and detailing can enhance or inhibit the operation and maintenance of SuDS; if not fully considered it can increase operational expenditure (OPEX) and the range, and frequency, of maintenance activities.

Figure 1. Charter Square, Sheffield Grey to Green | Zac Tudor

The benefits of considering maintenance issues at an early design stage

- Reduce maintenance costs
- Avoid the risk of early failure of SuDS features
- Design in appropriate access
- Minimise safety issues to avoid the need for fencing
- Integrate practical requirements into the overall design to create attractive functional spaces

Technical references:

- ESRWMG: Section B: Design Principles
- CIRIA The SUDS Manual V6: E: Supporting Guidance, Chapter: 32: Operation and Maintenance, p 690

Relevant Factsheets:

W1 SuDS Trees in Streets
W2 Swales Factsheet
W3 Rain Garden Factsheet
W5 Sustainable Drainage in Heritage Areas
W6 Living Roofs Factsheet

Getting the Treatment Train in the Right Order

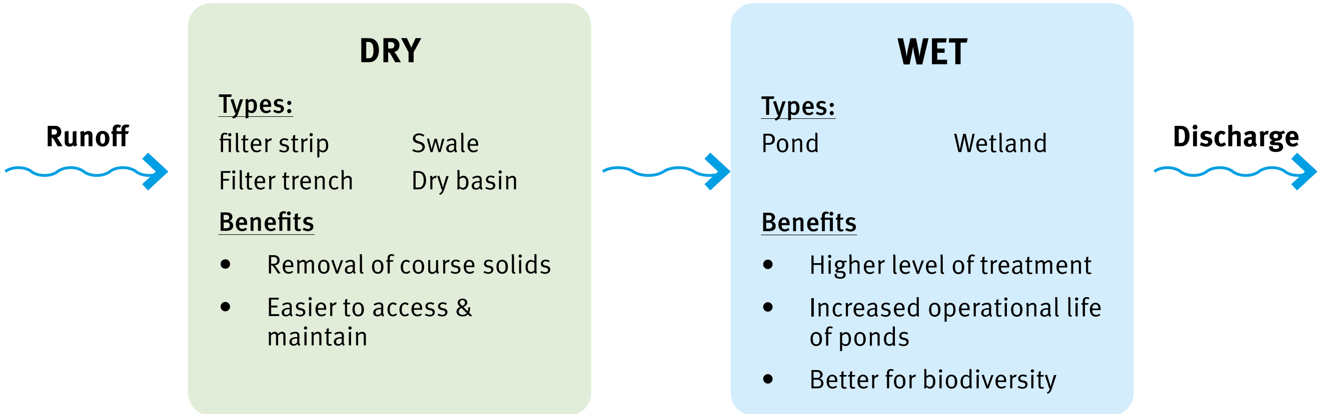
The types of SuDS techniques chosen, and their position within the management train will influence future maintenance requirements and determine the effectiveness of the SuDS.

SuDS selected for a catchment should mitigate pollution risk, but they should not be over-designed as this will in incur increased operational expenditure. Ownership and maintenance responsibility for SuDS must be clearly defined, and three-pipe systems (foul, surface water for roads and surface water for property and private grounds) should be avoided. This will require the use of formal agreements (Section 7 of the Sewerage Scotland Act 1968).

Above ground techniques are **easier to maintain compared to** underground options; where drainage is kept above ground, operational issues are easily identified. Issues within underground systems can go undetected until failure.

As a general principle **dry** SuDS that filter and treat water should always precede **wet** SuDS that convey and store water. This prolongs the operational life of features such as ponds and swales; and is more effective at removing silt and pollutants.

Management Train Design



Key Terms

- **Sediment -** Particles carried by moving water that may be washed from adjacent areas or eroded from the flow path
- **Transportation** - sediment moved by the flow of water
- **Erosion** - when the flow of water detaches particles from the surrounding ground
- **Sedimentation** - the build-up of sediment settling out of water onto the base of a channel or around an outlet

Technical references:

- ESRWMG: Section B: Design Principles, The SuDS Management Train,
- ESRWMG: Why Underground Storage is a Last Resort,
- ESRWMG: SuDS Close to Building and Structures,
- CIRIA The SUDS Manual V6: E: Supporting Guidance, Chapter: 32: Operation and Maintenance, p 690

Relevant Factsheets:

W1 SuDS Trees in Streets
W2 Swales Factsheet
W3 Rain Garden Factsheet
W6 Living Roofs Factsheet

Examples of Good Practice in Designing a Treatment Train

Figure 2. Multiple stage treatment | Abertay Univeristy

A multiple stage treatment train; detention basin and a three-pond cascade, Dunfermline. *This design works effectively for treatment however, more could be done to accommodate biodiversity and place.*

Figure 3. Treatment basin | Abertay Univeristy

Following initial treatment at the road edge, runoff passes through a wet stage (with forebay) before reaching the infiltration stage. *A good example of multiple stages of treatment. The scheme could be improved diverse planting for biodiversity.*

Figure 4. Swale | Abertay Univeristy

A simple robust design; sheet flow from the road flows over a filter strip before reaching the conveyance swale, J4M8 industrial site.

Figure 5. Roadside swale | Abertay Univeristy

Integrating simple, easily maintained SuDS within residential design; a roadside swale, Tavistock.

Designer Checklist For Treatment Trains

- ☑ **DO** use above ground SuDS where possible; operational issues are easier to identify.
- ☑ **DO** plan where sediment is removed in the management train.
- ☑ **DO** use dry SuDS upstream of wet SuDS, infiltration techniques and underground systems.
- ☑ **DO** use forebays or a small dry basin (hybrid) to manage sediment for standalone ponds and wetlands.
- ☑ **DO** maintain the functionality of infiltration surfaces by using a previous treatment or silt removal stage
- ☑ **DO** Support Biodiversity by providing water quality that can support wildlife by ensuring upstream SuDS elements effectively filter silt and sediment and other potential pollutants
- ☑ **DO** use a bypass to ensure that the SuDS can be taken offline for de-silting or other major works.
- ☒ **DON'T** discharge untreated runoff to infiltration or underground techniques.
- ☒ **DON'T** use underground techniques if these can be avoided

Maintenance & SuDS Masterplanning

Creating Site Specific Solutions

There is no one-size-fits-all answer for maintenance, however there must always be sufficient maintenance to maintain operation. There will be different requirements based on the design drivers, the type of SuDS chosen and their position in the management train.

Establishing the SuDS design that is best fit for the local context will result in survivable SUDS that can be easily, and cost effectively, maintained

A cohesive, master planned, approach should be taken for SuDS design. This should consider site conditions and topography, land use and local people accessing the site, context, appropriate SuDS techniques and sequencing.

Designers Checklist

- ☑ **Do** consider the drainage design on a catchment basis and plan for regional facilities
- ☑ **Do** think source-site-regional control
- ☑ **Do** consider the context and potential wider benefits of SuDS features
- ☒ **Don't** use one site control SuDS for more than one sub-catchment; isolate drainage streams

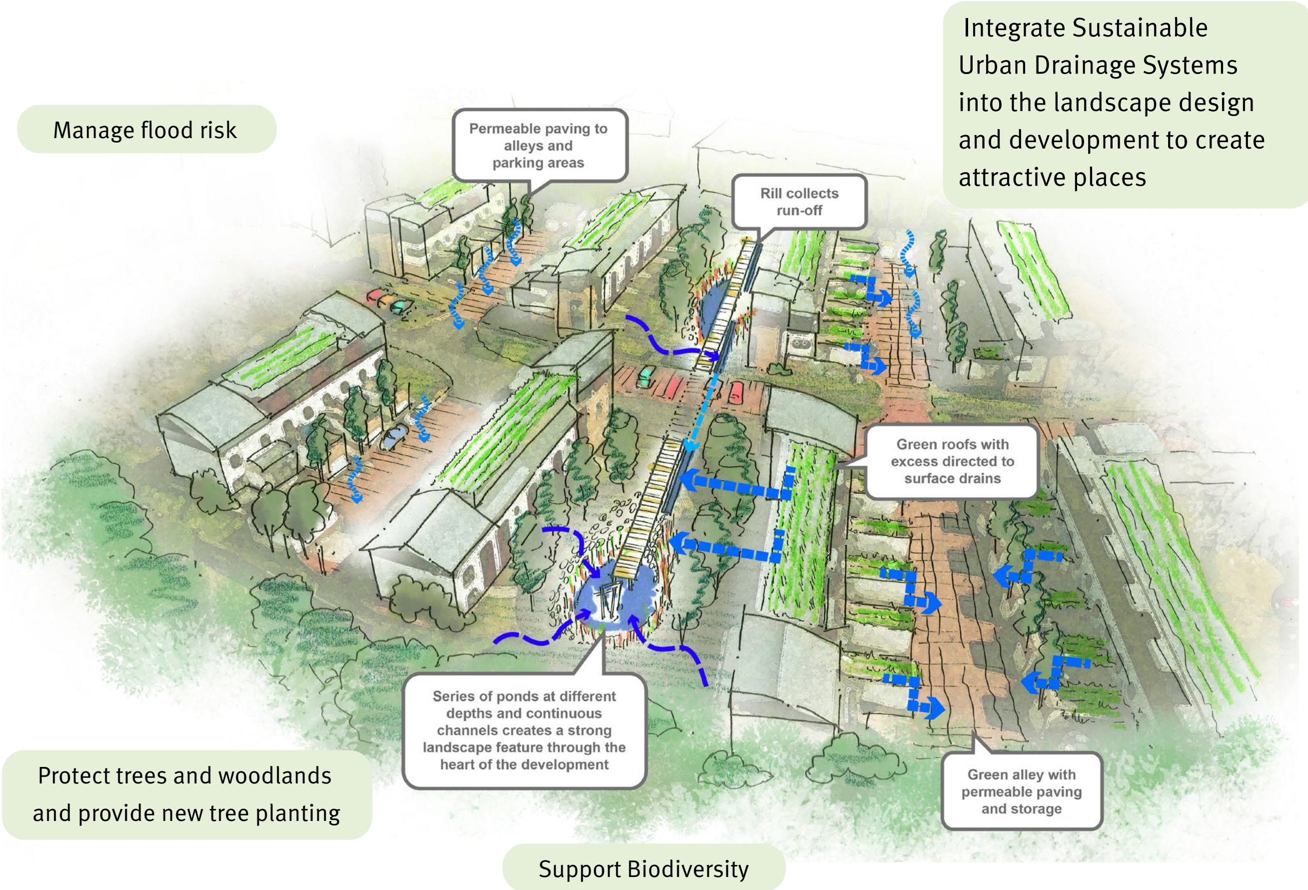


Figure 6. Consider Drainage Design in New Developments | Atkins

Maintenance & Design Principles for SuDS Masterplanning

Ensuring that each development (sub-catchment) has its own source and site control(s) provides several maintenance benefits:

- **Key pollutants** can be targeted (for removal) at specific stages within the management train; this is particularly beneficial for management of sediment.
- Should SuDS become inundated with **sediment** and or other pollutants, then the pollution can be isolated and prevented from passing to subsequent parts of the management train.
- Identifying the source of **operational issues**, for example cross connections, is much simpler.

Technical references:

- ESRWMG: Section B: Design Principles
- CIRIA The SUDS Manual V6: E: Supporting Guidance, Chapter: 32: Operation and Maintenance, p 690
- Scottish Water Surface Water Policy

Other Considerations

- Look for opportunities for **dual purpose design**, for example shallow under-drained basins used as football pitches or basins with shallow interesting contours and biodiverse planting providing both attenuation and usable space.
- **Avoid the need to fence** basins. Designing out fences reduces future maintenance burden.
- **Consider pedestrian movement,** particularly desire lines, when designing SUDS in streets and public spaces.
- **Locate services** for the SuDS area and retain the information to inform future maintenance operations.
- **Consulting with residents** and allowing their input into design and planting can be a key to success. Many good examples have included local schools planting rain gardens and local community groups carrying out maintenance.
- Provide clear delineation of **maintenance responsibility**, which is beneficial where there are multiple parties involved in ownership, maintenance or inspection.
  See ESRWMG: Shared Responsibilities, p20.

Figure 7. Community Maintenance | DSA Environment & Design

Figure 8. SuDS site inspection | Abertay University

Designing for Site Topography

The characteristics of the catchment will influence design and future maintenance. Where sites are steep, there can be risk of erosion or wash-out of surfaces within SuDS. There is a common misconception that SuDS are not suitable for steep sites; this is not the case, and good design can reduce risk of future remedial works.

Designers Checklist

- ☑ **DO** use check dams and/or armoured sections to limit risk of surface erosion and wash-out
- ☑ **DO** consider risk of accumulation of leaf litter on screens and pipes.
- ☒ **DON'T** dismiss the use of SuDS on a site with steep gradients; consider techniques to slow flow rate

Technical references:

- CIRIA: The SuDS Manual, chapter 20 - Landscape, p631
- ESRWMG Section B: Design Principles: Design Considerations for SuDS in New Development,
- ESRWMG: Retrofitting SuDS in Streets,

Where space is available, and placemaking is a key driver, then a series of wet ponds (or wetlands) provides more effective treatment than a single pond. A series of ponds can be used on steep sites to deliver the attenuation volume and maintain safe design geometry.

Where gradients are steep, stepped bases (for example within a swale or basin), or check-dams can be used to slow flow.

Check dams can be constructed from a range of materials to compliment the site design including gabions baskets or railway sleepers. It is important that the check dam is not a solid wall; its purpose is to slow flow, not pond water within the SuDS.

Design should ensure that the check dam is placed across the extent of the channel and constructed within the banks, reducing risk of water bypassing, or eroding the soil around the dam edges.

Figure 9. Swale constructed on a slope, Millbrook Park | Arc

Approaches to Designing for Site Topography

Figure 10. Balvonie Street, Inverness | Architecture+Design Scotland

Swales have been integrated into the street scape navigating the slope using check dams to slow the flow of water downhill.

Figure 11. Swale constructed on a slope | Sheffield City Council

Figure 12. Swale constructed on a slope |Sheffield City Council

Sheffield's Grey to Green SuDS project has retrofitted swales and rain gardens with check-dams within existing streets and carriageway to accommodate topography

Figure 13. Park, Millbrook Park | ARC

New development at Mill Hill in Borough of Barnet, London has utilised the steep topography across the site to integrate the SuDS treatment train with new green spaces as part of creative placemaking.

Figure 14. Armoured section of swale, Leicester | Susdain

Armoured sections can be used within SuDS to reduce erosion risk. This can be concrete reinforcement, however use of gabions or reno-mattresses can limit visual impact by becoming vegetated over time.

Managing Sediment and Pollutants

Managing sediment and pollution is a key function in the treatment train and an important maintenance factor.

Managing Silt and Sediment

Management of silt within the treatment train should be a key consideration of design; **desilting SuDS can be costly. Good practice is to use dry, above ground, SuDS** (i.e. filter strip, swale or basin) **at the start of the management train** to remove sediments and litter. This allows monitoring and removal of sediment simple and cost effective.

Where it is not possible to provide treatment prior to an end-of-pipe wet SuDS (i.e. a pond or wetland) then a sediment forebay or dry basin (hybrid) should be part of into the design. This prevents siltation of the main pool and minimises desilting costs. It is essential that the forebay is set at a higher level than the main pool, so that it can be fully drawn down for maintenance. A bypass should be included to take the pond offline for desilting.

Pre- treatment and silt removal stages such as grass filter strips, pea gravel, or hard-engineered traps (for example raised cobbles) are easy to implement and maintain.

Figure 15. Forebay, Dunfermline | Abertay Univeristy

Newly constructed pond with forebay, Dunfermline.

Figure 16. Bioquarter, Edinburgh | RaeburnFarquhar-Bowen

Swale with filter strip

Infiltration and water quality

Where infiltration techniques, or underground systems (for example filter trenches or geocellular units) are used, it is critical that runoff be treated beforehand **- infiltration surfaces can be easily blinded by sediment**. Underground infiltration techniques (e.g. soakaways) and underground storage can be particularly costly to reinstate.

'The best way to protect infiltration surfaces from sedimentation is to use of above-ground measures (for example a filter strip) opposed to underground techniques, e.g. catch pits. Catch pits have limited volume, require regular inspection and emptying; they are only effective if maintained.

Managing Sediment and Pollutants - Examples and How Things Can Go Wrong

Figure 17. Sump full at manifold | Abertay University

Out of sight, out of mind: a catch pit (sump) full to invert level of the inflow pipe to a geocellular unit.

Figure 18. Infiltration basin | Abertay Univeristy

An end-of-pipe infiltration basin in Aberdeenshire; it relies solely on a catch pit to remove silt. The sewer network (including catch pit) and the basin have two separate owners.

Figure 19. Infiltration basin | Abertay Univeristy

Failed infiltration basin, Perthshire. The basin has been inundated with construction runoff and the infiltration capacity is lost. The basin is holding water like a pond and there is no attenuation of flow.

Figure 20. Vortex flow control | Abertay Univeristy

Vortex flow control (VFC) and penstock in control manhole inundated with silt.

Figure 21. Sediment Forebay, Bellsdyke | Abertay Univeristy

Figure 22. Sediment Forebay, Bellsdyke | Abertay Univeristy

Figure 23. Sediment management | Abertay Univeristy

Figure 24. Permeable paving | Abertay University

The images represent effective SuDS components. To better enhance the place making and aesthetics consider using natural shapes and forms, and use vernacular materials. Best practice can be achieved by engineers and landscape architects working together from the outset of the project.

Design Maintainable Planting

Ensure the growing medium are planting specification are appropriate to the type of SuDS and context of the SuDS feature. For example, planting within or adjacent to a busy road may need to be exposure and salt tolerant as well as very dry and wet conditions. In other locations planting may need to be tolerant of very damp conditions for all or part of the year. Getting the planting right at the outset can help a scheme to establish quickly, reduce erosion risks and minimise the need to replace dead or failing plant material.

Figure 25. Sheffield Grey to Green | Nigel Dunnett

Figure 26. Phragmites Australis invasive species |

Designers Checklist for planting

- ☑ **DO** use SUDS guidance for planting specification but also consider local context, biodiversity and the benefits the planting design can provide to the wider site.
- ☑ **DO** select slow growing species, for rain gardens such as grasses and plants that take two seasons to establish, and replant as required.
- ☒ **DON'T** plant deep-rooted trees and plants within lined SuDS features to limit risk of liner breach.
- ☑ **DO** consider selecting suitable plant for a changing climate. See ESWRMG p26
- ☑ **DO** Check for invasive species and self-sown woody plants that could damage liners or block inlets or outlets, these should be identified and removed.
- ☑ **DO** consider the appearance of planting in public areas and in particular where SuDS are intended to provide amenity value
- ☒ **DON'T** plant trees and woody shrubs close to key structures unless appropriate root barriers are in place. This will reduce risk of root damage to the structure and allow safe access at time of emergency (e.g. to flow control manholes or blocked screens).
- ☑ **DO** consider human activity in specification of plants; hardy, quickly established and low maintenance plants can be used in residential areas. Where SuDS are in areas of nightlife, consider semi mature trees that cannot be deliberately broken and spiky/thorny vegetation.
- ☒ **DON'T** plant dense vegetation or tall emergent species where blocking of sight lines could create risk.
- ☑ **DO** use dense planting and emergent species to mitigate hazards as an alternative to fencing

Designing in Maintenance Access

When designing SuDS, safe access for those carrying out surveys, inspections and long-term maintenance must be considered along with public safety.

Technical references:

- ESRWMG: Section B: Design Principles: Designing Out Risk, p31 & Designing with Nature Do's and Don't, p35
- CIRIA: The SuDS Manual, Part E Supporting Guidance: Chapter 29 Landscape & Chapter 36 Health and Safety

Where vehicle access is required to desilt, repair or reinstate the SuDS. Reinforced porous surfaces, (for example structural grid reinforcement) should be used to limit vehicle damage and provide safe access and the design should provide adequate access to desilt the main body and reinstate key structural items (for example headwalls). There should be sufficient space on site to de-water excavated sediments and/or stockpile removed vegetation.

Consider where SUDS are located and where the key structural points (i.e., inlet and outlet) are; this will reduce the need for 360-degree vehicle access. The inlet and outlet on the same side of a basin so that access is required only to one side.

Designers Checklist for Access

- ☑ **DO** plan for access: inspection, regular maintenance and remedial work. Make use of existing access routes where feasible.
- ☑ **DO** consider location of gates; these should be near to key structures (inlets and outlet) for emergency access.
- ☑ **DO** consider the specification of any fences and gates for future maintenance.
- ☑ **DO** consider safety and access in relation to local context..
- ☑ **DO** consider allowing for future maintenance access when designing layout and planting around key structures;
- ☒ **DON'T** use high fences to restrict access.
- ☒ **DON'T** specify quick colonising tall emergent plant species for wet SuDS.

These examples illustrate different approaches to access tracks - however better design would remove the need for this type of 'end of pipe' basin entirely.

Figure 27. Grasscrete access track | Abertay University

Vehicle access along one side of detention basin using a reinforcement grid allowing the area to become vegetated.

Figure 28. Compacted access track | Abertay University

The 360 degree compacted surface access is visually unattractive and takes up more land than necessary; a better less obtrusive design could be as effective, provide cost savings and help to integrate the SuDS elements into the landscape

When to Provide Fencing

Wherever possible avoid the need for fencing by designing out risks such as steep banks or deep water. Where dry basins (infiltration or detention) with shallow bank gradients are used fencing should not normally be necessary.

Where fencing is necessary, t**he fences should be low height,** with no step-up that young children can use. The type of fence specified will impact on future maintenance.

Metal bow-top fencing is commonly used (for SuDS) providing a durable and effective barrier, however this may not align with place-making drivers for design. The design of fencing should also consider long term maintenance including risk of vandalism.

Low, wooden knee-rail fencing is less visually intrusive and prevents vehicle over-run whilst deterring access to areas of risk (for example a bank) but might be less suitable where SUDS provide risks within a residential development.

Alternatives to fencing can include the use of dense or thorny barrier vegetation, which once established, can deter access to areas of higher risk.

Figure 29. Dense dogwood plating | Abertay University

Technical references:

- ESRWMG: Section B: Design Principles: Designing Out Risk, & Designing with Nature Do's and Don'ts,
- CIRIA: The SuDS Manual, Part E Supporting Guidance: Chapter 29 Landscape & Chapter 36 Health and Safety

Figure 30. Upton, Northamptonshire | The Land Trust

Designing Headwalls, Inlets and Outlets

Inlet and outlets should, where feasible be located above ground/permanent water level so they can be easily inspected and maintained.

Underwater outlets can be particularly susceptible to blockage by accumulated silts, and costly to remediate. Above ground/water outlets are often regarded as a negative visual, however headwalls can be designed to be visually appealing (e.g. use of local stone) or disguised from line of sight by structured planting.

Technical references:

- CIRIA: The SuDS Manual, Part E Supporting Guidance: Chapter 28 Inlets, Outlets and Flow Control Systems, p604 & Chapter 32 Operation and Maintenance, p690
- Sewers for Scotland V4.0

Relevant Factsheets:

W1 SuDS Trees in Streets

W2 Swales Factsheet

W3 Rain Garden Factsheet

Designers Checklist

- ☑ **DO** design inlets and outlets to be at ground level/at water level.
- ☒ **DON'T** use underground/water inlets and outlets.
- ☑ **DO** consider the need/appropriateness of screen use.
- ☒ **DON'T** design flow controls flush with the manhole bench.
- ☑ **DO** ensure screens are hinged and have vertical bars (and not horizontal bars).
- ☑ **DO** use pitched screens for outlets and ensure there is adequate access to maintain.
- ☑ **DO** consider the diameter of flow controls. Narrow diameter flow controls should use a protective screen (on the headwall) or cage (within the manhole).
- ☑ **DO** consider risk of vandalism – consider the specification of headwalls.
- ☑ **DO** include a drain-down mechanism (e.g. penstock) to allow for maintenance.
- ☑ **DO** consider using local stone and materials to face visible inlets and outlets

Figure 31. Gabion Inlet, Pitblae | Abertay Univeristy

Figure 32. Stone facing headwall | Abertay University

Design of Flow Controls

"Control structures limit the flow through the outlet and are usefully necessary in order to meet the site discharge rate."

CIRIA: Chapter 28: Inlets, Outlets and flow control systems, p605

There are different types of flow control that can be used for SuDS, including orfice plates, weir plates, perforated risers and vortex flow controls (VFC).

VFCs are commonly used as they have a different discharge curve that reduces the required size of the SuDS. Where used, it is important that they are installed in accordance to the manufacturers' guidelines. For snail-shaped VFCs there should be a sump beneath the intake to prevent blockage by sediment.

Where high flow rate conical VFCs are used, these are Less prone to blockage and are fitted flush with the manhole bench; the large internal dimensions allow self-cleansing (wash-through of debris).

Orifice plates can be easily blocked by debris, particularly narrow diameter orifice plates Where narrow diameter orifice plates must be used then an exterior screen (on the headwall) or interior cage (within the control manhole) should be used.

Perforated risers can be used as an alternative method to reduce blockage of the control. Good practice includes the use of a trash screen to prevent floatable debris accumulating on the riser surface.

Use of a draw down mechanism (for example penstock) should be included to ensure that the SuDS can be drained down for desilting or in the event of blockage of the flow control. Most vortex flow controls incorporate a drain down plate, normally hinged and operated by a cord. mounted at cover level, these can fail (e.g. the cord can become unattached from the plate or fouled) rendering the drain down mechanism non-operational.

Technical references:

- CIRIA: The SuDS Manual, Part E Supporting Guidance: Chapter 28 Inlets, Outlets and Flow Control Systems, p604 & Chapter 32 Operation and Maintenance, p690

Figure 33. Vortex Flow Control | Abertay University

Snail shaped vortex flow control (VFC) with sump below the intake and draw-down cord attached at cover level.

Figure 34. Litter Screen | Abertay University

Trash screen protecting a perforated riser from floatable debris, Alloa.

Figure 35. Vortex Flow Control | Abertay University

Conical vortex flow control (VFC); a high flow rate unit and designed to be fitted flush with the manhole bench

Headwalls and Screens

Headwalls and Screens

Specification of headwall should be considered with future maintenance in mind, for example concrete headwalls are less prone to vandalism than brick headwalls.

Screen use should be carefully considered at the design stage. Whilst screens can mitigate risk (restrict access, reduce risk of blockage of flow controls) their use can also present additional risk of blockage and require enhanced maintenance regimes.

Good practice is to use screens on pipe diameters >350mm to restrict access, unless short sections of culvert daylight (for example a culvert length under a road).

Screens on outlets and overflow headwalls should be pitched to promote self-cleansing (and reduce risk of complete surface-blinding), hinged to allow access to maintain, and there should be access to safely maintain the screen from above (the flood water level).

Screen bars should be in the vertical plane (not horizontal, lattice or mesh style). Bar diameter and spacing should be designed in accordance with CIRIA (Culvert and C753 manuals).

What can go wrong

Figure 36. Lattice screen | Abertay University

Lattice shaped screen; this will increase risk of blockage and will require increased frequency of maintenance.

Figure 37. Bar screen | Abertay University

Littered bar screen; pitched screens are less prone to blockage.

Figure 38. Blocked | Abertay University

Screens can prevent the wash through of materials that can block the flow control

Figure 39. Blocked headwall outlet | Abertay University

Windblown leaf litter can quickly blind screens and increased frequency of maintenance visits may be necessary in autumn.

Designing for Extreme Weather Events

Sustainable drainage systems in new developments should be designed to manage 1 in 200 year return period rainfall events (plus Climate Change). SuDS in existing streets and roads will often be designed for a 1 in 30 year rainfall event. When this is exceeded, or if the flow control is blocked, exceedance flow must be channelled to a predetermined route/location. Two techniques are commonly used for managing exceedance flow: overspills and spillways.

Overspills are normally located within manholes and are usually in the form of either a weir wall, or a high level pipe.

Spillways are above ground and can be a lowered section of bank allowing the SuDS to overtop (for example into a woodland area), or a channel where the flow is conveyed away from areas of risk.

Where possible, it is recommended that spillways are used; these keep the water above ground and any exceedance (for example due to a blocked flow control) can be quickly identified. Spillways are often formed ground and it is important that they are regularly mown to prevent thatching and to maintain level. The weir of the spillway can be hard engineered with concrete to maintain design level and identification of the structure.

Technical references:

- Sustainable Drainage Consent Process

Figure 40. Lowered bank at footpath and overspill channel | Abertay University

Figure 42. Grass spillway saltens | Abertay University

Figure 41. Concrete spillway weir under construction in west of Scotland | Abertay University

Figure 43. Internal o/spill above VFC | Abertay University

Glossary

Abbreviations

CEC	City of Edinburgh Council
CIRIA	Construction Industry research and Information association
EBAP	Edinburgh's Biodiversity Action Plan
EDG	Edinburgh Design Guidance
ESDGF	Edinburgh Street Design Guidance Factsheets
ESRWMG	Edinburgh's Sustainable Rain Water Management Guidance
OPEX	operational expenditure
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage
VFC	Vortex flow control

Glossary

Act	Flood Risk Management (Scotland) 2009 from where the Lead Local Flood Authority and need for SuDS adoption arises.
Adoption	related to someone or an organisation taking responsibility for management and maintenance of the SuDS components.
Amenity	a general term used to describe the tangible and intangible benefits or features associated with a property or location that contribute to its character, comfort, convenience or attractiveness.
Approval	the process of approving all qualifying drainage designs before construction starts. In order for adoption to take place, certain drainage requirements will need to be met.
Attenuation / detention of water	the process of slowing down the rate of flow, reducing the peak, and increasing duration of a flow event.
Basin	A ground depression to hold water and attenuate or provide water treatment that is normally dry and has a proper outfall, but is designed to detain stormwater temporarily.
Biodiversity	the variety of species of plants, animals and ecosystems within a habitat.
Catchment	A catchment is an area contributing to a flow at a point in a drainage network or river.
Combined sewer	A combined sewer collects sanitary sewage and stormwater run-off in a single pipe system. Combined sewers can cause serious pollution issues when heavy rain reduces the capacity in the sewers for foul water and overflows pass into the environment. The use of such systems is rarely used in modern drainage design.
Conventional drainage	The traditional method of draining surface water using subsurface pipes and storage tanks
Conveyance	movement of water from one location to another.
Detention basins	Detention basins are dry flat areas with shallow depressions used for the temporary storage of excess storm water. In a storm event water accumulates in the depression and then is either slowly discharged to the next SuDS component or to a receiving watercourse.
Erosion	natural processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is worn away from the earth's surface
Exceedance routes	allow water volumes exceeding the capacity of the SuDS system to escape from the site without causing damage to property. This route must be clear of obstructions at all times
Filter drain	Filters drains (also referred to as filter trenches or French drains), are linear excavated trenches which are backfilled with graded rubble or stone and convey water to another feature or allow it to soak into the ground. They are sometimes with a perforated pipe in the bottom. These may be enlarged to treat dirty water, as treatment trenches, or increase soakage into the ground, as infiltration trenches.
Filter strips	are grass verges that allow run-off to flow through vegetation to a swale, wetland, infiltration area or other SuDS technique.
Filtration	fluid flow through a filter to remove particles and pollutants.
Flow control	Flow controls are used to control the flow rate and volume from a SuDS and are designed specifically for each site. They can be simple orifice or weir plates, perforated risers or vortex flow controls. Flow controls are the most critical part of the structure and should be regularly inspected/maintained.
Forebay	A small pool used to promote sediment deposition. Forebays can be used for "wet" and "dry" SuDS (i.e. ponds and basins) and their use will greratly reduce the cost to desilt the strcuture. Where ponds are standalone (no upstream SuDS) then a forebay is essential.
Geocellular	a proprietary system of box shaped cells (normally made from modern plastic materials) used to form an underground void intended to provide attenuation of collected surface water run-off. These can be wrapped in geotextile to provide coarse filtration for pollutants.
Greenspace	publicly accessible amenity areas of open space with trees, grass or planting.

Grille	Grilles (or the interchnageable term, screens) are used to either trap litter and debris to prevent blockage of a downstream item (commonly a flow control), or restrict access (children) into pipes.
Gully	an inlet taking run-off from a road into a drainage system, usually through a metal grate and into a sump.
Habitat	The area or environment where an organism or ecological community normally lives or occurs
Headwall	Headwalls are used to support the pipe conveying flow in (or out) of the SuDS. They can be small rectangular block strcutures, or larger "wing-walls" that support the banks and the pipe.
Impermeable	a surface or material which water cannot penetrate or pass through.
Infiltration	the soaking of water into the ground.
Infiltration basins,	trenches, soakaways and other SuDS features that allow water to soak into the ground.
Infiltration trench	A trench, usually filled with permeable granular material, designed to promote infiltration of surface water to the ground.
Interception storage	the storage of small rainfall events (up to 5mm).
Inlets and outlets	structures are often conveyance pipes protected with mesh guards. They must be free from obstruction at all times to allow free flow through the SuDS.
Local Development Framework	the collective term for the whole package of planning documents which are produced by a local planning authority to provide the planning framework for its area.
Maintenance plan	a plan for the SuDS to record information on its functionality and maintenance requirements. This will ensure that the long term performance of the feature meets the needs and expectations.
Orifice plate	A type of flow control, typically a circular hole within a metal sheet plate which is mounted within a manhole.
Overflows	Overflows are used to safely convey runoff from the SuDS shoul the design volume be exceded (or the flow control blocked). Overflows can be below ground (weirs or high level pipes within manholes) or at ground level (gratings permitting flow to a seperate manhole) or over grass weirs in the open. They must be kept clear at all times to protect areas from flooding.
Peak flow	the maximum flow rate of water in a river during a particular period.
Penstock	A mechanical valve, that can be opened (raised) or closed (lowered). Typically used in SuDS to drain down ponds or wetlands, or in dry basins as an emergency drain down should the flow control become blocked.
Perforated riser	A type of flow control, typically a vertical pipe with multiple small holes in the pipe wall that control the flow rate and volume from a SuDS. Perforated riseres can be used in manholes (mounted on the weir wall) or in the ground (for stone fill attenuation techniques).
Permeable surface	can be either porous or permeable. Porous surfacing is a surface that infiltrates water across the entire surface. Permeable surfacing is formed of material that is itself impervious to water but, by virtue of voids formed through the surface, allows infiltration through the pattern of voids.
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 use of the resource.
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
Rain gardens	a planted basin designed to collect and clean run-off.
Regulations	the Water Environment (Controlled Activities) (Scotland) Regulations 2011
Retention basins	A retention basin is a SuDS feature akin to a pond. The basin holds water permanently, although may empty during prolonged dry weather. The design of ponds and retention basins are very similar.
Return period	the statistical chance of an event happening expressed in terms of a single change in a given number of years. For example, the 1 in 30 year event is likely to be exceeded at least once every 30 years.
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.
Runoff	the flow of water over the ground surface. This occurs if the ground is impermeable or saturated, if rainfall is particularly intense, or if surface water drainage systems exceed their capacity and overflow.
Screen	See "Grille"
Sediments	the layer of particles that cover the bottom of water-bodies such as lakes, ponds, rivers and reservoirs. Can include silt, stones etc.
Sewer	A pipe or channel taking domestic foul and/or surface water from buildings and associated paths and hard-standings from two or more cartilages and having a proper outfall.
Sewers for adoption	standards agreed between sewerage companies and developers to specify allowable sewer dimensions and characteristics to allow adoption of responsibility
Soakaway	A sub-surface structure into which surface water is conveyed, designed to promote infiltration.

Soil	The terrestrial medium on which many organisms depend, which is a mixture of minerals (produced by chemical, physical and biological weathering of rocks), organic matter, and water. It often has high populations of bacteria, fungi, and animals such as earthworms
Source control	surface water run-off dealt with at or close to its source.
Spillway	A lowered section of bank and shallow channel that will safely direct flow from the SuDS (away from property) if the design capacity of the SuDS is exceded, or if the flow control is blocked.
Sump	a pit that can be lined or unlined and is used to collect water and sediments before being pumped out.
Surface water	water which occurs on the land surface. e.g. ponds, lakes watercourses, standing water... etc.
Sustainable drainage systems (SuDS)	a sequence of management practises and control structures often referred to as SuDS, designed to drain water in a more sustainable manner than some conventional techniques. SuDS processes are designed to replicate natural drainage systems which improve water quality and amenity as well.
Swales	A swale is a linear shallow channel which can convey run-off from one place to another, holding water and, ground conditions permitting, infiltrating water to the ground. Swales can be used in conjunction with other SuDS features to link components. For example, a swale could link areas of permeable pavement and rain gardens to retention or detention ponds.
Treatment	Improving the quality of water by physical, chemical and/or biological means

Watercourse	all types of passages in which water flows i.e. rivers, streams, ditches, drains, culverts, dykes and sluices.
Weir wall	A wall, typically in flow control manholes, that directs flow out of the SuDS if the flow control is blocked, or if the design volume of the basin is exceded.
Weir plate	A type of flow control, typically made from a metal sheet plate with a V-shape cut-out (vee-notch weir) or a rectangular cut-out (rectangular weir). Weir plates are simple non-mechanical devices and can be used in manholes or above ground.
Wetlands	are open areas of shallow water creating habitats and storage for excess water as well as water quality and biodiversity benefits.
Weir	Horizontal structure to a predetermined design height which controls flow.
Vortex flow control	A type of flow control, that has a two stage discharge - under low flow it will act like an orifice, under high flow the water "spins" in the unit, creating a vortex with an air filled core. A very common flow control as the two-stage discharge allows the volume (hence land take) of the SuDS to be reduced than if a different flow control is used (for example an orifice plate).

Image References

Figure 1. Charter Square, Sheffield Grey to Green | Zac Tudor
Tudor, Z, 2019 Charter Square, Sheffield Grey to Green

Figure 2. Multiple stage treatment | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 3. Treatment basin | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 5. Roadside swale | Abertay Univeristy
Diagram Courtesy of Abertay University

Figure 6. Consider Drainage Design in New Developments | Atkins
Photograph Courtesy of Abertay University

Figure 7. Community Maintenance | DSA Environment & Design
https://dsa-ed.co.uk/

Figure 8. SuDS site inspection | Abertay University
Photograph Courtesy of Abertay University

Figure 9. Swale constructed on a slope, Millbrook Park | Arc
https://www.arcldp.co.uk/landscape-green-infrastructure-public-realm-design

Figure 10. Balvonie Street, Inverness | Architecture+Design Scotland
Scotland's Housing Expo Case Study produced by the A+DS, Available: https://www.ads.org.uk/sites/default/files/2022-06/case-study-scotlands-housing-expo-2013.pdf

Figure 11. Swale constructed on a slope | Sheffield City Council
Tudor, Z, 2019 Charter Square, Sheffield Grey to Green

Figure 12. Swale constructed on a slope | Sheffield City Council Central
Tudor, Z, 2019 Charter Square, Sheffield Grey to Green

Figure 13. Park, Millbrook Park | ARC
https://www.arcldp.co.uk/landscape-green-infrastructure-public-realm-design

Figure 14. Armoured section of swale, Leicester.
Susdain (full eference pending)

Figure 15. Forebay, Dunfermline | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 16. Bioquarter, Edinburgh | RaeburnFarquhar-Bowen
Photograph Courtesy of Abertay University

Figure 17. Sump full at manifold | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 18. Infiltration basin | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 19. Infiltration basin | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 20. Vortex flow control | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 21. Sediment Forebay, Bellsdyke | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 22. Sediment Forebay, Bellsdyke | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 23. Sediment management | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 23. Sediment management | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 24. Permeable paving | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 25. Sheffield Grey to Green | Nigel Dunnett
Full Reference Pending

Figure 26. Phragmites Australis invasive species

Figure 27. Grasscrete access track | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 28. Compacted access track | Abertay University
Photograph Courtesy of Abertay University

Figure 29. Dense dogwood plating | Abertay University
Photograph Courtesy of Abertay University

Figure 30. Upton, Northamptonshire | The Land Trust
Photograph Courtesy of Abertay University

Figure 31. Gabion Inlet, Pitblae | Abertay Univeristy
Photograph Courtesy of Abertay University

Figure 32. Stone facing headwall | Abertay University
Photograph Courtesy of Abertay University

Figure 33. Vortex Flow Control | Abertay University
Photograph Courtesy of Abertay University

Figure 34. Litter Screen | Abertay University
Photograph Courtesy of Abertay University

Figure 35. Vortex Flow Control | Abertay University
Photograph Courtesy of Abertay University

Figure 36. Lattice screen | Abertay University
Photograph Courtesy of Abertay University

Figure 37. Bar screen | Abertay University
Photograph Courtesy of Abertay University

Figure 38. Blocked | Abertay University
Photograph Courtesy of Abertay University

Figure 39. Blocked headwall outlet | Abertay University
Photograph Courtesy of Abertay University

Figure 40. Lowered bank at footpath and overspill channel | Abertay University
Photograph Courtesy of Abertay University

Figure 41. Concrete spillway weir under construction in west of Scotland | Abertay University
Photograph Courtesy of Abertay University

Figure 42. Grass spillway saltens | Abertay University
Photograph Courtesy of Abertay University

Figure 43. Internal o/spill above VFC | Abertay University
Photograph Courtesy of Abertay University