



Standard

Title	Bioswales
Purpose	The Design Manual (DM) details current ST best practice in the selection, design, construction and commissioning of new or modified treatment processes and civil and MEICA assets. The purpose of the DM is to ensure that the delivery of assets comply with all Client requirements and are of a consistently high quality with respect to workmanship and selection/use of materials. The Clients Standards Deviation/Improvement process shall be used to raise: • Suggested improvements • Use of innovative techniques/processes/equipment not included in current DM guidance • Deviations from current standards
Who	Those undertaking planning, design, specifying, construction or commissioning of new assets or modifying existing assets.

Must Have (H&S, Quality, Quantity, Environment, Training, Resources)
• N/A
Remember – ‘Stop, Think, Take 20’

Summary Must Do
• N/A

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Bioswales	Owner: Alex Tree	Page 1 of 24
Version No. 1.0	Next Review Date: 01/07/2030	Published on: 18/8/2025



Document Control & Governance:			
Document Owner Name		Alex Tree	
Document Owner Role		Design Manager	
Date of Next Review		01/07/2030	
Version Number		1.0	
Waterpedia Reference		100351	
Version	Date Reviewed	Summary of Changes	Reviewed by
1.0	01/04/2023	New Document	Howard French
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Document Control

RED/AMBER CLAUSE CHANGES

Document Version	Description/Comment	Author	Check		Review		Approve		Authorised for Issue		Published
			Name	Date	Name	Date	Name	Date	Name	Date	Date
1.0	New Document	Alex Tree	Alex Tree	23/06/2025	Howard French	28/07/2025	Graham Morris	29/07/2025	Graham Morris	29/07/2025	

GREEN CLAUSE CHANGES

Document Version	Description/Comment	Author	Check		Review		Approve		Authorised for Issue		Published
			Name	Date	Name	Date	Name	Date	Name	Date	Date
1.0	CoP review and update, changed to RAG format	Alex Tree	Alex Tree	Alex Tree	23/06/2025	Howard French	28/07/2025	Graham Morris	29/07/2025	Graham Morris	29/07/2025

Contents

General Introduction	5
Design Criteria	6
1. Template Overview	6
1.1. Application	6
1.2. Design Requirements	7
1.3. Project Parameters	8
1.4. Operation and Maintenance	9
1.4.1. Operating Regime	9
1.4.2. Maintenance Requirements	9
2. System Design	9
2.1. Location and Siting of Works	9
2.1.1. Parking Requirements	10
2.2. Civils Design	10
2.2.1. Fencing	11
2.2.2. Bollards	12
2.3. Hydraulic Design	12
2.3.1. Requirement for Hydraulic Modelling	13
2.3.2. Risk to receptors from exceedance	13
2.3.3. Existing flood risk	13
2.3.4. Size of bioswale	13
2.3.5. Diversion of Sewer Network	14
2.4. Highway Design	14
2.4.1. Kerb and Inlet Design	14
2.5. Landscape Design	15
3. Component Design	15
3.1. Attenuation	15
3.2. Check Dams	16
3.2.1. Earth Check Dams	16
3.2.2. Timber Check Dams	16
3.2.3. Check Dam Design	16
3.3. Perforated Pipes	17
3.4. Low Flow and Exceedance Flows	17
3.4.1. Inflow	17
3.4.2. Surface Water Sewer Diversions	17
3.4.3. Exceedance	18

4.	Control and Monitoring.....	19
4.1.	Overflows / Bypasses.....	19
5.	Testing and Commissioning	19
6.	Operation and Maintenance	20
6.1.	Failures and Emergencies	20
6.2.	Routine Operation and Maintenance Tasks	20
References		21
Glossary		22

General Introduction

This document is predominantly an instructional document to provide guidance to develop the scope and design of new and/or refurbished assets. All clauses should be read and understood thoroughly as part of the design process.

This document is intended to provide instruction on how to design assets according to Severn Trent's and Hafren Dyfrdwy's (hereinafter referred to as Severn Trent) standards and best practice. This document does not override the Engineering Specification, and all designs should comply with the Engineering Specification¹.

All capital projects should abide by the instructions in this document; however, this document does not apply retroactively to existing assets. Where practical existing assets fall within the scope of new capital schemes, they should be brought in line with the current design manual; however, this is not a requirement and the decisions to upgrade should be made on a scheme-by-scheme basis.

In addition to the instructional and guidance function, the clauses in this manual are used to provide contractual limitations on any new design and fall into three categories:

RED	These clauses are mandatory and can only be deviated by following the official deviation process, as outlined in DM0114-01.
AMBER	These clauses may be deviated from with the agreement of the service manager without requiring the official deviation process, as outlined in DM0114-01 ² . Deviations for amber clauses should be recorded in the Action Decision Log, and/or specified in the Output Sheet ³ .
GREEN	These clauses are advisory and/or contextual and should be followed as a matter of course. These clauses are important and should be used to inform the design of the new asset, however, they do not represent a specific contractual clause unless specified in the output sheet or other part of the contract (where they revert to red status).

In all cases, a note should be made in the Action Decision Log of any deviation from the Design Manual, regardless of clause colour.

Severn Trent have chosen the colours red, amber, and green as they are universally accepted, and their meanings are well understood. However, due to these colours being used, this document may not be 100% accessible, particularly to those who have a colour vision deficiency. If you require an accessible version of this document, please contact designexcellence@severntrent.co.uk to make the request.

NB: for the NEC Professional Services Contract (PSC) Consultant Framework Lot 1-5, substitute the following, "Consultant" for "Contractor", and "Service Manager" for "Project Manager", in the clauses below.

¹ Where it is found that it is not possible to abide by the Engineering Specification, or the design manual contradicts the Engineering Specification, this should be raised immediately with the document owner.

² Once amber clauses are specified in the output sheet, these clauses will revert to red status in line with the contents of the output sheet.

³ The Output Sheet for this Design Manual is to be used to specify deviations and requirements for amber clauses, along with any other supplementary requirements not specified in the body of the Design Manual. The Output Sheet can be found in Waterpedia under 'Associated Documents,' or in the 'Templates' section of this document.

Design Criteria

This document has been produced to define parameters which must be applied whilst also providing guidance on the other issues which may need to be addressed through proper engineering judgement. Where appropriate, variations and options are identified within this document.

This document must be read in conjunction with the General SuDS Design Manual.

The result of which should be, a complete solution which is safe (to construct, operate and maintain), robust and efficient both in its operation and maintenance.

The use of this document is recommended for the detailed design stage; however, it is recognised that, particularly with regards to Sustainable Drainage Systems, it will be necessary to tailor the design for a project to suit site specific situations. If in doubt, discussions should take place with the ST Project Manager and Designer. Engineering judgement should be applied at all stages to ensure that the guidance contained within this document is being suitably applied to each situation and location.

The works covered by this technical note include:

- Location and siting of the works
- Enabling works
- Hydraulic Design
- Exceedance arrangements
- Site works including any geotechnical, ecological, and landscaping requirements.

1. Template Overview

1.1. Application

Bioswales are shallow, continuous, vegetated channels designed to manage overland flows from adjacent surfaces, refer to Figure 1. In addition to being a sustainable method of drainage that provides attenuation of flows, bioswales improve water quality, enhance the natural landscape, and provide amenity and biodiversity benefits. They store runoff within the engineered layers and in ponding on their surface. The layers include a mulch layer, a growing medium or planting layer, a transition or filter layer, and a drainage or storage layer. These layers and the planting provide filtration, absorption, and biological uptake of dissolved and suspended pollutants. The grassed slopes will be underlain by low nutrient topsoil.

Bioswales are set predominantly within the verges and other existing green areas adjacent to impermeable surfaces. Point inlets carrying highway runoff can be piped under footways and surrounding green areas whilst footway and other, wider catchment runoff can enter the bioswales directly as overland flow. The runoff percolates through the growing medium and filter layers before being stored within the storage layer. Ultimately flows are either infiltrated into the ground or discharged via pipe into the existing drainage system. Generally, exceedance flows will spill back onto the highway and will not impact properties.

Where exceedance flows from interventions may impact properties or where they are significantly altered by the intervention and therefore pose a detriment to flood risk, the designer shall propose appropriate means to manage the exceedance.

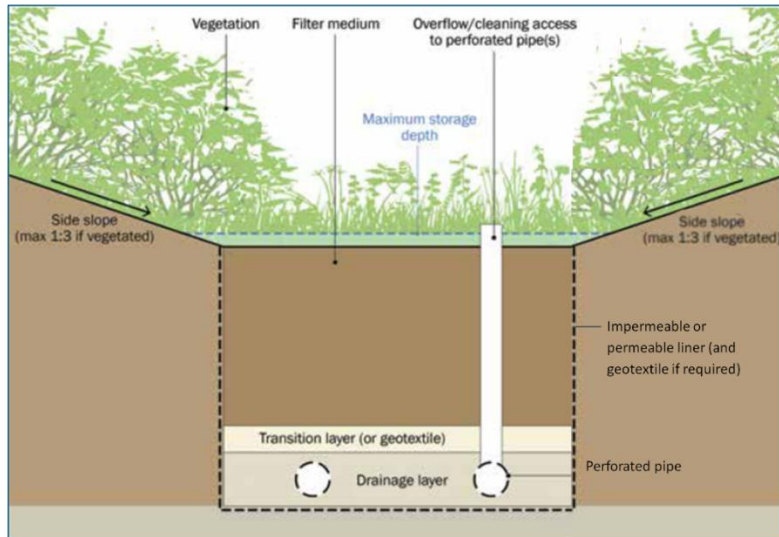


Figure 1 - Typical cross-section through a bioswale

Source: Adapted from Figure 18.1 from The SuDS Manual C753⁴

1.2. Design Requirements

Design of all sites shall consider the items identified in the table below.

Items required
Shape and size of the bioswale
Infiltration potential
Storage size and type
Inspection chamber and outlet piping layout
Exceedance flow routes and overflow gullies

Design of sites shall also consider the items identified in the table below.

Items that may be required	Circumstances where required
Inlet / headwall design	Where runoff from the highway is concentrated through a piped inlet
Overland flow routing	Where adjacent impermeable areas are to drain into the bioswale
Flow control device	Type B (partially infiltrating) and Type C (non-infiltrating) systems and/or where check dams occur
Inspection chamber, and outlet pipe	Where discharge into the existing drainage system is required
Service corridors	Where services cut through the site and cannot be redirected
Check dam spacing	Where the site gradient is such that check dams are required to optimise storage

⁴ The SuDS Manual C753, CIRIA (2015)

1.3. Project Parameters

The following design parameters shall be used in the design.

Parameter	Units	Value
Side slope gradient (maximum)	-	1 in 3 (1 in 4 recommended wherever possible, where space allows slacker gradients should be considered)
Bioswale width (maximum)	m	20 (Where accessible from both sides of the bioswale. Where access is only available on one side, the width should not exceed 10m)
Bioswale width (minimum)	m	3
Bioswale length (minimum)	m	5
Above ground storage depth	mm	200 – 800 (600 maximum adjacent to timber check dams)
Freeboard (minimum)	mm	50 – where no exceedance gullies are provided 100 – where exceedance gullies are provided
Growing medium layer depth (minimum)	mm	450
Filter layer depth	mm	100 (to be excluded when Hydrorock is used)
Underdrain pipe diameter (minimum)	mm	100
Minimum permeability rates for all internal layers	mm/h	200
Maximum permeability rates for all internal layers	mm/h	650
Minimum porosity of storage layer	%	30
Minimum distance between check dams	m	2.6 (minimum based on apparatus required between check dams, this spacing may be larger in practice to ensure maximum gradient requirements of 1:20 are met)
Maximum top water level difference across check dam	mm	300

The following design parameters should be determined as part of the design.

Parameter	Units	Determined by
Bioswale width	m	Determined based on-site opportunity and storage requirements / upstream catchment and topography
Bioswale length	m	Determined based on-site opportunity and storage requirements / upstream catchment
Drainage depth	mm	Determined based on storage requirements / upstream catchment
Storage layer type / porosity	-	Determined based on storage requirements / upstream catchment
Length of scour protection at point inlets	mm	Distance from inlet to base of bioswale and size of inlet
Inlet frequency and size	mm	Dependant on catchment size and characteristics
Flow control device type and size	mm	Dependant on potential for infiltration and catchment size and characteristics
Number of exceedance overflow gullies	-	Dependant on catchment size
Liner type	-	Determined by system type (Type A, Type B or Type C) at detailed design stage

1.4. Operation and Maintenance

1.4.1. Operating Regime

Surface water runoff can reach the bioswale either via a discrete inlet, or as overland sheet flow from impermeable surfaces adjacent to the bioswale. The runoff will percolate down into the growing medium, through the filter layer and subsequently into the storage layer. The runoff can then be temporarily stored and infiltrated into the ground or discharged through a drainage system.

In extreme rainfall events, where the design capacity of the system is exceeded, the above ground storage area will fill before water overflows.

In interventions which alter the existing exceedance flow routes and may have a detrimental impact on flood risk to a property or structure, the designer shall propose appropriate means to manage the exceedance such as trapped gullies which carry the flows directly to the outgoing pipe, shortcutting the flow control device within the inspection chamber.

1.4.2. Maintenance Requirements

The works should be designed to minimise maintenance and to facilitate safe and appropriate methods of working.

Regular inspection, cleaning and maintenance is however required for proper operation of the system. Below are maintenance factors which should be considered in addition to those set out within section 1.2.2 in A7S14649-STW-XX-XX-TN-C-0020:

- Adequate access should be provided to all swale areas for inspection and maintenance, including for appropriate equipment and vehicles
- The width of the bioswale shall be less than 10m (if can only be accessed one side) or 20m (if access is available both sides) so it can be maintained using a 10m reach excavator
- The length of any section of swale between culverts should be 5m or greater for maintenance access
- Grass on bioswale slopes should be maintained at 75mm – 150mm long, where the bioswale is planted this can potentially be longer
- A swale side slope of 1 in 4 is recommended for safety and maintenance purposes, however a 1 in 3 slope is permitted where space is constrained. Where space allows the designer should consider slacker gradients
- The location of these systems adjacent to highway carriageways and footways leaves them susceptible to collecting litter and other debris from the highway. This should be considered during the design, and additional maintenance may be required to maintain the aesthetic appearance of the bioswales if they are in sensitive locations
- During the first few months after installation, the system should be visibly inspected after rainfall events and the amount of deposition measured, to give an idea to the operator about expected rate of sediment deposition
- Sediment should be removed once deposits exceed an agreed depth.

2. System Design

2.1. Location and Siting of Works

Suitable locations for retrofitting bioswales include existing hardstanding or grassed areas behind footways and within parks and green spaces, particularly in areas with drainage and/or flooding issues in the local vicinity.

The sites should ideally be situated in areas with adjacent impervious areas, such as roads, paths, and buildings. Redirecting the runoff from these areas into the bioswales will allow more water to be retained

rather than entering the sewer network. For general factors to consider when siting SuDS features refer to section 2.1 in A7S14649-STW-XX-XX-TN-C-0020.

Areas where bioswales should be sited include:

- Existing verges
- Parks and amenity areas
- Large pedestrian areas with potential for regeneration.

2.1.1. Parking Requirements

Where bioswales are proposed to be located in grassed areas adjacent to carriageways these should be checked to see if evidence of tyre marks is visible on site and online maps should be reviewed to see if vehicles can be seen parked on verges. Although parking in these areas is not legal, caution should be exercised when replacing a known parking area with a bioswale and consideration given to impact on residents. Thought should also be given to if the area is used for access, legal or not.

2.2. Civils Design

Bioswales consist of multiple engineered layers below a landscaped depression designed to optimise the storage both above ground and below ground for surface water runoff.

The engineered layers should be made up of the following:

- Above ground storage – this will provide storage when the layers below are saturated or when the inflow exceeds the permeability of the growing medium
- Mulch layer – this provides the planting with a growing media and assists with preventing erosion and weed growth
- Growing medium – this filters runoff and provides a soil for planting to establish
- Filter layer – this prevents the storage layer being clogged with fines from the growing medium. This layer is to be omitted when Hydrorock is proposed in order to allow for the capillary action of the Hydrorock to irrigate vegetation above.
- Storage layer – this collects and stores runoff prior to discharge into either the ground or an existing drainage system
- Granular bedding material – this is to support the load of solid and perforated pipes (can be excluded if hydrorock blocks with integrated pipes are proposed)
- Cohesive fill – to be used if required due to existing substrate.

For interventions proposed using aggregate storage a length of 100mm diameter perforated pipe should sit in a 200mm depression for Type C and Type B systems, so that the pipe soffit is level with the invert of the storage layer. The perforated pipe may be bedded on storage layer material or granular bedding. Where interventions are proposed with Hydrorock as a storage layer, blocks with integrated pipes should be used instead of a perforated pipe with these blocks set 150mm lower than surrounding blocks with filler blocks used above. Where deemed necessary to do so these integrated blocks could be replaced with standard blocks with a perforated pipes in a 200mm depression below them as per aggregate storage interventions.

For all these, depressions and pipes shall be located beneath/through check dams and at the downstream end of the intervention. This is to collect water from the storage layer and convey it to the downstream cell or outlet.

This 200mm depression can be adapted by the designer to suit intervention topography whilst ensuring the intervention/cell is still able to fully drain.

The perforated pipe shall couple to a solid pipe where not within the intervention footprint (i.e. between intervention and flow control chamber).

The length of the perforated pipe or number of integrated hydrorock blocks should be determined during detailed design.

Discharge pipes shall be designed such that they do not restrict discharge from the storage layer. All perforated pipe stubs should be capped using an end cap and a band seal.

Scour protection shall be required at point inflow locations where headwalls are located. This is to prevent scour to the grassed slopes, mulch layer and growing medium and prevent damage to any planting in the bioswale. The scour protection shall extend from the headwall outlet to the base of the bioswale.

This scour protection may be formed using gabion mattress or aggregate embedded into concrete.

Scour protection shall also be proposed immediately downstream of each check dam to prevent scour to the mulch layer and growing medium layer. This protection shall extend a minimum of 0.5m either side of the weir notch.

Where the intervention is proposed adjacent to a footway or carriageway there shall be a 500mm offset to the start of the banking of the bioswale side slopes.

The side slopes shall start level with the surrounding ground and fall to the base level at an optimum gradient of 1 in 4. This could be steepened to a maximum slope of 1 in 3, depending on site specific constraints, for example, to increase sub-surface storage or account for existing site gradients.

Where space allows the designer should consider the use of slacker gradients or variable gradients around the perimeter of the swale.

This provides a buffer strip and a gentle gradient to the base, mitigating against any public safety issue, allowing mowing as well as providing a filter strip to treat flows and dissipate energy from the runoff.

The base should aim to be an optimum width of 1.2m or greater to slow flows, encourage sediment removal and improve water quality.

The overall width of a storage bioswale shall be a minimum of 3m.

Aside from this, widths and depths can be flexible in order to maximise the bioswale efficiency in diverse kinds of environments. For example, it is feasible to have stepped sides or raised sections within the bioswale in order to avoid constraints such as service crossings and trees.

For bioswales where there is significant fall over the length of the intervention, check dams shall be proposed in order to maximise storage. Where check dams are required the water depth immediately adjacent to the check dam shall not exceed 600mm.

2.2.1. Fencing

Fencing may be required when there is a high risk of pedestrian interface with the intervention such as when located in proximity to amenities or play areas.

The designer shall consider whether fencing should be proposed around all or part of the bioswale in order to prevent pedestrian access.

The requirement for fencing shall be discussed and agreed with ST and the local highway authority

2.2.2. Bollards

Bollards may be required where it is necessary to demarcate an intervention such as where there is flush kerbing adjacent to the carriageway.

The designer shall consider whether bollards should be proposed in the intervention. The requirement and frequency of bollards shall be discussed and agreed with ST and the local highway authority.

2.3. Hydraulic Design

Bioswales can be classified as either Type A, Type B or Type C systems depending on the discharge method used. Type A systems are fully infiltrating with water infiltrating into the ground through a permeable geotextile. Type C systems are non-infiltrating; in this case the water will not be able to infiltrate and will instead pass through a length of perforated pipe located in the drainage layer. The water will flow through the perforated pipe into a chamber with a flow control device before discharging into the existing drainage system. Type B systems are partially infiltrating; in this case infiltration is possible but the infiltration rate is not high enough to allow the system to drain down in a reasonable time, refer to section 2.7 in A7S14649-STW-XX-XX-TN-C-0020. In this case some of the water will infiltrate and some will be discharged into the existing drainage system through a length of perforated pipe and chamber with a flow control device. Examples of the arrangements for the different system types can be found on drawings A7S14649-STW-XX-XX-DR-C-0050 and A7S14649-STW-XX-XX-DR-C-0051.

Bioswales are designed with both below ground and above ground storage. Bioswales can accommodate sites with a gradient across the width as well as the length of the site.

In some scenarios where the ground is steep, check dams can be incorporated to optimise storage. In other areas check dams will not be suitable and alternative flow controls (orifices, vortex flow control or pipes) can be used between sections of bioswale to optimise the storage. This should be determined on a site-by-site basis and is subject to detailed design and site-specific hydraulic modelling.

In all cases, the maximum gradient an intervention shall be proposed on is 1 in 20.

Where significant below ground storage is required to store runoff in the design event and the granular storage does not provide adequate capacity, Hydrorock natural aquifer system should be included as the storage layer in order to improve the porosity and hence capacity of the storage layer.

The detailed design of this solution shall be undertaken with input from the Hydrorock internal design team.

The bioswale should have a maximum contributing area of 50 times the surface area of the bioswale to prevent the surface storage from being inundated and exceeded.

The designer shall undertake capacity calculations with accurate permeability rates during the detailed design to confirm this. The design shall ensure, in addition to this, the maximum catchment area for adequate treatment is observed, as highlighted in Equation 18.1 of The SuDS Manual C753⁴.

In the design storm event, runoff will be able to permeate through the growing medium and will be stored in the storage layer as well as above ground, subject to the permeability for the growing medium being adequate. However, in shorter more intense events, runoff may be only stored above ground in the landscaped depression.

Therefore, at detailed design stage; as well as the overall storage capacity being checked for the critical duration; the above ground storage capacity shall be confirmed as adequate for the more intense shorter duration events.

It should be considered whether a non-return valve is required on the outfall into the existing drainage network, particularly if this is a combined system, refer to section 3.3.1 in A7S14649-STW-XX-XX-TN-C-0020 for information on when a non-return valve is required.

The final solution is summarised by the following elements:

- System type (Type A, Type B, Type C)
- Inlet type/s
- Storage layer type and thickness
- Liners and geotextile
- For Types B and C (and where check dams are proposed): Flow control measures and perforated pipe length
- Half drain down time.

2.3.1. Requirement for Hydraulic Modelling

In some cases a bioswale may require modelling due to the presence of 1 or more risk factors. These risk factors may include but are not limited to; risk to receptors from exceedance, existing flood risk, sewer diversions and the proposed bioswale storage volume. The key consideration for bioswale modelling is whether the proposed mitigation measures included in the design are adequate to mitigate the risk. In some cases modelling will therefore be necessary to fully understand the nature of the risk where it is unclear. Further information on the risk factors can be found in the sections below.

Where the designer determines modelling is required this shall be agreed with ST prior to being undertaken.

2.3.2. Risk to receptors from exceedance

The designer shall consider the land use and potential impacts to third parties or sensitive receptors. If there is a possibility that a receptor is exposed to a new or elevated flood risk, hydraulic modelling will be required.

Indicators for changes to risk include:

- Intervention is likely to exceed
- Exceedance/failure route puts third parties/receptors at new or elevated risk compared to existing arrangement
- Elevated risk to third parties in event of inundation, failure and or exceedance
- Critical/sensitive land uses or third parties/receptor which if impacted by changes to flow paths or new exceedance gullies would be disproportionately affected.

The designer should refer to the Environment Agency's guidance on Flood Risk Assessments and the National Planning Policy framework regarding flood risk vulnerability classification⁵.

2.3.3. Existing flood risk

The designer shall consider whether the bioswale is located in an area where sewer network flooding is known either from historical evidence or catchment modelling. In this case the bioswale is likely to be hydraulically linked to the baseline flood risk so modelling shall be undertaken.

2.3.4. Size of bioswale

The designer shall consider if modelling is required based on the below:

- Large contributing area which potentially means an extended time of concentration
- Long drain down time due to size of the bioswale
- Larger bioswales are more likely to need sewer diversions, return of flows to the network or limiting of flows which require understanding hydraulically

⁵ National Planning Policy Framework Annex 3: Flood risk vulnerability classification

- Larger bioswale may result in infiltration variability throughout the bioswale, meaning that infiltration potential is reduced.

2.3.5. Diversion of Sewer Network

The designer shall undertake modelling where it is proposed to divert the sewer network (refer to section 3.4.2 for more information), in order to understand the hydraulic impact of diverting the sewers and assist in the detailed design of the intervention.

Understanding the change in hydraulics in the upstream and downstream system is essential to understanding flood risk.

2.4. Highway Design

It is likely that some bioswales will be within the highway verge.

Therefore, it is critical that highway design and safety is considered in parallel with the other design aspects. These design elements shall be considered at the detailed design stage:

- Width of footway
- Existing pavement construction
- Highway reinstatement
- Distance from junction
- Visibility on bends
- Intervention demarcation, refer to sections 2.2.1 and 2.2.2 for details
- Protection of headwalls
- Buried utility services
- Existing gully abandonment.

2.4.1. Kerb and Inlet Design

Inlet flows to the bioswales from the highway can be via flush kerb edging, chute gullies or combined kerb drainage units, associated piping, and headwalls. Inlets can also be via surface water sewer diversions (refer to section 3.4.2 for details).

Where flush kerbs are proposed as the inlet mechanism, the desired level of the lowered section shall be selected based on the length of the proposed inlet as below to encourage channelised flow into the intervention:

- Individual Inlet length <5m - desirable upstand at inlet = -25mm to -35mm
- Individual inlet length >5m and <10m - desirable upstand at inlet = -15mm to -30mm
- Individual inlet length >10m - desirable upstand at inlet = -10mm to -20mm.

For all inlets this shall require local regrading of the carriageway to direct flow.

For all inlet types where new kerbing is required, these shall be proposed in the same profile as the existing kerbs.

In cases where chute gullies or combined kerb drainage are proposed that require pipes crossing the carriageway, an absolute minimum of 360mm cover to the crown of all pipework shall be maintained, and the pipework surrounded in concrete in line with Type Z pipe bedding / protection (MCHW Volume 3 F Series).

In addition to the inlet types mentioned above, conveyance swales can also be used to convey flow into the main storage bioswale from the catchment area and/or to direct exceedance flow from the bioswale (e.g., to another bioswale or the carriageway).

Where a formal conveyance channel is proposed the typical dimensions should be 2m wide at the surface by 200mm deep with 1 in 4 side slopes to leave a 400mm horizontal base in the centre. These dimensions can be adjusted to accommodate various site constraints. Alternative conveyance swale details can be proposed such as shallow concrete lined channels or localised depressions in the ground. These are likely to be used in cases where the expected flow is lower such as when catchment is being taken from downpipes and as a minimum should be 100mm deep and 800mm wide with 1:4 side slopes. Where localised depressions are proposed these should be designed to ensure sufficient capacity for the expected flow. In all cases where conveyance swales are used, 1 in 4 side slopes should be used as standard, with a maximum of 1 in 3 side slopes where required due to space constraints.

2.5. Landscape Design

Bioswales can offer clear landscape benefits. However, these benefits can only be realised through careful consideration of the wide range of factors and constraints that impact on site design and plant performance. As well as providing sustainable flood resilience, an excellent quality scheme can transform the quality and perception of a space or place, encouraging stakeholder and resident buy-in and offering tangible evidence of the benefits of SuDS.

Bioswales comprise two landscape elements:

- A central flat-bottomed channel, with planting overlying a growing medium layer
- Two banks either side, guiding run-off towards the central channel, with a maximum gradient of 1 in 3 (a gradient of 1 in 4 should be proposed wherever possible).

Planting within the central channel should be adapted to wet regimes and be capable of withstanding periodic inundation, refer to landscape appendix in the General SuDS Design Manual A7S14649-STW-XX-XX-TN-C-0020.

3. Component Design

3.1. Attenuation

Attenuation within the bioswale is contained both above ground and within the storage layer. Attenuation above ground is limited by the available area of the bioswale, however storage within the storage layer can be increased depending on the requirements, by increasing the depth of the storage layer, plan area or increasing the porosity of the layer. Bioswales can be used on sloped sites and for sites with a gradient across the width of the site as well as along the length of the site, although this may have a detrimental impact on storage capacity.

If the site is steeply sloping, it is recommended that check dams are incorporated to maximise storage, and this should be assessed on a site-by-site basis. A more traditional approach for check dams should be used for bioswales, such as earth check dams or timber check dams. Flow controls (orifices, vortex flow controls or pipes) should be used between sections of bioswale to optimise the storage. The suitability of each flow control measure must be determined on a site-by-site basis at detailed design stage.

Bioswales shall not be proposed on sites with slopes greater than 1 in 20.

3.2. Check Dams

Where check dams are incorporated to maximise storage, they shall be constructed from timber or earth (mulch and growing medium layers). Earth dams shall be used where possible however where space is limited, timber check dams will have to be used. Requirements of each type of check dam are outlined below.

3.2.1. Earth Check Dams

- Length of check dam to be determined at detailed design depending on intervention dimensions.
- To be constructed from 75mm mulch surface layer with growing medium layer core
- Constructed with 1 in 3 side slope gradients.

Refer to drawing A7S14649-STW-XX-XX-DR-C-0051 for typical earth check dam section.

3.2.2. Timber Check Dams

- The exact specification of the timber check dams shall be determined at detailed design. This shall include (but is not limited to):
 - Type of timber and treatment
 - Timber section dimensions
 - Central support dimensions
 - Type of sealant (or sealing method) used between sections of timber
- Length of check dam to be determined at detailed design depending on intervention dimensions. Where length exceeds 4m, additional central supports are recommended, subject to confirmation by the designer
- Check dam to have a notch at the top to concentrate exceedance flows
- Maximum retained height of water to be 600mm immediately adjacent to the check dam
- Timber sections to be embedded into the surface storage by a minimum of 150mm.

Refer to drawing A7S14649-STW-XX-XX-DR-C-0052 for typical timber check dam detail

3.2.3. Check Dam Design

Where check dams are to be used the design shall consider the following:

- An impermeable liner (and protection geotextile as required) shall be used, refer to drawings A7S14649-STW-XX-XX-DR-C-0051 and 0052 for details. For Type B and Type C systems, where flow controls are required, the solid pipe between the flow control and downstream end of check dam shall pass through the liner
 - For timber check dams the liner should overlap by 0.15m and for earth check dams the liner should extend up to 0.1m below the check dam surface
- A notch at the top to concentrate exceedance flows. This notch should be a minimum of half the width of the bioswale base, where this would result in a notch wider than 1.5m, a 1.5m wide notch should be proposed as standard
- Scour pad embedded within the mulch/growing medium layers downstream of the check dam at the location of the notch. This shall extend a minimum of 0.5m either side of the weir notch
- For Type B and Type C systems, lengths of perforated pipe shall be laid in a depression beneath the storage layer. This will lead into a flow control chamber which shall be located upstream of each check dam. A length of solid pipe shall then be laid from the flow control chamber through the check dam. Then another length of perforated pipe shall be laid to distribute flow back into the next cell located downstream
- Maximum difference in top water level across a check dam shall be 300mm.

3.3. Perforated Pipes

For Type C and Type B interventions, perforated pipes shall be used to drain the system. Perforated pipes shall be 100mm diameter, set within a localised depression.

The localised depression should be 200mm below the invert of the storage layer allowing the pipe soffit to be level with the invert of the storage layer. The perforated pipe should be bedded as standard on 100mm of material. This may be granular bedding material or the same material as the storage layer. The designer can adapt this depression to suit the intervention topography whilst ensuring the intervention / cell is still able to fully drain.

The perforated pipe is to couple to a solid pipe where not within the intervention footprint (i.e. between the intervention and flow control chamber). All perforated pipe stubs up and downstream of flow control chambers shall be capped using end caps and a band seal to prevent aggregate from washing into the pipe.

In the case where Hydrorock is proposed to be used as the storage media the perforated pipes can be replaced with Hydrorock blocks with integrated pipes.

3.4. Low Flow and Exceedance Flows

3.4.1. Inflow

Inlet flows to the bioswales from the highway can be via flush kerb edging, chute gullies or combined kerb drainage units, associated piping, and headwalls. Inlets can also be via surface water sewer diversions, refer to section 3.4.2 for details.

At these locations, an element of scour protection shall be used to ensure the point inflows do not erode the engineered layers within the bioswale.

Inflows to the bioswale from the footway and adjacent grassed areas are via overland sheet flow and due to the grassed banks and the dispersed nature of this flow, scour protection should not be required here.

During standard operation, runoff will percolate through the growing medium and filter layer and then into the storage layer.

For public safety, headwalls shall be as small as possible whilst meeting the hydraulic requirements of the design. Proprietary swale inlets are recommended for any 150mm diameter inlets to the swale.

The removal and relocation of existing highway drainage features may be necessary to maximise the intervention's contributing catchment area. This shall be done in line with the local highway authority's guidance.

3.4.2. Surface Water Sewer Diversions

In cases where it is possible to intercept surface water sewers and divert them to convey flows from an upstream catchment to the intervention, the impermeable area contributing to the network shall be verified. This shall be verified using either catchment hydraulic models or connectivity surveys.

Once the network to be diverted is identified surveys shall be undertaken to identify any historical misconnections from foul drainage to the surface water network. Where these surveys identify the presence of misconnections ST shall be made aware to allow for them to be located and fixed prior to the construction of the intervention.

Where the catchment area identified exceeds the storage capability of the bioswale the designer shall put in place mitigation to ensure the intervention does not become overloaded.

This should be done using a hydraulically safe chamber or using flow controls to throttle the flows. A hydraulically safe chamber should be used wherever possible provided that the levels of the existing sewer and intervention permit this.

Any hydraulically safe chambers shall include a weir across the chamber perpendicular to the existing sewer run and a new pipe installed upstream of the weir to divert flows to the bioswale. The weir level shall be set at the designed top water level considering freeboard requirements so that when the level in the bioswale reaches the maximum water level the weir will be overtopped, and flows continue down the existing network.

Where possible existing chambers can be modified to function as a hydraulically safe chamber. Where this is not possible a new chamber can be proposed on the existing sewer line.

Where a hydraulically safe chamber is used there is no requirement for exceedance gullies.

3.4.3. Exceedance

Should a storm event over and above the designed return period occur, the storage above ground within the depression will be exceeded and the water will reach the maximum level.

If, when constructed, the intervention changes the current exceedance flow path and may have a detrimental impact on flood risk to a property or structure, the designer shall ensure that the exceedance flow is managed. The method of managing the exceedance flow will be dependent on the site constraints but may include, but not be limited to, redesign of the intervention to increase storage capacity, design of additional interventions within the catchment or reduction in proposed catchment area provision of exceedance gullies. Where the designer specifies the provision of exceedance gullies, the number of exceedance gullies shall be calculated based on catchment size. However, where the exceedance flow route from the intervention is back onto the public carriageway and will flow indirectly to another SuDS intervention without causing excessive ponding, exceedance gullies shall not be required. Similarly, where exceedance is back to the public carriageway and will flow to a downstream gully, provided the gully is within 20m of the intervention then exceedance gullies shall not be required.

Exceedance gullies should be sited 20mm above the surrounding finish levels to protect against significant silt wash over the gully. Where deemed necessary a 150mm concrete apron can be proposed around the gully to further separate the grating from the surrounding landscaped surfaces.

At detailed design, the catchment areas and low spots should be analysed, and gully locations and numbers confirmed based on site specific factors such as hydrology, risk of blockage, exceedance flow routes and downstream receptors.

Gullies shall be trapped and designed and installed in accordance with the local highway authority's guidance. The inclusion of a bespoke gully cover to limit access to the gully is to be confirmed at the detailed design stage and included if required.

Should an extreme storm event occur that is over and above the capacity of the overflow gullies, runoff from the bioswale shall be diverted back into the highway carriageway to continue along the existing overland flow routes wherever possible. Spillways may be required in some scenarios to ensure the flows from extreme storms are carefully managed, this should be determined on a site-specific basis at detailed design. Careful assessment is required at detailed design to ensure that the construction of the bioswale does not generate or accelerate new overland flow routes which may increase flood risk to any receptors.

4. Control and Monitoring

4.1. Overflows / Bypasses

Controls on the bioswale systems are extremely limited and shall be passive, without requiring any manual operation.

For bioswales the risk of blockage in the flow control chamber is low as most of the sediment is trapped within the growing medium, filter and storage layers.

However, if this is blocked, access to the flow control shall be provided via a chamber and the flow control may be required to be removed.

If a blockage does occur, the system should be designed such that storm water will back up into the above ground storage and follow the designed exceedance route. This will direct runoff into the existing drainage system, bypassing the flow control.

5. Testing and Commissioning

Other than standard testing and commissioning expected as part of the construction contract, there are no specific testing and commissioning requirements required for the bioswales.

Handover of SuDS features is however important and requires careful construction. The items below, taken from Guidance on the construction of SuDS⁶ is provided for reference as examples of key checks should be conducted, further component specific checklists can be found in the guidance.

- Completed levels along the length of the system agree with original design drawings
- Where infiltration is required by the design ensure that permeability of natural soils is effective and delivers the design infiltration capacity
- Gradient of side slopes and width of base to swale are as designed
- Particle size of delivered engineered soils or individual soil elements for site comply with the specification
- Depth of engineered soil is as designed / specified and undertake an on-site permeability test to check soils drainage capacity
- Audit trail of changes to ensure revisions to scheme still fulfil requirements in-line with the original scheme
- Graded filter or geo-textile used and compliance to specified materials / depth
- Piped drains are installed in base of system and connected to main drainage system correctly (Type B and C systems)
- Overflow system is in place and functioning correctly
- Inspection chamber installed correctly
- That seed/turf mix or plants supplied complies with the original specification
- The vegetation is sufficiently dense to withstand water flow before use
- Level of grass/road edge where 'over-the-edge' drainage is used is as designed
- Plant sizes and species are supplied and located to the correct specification and design
- Organic soil mulches have not been used
- Specified components are in the correct place to break inlet velocity
- Drainage material and pipe in under-drained swales are as specified
- Correct geotextile provided to underdrain and pipe are as specified.

Source: Extracted from Table A1.15 and Table A1.16 of the Guidance on construction of SuDS⁶.

⁶ Guidance on the construction of SuDS C768, CIRIA (2017)

6. Operation and Maintenance

6.1. Failures and Emergencies

Below is a list of some failures and emergencies which can occur with bioswales:

- Failure to maintain the vegetation at correct size causing planting to get out of control
- Sediment can build up, which will reduce the attenuation volume
- Trash or debris in chute gully causing a blockage.

These are in addition to the failures noted in section 8.1 of A7S14649-STW-XX-XX-TN-C-0020. The dynamic nature of planting is a particular risk for seed-based establishment. Poor species choice, soil specification/preparation and maintenance will be more apparent for such mixes, potentially leading to community and stakeholder dissatisfaction and a desire to return to traditional planting e.g., low biodiversity mown ryegrass. Gradual reversion to 'rank grassland' is a common failing of such schemes. Maintenance is equally as important as implementation and should be given commensurate attention at the tender and contract stage.

6.2. Routine Operation and Maintenance Tasks

The following table indicates the routine operation and maintenance tasks that should be undertaken. These should be reviewed on a site-by-site basis to confirm they are suitable, and the final maintenance plan provided to the operator / adopting party as part of the Health and Safety File.

Maintenance Schedule	Required Action	Typical Frequency
Regular Maintenance	Remove litter and debris	Monthly, or as required
	Cut grass or wildflower/grass mixes – to retain grass height within specified design range	Monthly (during growing season), or as required. When cutting wildflower/grass mixes for biodiversity, annual cuts during later summer/early autumn may be required
	Manage other vegetation and remove nuisance plants including: December maintenance to remove dead and untidy plant materials February maintenance to remove all remaining grass and seed heads/stems, although some species are not cut back. All cut material is removed off-site	As required
	Weed removal (spot treatment and hand weeding)	Six times per year (April to October inclusive) during years 1 to 3
	Watering plants	Twice year 1, once year 2, additional watering during dry periods subject to SVT approval
	Inspect inlets, outlets, and overflows for blockages, and clear if required	Quarterly
	Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for >48 hours	Quarterly, or when required
	Inspect vegetation coverage	Monthly for 6 months, quarterly for 2 years, then half yearly
	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Annually or after severe storms

	Inspect pipework and clear blockages	Annually or after severe storms
	Inspect manholes and clear blockages	Annually or after severe storms
	Inspect chute gully structure and remove any litter/debris	Annually or after severe storms
	Inspect combined kerb drainage and remove any litter/debris	Annually or after severe storms
	Inspect headwall structure and remove any litter/debris on structure	Annually or after severe storms
Occasional Maintenance	Reseed areas of poor vegetation growth, alter plant types to better suit conditions, if required	As required, or if bare soil is exposed
Remedial Actions	Repair erosion or other damage by returfing and reseeding	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Scarify and spike topsoil later to improve infiltration performance, break up silt deposits and prevent compaction of the soil structure	As required
	Remove build-up of sediment on scour protection or at top of filler strip	As required
	Remove and dispose of oils or petrol residues using safe standing practices	As required
	Repair any defects in pipe network	As required
	Replace malfunctioning parts or structures in chute gully	As required
	Check scour protection for any misalignments	As required
	Replace malfunctioning parts of structure of headwall	As required

References

DM0114-01 – Design Standards Deviation Process

A7S14649-STW-XX-XX-TN-C-0020 – General SuDS Design Manual

A7S14649-STW-XX-XX-DR-C-0050 – Bioswale Template Drawing Sheet 1 of 5

A7S14649-STW-XX-XX-DR-C-0051 – Bioswale Template Drawing Sheet 2 of 5

A7S14649-STW-XX-XX-DR-C-0052 – Bioswale Template Drawing Sheet 3 of 5

A7S14649-STW-XX-XX-DR-C-0053 – Bioswale Template Drawing Sheet 4 of 5

A7S14649-STW-XX-XX-DR-C-0054 – Bioswale Template Drawing Sheet 5 of 5

A7S14649-STW-XX-XX-DR-C-0020 –Flow Control Chamber

A7S14649-STW-XX-XX-DR-C-0021 – Connection to sewer

A7S14649-STW-XX-XX-DR-C-0022 – Gully Abandonment

DM0104-07 - Manholes and Inspection Chambers

Glossary

Acronym	Description
CIRIA	Construction Industry Research and Information Association
MCHW	Manual of Contract Documents for Highway Works
NRV	Non-return Valve
ST	Severn Trent Water Ltd
SuDS	Sustainable Drainage Systems