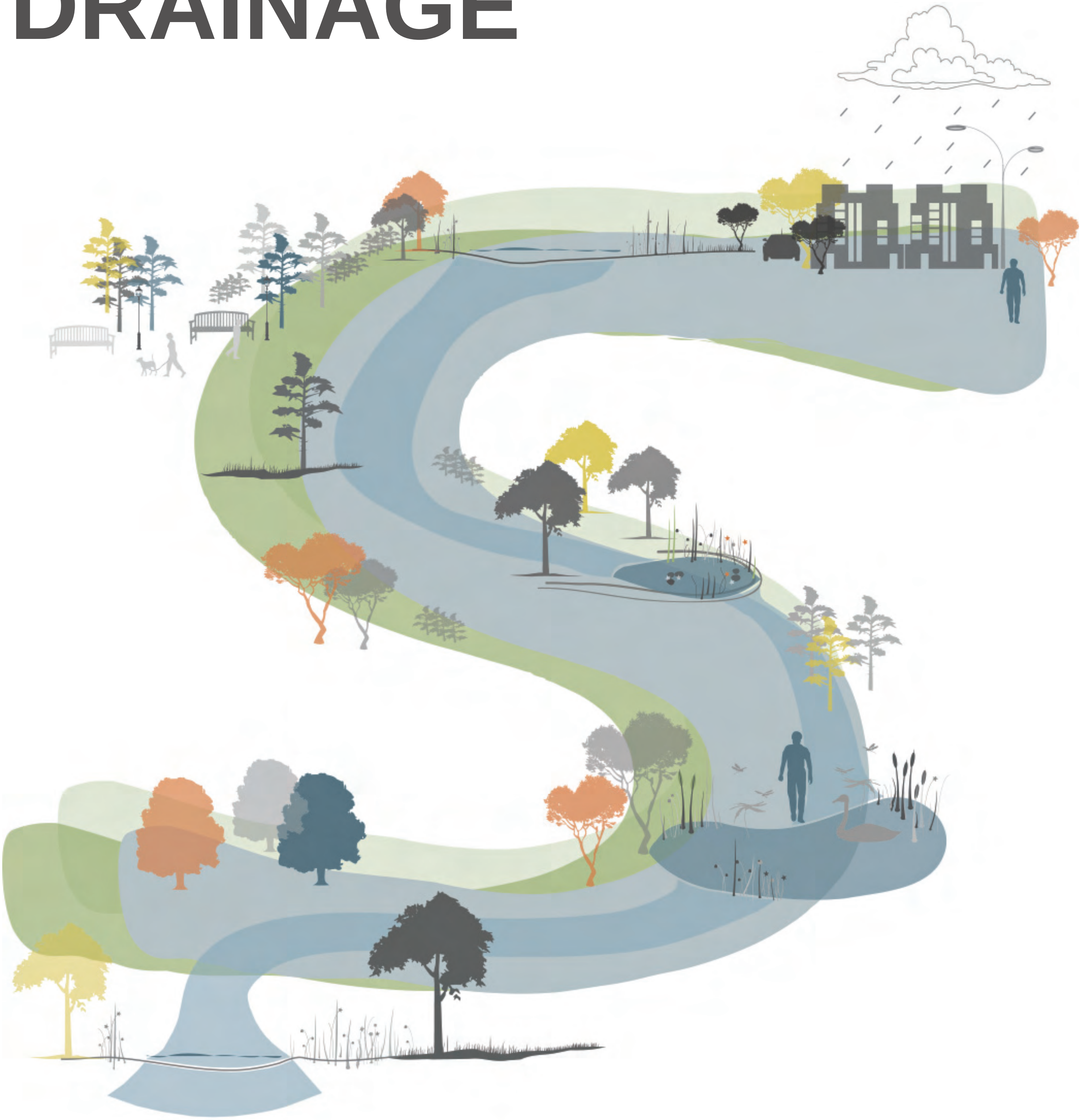
SUSTAINABLE DRAINAGE



Cambridge Design and Adoption Guide

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SUDS management train diagram based on original design by Catherine Greene and Eithne Flanagan

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Each sustainable drainage component throughout this document has been rated for all of the above benefits that they can provide. By comparison a traditional drainage scheme will only score high on storage.

Foreword

Water is an essential part of the Cambridge landscape, from the world renowned Backs, to the historic wetlands of Coe Fen and Sheep's Green through to the man-made watercourse of Hobson's Conduit and the unique Runnels along Trumpington Street. In the 21st Century, strains on historic drainage systems and the challenges of climate change mean innovative new solutions to water management are needed. It is widely recognised that sustainable drainage systems (SUDS) provide this solution and they offer an excellent opportunity to introduce water in the landscape throughout the new communities that are planned for the City.

SUDS can play a large part in shaping these high quality neighbourhoods, enhancing the opportunities for leisure, play and education within the open spaces. Wildlife thrives in well-designed SUDS. They will be especially significant in dealing with landscape and drainage issues in those areas of Cambridge that are due to see considerable expansion over the next few years.

This Design and Adoption Guide provides developers with all the information needed to meet our adoption standards. In the words of our Quality Charter, this guide should ultimately ensure that we treat 'water as a friend and not an enemy'.

Executive Councillor for Climate Change & Growth, Sian Reid

Executive Councillor for Arts & Recreation, Julie Smith

Introduction

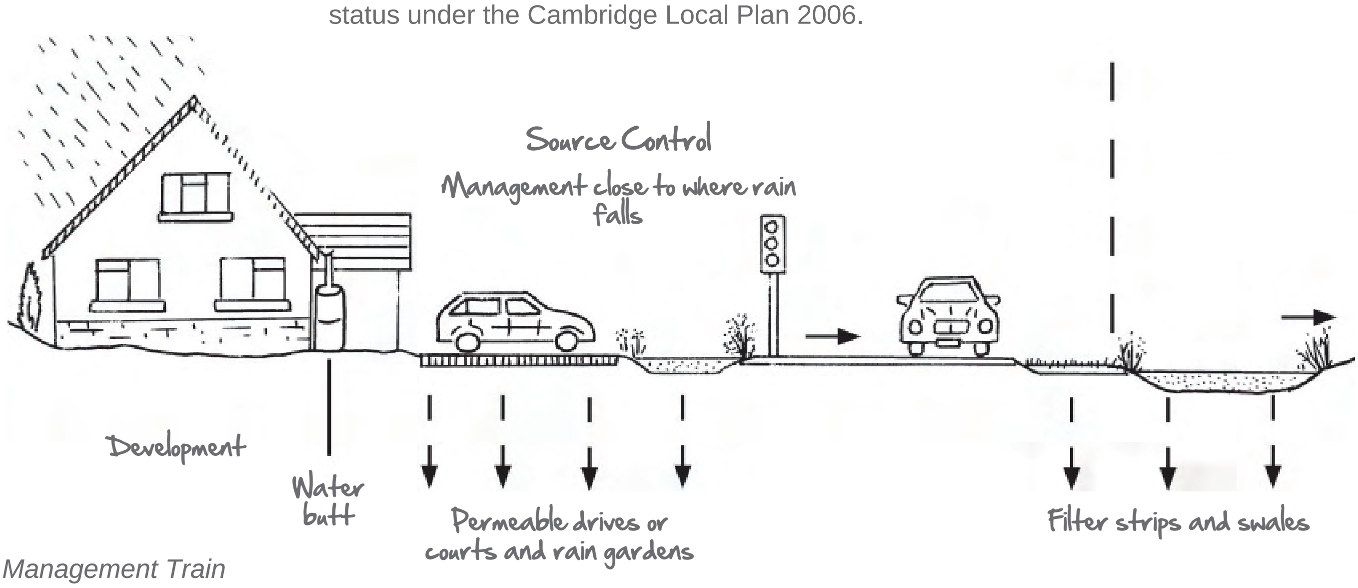
A successful SUDS scheme will deliver many **community** benefits, enhancing the **quality of life** of people living there, **increasing biodiversity** whilst reducing the risk to residents and their homes from **flooding** and providing greater resistance to the impacts of **climate change.**

The SUDS will ensure that local watercourses and rivers, such as Hobson's Brook and The Cam, will not suffer any detrimental **water quality** effects or increased flood risk due to the new developments discharging into them. The City Council will also be taking a lead role in ensuring that these systems are maintained and remain effective throughout the life of the development, a move in line with increasing responsibility for flood risk management being passed to local authorities.

Purpose of this Guide

This guide is primarily intended for use by **developers** and their **consultants** where they are seeking adoption of SUDS by Cambridge City Council within the public open space of new developments. It sets out the **design** and **adoption** requirements that the City Council will be looking for, in order to ensure a smooth and satisfactory adoption process.

This guide does not form part of the Cambridge Local Development Framework or have any formal planning status under the Cambridge Local Plan 2006.



SUDS Management Train

What are sustainable drainage systems or SUDS?

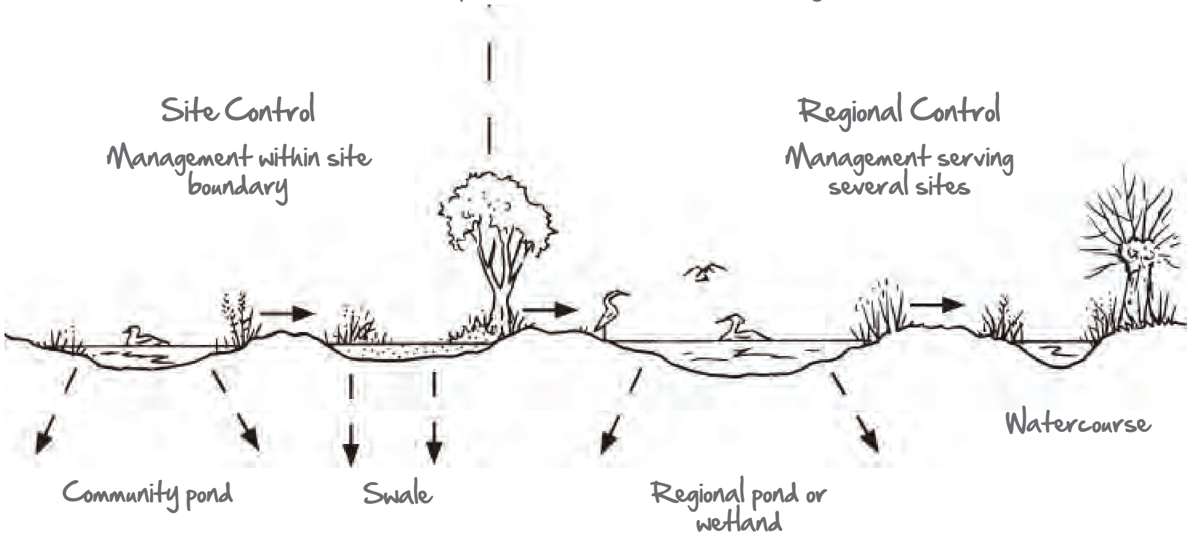
Sustainable drainage systems are now the preferred approach to managing rainfall from hard surfaces and can be used on any site. There are many different SUDS features available to suit the constraints of a site. These features include green roofs, and more natural features such as ponds, wetlands and shallow ditches called swales. Hard engineered elements are often used in high density, commercial and industrial developments. These include permeable paving, canals, treatment channels, attenuation storage and soakaways.

In a well designed SUDS a number of different features are provided in sequence, which is known as the **management train.**

The primary purpose of SUDS is to mimic the **natural drainage** of the site prior to development. This is achieved by capturing rainfall, allowing as much as possible to evaporate or soak into the ground close to where it fell, then conveying the rest to the nearest watercourse to be released at the same rate and volumes as prior to development. Along the way any pollutants, such as metals and hydrocarbons from roads and car parks, are reduced. Water entering a local watercourse is therefore cleaner and does not harm wildlife habitats.

SUDS generally replace traditional underground, piped systems that use grates or storm water drains at street level. If the water is kept on the surface as much as possible the SUDS can provide valuable amenity asset for local residents and create new habitats for wildlife. This also means that any problems with the system are quicker and easier to identify than with a conventional system and are generally cheaper and more straightforward to rectify.

SUDS will become increasingly important to control surface water as rainfall increases because of **climate change.** They can also provide other benefits in developments such as passive cooling, which will again help mitigate any increase in temperatures due to climate change.



However, it is also intended to act as a **design guide**, to assist developers when designing SUDS systems, irrespective of who the adoption body will be as it provides locally specific information on how to integrate SUDS successfully into the **Cambridge landscape.** It sets out a broad landscape vision that should help shape the approach to SUDS in the City, alongside the engineering design.

The guide will be reviewed regularly and updated, as the Council's experience of adopting SUDS grows and as information such as costs needs refreshing. It is possible that in future it could be adapted to become a Supplementary Planning Document (SPD), but this will require going through the formal process and would be set out in the Council's Local Development Scheme, if this was proposed.

Policy 9/3 of the Cambridge Local Plan 2006 requires the implementation of SUDS on the major growth sites. Further guidance on submission requirements is provided in the Sustainable Design & Construction Supplementary Planning Document (both are available at www.cambridge.gov.uk).

Included within the guide are design considerations and essential principles that developers and their consultants will need to take into account when designing and constructing SUDS for adoption by the Council. The aim is to ensure that high quality SUDS are delivered that reduce flood risk. They will also be easy to maintain and maximise the landscape, amenity and biodiversity potential of the scheme. Good quality SUDS should also help developments to adapt to the predicted effects of climate change.

All of the essential requirements for adoption are based on current best practice design guidance and practical experience from schemes implemented around the country. This guide does not seek to replicate or replace the existing body of technical design guidance for the creation of SUDS. Organisations such as British Standards, CIRIA and Interpave provide the information that should form the basis of any SUDS design.

Responsibility will rest with the designers for ensuring that the scheme is designed to the requirements of the Environment Agency and the City Council as local planning authority.

High quality SUDS for a high density development were achieved by early consideration in the design process – Stamford

Who is this Guide for?

This guide is primarily for **developers,** to provide them with the information they need if they would like the City Council to adopt SUDS features within their developments. It is also intended for use by all those involved in the design, construction and future maintenance of any adoptable SUDS. These include:

- Developers
- Engineers
- Landscape designers
- Architects & urban designers
- Development control and other City Council officers
- City Council maintenance team

SUDS can help adaptation of developments for increased future rainfall - Cambridge

A SUDS design team should be multi disciplinary and have:

- a strong **landscape** and **urban design** influence to guide the form and shape of the SUDS, especially in the early stages of the development design.
- **drainage engineers** with the expertise to ensure the proposed design will provide effective drainage.
- **ecologists** providing advice on how to maximise the biodiversity.

An effective SUDS team will work through these issues from early in the scheme development to find the most appropriate way to deal with any conflicting design aims.

SUDS pond increasing local biodiversity – Elvetham Heath

It must always be remembered that, although SUDS can and should enhance the environment, the primary and overriding function is to provide **effective drainage**. This may mean that some common landscape and ecological design requirements have to be adapted to suit the SUDS (e.g. immediate-effect flower rich vegetation will need to be sacrificed to the need for robust grass surfaces that resist erosion in the first instance. Such treatment will develop a good biodiversity over time).

When should it be used?

The guide should be used:

- by developers when developing the brief for their design team to ensure any SUDS that they wish the City Council to adopt are designed and constructed to the requirements of the City Council;
- by the design team responsible for the development masterplan, landscape and surface water drainage scheme to design adoptable SUDS to the requirements of the City Council;
- by development control officers when drawing up S106 contributions for SUDS;
- by City Council officers when inspecting the construction of adoptable SUDS on site and overseeing the commissioning of the scheme; and
- by the City Council maintenance team in developing their maintenance schedules.

What it is hoping to achieve?

The guide seeks to achieve **high quality SUDS** integrated into the overall design of a development and should:

- be aesthetically pleasing
- effectively manage water (including it's quality)
- accommodate and enhance biodiversity
- provide amenity for local residents (ensuring a safe environment)

SUDS offer a great opportunity to see a net gain in biodiversity within a new development as required under PPS 9, linking up with the wider green infrastructure and introducing corridors of wildlife throughout the new developments.

By **integrating** the design of the SUDS throughout the development it offers designers a creative free hand, utilising water in interesting and exciting ways but yet still providing a functioning sustainable drainage system.

Residents local to the system can benefit from safe access to water that can enrich their environment and developers can also benefit from this environment improvement by constructing highly desirable and saleable residences.

Cambridge has its own **unique** design considerations being one of the most arid parts of the UK, having limited gradients and having a higher than average surface water flood risk.

This guide provides the first stepping-stone for any SUDS designer, providing a landscape background and an achievable approach to a successful system.

adoption process

Adoption process

The adoption process will follow the same general principles that are proposed in The SUDS Manual (CIRIA C697) for the design of SUDS. It will run parallel with the normal development and drainage design and does not require any significant extra work to be carried out.The adoption process is set out in the table below. A key element to successful SUDS is integrating the design into the development master plan at an early stage. Good SUDS design also requires early and effective consultation with all parties that are involved in the approval process.

Planning stage		Development process/ required information (from the SUDS manual)	Drainage design process (from the SUDS manual)	Adoption process
Pre application discussions and submission of FULL application	Pre application discussions and submission of outline application	Submission of FRA and drainage strategy in line with PPS25. Identification of likely SUDS methods to satisfy planning policy	Conceptual drainage design flow routes through the site and storage locations. Outline drainage design and drainage impact assessment. Demonstrate storage areas and volumes, conveyance routes and controls.	Initial consultation with Cambridge City Council on adoption - locations and design requirements
Negotiation of Full submission and Section 106 discussions	Negotiation of Outline submission and Section 106 discussions	Submission of any amendments (if necessary)	Submission of any amendments (if necessary)	Agreement with City Council of outline drainage design and agreement to adopt in principle (or option to adopt in principle)
	Outline permission granted and Section 106 agreed			
	Design coding	Principles of the detailed design agreed site wide	Principles of the detailed design agreed site wide	Agreement with the City Council that the detailed design is compliant with adoption guide and S106 agreement
	Reserved matters applications	Detailed plans in line with agreed design code	Final submitted design with location and size, depth, etc. compliant with approved detail above	Submitted design compliant with adoption guide
Full approval/ S106 approval	Reserved matters approval			
Construction of development	Construction of development	Discharge of any outstanding conditions	Construction of drainage system	Verification of construction to agreed design and specification
Formal adoption of SUDS and monies paid to the City Council as per the trigger/amount agreed in the S106				

Adoption model

The City Council will normally adopt SUDS that are located in public open spaces. These will generally be landscape features such as ponds, wetlands and swales. They will not adopt SUDS that are located within private property, although they will require source control features to be provided to any adopted scheme and these are usually located in private areas (e.g. soakaways to individual houses where appropriate, permeable driveways, etc.).

As the City Council does not generally adopt highways, it will not therefore adopt SUDS located within the highway. However, it will work with Cambridgeshire County Council, which is the responsible agency to promote the use of SUDS within the highway, which currently the County Council will not adopt if non-highway drainage is to be accommodated.

Where sites span the city boundary into the neighboring authority of South Cambridgeshire, Cambridge City Council would consider adopting any SUDS within the public open space if the majority of the public open space falls within the City boundary (subject to agreement with SCDC).

The adoption model for Cambridge is shown in the plan and table on the following page.

Type	Features	Typical locations	Adoption/ ownership
SUDS in open space	Ponds and wetland Infiltration and retention basins Filter strips Swales Rain gardens (bioretention)Filter drains Canals and rills	Public open space	Will be adopted by Cambridge City Council if located in public open space, where this is being adopted by the Council. This is unlikely to include large commercial or industrial sites, as the Council is unlikely to be adopting public open space within these types of development. Where the City Council adopt any feature, it will also adopt all control structures that are located in the open space (providing they meet adoption criteria).
SUDS in roads	Filter strips Swales Rain gardens (bioretention) Filter drains Canals and Rills	Roads	Will be adopted by the City Council if located in public open space and not provided solely for the purpose of highway drainage. May be adopted by the County Council where SUDS takes only highway drainage. Adoption route must be identified if incorporated into management train above SUDS adopted by City Council
Private SUDS	Green roofs Permeable driveways and parking Soakaways Proprietary treatment systems Geocellular storage (preferably combined with rainwater harvesting)	Within the boundaries of private properties	Located in privately owned land and therefore not adopted by the City Council. Management responsibility must be identified and agreed if discharging into SUDS adopted by the City Council.

Permeable surfaces may also be used in roads subject to the agreement of the County Council.

Adoption model for Cambridge City Council showing the locations and type of SUDS that will be adopted in an example development layout.

How to use the Guide

The introductory sections cover the broader issues involved in designing a comprehensive and successful SUDS system, before focussing on individual SUDS features in subsequent sections. There is particular focus in these early sections on Cambridge specific design opportunities and constraints.

The landscape section aims to provide a starting point for developers and their design team to understand the context in which they will be designing a SUDS system.

Detailed information on the adoption requirements for each type of SUDS feature that the City Council will consider for adoption is provided in the subsequent individual sections. Each individual section relates to a particular type of SUDS feature and contains:

- a description of the feature, what it is for and how it works;
- Cambridge specific design requirements;
- practical issues and solutions;
- maintenance requirements

A separate section contains all the essential design and construction requirements if the SUDS are to be adopted by the City Council.

Within the appendices are costs for the purposes of S106 negotiation.

The final sections are of a more general nature and may apply to any or all of the SUDS features. A checklist of the adoption requirements for easy reference is provided in Appendix D.

"Oxfordshire, like most of the country suffered flooding in July 2007. We also had further flooding this year in January, February and June 2008.

None of the developments that have permeable surfaces or other SUDS flooded.

This makes real sense for the County officers, councillors and the people who live on these developments."

Barry West, Highways Adoption Officer, Oxfordshire County Council speaking at Landform

FAQs about SUDS

I am unable to utilise infiltration because of clayey soils, how can SUDS be used?

Soakaways and other infiltration methods may not be suitable but there are many other methods that can be used in clayey soils, e.g. swales, ponds, wetlands. Ground conditions should not prevent the use of SUDS but may affect the choice of system. See Section 2.

Are SUDS a health and safety risk?

No, SUDS that are well designed to be shallow and with gentle slopes should not pose a significant health and safety risk. See health and safety section (Section 13).

Can SUDS be used in high density developments?

Yes; however, the nature of a development will affect the type of SUDS that are used (See Section 2). There are many examples of SUDS in high density developments in the UK. Permeable surfaces (see Section 10) and multi functional spaces (using public open space to store water) are usually an important aspect of the SUDS in these types of development.

SUDS in Sheffield during the 2007 floods – there was no flooding from this system and it effectively managed runoff in rainfall that far exceeded the design storm, because it had a management train.

Can SUDS be used on brownfield sites?

Yes, but the type of SUDS that can be used may be constrained by the nature of any contamination. Infiltration may not be possible. See Section 2.

Can SUDS be used in high flood risk areas?

Yes, but the design must ensure that storage for development runoff is available during river or other flooding events. SUDS must be located outside the floodplain. See Section 2.

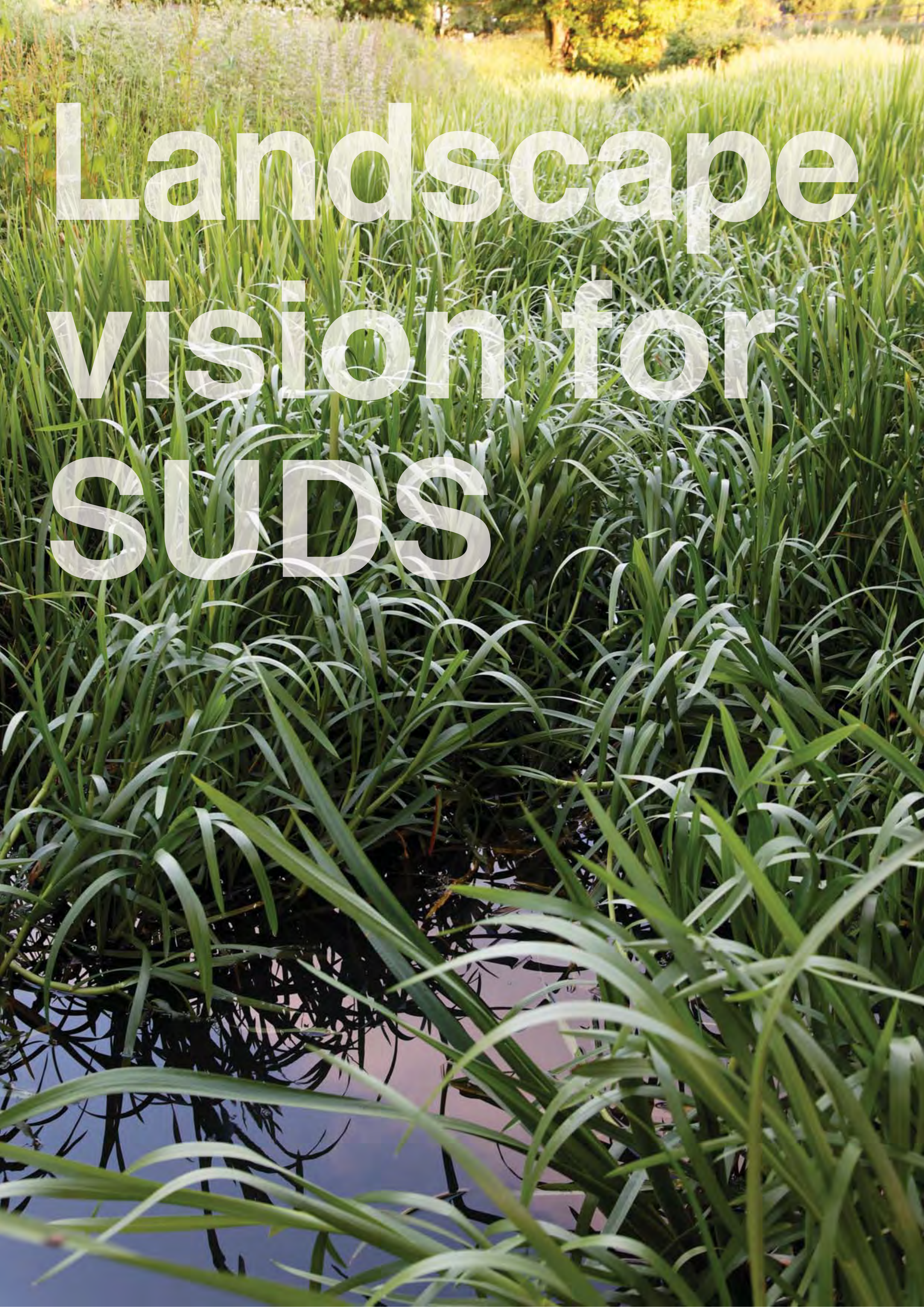
Can SUDS be located in private areas?

Yes. some methods are appropriate (e.g. permeable driveways) but responsibility for management of the systems must be identified. Normally responsibility should rest with a management company rather than individual house owners.

SUDS techniques that are more strategic (e.g. swales serving more than one or two properties) should not be located in private gardens.

Low flow channel though public park in Malmö.

Landscape vision for SUDS



The landscape vision for SUDS

The Cambridge landscape

Cambridge lies at the edge of the East of England fenlands with its open, flat and low-lying landscape dissected by numerous rivers, dykes and drainage ditches. Cambridge itself has a distinct and unique local landscape character where water has always been present and has been woven into the fabric of the city by way of the River Cam, its tributaries, and its water meadows.

The city will experience considerable growth over the next decade as a result of being designated as part of one of the four national growth areas. Ensuring this growth is implemented sensitively, with due regard to the existing character of the City, and championing a high standard of design, will be paramount in protecting and maintaining the distinctiveness of the Cambridge landscape.

The promotion of SUDS is one measure whereby the council's aims for quality, sustainable development, work hand-in-hand with its aim to ensure that the vital character of the city is maintained and enhanced.

By using the landscape to manage rainfall and harness water in a creative way, SUDS will strengthen local distinctiveness and add value to the local environment. For this reason, it is important that design teams have a strong landscape focus.

It is important to remember that the primary and overriding function of SUDS is to drain surface water effectively, and this function must not be compromised by other design considerations. Effectiveness and quality of design must be considered together.

Hobson's Conduit – Water in the landscape in central Cambridge

Coe Fen – Wetland in central Cambridge

Wetland, The Backs, Cambridge

SUDS & landscape design

New SUDS features, based on the existing historic watercourses and features, are a most appropriate method of providing efficient drainage to new developments and will integrate these developments into the character of the city.

However, the use of SUDS will only help deliver better quality development and amenity improvements across the city, if:

- The design of SUDS has a strong landscape and urban design focus – design teams must comprise landscape and engineering disciplines;
- Reference to and consideration of the 'Cambridge Landscape Character Assessment' is undertaken at the earliest stage in the design process to enable judgments to be made to ensure that the design and execution of SUDS takes account of the existing character and achieves environmental and visual improvement;
- SUDS measures are fully integrated with the overall master plan for a development at an early stage to ensure that the maximum benefits are achieved and, most importantly, SUDS measures are not added after the key elements of the development layout have been determined. When this is achieved land-take is accounted for early and the SUDS features are invariably less costly to construct and are more effective as a drainage system. Cambridge City Council will also ensure that strategic planning of sites allow sufficient space for SUDS as part of the master planning process.
- Careful consideration is applied to the position and design of SUDS elements to ensure that they form an appropriate and integrated component of the landscape -taking into account all site constraints, including issues of access and safety. This does not cover just the general layout but also the design character and distinctiveness of schemes to ensure special landscapes are retained or established;
- The use of advanced planting is considered to enable SUDS to provide amenity and biodiversity value from the outset;

"To ensure space can be provided for SUDS, it is essential that there is early consideration at the overall concept stage."

"Developers, particularly when undertaking master plans for developments, will need to allow for sufficient land for SUDS features, as it is more difficult and costly to incorporate these once detailed design is underway."

From Planning Policy Statement 25: Development and Flood Risk, Practice Guide

Specific opportunities in Cambridge

Local character types should be used to guide the choice of SUDS features used in each scheme. Within the city there are distinct local character types, each determined by the presence of landscape features such as rivers or water meadows or particular types of built forms. The use of SUDS will help safeguard the character of rivers and their immediate floodplain, as well as improving opportunities for informal recreation and nature conservation enhancement. This is primarily provided through the creation of a variety of habitats - including rough grasslands, wildflower meadows, aquatic planting and open water. A series of SUDS elements can provide wildlife corridors, linking existing nature conservation features.

Wetlands

Historically, areas around Cambridge have comprised low lying wetlands that have been subsequently drained to allow the town to develop. The use of wetland features in SUDS provides an opportunity to replace some of this lost landscape and habitats.

Even in the confined historic core of the city, where collegiate and vernacular buildings were developed side-by-side within a tight pattern of narrow streets, there has always been watercourses and drainage features. An example of this is Hobson's Conduit which once brought drinking water into the city from fresh springs to the south of the city.

Hobson's Conduit still delivers water into the city, but not for drinking. It does this via a brook, rill and canal system, which forms open, lined watercourses.

The urban runnel or rill

Cambridge already displays some architectural water features that can be applied to SUDS design. The open rill or runnel is an effective surface conveyance feature that carries water in a shallow channel from one place to another. This can be a simple channel or ribbed paver delivering roof water to another feature or a roadside gutter taking water down the street.

Open channels can be designed to be attractive with imaginative crossing points and are always a source of interest when rain brings them to life. Although they are not commonly used in the UK in modern housing, they were a common way of dealing with surface water in many historic cities, and the Cambridge examples, demonstrate that they can be used throughout the urban fabric of urban spaces.

SUDS can replace lost wetland landscape

The urban canal

Just outside the city centre, Hobson's Conduit is a slow moving canal with a formal character that is appropriate for urban areas. It is particularly suitable for courtyards and as part of a conveyance system between urban development centres. Although the canal may have a formal design, the content of the canal can be designed with high biodiversity value with access points for wildlife along the edge.

Another famous Cambridge characteristic is its water meadows or floodplain adjacent to the River Cam, which are in parts bounded by residential developments. These water meadows are often grazed and are unique in as much as they extend into the city itself, for example Sheep's Green. Again, these are a much loved feature and typify the Cambridge landscape.

Hobson's Conduit in Trumpington Street

Specific constraints in Cambridge

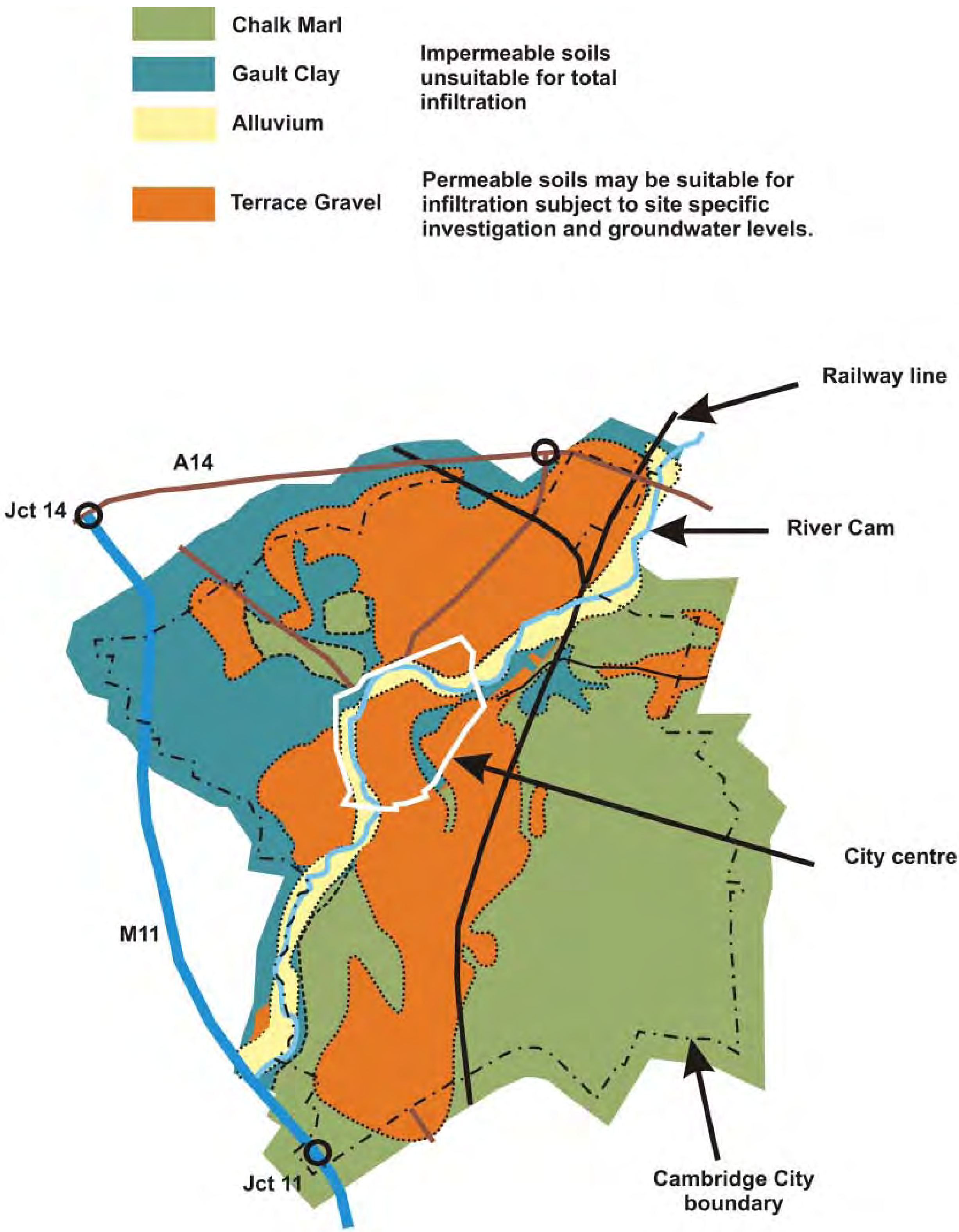
A large part of Cambridge is underlain by clayey soils (Gault Clay to the west of the River Cam and Chalk Marl to the east) which will limit the opportunities to use infiltration methods such as soakaways. However, this is not always the case; in some areas there are sand and gravel deposits over the top of the clay soils that may be suitable for infiltration. In many areas there is shallow groundwater in the sand and gravels and the variation in water levels must be understood and their effect on the operation of infiltration systems allowed for.

Each site should be evaluated on its own merits by undertaking comprehensive soil Standard BS 5930: 1999, Code of practice for site investigations, including infiltration testing and groundwater level monitoring. This will identify any opportunities for infiltration.

Although clay soils may prevent a complete infiltration solution it will still be possible to use other SUDS features such as ponds, wetlands and swales. It is also possible to allow some water to soak into the ground, even if the drainage design calculations do not allow for it (for example out of the bottom of an unlined swale).

Sheep's Green water meadow near Cambridge city centre

Rill leading to an urban wetland - Malmo



Simplified geological map of Cambridge

Swales in Cambridge

One particular character of watercourses in the fen landscape is the shallow gradient of ditches and wetlands where water moves slowly under hydraulic pressure rather than by gravity and a topographical gradient.

This hydraulic pressure results in ditches with a very gentle or negligible slope and shallow, slow moving permanent water in the base. This allows the development a linear wetland with say, common reed (Phragmites communis) the dominant plant. The use of a wet swale retaining water in the bottom for most of the year creates a SUDS feature that reflects the character of the fen landscape and provides enhanced biodiversity. The growth of common reed both in summer and in winter, when the stems remain until spring, provides a visual route marker or informal hedge to develop a subtle space hierarchy.

Therefore, the normal swale profile, which has a fall to drain by gravity, is modified to a local variant that drains by hydraulic pressure to create a linear fenland wetland with a local character. The fenland swale provides a visual link through the landscape with high biodiversity value.

The flat gradients can cause problems for piped drainage because it often results in very deep trenches and large pipe diameters. SUDS can deal with the shallow or even totally flat gradients in the same way that nature has done, by using wide shallow features to manage water flows.

Watercourse at Clay Farm, in Trumpington with common reed

Landscape and nature conservation considerations for SUDS

There are a number of common practices in landscape design that may need to be modified for SUDS:

- Planting areas are often raised slightly above surrounding hard surfaces. For SUDS they should be lower than adjacent surfaces and dished wherever possible to avoid excessive volumes of silt washing onto permeable surfaces.
- Grass edges in landscape are usually specified at 10-20mm above hard surfaces to allow for mowing. In SUDS where surfaces shed water to grassed areas, it must be 20 to 25mm below the edge of the hard surface, assuming the grass will be cut to a height of 50 to 100mm.
- The vegetated side slopes of SUDS features should not exceed a gradient of 1:3 in order to avoid soil slippage and the resultant non-establishment of vegetation.
- Subsoils and topsoils should not be compacted by excessive tracking of machinery. Compaction results in roots not being able to penetrate the soil and anaerobic soil conditions.
- Planting techniques in SUDS areas should also be varied slightly. Where drainage systems are to be planted the use of grass or a dense ground cover is preferable, without mulch. This avoids soil erosion and prevents soil and mulch washing into the SUDS.
- When undertaking planting design and selecting plant species, consideration should be given to the surrounding landscape or urban character, e.g. extensive reed beds would not be appropriate in high density areas.
- Plant choice should be carefully researched and be undertaken in close liaison with the SUDS designer. For example, a swale may have a very different soil/moisture profile at the top of the bank (very dry) to the bottom of the bank (very wet). Considered choice of plants will be the key to success in these conditions.

Banded Demoiselle Damselflies quickly take up residence in SUDS ponds

- Every effort should be made to create new habitats that enhance nature conservation and amenity space.
- Planting for nature conservation requires minimum topsoil, i.e. nutrient poor soil, to encourage wild flowers and a natural vegetation. SUDS need rapid establishment of a dense grass/wildflower sward that is self –repairing. Therefore a minimum of 50mm topsoil blinding should be used on wildflower areas adjacent to SUDS to ensure rapid establishment and 100-150mm topsoil used on vegetated SUDS features to ensure a robust surface for the life of the development.
- Planting areas should be designed to avoid initial fertilizers. Also ongoing maintenance should require only physical cutting with no application of herbicide, fertilizer or other chemical applications, which can cause pollution.

- The form of a swale may well be designed by the landscape designer However, the drainage performance should always be checked by the SUDS engineer, who may require adjustments to the shape and form. For instance if the swale is designed to only accommodate occasional inundation, it may be more appropriate to provide an underdrain to avoid a muddy lower level to the swale, or to plant it as a vernal wetland.
- Bridge design for crossing swales and other water features should also take account of the surrounding landscape and urban character and should provide a positive addition to the landscape. For instance, it may be more appropriate to use a metal and timber or brick structure in high-density areas, rather than timber on its own.
- Likewise, the design of headwalls should be appropriate to their surroundings and not always purely functional. A well-designed headwall with the incorporation of, say, a brick arch or even a large gargoyle feature could add a highly valued design feature to a development.
- Similarly, the ecologist must understand SUDS requirements (see above) and recognize that immediate flower-rich vegetation will need to be sacrificed to the need for robust grass surfaces in the first instance. These will develop good biodiversity over time.

There are several BAP species and habitats that can be supported by well designed SUDS. Good design for biodiversity should consider the integration of well designed sanctuary areas into ponds and wetlands wherever possible, to give spaces for the more sensitive faunal wildlife species such as king fisher, heron, water vole, etc. The provision of such areas will be dependent on the location of the SUDS (for example this would not apply to a small SUDS water feature in an urban street setting). Where suitable, the principle design features are:

- Only one third of a linear water feature should be accessible and on one side only;
- Crossovers (bridges, culverts, etc.) should be kept to a minimum and balanced with people access/connectivity between neighbourhoods and places.
- Maintenance tracks/ paths should not be accessible by the public, in order not to disturb feeding and nesting faunal species and some BAP species.

SUDS on previously developed sites

Previously developed sites (brownfield sites) should not be seen as a barrier to using SUDS. The use of shallow surface features can often be a benefit in brownfield sites as they limit excavations into contaminated soils. The impact of the proposed SUDS features on any contamination and vice versa needs to be carefully assessed by an experienced professional.

The presence of contamination in the ground may limit the use of certain features (e.g. soakaways) or require liners below ponds, basins and permeable pavements. However, it will never prevent use of all SUDS features and a suitable system can be designed.

Further information is provided in The SUDS Manual (CIRIA C697).

SUDS in high density developments

In some new developments there may be limited landscape features; for example high density housing developments or in commercial and industrial developments. It is still possible to use SUDS in these locations, but it is more likely that engineered features such as permeable pavements or treatment channels will be appropriate.

Green roofs are also a useful feature on buildings with flat or gently sloping roofs. Further guidance and information is provided in the document 'Use of SUDS in High Density Developments', HR Wallingford Report SR 640.

Children pond dipping in a SUDS feature

Flood plain issues

The Environment Agency promotes SUDS but the natural floodplain must be protected. Therefore the Environment Agency is unlikely to agree to the location of SUDS within a floodplain, since the SUDS feature will fill up with river flood water when the area floods and will not have capacity to hold the rainfall runoff from the site as originally intended. The features may also remove valuable flood plain storage.

Legislation and guidance

Legislation and Guidance

The Cambridge landscape

Legislation and guidance that recommends the implementation of SUDS is varied and includes high level Government strategy. Although SUDS to be adopted by the City Council are required to be in accordance with this guide there are other sources of guidance that must be considered when approaching any design. The main relevant documents are listed below, but should not be considered as an exhaustive list:

- Future Water, published by DEFRA sets out the Government's vision for water, including good surface water management which will involve increased use of SUDS and surface water flow routes. This will be achieved through the design and planning of the whole urban fabric, as the capacity of the landscape to store and convey water is much greater than with below-ground systems.
- The Water Framework Directive 2000/60/EC and the associated River Basin Management Plan - Anglian River Basin District, published by the Environment Agency. This sets down quality targets for local rivers and water-courses including Hobson's Brook and The River Cam and encourages the enhanced use of SUDS.
- Great Ouse Catchment Flood Management Plan soon to published by Environment Agency provides actions that Local Authorities must report against including the provision of SUDS in new developments.
- Flood and Water Management Bill published by DEFRA which builds on the recommendations of Sir Michael Pitt's review of the summer 2007 floods and includes a recommendation that Local Authorities adopt SUDS.
- Planning Policy Statement PPS 25, Development and flood risk states that priority should be given to the use of SUDS and where they are not deemed appropriate (which is unlikely on all except the rarest of sites), justification should be given for not using them.
- The Building Regulations part H, Drainage and Waste Disposal, states that infiltration should be the first considered option for rainwater disposal, followed by discharge to a watercourse. Discharge to a sewer should only be considered where other forms are not practicable.
- The Cambridge Water Cycle Strategy Phase 1 aims to provide a sustainable approach to the provision of water services infra-structure to the growth sites in and around Cambridge. This includes aspects such as flood risk management, drainage and ecology. The strategy has been developed in conjunction with organizations including Cambridge City Council and Cambridgeshire County Council. The use of SUDS can play an important part in helping achieve the aims of the Water Cycle Strategy. Phase 2 is currently being developed.
- Cambridge City Council Local Plan 2006. Policy 9/3 which states "the development of the urban extensions will incorporate Sustainable Drainage Systems where practicable" policy 9/3m.
- Cambridge City Council Sustainable Design and Construction Supplementary Planning Document.
- East of England Plan, published by the Secretary of State for Communities and Local Government, Constitutes the regional spatial strategy for the east of England. Policy WAT 4 requires that sustainable drainage systems are employed in all appropriate developments.

- The Green Infrastructure Strategy published by Cambridgeshire Horizons recognises that water management features can create opportunities to enhance the landscape and biodiversity value. Wetlands are a particular target habitat. Green infrastructure should where possible be multi functional. SUDS features can provide opportunities for informal, quiet recreation and can help link up fragmented habitats and will provide an important contribution to achieving the aims of the strategy.
- Planning Policy Statement PPS 1 Delivering sustainable development
- Planning Policy Statement PPS 9 Biodiversity and geological conservation
- Biodiversity Action Plans
- Environment Agency Pollution Prevention Guideline PPG 3, Use and design of oil separators in surface water drainage systems.
- Under the terms of the Water Resources Act 1991 and the Land Drainage Byelaws, the prior written consent of the Environment Agency is required for any proposed works or structures in, under, over or within 9m of the top of the bank of the main river (Cam), this includes any headwalls.
- Any culverting or works affecting the flow of a watercourse requires the prior written Consent of the Environment Agency under the terms of the Land Drainage Act 1991/ Water Resources Act 1991. The Environment Agency seeks to avoid culverting, and its Consent for such works will not normally be granted except as a means of access. Please contact the Development and Flood Risk team within the Environment Agency direct.

Design guidance is available from a large number of organisations, listed below are a small selection. The guidance listed here is not exhaustive and is current at the time of publication:

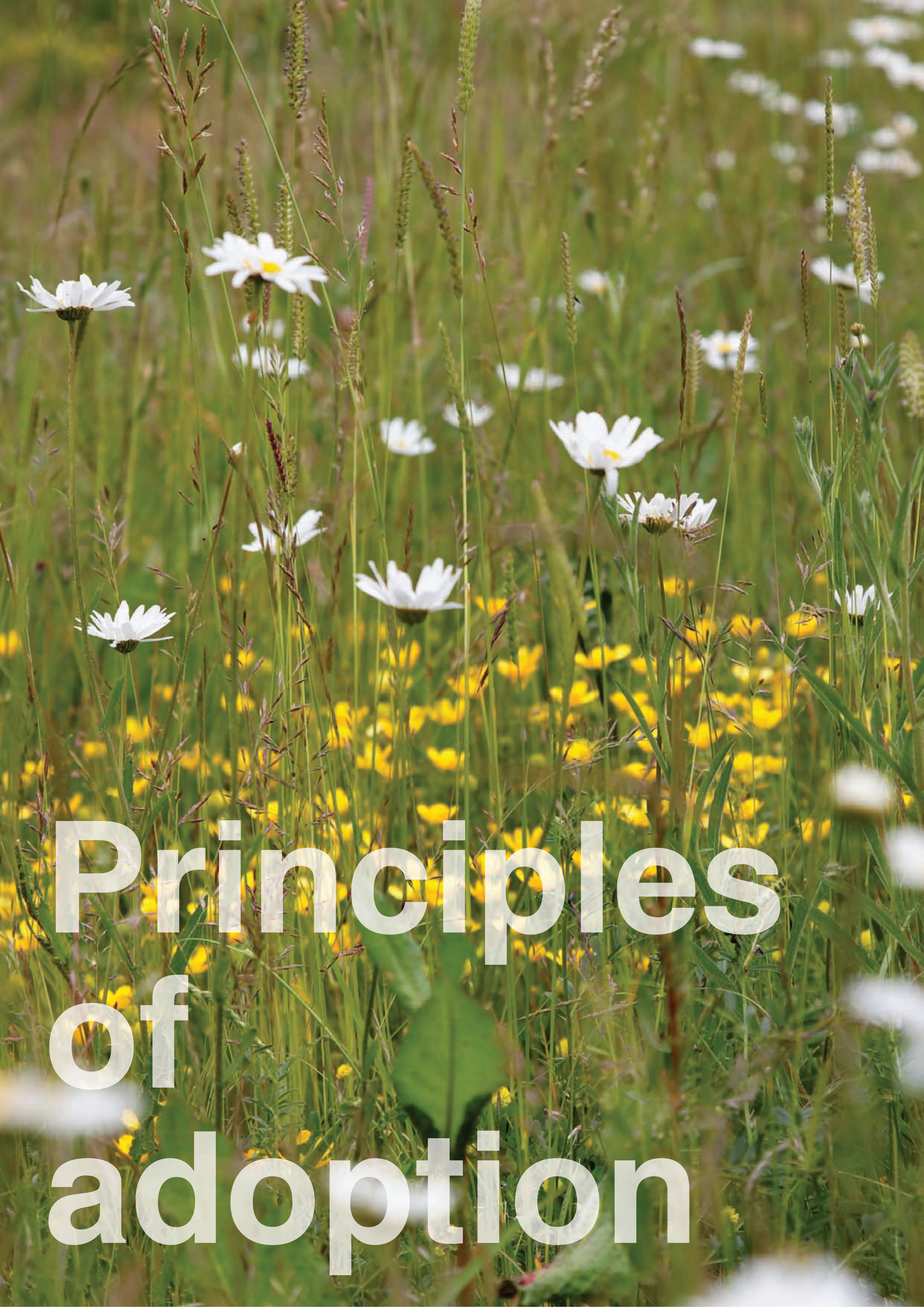
- British Standard BS 7533-13: 2009. Pavements constructed with clay, natural stone or concrete pavers – Part 13: Guide for the design of permeable pavements constructed with concrete paving blocks and flags, natural stone slabs and setts and clay pavers.
- CIRIA Source control using constructed pervious surfaces. C582
- CIRIA Rainwater and greywater reuse in buildings: best practice guidance.C539.
- CIRIA Designing for exceedance in urban drainage – good practice. C635.
- CIRIA Building greener. Guidance on the use of green roofs, green walls and complementary features on buildings. C644.
- CIRIA The SUDS Manual.C697.
- CIRIA Site handbook for constructing SUDS. C698.
- CIRIA Structural design of modular geocellular drainage tanks. C680.
- Interpave - Guide to the Design, Construction and Maintenance of Concrete Block Permeable Pavements
- Interpave - Understanding Permeable Paving
- Environment Agency Green roof tool kit.
- Kellagher RBB and Lauchlin CS Use of SUDS in high density developments, defining hydraulic performance criteria. HR Wallingford Report SR 640.
- Kellagher RBB and Lauchlin CS Use of SUDS in high density developments, guidance manual. HR Wallingford Report SR 666.

The Flood and Water Management Bill may lead to potential changes in the design and adoption criteria for SUDS which (for example there is currently discussion regarding provision of National SUDS adoption criteria and which bodies will be responsible for adopting SUDS).

This guide follows best practice in the design and construction of SUDS and adherence to it should not cause any conflict if the proposed legislation is enacted.

The guide will be updated when the legislation is enacted, if necessary.

Principles of adoption



Principles of adoption

Principles

Where Cambridge City Council adopts SUDS, the design philosophy should embody the four key high level principles that the Council wishes to see as set out below. Specific guidance on how to achieve these principles is provided in each individual section. This is to ensure that SUDS for adoption provide a robust engineering solution, are of sufficiently high quality and can be easily maintained so the Council is not burdened by excessive costs or liabilities in the future. Following these principles will provide multiple benefits to the residents of Cambridge in the form of reduced flood risk, increased biodiversity and more attractive spaces.

These four key principles are:

Performance

- Reduce flood risk
- Improve water quality
- Delivering biodiversity benefits
- Provide amenity for residents

High Quality Design

- Micro managed bespoke design
- Integration with wider landscape setting
- Use of robust, low impact materials
- Designed to be attractive all year round

Integrated Approach to Health & Safety

- Easily identifiable features and risk
- Shallow gradients
- Planting and design used to create barriers where necessary

Ease of Maintenance

- Simple, surface features
- Minimise use of grills and other engineered features
- Shallow gradients
- Robust appropriate planting for ease of maintenance but not at the expense of biodiversity (unless erosion prevention is a priority)

SUDS integrated into urban design provide a high quality urban environment, Malmo, Sweden

High Quality Design integrated into an urban environment

The more successful SUDS schemes are integrated within the form of the development and because the drainage will be predominantly an above ground system rather than an underground one it is part of the urban and landscape design of the development. The successful scheme will be well integrated and sympathetic to the type and form of the development.

Well designed SUDS are valued by residents and are often used for other purposes (e.g. as an educational resource).

The concepts in the document can be used to provide larger areas of ponds and wetlands on a strategic scale. This does not mean that large ponds and wetlands are required. The principles would remain the same to provide a mosaic of features over a wider area.

This approach will lead to a more robust system that reduces the consequences if any one part of the system fails. They are also easier to maintain and this approach follows the concepts of natural drainage systems and gives greater opportunities for amenity and ecological betterment than large bodies of deep open water.

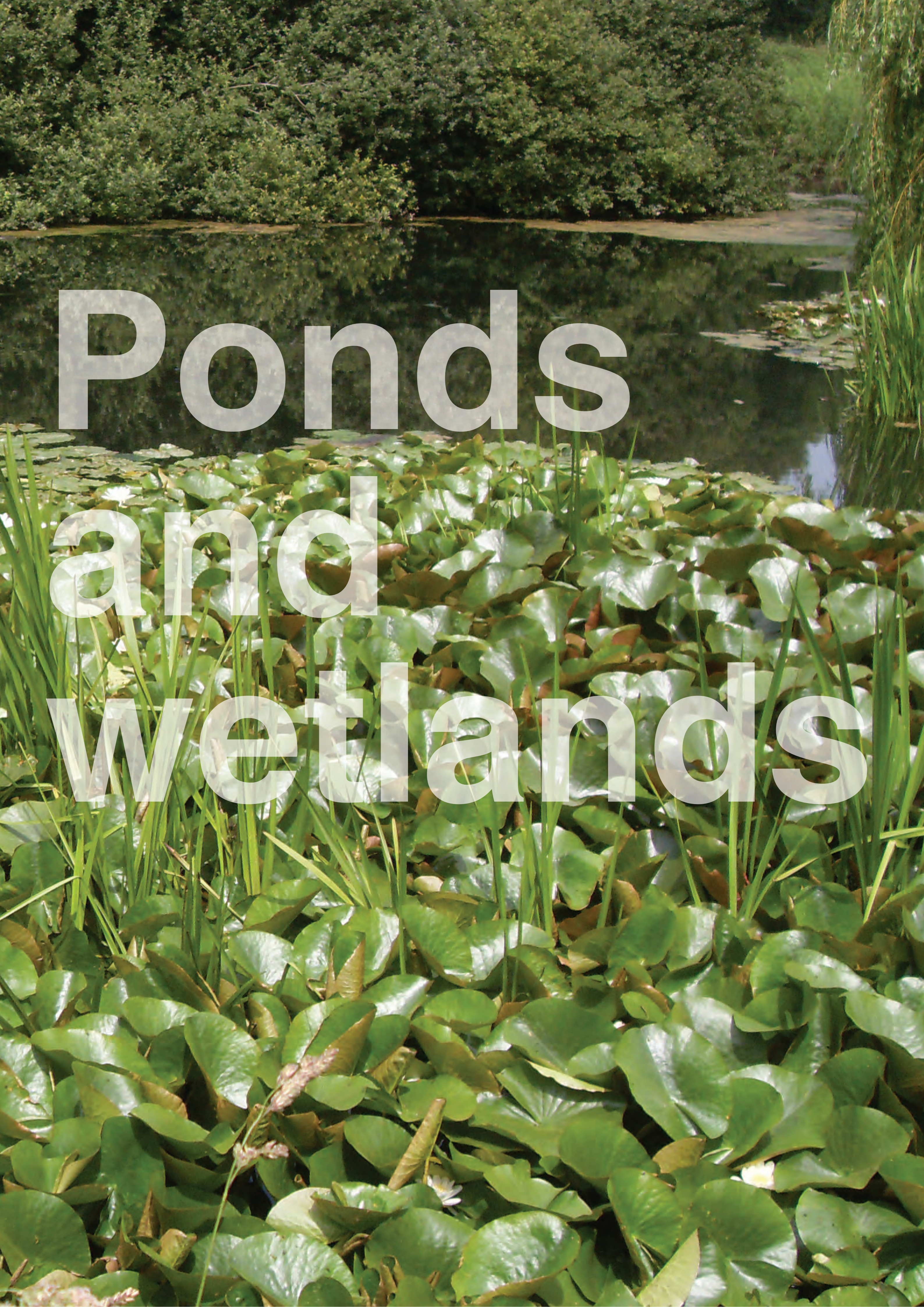
Other important considerations in the design of SUDS are:

- Use of the SUDS management train
- Use of source control
- Consideration of drainage exceedance

A checklist of adoption requirements is provided in Appendix D.

Specific Adoption requirements for each SUDS feature are found within Section 13 of this document.

Ponds and wetlands



Ponds and wetlands

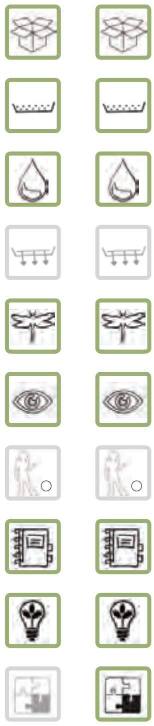
Ponds and wetlands are open areas of shallow water designed so the water level can rise to provide temporary storage for excess water during rainfall events. The water level rises temporarily when it rains. Equally as important, they provide valuable environmental benefits by helping to remove pollution from surface water runoff. Ponds are similar to wetlands but have a greater focus on storing excess water whereas wetlands have a greater focus on treatment of pollution.

Features that are adopted by Cambridge City Council will be located within areas of public open space and must be designed to be visually attractive, to enhance the space they occupy, to provide wildlife habitat and be safe. In general, ponds and wetlands that form part of a SUDS can be relatively small and should be designed so that they do not take up excessive space within a development as generally multiple smaller features can provide better biodiversity and easier maintenance.

Small ponds can be used in a housing development if integrated into the urban design, Malmo, Sweden

Benefits

Ponds Wetlands



How they work

In a well designed system most of the storage and treatment is performed by the upstream source control elements of the SUDS. Ponds and wetlands will provide a final `polish' to remove any remaining pollution. This is achieved by ensuring that water flows slowly through the pond over an extended period of time. The time water takes to travel through is known as the residence time. The greater this is the slower the water flow, which helps silt drop to the bottom of the pond and allows the vegetation and other organisms to remove pollution.

An important mechanism is biodegradation of oils by natural organisms in the pond. The organisms need a good supply of oxygen which means the permanent water must be shallow so oxygen can reach the bottom of the pond.

Cambridge specific design considerations

The exact form of the ponds and wetlands will depend on the specific topography and ground/soil conditions present at the site, as well as its orientation, aspect and proximity to other landscape features, buildings, etc. The design should contribute to the amenity of the local communities and be of an appropriate scale and form to suit the surrounding landscape character. In green open spaces they should have a natural feel with soft edges and forms that flow into the surrounding area.

The creation of bays suitable for breeding wildfowl should be integrated into the shape of larger ponds where possible. Hard edges and straight lines may be appropriate in some hard urban landscapes.

Small SUDS pool in high density housing – due to the close proximity to buildings hard edges are appropriate in this development, Stroud, Gloucestershire

Small SUDS pond, fully developed, Hopwood Services

For health and safety reasons, space constraints on most sites and due to the fact that natural ponds are generally small, it is likely that SUDS ponds will be small features that blend unobtrusively into the landscape. Large bodies of open water need careful consideration as SUDS ponds or wetlands in Cambridge.

Ponds should have varying depths and should include deep (1m) over-wintering areas as refuges for wildlife during severe winters.

Ponds and wetlands should be placed in developments so they are overlooked by housing and not hidden in an unseen corner. Alternatively, they can be located in larger areas of open space. This ensures the water features are a valued part of a development.

Wherever possible, the ponds or wetlands should be located away from artificial light sources as this will reduce the value of the feature to foraging bats. Like-wise, new lighting features should be avoided in close proximity to ponds.

There should be an assumption to retaining all existing native trees and vegetation. The layout of the ponds should respect the presence of trees, and in particular, ensure that their root systems are not compromised. Proposals should accord with BS5837: 2005 and take account of any implications resulting from the presence of Tree Preservation Orders (TPOs) and Conservation Areas.

SUDS ponds should be overlooked by housing where possible, development in Elvetham Heath

The location of ponds in a development should be considered carefully in terms of biodiversity and connectivity to other areas. For example, if located next to a wildlife hazard such as a road it may be necessary to provide a route for wildlife to reach the pond. The design of fencing, if used, should allow access for wildlife below it.

Small interpretation boards should be provided and should include information relating to the function of the pond and the local fauna and flora the system supports.

Ponds and wetlands should be designed to prevent/discourage the introduction of unsuitable species such as fish and wildfowl into ponds or wetlands that are to support amphibians, particularly great crested newts. However, this and similar issues should be dealt with on a case by case basis.

Where a pond or wetland is intended to support nesting birds and/or waterfowl, islands should be provided to prevent foxes reaching nesting sites. The channel between the island and bank must be at least 3m clear width.

Shallow pond with gentle side slopes provides a safe feature with easy access for maintenance, Florida, USA

Planting

Providing there is no conflict with the SUDS operation the City Council will expect new ponds and wetlands to be planted to enhance biodiversity. Native species of local provenance will be favoured and should be appropriate for the individual conditions provided by each feature. Non-native species may be considered in the more formal or urban settings but care must be taken not to introduce invasive species to the pond or wetland system.

Were appropriate the species mix should aim to create habitats that contribute to local, regional and national Biodiversity Action Plan, which can be found at http://www.ukbap.org.uk/

Some ponds at the end of the system may lend themselves to natural colonisation, particularly if linking to existing wetlands or watercourses. The slow colonisation of these ponds can provide valuable successional habitats. However erosion during establishment of the vegetation needs to be carefully considered.

A planting list is provided at the end of this section

Practical issues and solutions

Many problems that have occurred with ponds are due to a lack of attention to detail during design and construction. Some of the most common pitfalls and solutions are discussed below. Good construction practice will mitigate these problems, reduce overall construction costs and ensure a smoother adoption process. CIRIA publication C698, Site Handbook for the Construction of SUDS also contains practical construction help and advice.

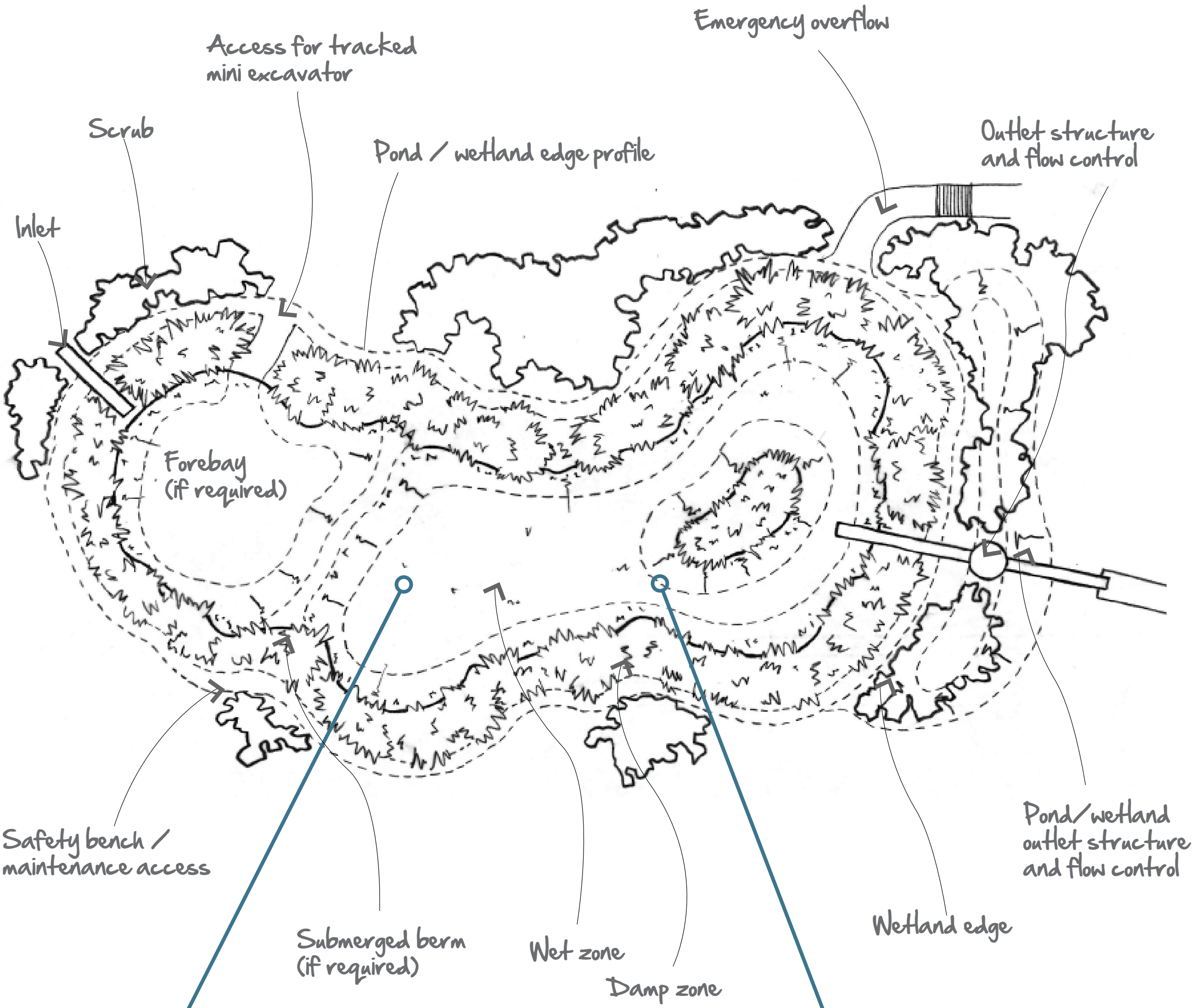
Algae in a SUDS pond is common in the first year or two after construction, Worcestershire

Silt in a pond during construction caused by erosion due to lack of topsoil and vegetation, motorway service area, M42

Turf used as erosion control in a pond, Worcestershire

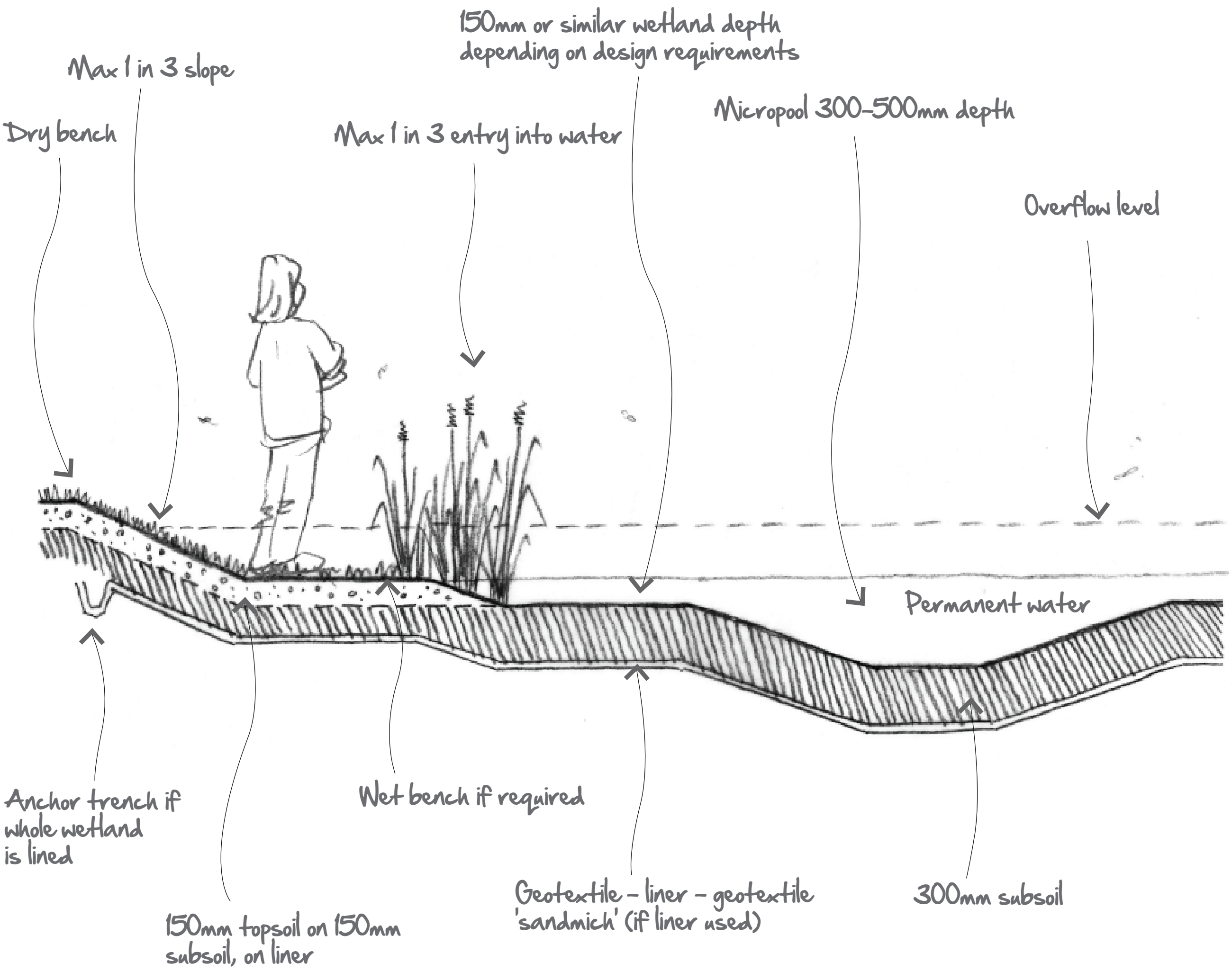
Practical issues and solutions

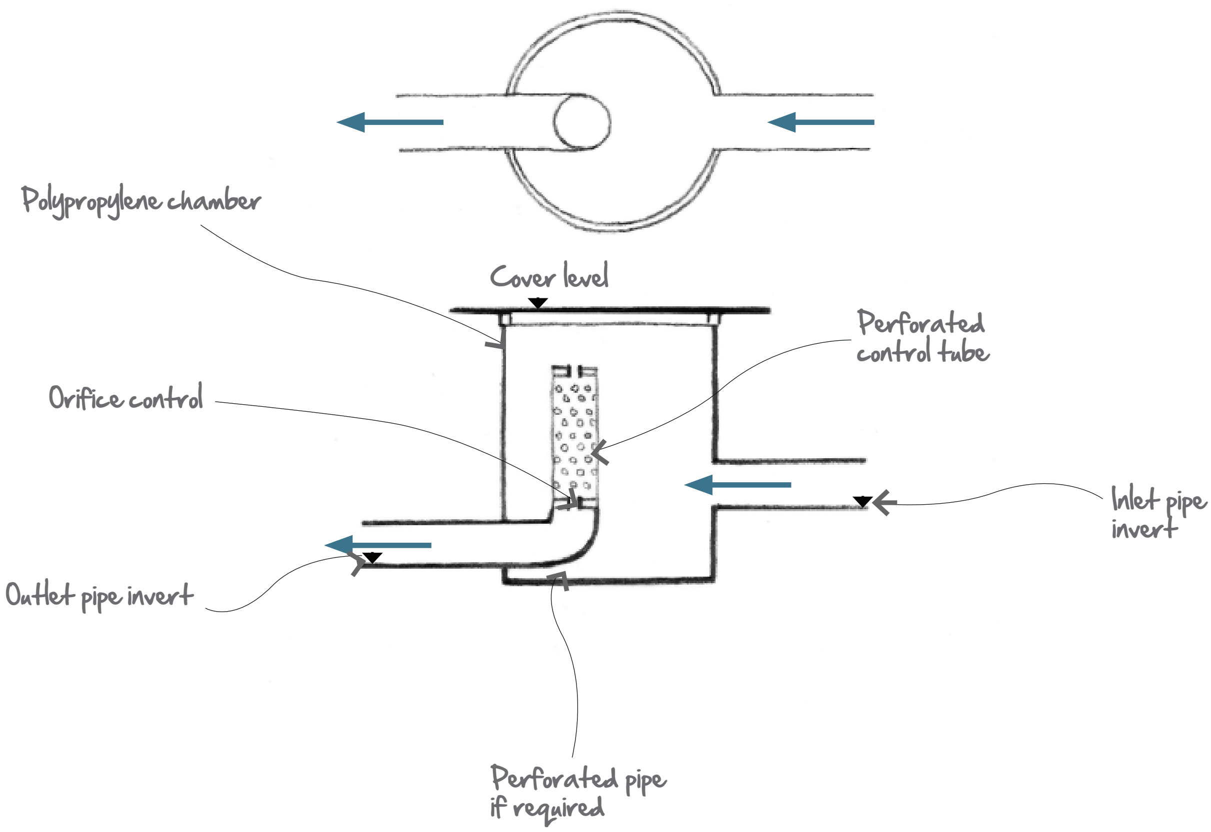
Problem: Silt build up during construction	**Solution:** Manage construction runoff and prevent it entering the pond by using straw bales or geotextile traps. If the pond is used to control construction runoff remove silt at end of project.
Problem: Erosion during construction before planting is established.	**Solution:** The easiest solution is to reuse topsoil without any application of weed killer. This allows existing vegetation in the topsoil to establish quickly. Another alternative is to use biodegradable erosion control mats.
Problem: Algal blooms in the water.	**Solution:** Avoid excessive use of fertiliser in surrounding landscape. However algal blooms are not uncommon as the pond establishes and will disappear in time.
Problem: Water is not retained in the pond.	**Solution:** Ensure that soils below the pond are suitable to retain water. If not provide a clay subsoil that is compacted correctly over base of pond or use a liner.
Problem: Pond liner exposed around edges of pond or wetland	**Solution:** Correct detailing and construction to ensure that liner has sufficient cover of stable soil at the edges (300mm minimum) and slopes do not exceed a gradient of 1:3; steeper slopes would encourage soil slippage.
Problem: Erosion at inlets. This is almost always a sign that source control is not provided upstream.	**Solution:** Water flows in to ponds and wetlands should normally be at low rates because source control has been provided upstream. The City Council will not adopt ponds or wetlands that do not have source control provision upstream.
Problem: Poor establishment of marginal plants due to over compaction of slide slopes and anaerobic conditions.	**Solution:** Correct construction to avoid excessive tracking of machinery. Subsoils should be ripped prior to topsoils being placed above.



SUDS pond in a public park designed for biodiversity with shallow side slopes and safety bench, Sheffield

SUDS pond/wetland in a motorway service area showing different zones, Hopwood Service Area, M42





Pond/wetland outlet structure and flow control

Maintenance requirements

Maintenance of ponds is relatively straight forward for landscape contractors and typically there is only a small amount of extra work required for a SUDS pond or wetland.

More intensive maintenance work such as silt and/or vegetation removal is only required intermittently, but it should be planned to be sympathetic to the requirements of wildlife in a pond. The best time to carry out more intensive work is between September and November when the impact on wildlife will be minimised (e.g. no newt breeding or young, ground nesting birds are not breeding, impact on water voles is less, etc.).

Intensive silt and vegetation removal should only be carried out to limited areas at any one time (25% to 30% of the pond area on one occasion each year). Again this is to minimise the impact on biodiversity.

Wherever possible the SUDS ponds and wetlands should be designed so that special machinery is not required to undertake maintenance.

The costs of maintenance can be found within Appendix B.

Managing wetland vegetation with a mini excavator. Larger excavators should not be necessary, motorway service area, M42

Planting list for SUDS ponds/ wetlands

The following species list is considered suitable for planting in Cambridge SUDs. This list should not be considered exhaustive and the exact choice should relate to site-specific conditions. Designs that aim to create a range of plant communities and habitats across a scheme are favourable.

Aquatics – submerged and floating, plant with weights, in permanently wet zone, equate to National Vegetation Communities, group A11

Potamogeton pectinatus (fennel pond weed)
Potamogeton natans (broad – leaved pond weed)
Myriophyllum spicatum (spiked water-milfoil)
Sparganium emersum (unbranched bur-reed)
Ranunculus circinatus (fan-leaved water-crowfoot)
Potamogeton lucens (shining pondweed)

Damp zone - inundation-tolerant, plant up to 250mm above anticipated normal water level as plugs in groups of 5-10Nr plants to create stands

Persicaria amphibia (amphibious bistort)
Caltha palustris (marsh marigold)
Phalaris arundinacea (reed canary grass)
Veronica beccabunga (brooklime)
Angelica sylvestris (wild angelica)
Lythrum salicaria (purple loosestrife)
Lotus uliginosus (greater bird's-foot trefoil)
Lycopus europaeus (gypsywort)
Myosotis scorpiodes / laxa-cespitosa (water forget-me-not)
Apium nodiflorum (fool's-water-cress)
Lychnis flos-cuculi (ragged robin)
Rumex hydrolapathum (water dock)
Mentha aquatica (water mint)
Cardamine pratensis (cuckoo flower)
Ranunculus flammula (lesser spearwort)
Juncus articulatus (jointed rush)
Carex pseudocyperus (hop sedge)
Stachys palustris (marsh woundwort)
Scrophularia auriculata (water figwort)

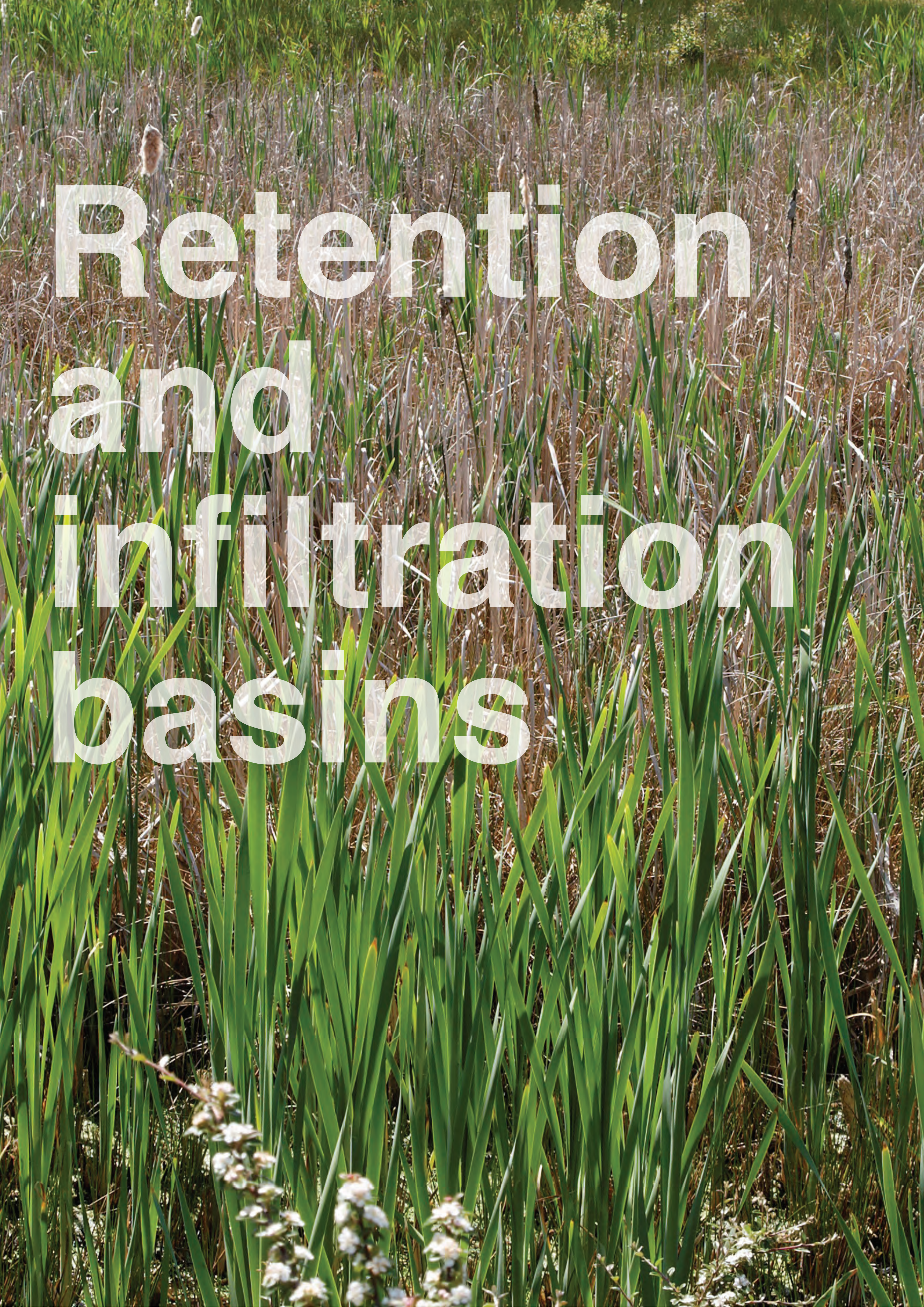
Wet zone – emergents, plant in 0-250mm of water, as plugs in groups of 5-10Nr. plants to create stands

Sparganium erectum (branched bur-reed)
Typha angustifolia (lesser bulrush)
Schoenoplectus lacustris (common clubrush)
Iris pseudacorus (yellow flag iris)
Glyceria fluitans (flote-grass)
Carex acutiformis (pond sedge)
Alisma plantago-aquatica (water-plantain)
Glyceria maxima (reed sweet-grass)
Veronica scutellata (marsh speedwell)

Dry zone - plant on upper slopes and bank-top as seed, at the following % cover

Festuca rubra (red fescue)
Anthoxanthum odoratum (sweet vernal grass)
Cynosurus cristatus (crested dogtail)
Briza media (quaking grass)
Deschampsia caespitosa (tufted hair grass)
Prunella vulgaris (selfheal)
Rhinanthus minor (yellow rattle)
Filipendula ulmaria (meadow sweet)
Lathyrus pratensis (meadow vetch)
Lotus corniculatus (common birdsfoot trefoil)
Carex hirta (hairy sedge)
Centaurea nigra (black knapweed)
Plantago lanceolata (ribwort plantain)
Potentilla anserina (silverweed)
Rumex acetosa (common sorrel)

Retention and infiltration basins



Retention and infiltration basins

Description

Retention and infiltration basins are open, usually flat, areas of grass that are normally dry. In heavy rainfall they are used to store water for a short time and so they fill with water. They are often multi use; for example, they can double as play areas. Retention basins can have local areas of wetland depending on the design. Shallow depressions can potentially provide relatively large areas of storage.

Benefits

Retention Basins	Infilltration Basins

How they work

Retention basins provide short term storage for excess rainwater. During very heavy rainfall the water level will slowly rise. Afterwards the water level drops slowly as the water flows out of the basin into a nearby watercourse or sewer.

Infiltration basins are similar to retention basins except that the stored water soaks into the ground below the basin. The soils below the basin have to be sufficiently permeable to allow water to soak in quickly enough. If the soils are marginally suitable for infiltration then trenches may be constructed below the basin to make it work more effectively.

Basins remove some pollution from rainwater runoff but still require source control up stream to operate most effectively.

Infiltration basin during rainfall in a housing development. The basin is normally dry and contains water occasionally, Petersfield

Cambridge specific design considerations

Retention basins are most suitable to the clayey soils present below much of Cambridge. This is because the clays soils do not soak up a lot of water (although in summer some water will soak into the clay following a particularly dry period).

The exact form of basins will depend on the specific ground levels, topography, etc. As with ponds and wetlands, basins should have an appropriate scale and form to suit the surrounding landscape character. They should be designed to provide attractive landscaped areas that are not simply areas of plain grass.

The bottoms of infiltration basins are normally flat, although water can infiltrate through sloping areas as well. Retention basins may have a damp zone at the bottom depending on the design and can be designed to provide ecological and/or amenity value.

Housing should be designed to overlook basins, rather than basins being placed in an unseen corner. Basins can also be located in larger areas of open space.

There should be an assumption to retaining all existing native trees and vegetation. The layout of the basins should respect the presence of trees, and in particular, ensure that their root systems are not compromised. Proposals should accord with BS5837: 2005 and take account of any implications resulting from the presence of Tree Preservation Orders (TPOs) and Conservation Area designations.

Small interpretation boards should be provided and these should include information relating to the function of the basin and the local fauna and flora the system supports.

Planting

The City Council will expect new basins to be planted to enhance biodiversity and contribute to local, national and regional aims, for example Biodiversity Action Plans (BAP). Landscaping requirements will take precedence over enhancing biodiversity when planting basins. The following should be considered:

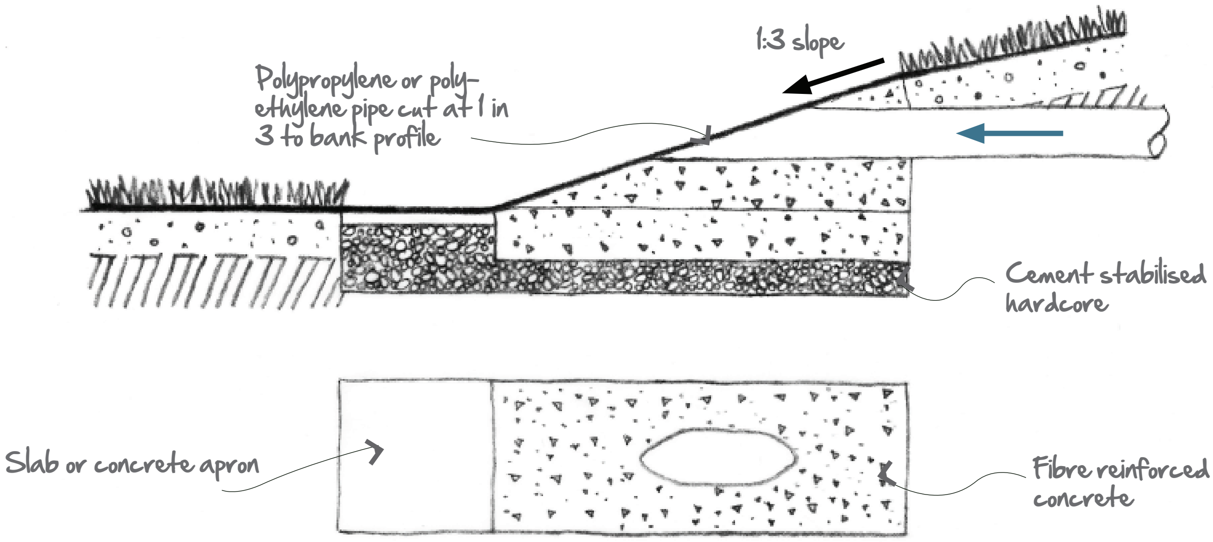
- The planting should provide a permanent ground cover so that bare soil is not washed out of the basin when it operates.
- The planting should be able to tolerate periodic cover by water up to 1m depth for up to 48 hours.
- The bottom of an infiltration basin is likely to be quite a dry environment due to the sandy rootzone and permeable underlying soils.
- Planting introduced to improve ecology actually makes infiltration basins work more effectively by slowing down flows and keeping the soil free draining.

Basin in a housing development with an information board to explain its purpose to residents, Cambourne

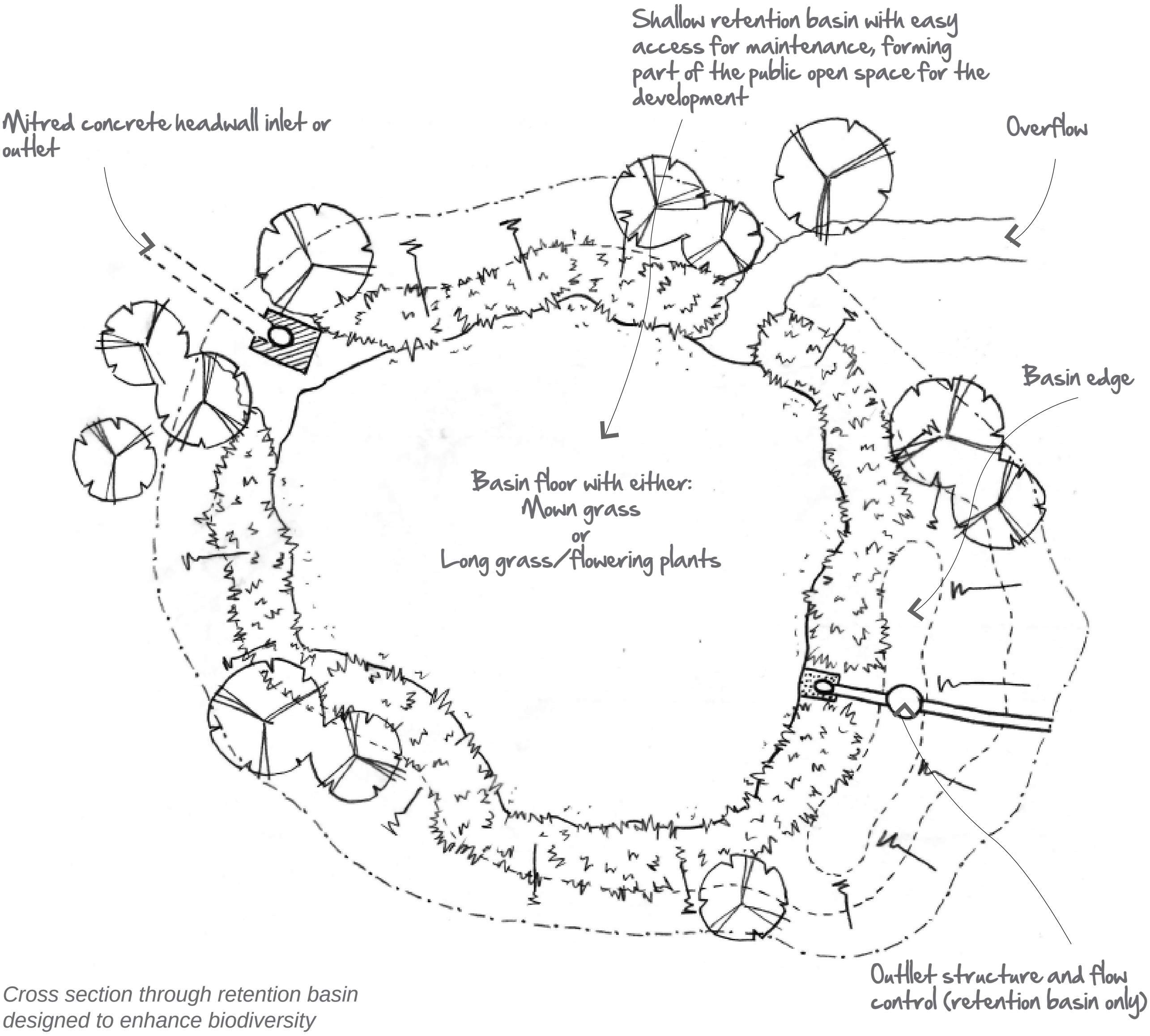
Practical issues and solutions

Problem	Solution
Problem: Compaction of soil in base of infiltration basin during construction, resulting in reduced infiltration rate.	**Solution:** Manage construction plant and prevent heavy plant using the basin as an access route.
Problem: Topsoil is not sufficiently permeable.	**Solution:** Use a root zone mix that has a high sand content to maximise the permeability.
Problem: Wet or boggy patches develop in base, especially close to inlets, where not expected.	**Solution:** This often occurs because the base has not been constructed to the correct levels. Use a rootzone material to cover the base or a short length of infiltration trench at the inlets. The bottom of flat basins should be constructed to quite tight tolerances of 10mm level difference in 3m.
Problem: Silt build up during construction.	**Solution:** Manage construction runoff and prevent it entering the basin by using straw bales or geotextile traps. If the basin is used to control construction runoff remove silt at end of project.
Problem: Erosion during construction before planting is established.	**Solution:** The easiest solution is to reuse topsoil without any application of weed killer. This allows existing vegetation seed in the topsoil to establish quickly. Another alternative is to use biodegradable erosion control mats.

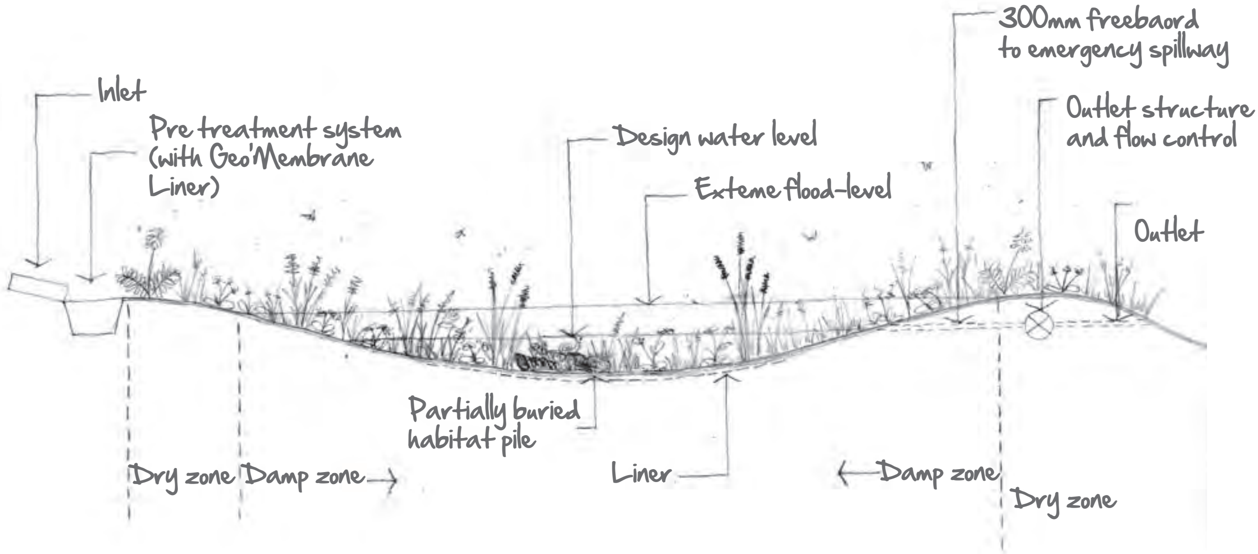
Basin with a water channel maze at a school in Worcestershire



Mitred concrete headwall



Cross section through retention basin designed to enhance biodiversity



Cross section through retention basin designed to enhance biodiversity

Retention basin with a wetland bottom, motorway service area, M42

Shallow retention basin with easy access for maintenance, forming part of the public open space for the development

Maintenance requirements

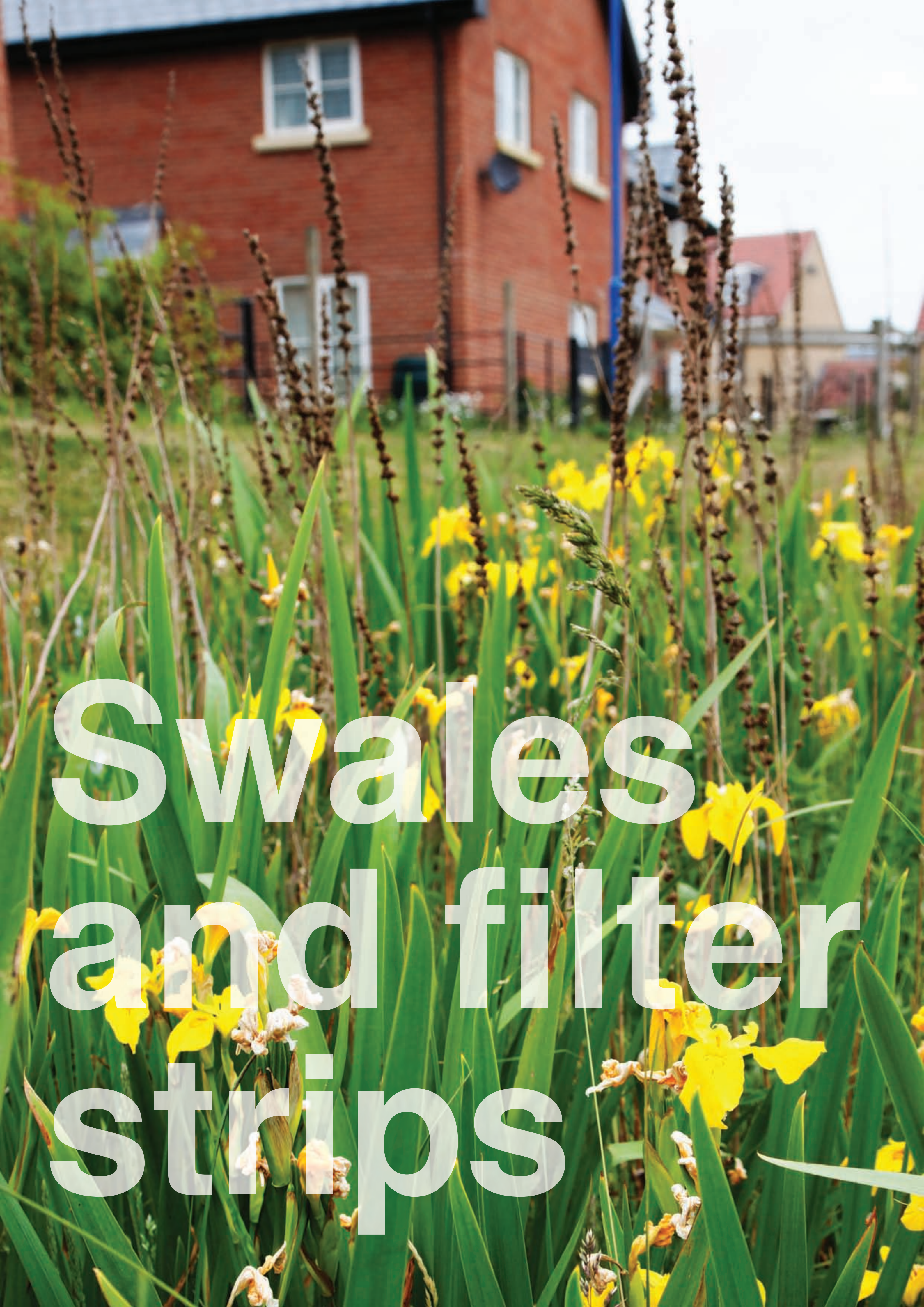
Maintenance of basins is relatively straight forward for landscape contractors and typically there is only a small amount of extra work (such as the management of control structures) required over and above that required for any open space. More intensive maintenance work such as silt removal is only required intermittently.

Basins should be designed so that special machinery is not required to undertake maintenance. Grass cutting in the bottom of basins should not be carried out when it is wet.

The costs of maintenance can be found at Appendix B.

Mowing amenity grassland around basins, Sheffield

Swales and filter strips



Swales and filter strips

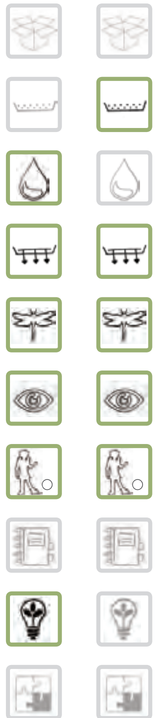
Description

Swales are very shallow channels that are used to collect and/or move water and also remove pollution from it. They can be covered by grass or other vegetation and have shallow side slopes and a flat bottom which means that for most of the time the water flows in a thin layer through the grass or other vegetation.

Filter strips are gently sloping areas of grass that water flows onto and across, usually towards a swale or filter drain. The main purpose of the filter strip is to remove any silt in the water so that it does not clog up the swale or filter drain.

Benefits

Swales   Filter strips



Shallow swale in a housing development, Malmo, Sweden

Filter strip leading to a filter drain. The filter strip removes silt and reduces the maintenance required for the filter drain, Hopwood services, M42

How they work

Swales and filter strips are source control elements of SUDS. They are simple and yet are very effective in managing surface water runoff. The grass or other vegetation slows water down and also traps some of it by allowing it to soak into the ground. In addition, the plants help evaporate some water and filter out pollution from the water.

Swales can have a wet base, in which case they will behave like a wetland. In areas where a wet base is not desirable (for example along the edge of streets) a perforated pipe and sand or gravel can be installed below the bottom (under drain). A particular type of under drained swale can be constructed with enhanced vegetation and filtration; these are known as rain gardens, bioswales or bioretention areas. They are essentially landscaped areas that are depressions to collect and treat rainwater.

Small filter strips that are 1m to 2m long, leading to the side slope of a swale, are an ideal way of allowing water to enter the swale.

Recently constructed rain garden (bio retention) in a car park, Maryland, USA

Cambridge specific design considerations

The exact profile of swales will depend on the specific ground levels, topography, and ground/soil conditions present at the site, as well as its orientation, aspect and proximity to other landscape features, buildings, etc. The swale should have an appropriate scale and form to suit the surrounding landscape character. In green open spaces they should have a natural feel with soft edges and forms that flow into the surrounding area. Hard edges and straight lines may be appropriate in some hard urban landscapes.

The design should contribute to the amenity of the local communities.

There should be an assumption to retain all existing native trees and vegetation. The layout of the swales should respect the presence of trees, and in particular, ensure that their root systems are not compromised. Proposals should accord with BS5837 2005 and take account of any implications resulting from the presence of Tree Preservation Orders (TPOs) and Conservation Areas designations.

Small interpretation boards should be provided and should include information relating to the function of the swale and the local fauna and flora the system supports.

Children paying in a shallow swale designed to provide amenity, School, Worcestershire

Planting

The City Council will expect swales and filter strips to be planted to enhance biodiversity and contribute to local, national and regional aims, for example Biodiversity Action Plans (BAP). Considerations will include:

- Linking to existing wildlife corridors
- Providing a diverse range of plants that are suited to the specific conditions of a SUDS swale (tolerant of varying water levels, slight pollution, etc.).

Planting in the swale or filter strip is essential to stabilise slopes, reduce erosion and slow water flows to aid sedimentation, as well as to provide some nutrient take up.

Planting should be designed to establish quickly and water should not be allowed to flow in swales until the vegetation is established (or erosion protection is provided).

Hard swale to suit surrounding urban landscape, Portland, USA

Shallow swale alongside a distributor road – check dams maximise storage and slow water, Witney, Oxfordshire

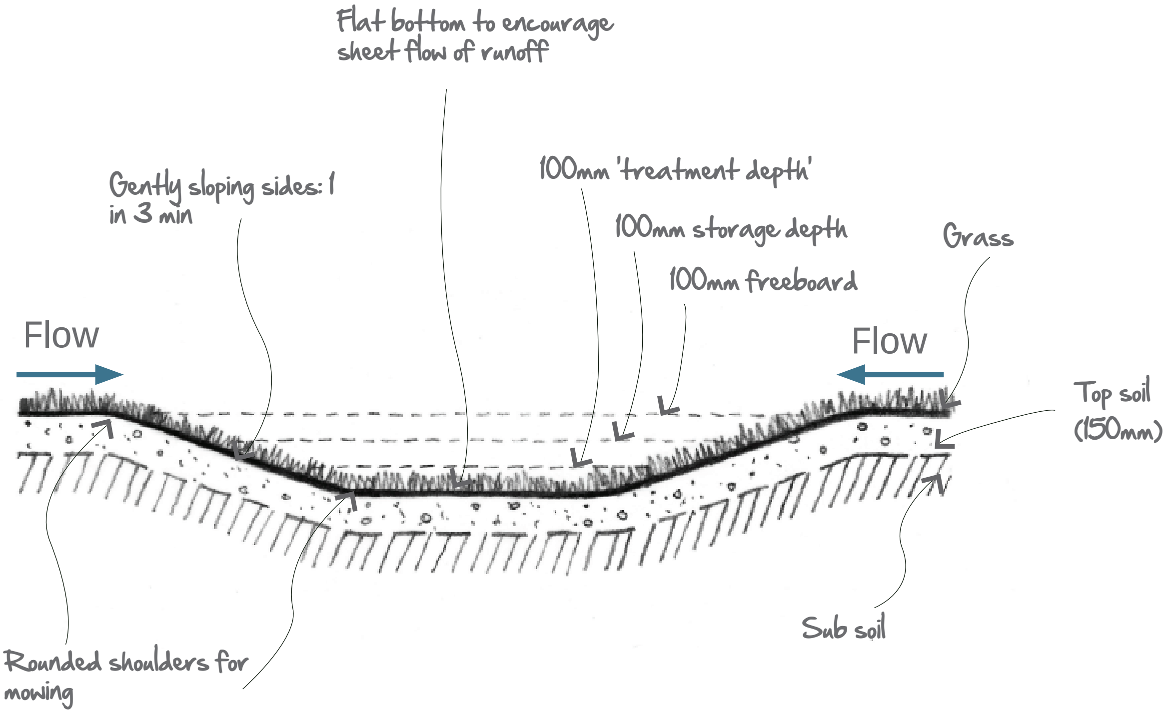
Practical issues and solutions

Many problems that have occurred with swales are due to a lack of attention during design and construction. Some of the most common pitfalls and solutions are discussed below. CIRIA publication C698: Site Handbook for the Construction of SUDS also contains practical construction help and advice.

Problem: Wet or boggy patches develop in base where not designed for.	**Solution:** This often occurs because the base has not been constructed to the correct levels and there may be a low point in the swale. Construct to correct levels and possibly use a rootzone material to cover the base, and/or an underdrain.
Problem: Silt build up during construction	**Solution:** Manage construction runoff and prevent it entering the swale by using straw bales or geotextile traps. If the swale is used to control construction runoff remove silt at end of project.
Problem: Erosion during construction before planting is established.	**Solution:** The easiest solution is to reuse topsoil without any application of weed killer. This allows existing vegetation in the topsoil to establish quickly. Another alternative is to use biodegradable erosion control mats or turf.
Problem: Erosion after planting is established. Occurs if the water is forming channels due to incorrect levels, or the filter strip vegetation is higher than the edge of the paved area it is draining.	**Solution:** Correct detailing and tolerances during construction. Drop from edge of hard area to filter strip or swale should be 20mm to 25mm and the tolerance on construction of a filter strip should be 10mm level difference in 3m at right angles to the water flow.
Problem: Water does not flow over edge into swale along whole length (where designed to do so) and enters via preferential route and concentrates flows and silt in one area.	**Solution:** Ensure that where over-the-edge drainage is required the grass is 20mm to 25mm below the edge of the hard surface to be drained.

Water flows along edge of grass before entering swale

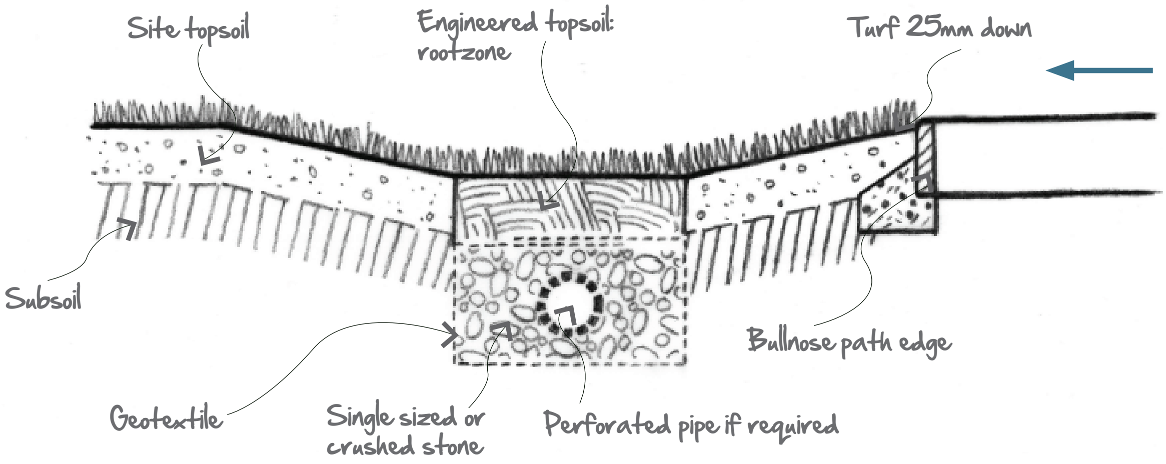
High grass at edge of road prevents water entering swale



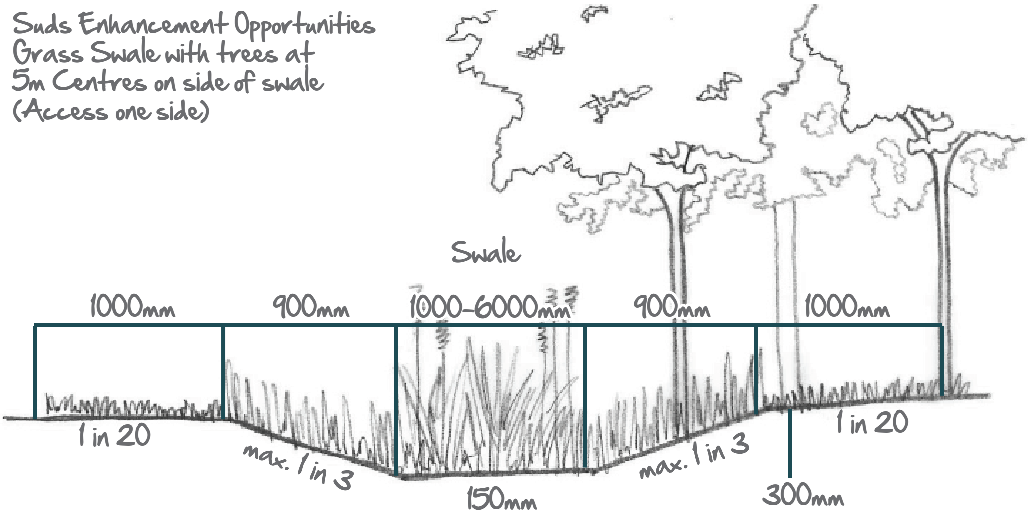
Cross section through a swale

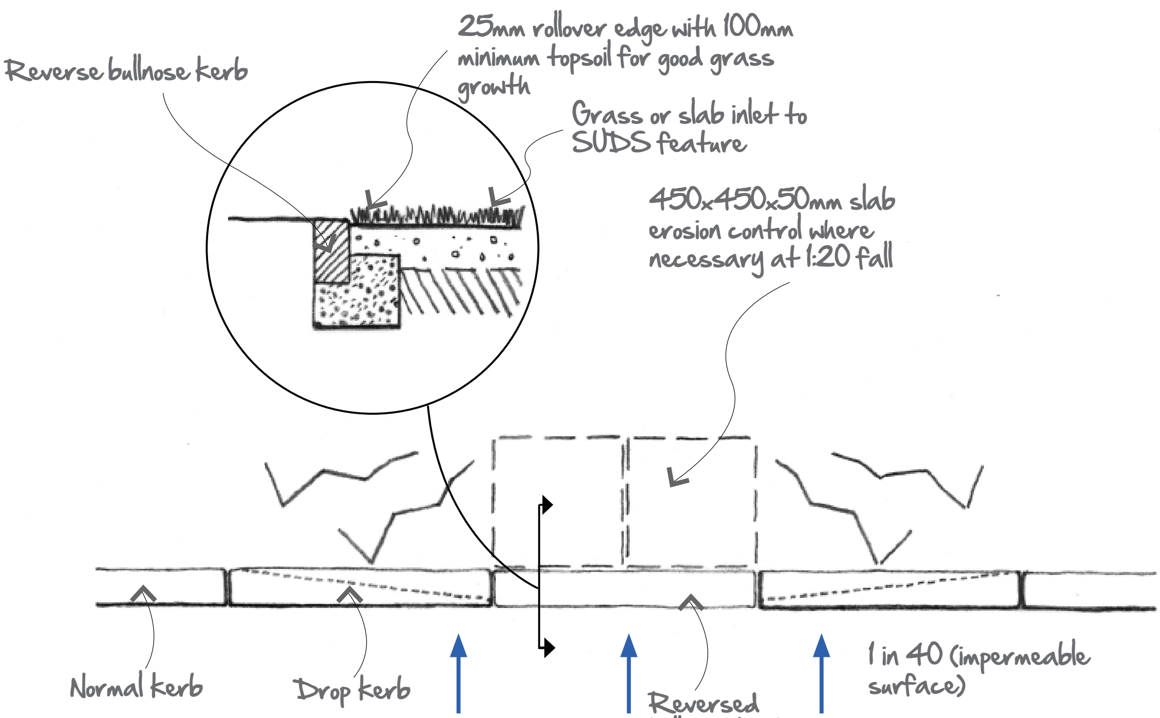
Swale detail where it passes through a wall in a park, Sheffield

Swale integrated onto surrounding ground in a park, Sheffield



Cross section through enhanced or dry swale with under drain





Cross kerb inlet to a swale

Maintenance requirements

Maintenance of swales and filter strips is relatively straight forward for landscape contractors and typically there is only a small amount of extra work required over and above that required for any open space.

More intensive maintenance work such as silt and/or vegetation removal is only required intermittently but it should be planned to be sympathetic to the requirements of wildlife.

The swales and filter strips should be designed so that special machinery is not required to undertake maintenance. Grass cutting should not be carried out when the swale or filter strip is wet.

The costs of maintenance can be found at Appendix B.

Shallow swale in a housing development with wetland planting, Elvetham Heath

Do not cut grass when swale is wet

Filter drains

Filter drains

Description

Filter drains are gravel filled trenches that collect and move water. They also treat pollution. The trench is filled with free draining gravel and often has a perforated pipe in the bottom to collect the water. They are widely used to drain roads and are often seen along the edge of main roads.

There is frequently a geotextile just below the surface that is used to trap silt and stop it clogging the gravel deeper in the trench. A small filter strip before the trench is also a good way of stopping silt clogging the trench.

Road side filter drain, A74, Scotland

Filter drain protected from silt by a filter strip

Benefits

Filter drains

How they work

Surface water runs off the edge of a hard surface such as a road and into the filter drain. The water flows down through the gravel which removes some of the pollution. The gaps between the pieces of gravel also provide space to temporarily store water during rainfall.

Cambridge specific design considerations

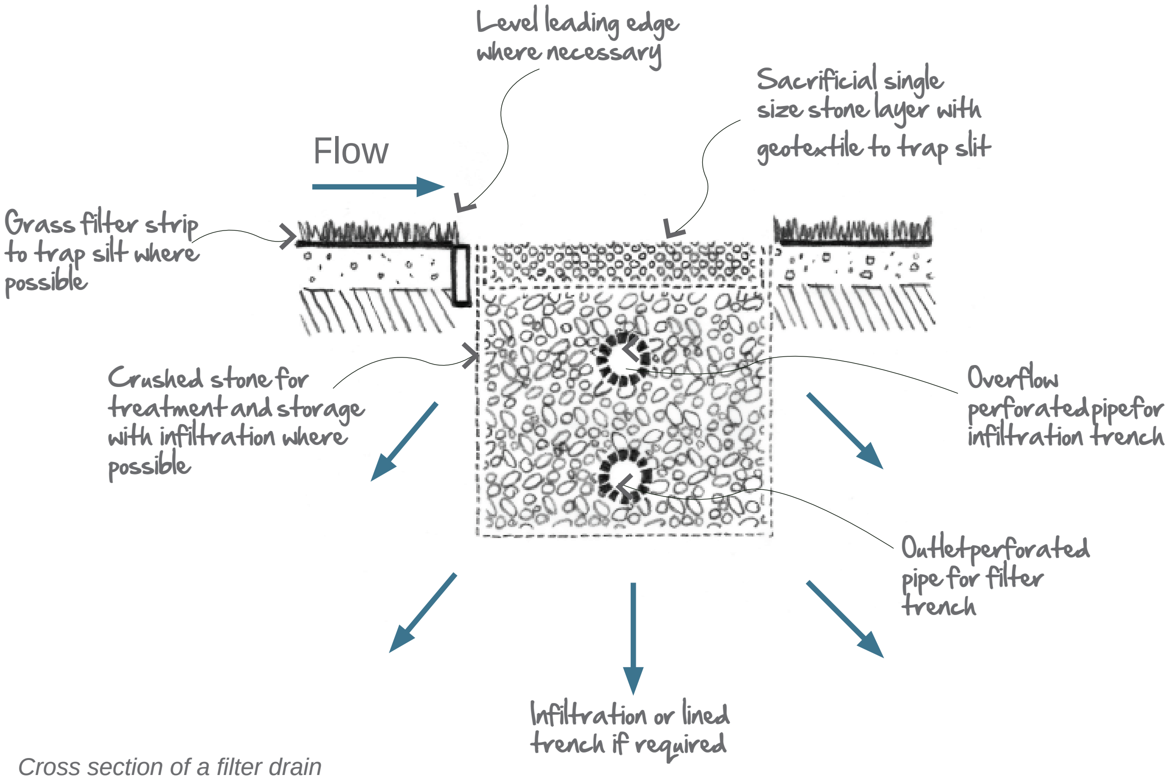
Filter drains are essentially an engineering feature and are to be used only as a last resort where no other feature will work. Often an area of permeable surfacing or open graded subbase below an impermeable area can be used instead of a filter drain, which in Cambridge is an advantage as it keeps the system shallow. In some cases there may be opportunities to integrate them into the landscape in innovative ways that enhance the local environment.

In Cambridge it is important to keep filter drains shallow because of the flat landscape. Where filter drains lead to ponds or basins it helps keep these shallower. It will also help prevent problems meeting shallow outfall points.

Practical issues and solutions

Many problems that have occurred with filter drains are due to a lack of attention to detail during design and construction. Some of the most common pitfalls and solutions are discussed below. CIRIA publication C698: Site Handbook for the Construction of SUDS also contains practical construction help and advice.

Problem: Using a geomembrane instead of a geotextile just below the surface (geotextiles are specified to be permeable whereas geomembranes do not allow water through).	**Solution:** Good site supervision and communication to the staff that are constructing the drain about the purpose of the different materials.
Problem: Filter drains cause problems when mowing surrounding grass if they become overgrown (the stones are thrown up and can damage mowers if they go over them).	**Solution:** Regular cutting back of grass is required to keep the surface clear and visible.
Problem: Silt build up during construction	**Solution:** Manage construction runoff and prevent it entering the filter drain by using straw bales or geotextile traps. Filter drains should not be used to control construction runoff because of the high silt loads.



Cross section of a filter drain

Maintenance schedule and costs

Maintenance of filter drains is relatively straight forward if they are constructed in accordance with The SUDS Manual (CIRIA C697) and incorporate a sacrificial geotextile layer close to the surface. Routine maintenance involves removing debris and litter from the surface and cutting back vegetation. More intensive maintenance work such as removing and cleaning or replacing the surface layer of gravel is only required intermittently, about once every five to ten years.

Cleaning and replacing gravel is the preferred option as it is more sustainable than disposing of the gravel. There are specialist contractors that remove the gravel from filter drains, clean and replace it.

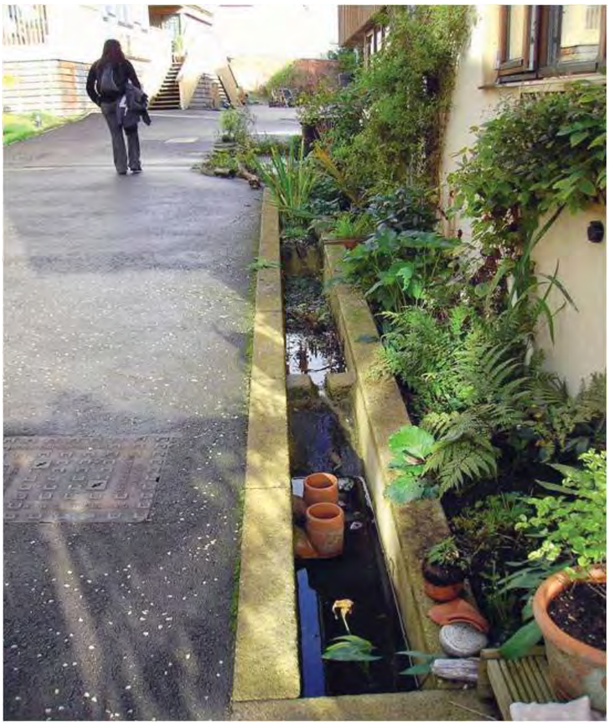
The costs of maintenance can be found at Appendix B.

Canals, rills and other channel systems

Canals, rills and other channel systems

Description

Canals and rills are open surface water channels with hard edges. They can have a variety of cross sections to suit the urban landscape and can also be planted to provide water treatment. In dense urban developments where space can be at a premium they are an effective way of providing SUDS and can also act as pre-treatment to remove silt before water is conveyed into further SUDS features. There are many SUDS schemes that use channels in imaginative ways to enhance hard urban landscapes.



Rill in a housing development, Stroud

Benefits

Canals, rills and other channel systems

How they work

Rills and canals can be used to collect water directly from hard surfaces or they can be used to convey water, for example where it has been collected via a permeable pavement. They are simply channels that water flows along.

Treatment channels collect water, slow it down and provide storage for silt and oil that is captured. The outlet is designed to act as a mini oil separator thus the channel is very effective at treating pollution.

Cambridge specific design considerations

Channels and rills are essentially an engineering feature, although wherever possible they should be planted to enhance their visual appeal and treatment effectiveness. In many cases there will be opportunities to integrate them into the landscape in innovative ways that enhance the local environment.

Canal with planting in a high density housing development, Stamford

Practical issues and solutions

It is easy to construct canals, rills and treatment channels that meet the aspirations of the City Council. However, many problems that have occurred with these systems are due to a lack of attention during design and construction. Some of the most common pitfalls and solutions are discussed below. CIRIA publication C698: Site Handbook for the Construction of SUDS also contains practical construction help and advice.

Problem: Sparse planting in canals	**Solution:** Good site supervision and communication to the staff and adherence to the SUDS planting specification.
Problem: Silt build up in canals often occurs due to incorrect planting of the surrounding area.	**Solution:** Planting of adjacent landscape areas should provide good ground cover and bind the soil together. Bare soil or mulch areas are not acceptable.

Canal leading to an urban wetland Malmo, Sweden

Decorative canal and water feature, Malmo, Sweden

Maintenance schedule and costs

Maintenance of canals, rills and treatment channels is relatively straight forward if they are constructed in accordance with The SUDS Manual. Routine maintenance involves removing debris and litter from the channel or rill. More intensive maintenance work such as removing silt is only required intermittently, about once every 5 years.

The costs of maintenance can be found within Appendix B.

SUDS features in private ownership

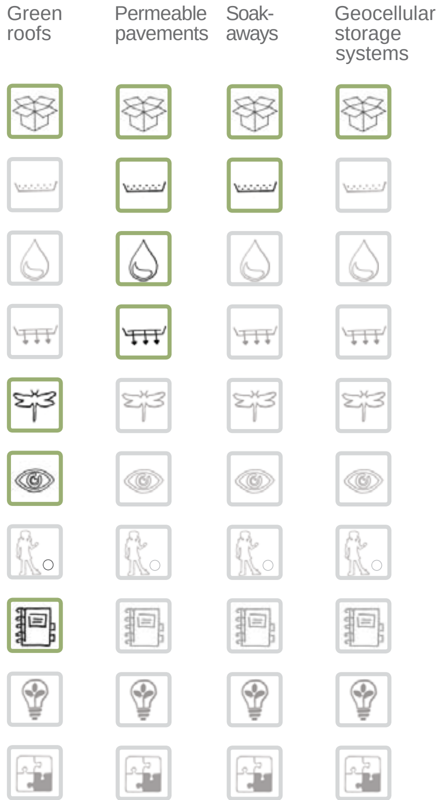
SUDS features in private ownership

As explained in the earlier parts of this guide, Cambridge City Council will require source control SUDS to be provided upstream of any ponds, wetlands, basins or other SUDS features it adopts. Most source control features will be located within the private or highway areas of a development and as such will not be adopted by the City Council. The purpose of source control is to manage rainfall close to where it hits the ground instead of allowing it to become a problem elsewhere. The main types of source control that will be used in private areas are:

- Green roofs
- Permeable pavements
- Soakaways
- Geocellular storage

Other features such as filter strips, swales, canals, rills and treatment channels can also be used as source control in private areas. Water re-use features such as water butts or more comprehensive water harvesting systems are also useful additions to a SUDS system to provide an overall sustainable water management system.

Benefits



Green roofs

Green roofs have a thin layer of soil like material known as substrate that is planted to meet the specific visual and biodiversity requirements of the roof and location. Varying substrate depths are best from visual and biodiversity points of view with thicker areas located over stronger points in a roof such as columns. Simple sedum mats offer the least biodiversity. A roof top can be an inhospitable place for plants and the planting should be designed to suit the roof and the surrounding area.

Green roof on a community building, Lake Ledro, Italy

Green roofs are very effective as part of a SUDS system and can reduce the volume of ground level storage required. Further information on how to allow for the reduced runoff from green roofs can be obtained from Building Greener, published by CIRIA, and the Environment Agency's Green Roof Tool Kit.

Permeable pavements

Permeable pavements can be used in driveways, parking areas and some roads. They allow water to soak through the surface into the gravel subbase below. This temporarily holds the water before allowing it to either soak into the ground or pass to an outfall, often to another SUDS feature such as a swale. Permeable pavements are very effective at controlling the flow of water and removing pollution from it.

There are a variety of surfacing materials available. The most common are concrete or clay permeable block paving. Other surfaces include porous asphalt, reinforced grass and gravel. Further information is available in CIRIA Report C582, from Interpave and the Environment Agency. Concrete block permeable paving should be designed in accordance with British Standard BS 7533-13:2009.

It is now law in England that new and refurbished driveways in front gardens must be constructed using permeable surfaces, otherwise planning permission will be required for the construction. Their use in new developments is essential under this legislation.

There is common misconception that permeable surfaces quickly clog. Studies in the UK and elsewhere have found that there is a reduction in the permeability of the surface but in normal situations this levels off at a rate that is still more than adequate to deal with UK rainfall. If they become completely clogged they can be cleaned out with a road sweeper using a water jet and suction. Most problems occur due to clogging caused by construction debris or inappropriate levels for the adjacent landscape areas, such that dirt washes onto the surfaces.

Permeable block paving being machine laid in Cambridgeshire

Soakaways

Soakaways are buried chambers that store surface water and allow it to soak into the ground. The potential to use soakaways in many areas of Cambridge will be limited because the presence of clay soils and high groundwater levels. However, where conditions are suitable they can be used to manage water from roofs, driveways and patios for individual houses. Further information is provided in The SUDS Manual (CIRIA C697).

Reinforced grass car park surface, Lake Garda, Italy

Geocellular and other storage systems

Geocellular and other storage (oversized pipes, culverts, etc.) can be used to provide extra storage volume, especially in dense urban areas where open green space is limited. These features if used on their own would not be a SUDs scheme. It should be designed following the principles of source control. Geoecellular storage must be designed so that silt is prevented from entering the tanks. The testing and structural design of geocellular storage systems should follow the guidance in CIRIA Report C680. These types of storage systems can double up as rainwater harvesting systems when carefully designed.

Shallow geocellular storage used below permeable paving as a subbase replacement at a Park and Ride site in Cambridgeshire

Rainwater harvesting

Rainwater can be collected in water butts for watering gardens or more complicated systems can be installed for re-using water to flush toilets or for supplying water to outside taps. Larger rainwater harvesting compliments SUDS and helps to provide interception storage. Further guidance is provided in CIRIA Report C539 and British Standard BS 8515: 2009, Rainwater harvesting systems – code of practice.

Rainwater harvesting tank being constructed below a patio, Derbyshire

Inlets, outlets and controls

Inlets, outlets and controls

Description

Inlets, outlets and controls are key elements of a well designed SUDS. They allow water to flow into and out of features and also limit the rate at which water flows along and out of the system. There are many different variations available and they can easily be designed to add interest to the urban landscape.

Stainless steel outlet leading to a surface rill

How they work

Control structures are restrictions in a pipe or other outlet that limit the rate at which water can leave a SUDS feature. As it rains, the water backs up and thus fills the storage area (pond, basin, swale, etc.). Without control structures the water would simply flow through the system and the ponds, basins and other features would not fill.

Cambridge specific design considerations

The overriding design considerations for inlets, outlets and controls are ease of access and maintenance. This leads to a preference for surface control structures such as simple orifices (small diameter holes) or slot weirs, rather than those located below ground and out of sight in inspection chambers or manholes. Such underground features are more difficult to maintain and are often forgotten about.

In a well designed SUDS with source control, the rate of water flow should be much lower than in a normal drainage system that allows unrestricted discharge. This means that the velocity of the water is much lower and the risk of erosion is significantly reduced. Thus large erosion control features and vertical headwalls are not required, (vertical headwalls also have potential health and safety issues and are unsightly).

For shallow systems, where there is a limited depth of water storage, simple orifice controls are often the most suitable form of control.

Slot weir outlet from a canal

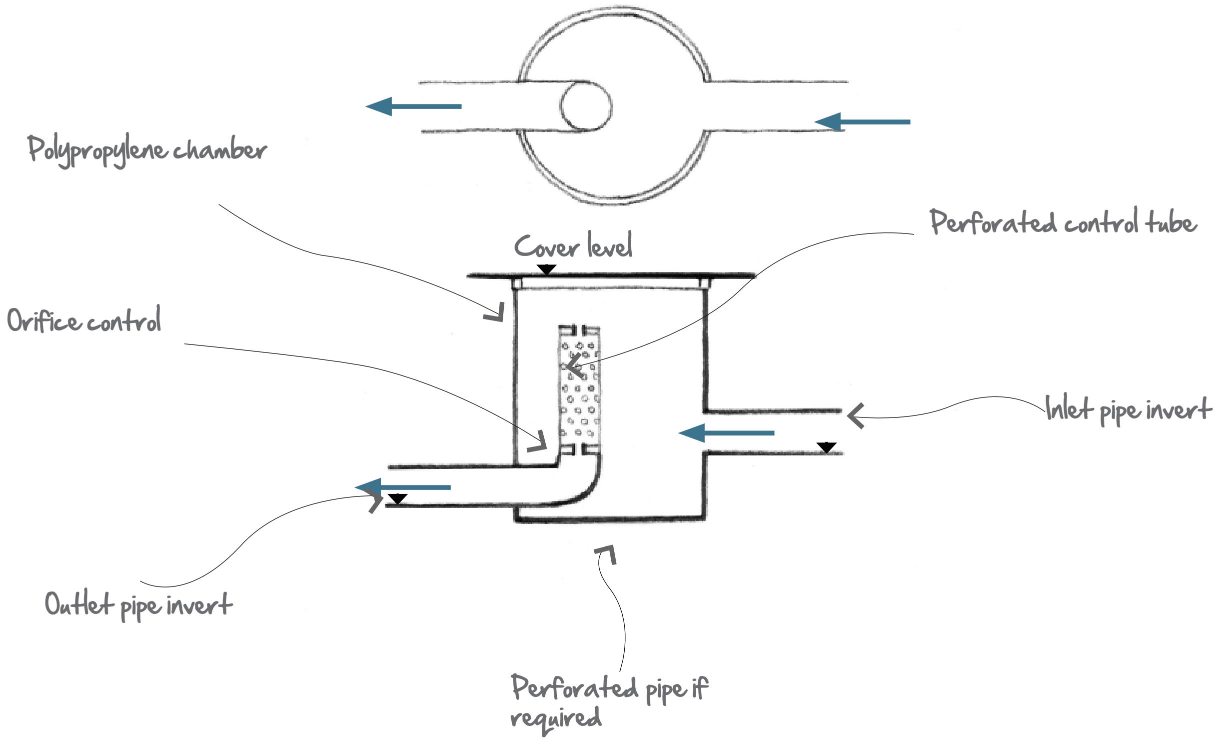
Dropped kerb inlet to rain garden

Orifice control to a basin located on the surface so that it is easily accessible

Overflow outlet from a pond

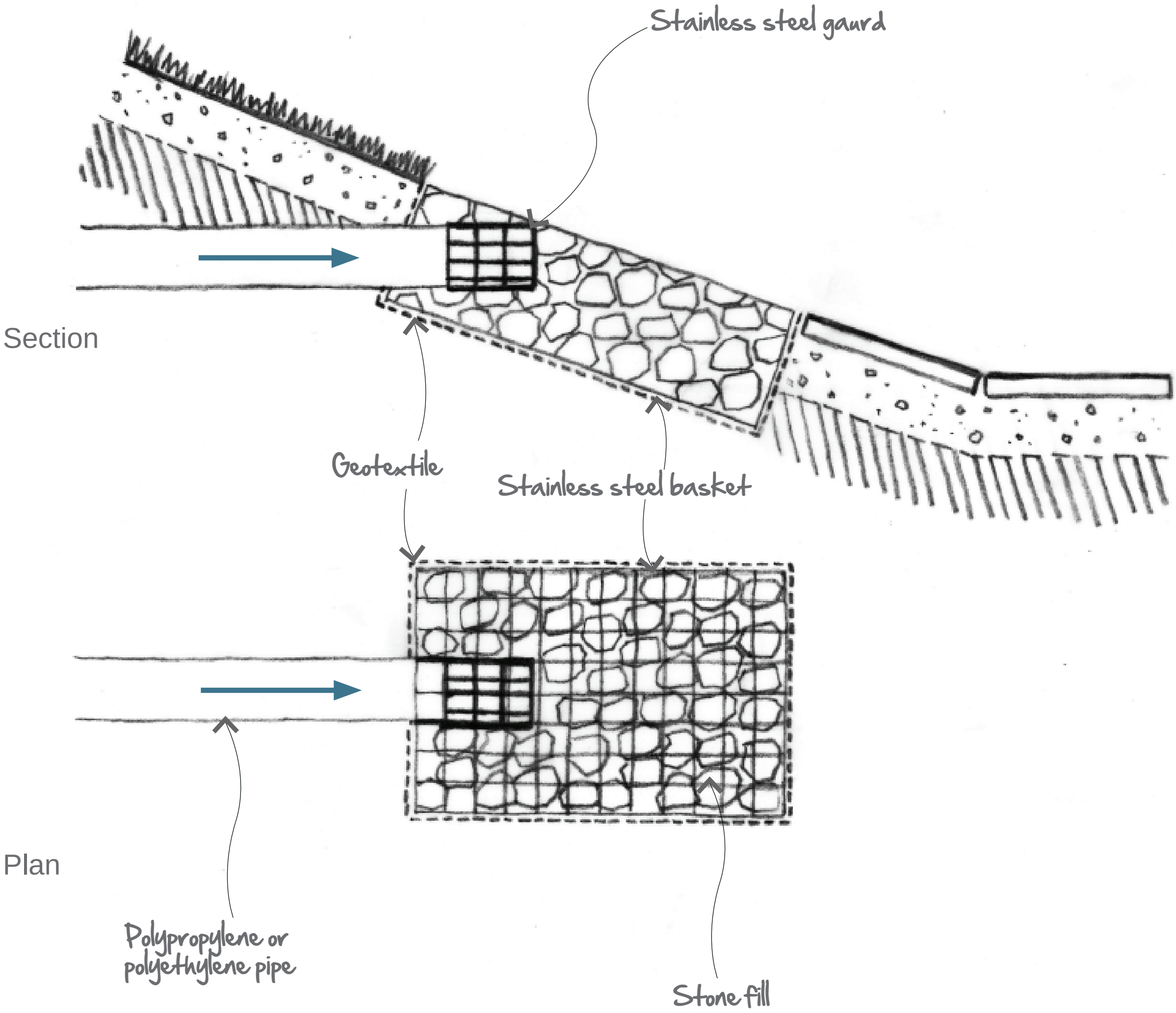
Slot weir outlet with steel plate to disperse water and debris guard behind

Shallow geocellular storage used below permeable paving as a subbase replacement



Perforated riser pipe detail (horizontal tube)

Perforated riser pipe to protect an orifice control in a chamber (see diagram above)



Basket or gabion inlet detail

Gabion inlet shortly after construction (see diagram above)

Maintenance requirements

Routine maintenance of inlets, outlets and controls involves a monthly inspection to make sure they are clear and not obstructed. Any debris, litter, etc. that has accumulated will require removal. The cost of doing this will normally be included in the cost for visiting a site to carry out other maintenance work.

Outlet from a small urban SUDS water feature


Waste
management
and other
environmental
issues

Waste management and other environmental issues

Waste management

When undertaking the maintenance of SUDS, waste will be generated. This will be predominantly grass and other vegetation, and may be managed on site in wildlife piles. There is still a requirement to comply with all relevant waste management legislation. This is even more pertinent when waste is disposed off site.

The options for disposal will depend on the characteristics of the silt and other material at each site.

On landscape sites green waste can be managed in a number of ways:

1. Shredded for surface spreading – as a mulch mimicking natural leaf or wood fall
2. As wildlife piles to provide habitat, usually when removed from managed landscapes (variation of 1/ above).
3. On-site compost piles (variation of 1/ above).
4. Removed from site to off-site composting facilities (e.g. as Council Green Waste)
5. Removal from site to tip – least preferred and least sustainable

However, the silt and other material removed from SUDS is defined as waste and in some specific situations could be defined as hazardous waste. Sediment that is removed may need to be tested to determine the extent and nature of any pollution in it. Where a management train is provided in low risk areas such as housing it is unlikely that silt will contain levels of pollutants that define it as hazardous waste.

It is also important to comply with the duty of care requirements of the waste management legislation. This means that silt should only be removed from site by authorised carriers and should be taken to authorised disposal locations. The necessary paper work to show this has been undertaken should be completed. Even if silt and vegetation is used on site, an exemption from the Environment Agency will be required.

Further information is provided in The SUDS Manual (CIRIA C697).

A practicable process for managing waste from SUDS in low risk areas, this is still to be agreed with the Environment Agency for SUDS in Cambridge, is as follows:

1. Evaluate whether the site is likely to operate 'hazardous waste'.

2. If this is the case, e.g. industrial or heavy vehicle management areas, then proceed to 'hazardous waste' disposal.

3. Where there is low risk of pollution, e.g. housing, schools, commercial sites, etc.,

- Silt accumulation 'at source' – remove and land-apply to vegetated surfaces outside the SUDS design profile but within, say, 10m of the SUDS feature.
- Silt accumulation in wetlands and ponds (very low if source control in place – remove, allow to dewater by the side of the SUDS feature for 24-48 hours and land-apply to vegetated surfaces outside the SUDS design profile but within, say, 10m of the SUDS feature.
- Vegetation or 'green' waste – remove from SUDS feature to designated wildlife piles, compost heaps or shred woody waste for in-situ mulch where appropriate – green waste to be applied when composted to ornamental plant beds or native planting areas outside the SUDS feature design profile.

This proposal is designed to manage non-hazardous silt and 'green' waste from SUDS systems in a sustainable manner on site. This reduces carbon emissions, landfill and cost to the community with minimal risk to the environment.

Litter should be collected and taken away for disposal off site.

Reuse of materials

The City Council will require demonstration that the creation ponds or basins does not require the wholesale removal of materials from site (with the resultant waste implications and noise and traffic impacts). Wherever possible, materials arising during construction works should be reused on site in a sustainable and appropriate manner that does not compromise the character of the existing landscape, e.g. the formation of shallow bunds or berms that form part of the overall landscape proposals. Where this is not practicable, it will be expected that materials are reused locally. Place partially-buried dead wood and recycled rubble/paving slabs on lower slopes of ponds and wetlands to create refuges for amphibians, reptiles and invertebrates.

Recycled concrete used in a control structure in Cambourne, Cambridgeshire

Creating wildlife piles

Wildlife piles are a sustainable way of managing green waste around SUDS. They provide a natural and cost effective wildlife resource and offer educational opportunities in construction, monitoring and after use.

Two types of wildlife pile can be used around a SUDS pond:

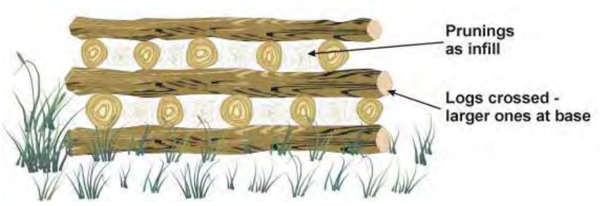
1. Log Pile
2. Hibernation/grass snake egg laying site.

Wildlife piles should be located in suitable areas where they will not be easily disturbed by vandals or dogs. The possibility of protected/ biodiversity species being present where log-piles/ compost heaps are to be dismantled also needs to be considered. Thorough checks should be carried out prior to any dismantling work being carried out and if protected/biodiversity species are found or suspected work should not commence until the species has vacated the area voluntarily. If in doubt the advice of a professional ecologist should be sought.

Log Pile

To construct a log pile, select a sheltered corner either with some sun or in shade for varied wildlife needs.

Pile logs and other woody material in a criss-cross pattern up to about 1m high. Fill the gaps between the logs with prunings. The pile creates different micro habitats for wildlife and can be left as a permanent feature.

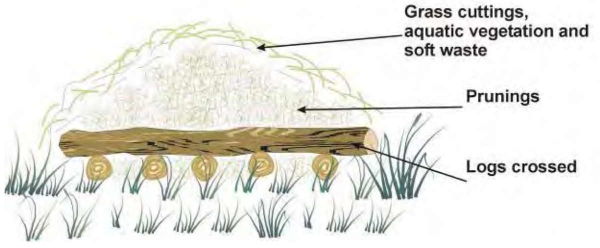


Log Pile

Hibernation/grass snake egg laying site

To construct a hibernation site, select a sheltered corner with sun for at least half the day to allow basking sites for reptiles. Pile logs, prunings and grass cuttings (or any other soft vegetation) in sequence up to a height of 1m to 1.5m.

The pile will heat up during the summer and attract many animals including slow worms and grass snakes that need heat to incubate their eggs and young. Each year, or as material is available, add grass to the pile or create a new pile next to the old one. After 5 years, the first pile can be used as compost and the process repeated.



Hibernation site

Adoption Requirements

Adoption Requirements

Specific drainage requirements for adoption

The drainage performance requirements are explained in detail in The SUDS Manual (CIRIA C697). The specific drainage requirements for each site will be specified by the Environment Agency via the normal planning consultation process. However, SUDS that are adopted by Cambridge City Council must as a minimum meet the following requirements from The SUDS Manual:

- Replicate natural drainage systems for a site as close as possible given the nature of a development. This is normally achieved by using source control and a management train. The management train provides different SUDS features that follow each other in sequence, gradually reducing the flows and volumes where possible and treating pollution in the water. This approach results in features that are located in public open space being protected from pollution. The Council may not adopt the source control part of the drainage system, but it must be in place to protect those parts that are adopted and will reserve the right not to adopt any down stream SUDS features should insufficient source control be in place.
- Prevent surface runoff from a site for small rainfall events up to 5mm (greater depth if possible) by allowing it to soak into the ground or evaporate back into the air. This will require the use of source control features that can allow partial infiltration or evaporation of water. Examples include swales and basins, permeable pavements, green roofs or engineered systems that meet the same requirements (e.g. rain-water harvesting, irrigation systems, etc.). This is called interception storage in The SUDS Manual (CIRIA C697).
- Limit the frequency of volume of runoff from extreme rainfall events to the greenfield frequency of runoff volume (this is called long term storage in The SUDS Manual (CIRIA C697) and is based on a rainfall event that has a 1% chance of happening each year). This can be achieved using a range of features including ponds, basins, permeable pavements and soakaways.

Rainfall terminology

There are two commonly used ways of expressing how frequently a particular depth or intensity of rainfall occurs

Annual probability (chance) of happening or being exceeded	Return period (often used by drainage engineers to denote the average time interval between rainfall events of a given size)
1%	1 in 100 year
3.33%	1 in 30 years
10%	1 in 10 years
50%	1 in 2 year

- Keep the rate of runoff from rainfall the same as would happen from a greenfield site (this is called attenuation storage in The SUDS Manual and the design is normally based on a rainfall event that has a 1% chance of happening in any one year). To limit liability for flooding, Cambridge will also require an additional 30% rainfall intensity to be applied to allow for climate change (typically also an Environment Agency requirement). This can be achieved using a range of features including ponds, basins, permeable pavements and soakaways.
- SUDS that are to be adopted by Cambridge must be robust to minimise future liabilities for the council. All drainage systems can be overwhelmed by unusual rainfall events. Developers will have to demonstrate that when this happens the water flows over the surface of the ground along routes that minimise the risk of flooding to buildings or other sensitive locations (these are known as overland flow routes).

An example of overland flow routes is to allow water to flow along roads to a lower point in the site. This is no different to current requirements for adoptable sewers.

- Low flow channels may be required to carry every day flows (i.e. a specific route for flows up to 1 in 1 year) to help maintain the high quality appearance of SUDS (for example to avoid the bottom of a basin becoming a large area of waterlogged ground).
- SUDS features must be as shallow as possible with gentle side slopes and shallow water depths. Large, deep ponds with steep sides are not acceptable.
- Vertical head walls, poorly designed rip rap and other visually obtrusive features will not be acceptable.
- Water level rises within any temporary storage areas should be kept to a minimum. Further information is provided for each feature.
- Outlet flow controls are a very important aspect of SUDS and should be provided on all features that are intended to store water to ensure the storage operates when required and flows to watercourses do not exceed agreed rates. The precise location should be considered on site specific basis (See Section 11 for more details).
- A safe exceedance or overflow route must be provided that directs flows away from buildings or other sensitive infrastructure.
- Any features that are to be adopted by Cambridge City Council must be designed in accordance with The SUDS Manual (CIRIA C697). Where there are conflicting requirements this guide shall take precedence.
- A flat area should be provided around features and inside when considering basins, to provide easy access for maintenance. This should be at least 2m wide. There should be access to the feature from a road for small tracked excavators. This requires suitable space and gradients but often does not require a specific hard surface.
- One of the most important aspects to ensure SUDS work properly is the design and maintenance of the outlet flow control. This will be site specific but Section 11 provides further information.

Specific treatment requirements for adoption

- The SUDS Manual requires sufficient treatment stages to be provided within a SUDS to remove pollution from run-off. The Environment Agency guidance in removing pollution from surface water (Pollution Prevention Guideline, PPG 3) recognises the importance of using SUDS to treat pollution in surface water runoff. SUDS will also help to meet some of the targets set by the European Water Framework Directive (which became UK law in December 2003) for improving the quality of rivers and streams.
- SUDS to be adopted by Cambridge must be part of a system that provides sufficient treatment stages to remove pollution from the runoff (the rain picks the pollution up from the road or car park surface). It is especially important that silt and pollution is removed before it reaches features such as ponds or wetlands that are to be adopted by the City Council.

SUDS treatment requirements

Runoff pollution content	Catchment characteristics	No of treatment stages or features
Low	Roofs, school playgrounds	1
Medium	Residential roads, parking areas, commercial zones	2
High	Refuse collection and industrial areas, loading bays, lorry parks, distributor roads and other highways	3

Taken from The SUDS Manual

The water in the left hand bottle in the picture below is runoff from a polluted surface. Subsequent bottles to the right are taken as the water flows through a SUDS management train of swales, ponds and wetlands, clearly showing the cleaning process.

These samples were taken from locations along a SUDS management train draining a heavily polluted runoff and show the gradual pollution removal by the treatment stages (courtesy Neil McLean of SEPA)

SUDS to be adopted by the City Council should be designed to be easy to maintain. This requires small and shallow SUDS features. Access should be provided to allow maintenance, including for any mechanical plant required. In most cases this only requires small tracked excavators and the main concern is with providing sufficient space and gradients. A surfaced track is not always necessary.

A checklist of adoption requirements is provided at Appendix D.

Specific pond adoption requirements

Specific Adoption requirements for Cambridge City Council are:

- Ponds should have varying permanent water depths to add interest and habitat but should not be more than 1,200mm deep. The water level must not rise more than 500mm during a 1 in 30 year or greater rainfall event.
- Slopes down to the water's edge must be as shallow as possible and will not exceed 1 in 3. This allows for successful vegetation establishment and safe public and maintenance access. Where spatial constraints prohibit the construction of slopes within the specified gradients, the City Council may approve the use of steeper profiles in some areas. The steeper slopes should be limited to less accessible areas of a pond.
- A shallow sloping area below the water line that leads to a shallow underwater bench to support emergent vegetation. This should be at a slope of 1 in 3 to an underwater bench with a depth of 150mm. Shallow profiles maximise the area of the pond's 'wet zone' and thus its biodiversity value. They also enable improved vegetation survival when water levels fluctuate and mean that bank stabilisation techniques such as coir rolls are unlikely to be necessary.
- Natural colonisation of the pond should be considered first before any planting schemes are devised. However, the overriding requirement is to prevent erosion as soon as the SUDS starts to drain water. This may require planting to be carried out. Where planting lists are used they should comprise native non-invasive species found naturally within 30km of Cambridge (plant list provided at Section 5). The City Council will require an agreement that should natural regeneration prove unsatisfactory after an approved period of time (usually 12 months), supplementary planting will be undertaken at the developer's expense.

- Providing water features are shallow and blend into the landscape then fencing should not generally be required to prevent access. Barrier planting preventing accidental access should be considered before fencing but is not always necessary. The use of fencing detracts from the amenity value and aesthetic quality of features and is a barrier to successful maintenance regimes. If fencing is required, it should be visually attractive and should be toddler proof but not prevent easy access by adults in case of emergencies.
- Liners should not be used except where required to stop water soaking into the ground. Examples include where it is necessary to create permanently wet areas or prevent contamination from known sources of pollution entering the ground. Where a liner is used it should be sufficiently robust to resist puncture and should be covered with a minimum of 300mm depth of mixed topsoil and subsoil including at the edges.
- Topsoil (150mm thick) should be applied to the banks between the permanent water level and maximum water level and also over the wet bench. This topsoil will feather down into the pond profile below the water level. Topsoil is not to be placed over the subsoil below the permanent water level beyond the wet bench. This approach is contrary to ecological best practice and the reason it is required is to help rapid and permanent establishment of vegetation to resist erosion.

Specific basin adoption requirements

Specific adoption requirements for Cambridge City Council are:

- The water level must not rise more than 1.000mm during a 1 in 30 year or greater rainfall event. It should drain down in 48 hours maximum.
- Slopes down to the bottom of the basin shall be as shallow as possible and will not exceed 1 in 3. This allows successful vegetation establishment and safe public and maintenance access. Where spatial constraints prohibit the construction of slopes within the specified gradients, the City Council may approve the use of steeper profiles in some areas. The steeper slopes should be limited to less accessible areas of a basin.
- Providing slopes are shallow and the water is only stored infrequently for a short time then fencing should not generally be necessary to prevent access. Indeed, basins can also be used as play areas. The use of fencing detracts from the amenity value and aesthetic quality of features and is a barrier to successful maintenance regimes. If fencing is required it should be visually attractive and should be toddler proof but not prevent easy access by adults in case of emergencies.
- The base and sides of infiltration basins (up to the maximum water level) should be covered with rootzone soil (or similar material) that is sufficiently permeable to allow water to soak through. This may also be considered in retention basins if a dry firm surface is required in the base. The rootzone must also have sufficient organic content to support the vegetation.
- Topsoil (150mm thick) should be applied to the banks and base of retention basins up to the maximum water level. This approach is contrary to ecological best practice but is necessary to aid rapid and permanent establishment of vegetation and so resist erosion of the basin.
- Liners for retention basins should not be used. Liners are not suitable for infiltration basins as they stop water soaking into the ground.

Specific swale adoption requirements

The adoption requirements for Cambridge City Council are:

- For health and safety reasons, swales should be as shallow as possible and side slopes should normally be less than 1 in 3. The maximum depth of a swale should normally be less than 450mm. This allows successful vegetation establishment and safe public and maintenance access. Where spatial constraints prohibit the construction of slopes within the specified gradients, the City Council may approve the use of steeper profiles in some areas. The steeper slopes should be limited to less accessible sides of a swale.
- Generally gullies should not be used to collect water and pass it into swales. This results in swales that are deeper than required, unsightly and less safe. Over the edge flow across a small filter strip or shallow inlets is preferred to achieve the maximum depth stated above.
- Sufficient cross over points should be provided where pedestrians will want to cross the swale. These can be small causeways or bridges to suit the location and landscape character.
- Where swales lead to ponds or basins it helps keep these shallower. It will also help prevent problems meeting shallow outfall points.
- The water level in a swale must not rise more than 150mm to 300mm during a 1 in 30 year or greater rainfall event (maximum depends on location with the lower depth appropriate in streets). Flows across filter strips rarely exceed 50mm depth.
- Providing swales are shallow and blend into the landscape then fencing should not generally be required to prevent access. However in street situations some form of fencing or bollards may be required to prevent vehicles parking in swales.
- Liners should not be used below swales except where required to stop water soaking into the ground. Examples include where it is necessary to prevent contamination from known sources of pollution entering the ground. Where a liner is used it should be sufficiently robust to resist puncture and should be covered with a minimum of 300mm depth of mixed topsoil and subsoil including at the edges.
- Topsoil (150mm thick) should be applied to swales and filter strips wherever water will be present, usually up to the maximum water level. This approach is contrary to ecological best practice and the reason it is required is to help rapid and permanent establishment of vegetation to resist erosion. For swales with a drain below them. the base will require covering with rootzone material.

In urban areas swales may have harder edge features to suit the surrounding landscape, but can still be shallow and have a flat bottom with vegetation in it.

Specific filter drain adoption requirements

Specific adoption requirements for Cambridge City Council are:

- Any filter drains that are to be adopted by Cambridge City Council must be designed in accordance with The SUDS Manual (CIRIA 697) and the Specification for Highway Works (Highways Agency). Where there are conflicting requirements this guide shall take precedence.
- Gullies should not be used to collect water and pass it into filter drains. This is likely to clog the filter drain. Over the edge drainage across a small filter strip or via some other source control feature that removes silt is necessary.
- Liners should not be used around filter drains except where required to stop water soaking into the ground. Examples include where it is necessary to prevent contamination from known sources of pollution entering the ground. Where a liner is used it should be sufficiently robust to resist puncture.

Specific canal adoption requirements

The adoption criteria for Cambridge City Council are:

- Canals, rills and other channels should have a maximum water depth of 150mm.

Specific Inlet adoption requirements

The adoption criteria for Cambridge City Council are:

- Inlets and outlets in the sloping sides of ponds, basins or swales should be chamfered pipes to suit the angle of the slope.
- Vertical headwalls in open spaces will not generally be acceptable.
- Control features such as orifices and weirs should be on the surface where possible. Where control structures are below ground they should be accessible for maintenance from the surface without the need for entry into chambers.
- There should be an overflow route around a control feature in case it becomes blocked.

Verification of construction

The City Council will require verification that any SUDS they are to adopt have been constructed in accordance with the agreed design and specification. Verification will take the form of developer supplied documentation and City Council inspection during construction.

Work shall not start on site until the planning authority case officer has formally approved the adoption design plans and specification in writing. Once in place, the City Council should be given at least two weeks notice of the start of construction of the development and should be provided with a programme of works. The Council should be notified of any significant changes to the program.

The SUDS construction should be carried out to the satisfaction of the City Council's SUDS Engineer, who shall be provided with free access at all reasonable times to any part of the SUDS works or other works that may affect the operation of the SUDS.

During construction the developer may be required to prove the thickness and type of any material or layer, if it has been covered prior to inspection. Any work that cannot be inspected because the appropriate notice has not been received will result in the work being re-opened for inspection and reinstated at no expense to the City Council.

A pre-excavation inspection will be required to ensure construction run-off is being adequately dealt with and will not clog constructed SUDS features or pollute downstream features.

The developer's consultant should also inspect the construction and materials used. The consultant should prepare a site inspection plan and verification report. This will be site specific but as a minimum it will be expected to include the following:

- Photographs of excavations, confirmation of soil conditions, confirmation of levels, profiles and general earthworks.
- Photographs and full manufacturer's details (if appropriate) of inlets, outlets and any control structures associated with any feature to be adopted.
- Confirmation of topsoil sources with appropriate certificates.
- Full planting list and confirmation of plant sources, planting method statement and initial maintenance regime.
- Confirmation of subsoil and topsoil depths.
- Confirmation of gravel fill specification and sources, installation method statement of filter drains.
- Conformation of source and test certificates for membrane liners if used. Membranes shall have welded joints and shall be inspected and the joints tested after installation. Records of the tests shall be provided.

- Photographs of the feature before and after planting.
- Full as constructed drawings and a topographical survey of the 'as constructed' feature.
- Confirmation of initial maintenance regimes.

The City Council will require a maintenance period of one year after completion of the whole development served by a SUDS. During this period the provision for a review of the performance of the SUDS features to allow minor adjustments and refinements based on observed performance should be provided. Any adjustments made will be at the developer's expense. At the end of the maintenance period there will be a final inspection. Any accumulated silt will have to be removed at this time and any areas of erosion or other defects repaired.

The City Council reserves the right to decline the adoption of any system that is not designed in accordance with the essential adoption requirements and where construction is not verified as detailed within this document.

Health and safety

The City Council will generally require SUDS ponds to be small and shallow with gentle side slopes which should also minimise health and safety risks. However, all proposals should accord with the requirements of the Construction, Design and Management Regulations 2007. This requires hazards to be removed by design wherever possible rather than providing mitigation to manage risk. For example, a pond designed to the principles of this guide (shallow, gentle slopes, wet benches) minimises the hazard and is better than a large deep pond, with steep side slopes that requires a fence to make it safe.

Child safety must be considered in pond and wetland design. This is best dealt with by measures mentioned in the guide such as shallow slopes, minimising water bodies of any depth and the use of peripheral planting. Larger fences cause their own safety problems (ease of access for rescue is hindered and they attract older children to climb over them) and are not recommended. However, where very young children up to the age of five years are likely to be present, and could potentially be unsupervised, a low toddler proof fence may be considered, that is sufficiently low to allow adults to get over it quickly.

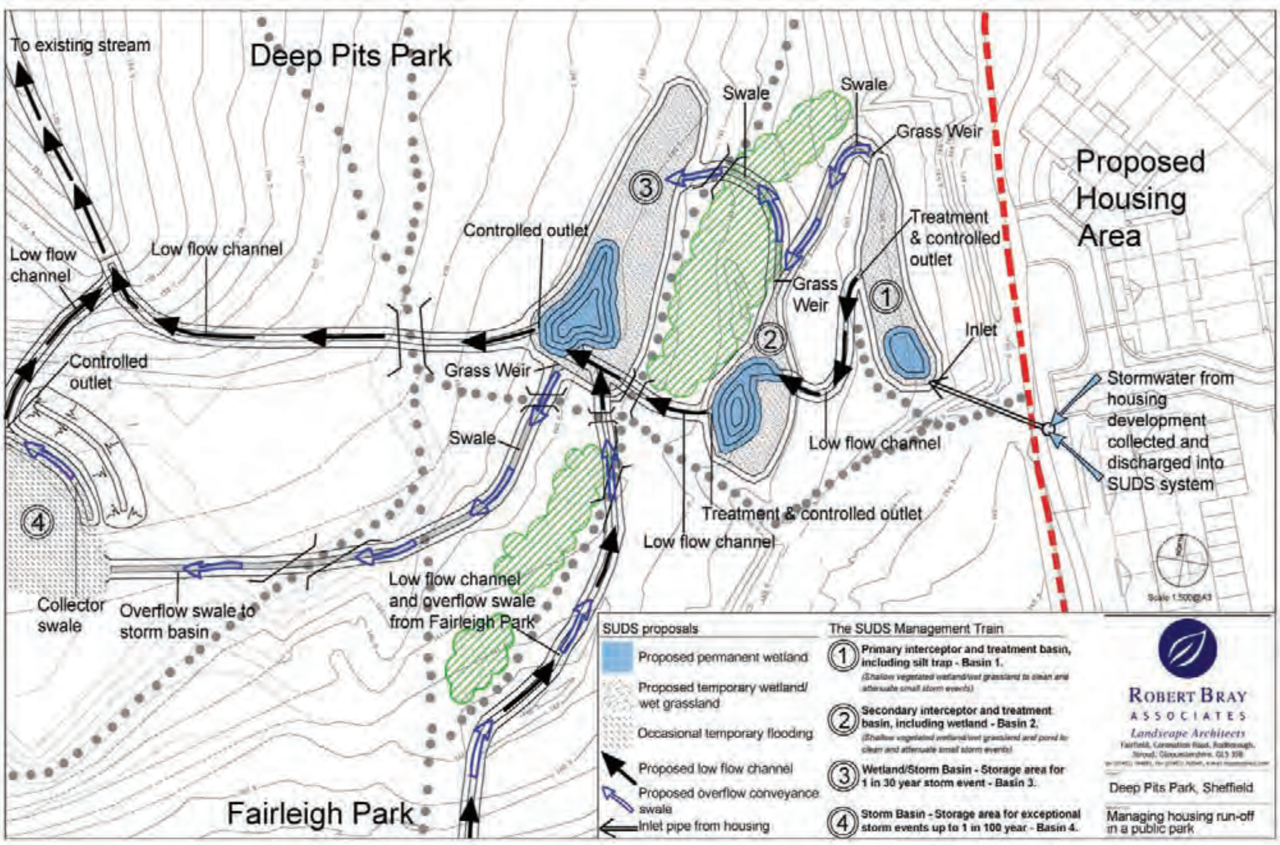
Written evidence prior to construction will be required to demonstrate that all necessary health and safety risk assessments of the proposals have been undertaken by the developer and their advisors. Such risk assessments should consider all work phases, including construction, long term maintenance work and risks to the public during operation.

Appendices

A. Example of maintenance costs

Costs for SUDS in public park

The costs to maintain the SUDS scheme shown on the plan below have been estimated. The scheme serves a housing estate to the east of the site which delivers unattenuated and untreated runoff to the system. The system was approved and adopted by the local authority (Sheffield City Council). It is located in a park that is also owned and managed by the local authority. The system has been operational since 2006 and dealt easily with flows that occurred during heavy rainfall that caused heavy flooding in other parts of Sheffield in 2007.



Example - SUDS in public open space or park

SUDS scheme

Item	Description	Unit	Total
1	Overall park area	m2	40000
2	Ponds/wetlands (total area)	m2	650
3	Ponds/wetlands (water area)	m2	325
4	Retention basin	m2	2800
5	Swale	m	415
6	Control structures	No	9
7	Catchment area (impermeable)	m2	23600

General rates - cost per visit to site **40000 m2 site**

No per year	Item	Unit	Rate	Total per visit for site inc all SUDS 40000 m2 site	Total per visit for site if no SUDS in site	Comments
12	Litter removal	100m2	0.67	£268.00	£268.00	
12	Inspect control structures to pond or wetland (assumes surface features and no special tools required)	Item	5	£45.00	£0.00	£20 per control structure
12	Grass cutting on slopes around pond above temporary water level - amenity grass	100m2	1.14	£448.59	£456.00	Total park area minus pond area assumed for SUDS costs
1	Scrub clearance from bankside	100m2	5.83	£91.53	£0.00	Around SUDS ponds and swale only only
1	Cut 25% to 30% wetland vegetation and remove to site wildlife piles	100m2	3.38	£21.97	£0.00	
1	Removal of all arisings (scrub clearance and wetland vegetation)	100m2	2.65	£50.22	£0.00	
	Total per visit if all items completed			**£925.31**	**£724.00**	
	Total per visit for litter removal, inspection and grass cutting			**£761.59**	**£724.00**	
	Total annual cost			**£9,302.80**	**£8,688.00**	
	Additional annual cost for presence of SUDS for a 40000 m2 site including a 15% contingency for unexpected work.			**£707.02**	**Plus silt removal every 5 years £907.97**	

Cost per visit based on labour rates

Item	No	Unit	Rate	Full day (8 hours)
Labourers x 3	8	hour	15.5	372.00
Light van (eg transit)	1	day	36	36.00
Small ride on mower	8	hour	8.75	70.00
Ancillary tools and equipment	1	day	20	20.00
Disposal of cuttings off site	1	Item	150	150.00
Total per visit				**498.00**
Total for 12 visits per year				**5976.00**
Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow one extra visit per year				**498.00**

Pond silt removal every 5 years

Assume a specific visit is made for this work	No	Unit	Rate	Full day (8 hours)
Labourers x 3	8	hour	15.5	372.00
Light van (eg transit)	1	day	36	36.00
Small mini excavator, rubber tracks (self drive)	8	hour	8.75	70.00
Delivery charge in Cambridge from local hire company	1	Item	30	30.00
Ancillary tools and equipment	1	day	20	20.00
Disposal of silt (volume depends on catchment area)	7.42	m^3	51.18	379.97
Total				**907.97**

Notes
All rates and base costs taken from SPON'S External Works and Landscape Price Book 2008

Silt loading

Parameter	Units	Value	
Silt load (TSS)	kg/ha/yr	755	Maximum load for high density housing
Silt density in pond	kg/m^3	1200	
Silt accumulation pond	m^3/y/ha impermeable catchment area	0.63	
Total silt accumualtion over 5 years for catchment	m^3	7.42	

B. Detailed maintenance costs for each feature

Maintenance requirements and costs of ponds and wetlands

Most of the maintenance will be required as part of the overall open space maintenance. The costs are based on the assumption that a specific visit to site is made to carry out the maintenance in the SUDS pond or wetland. If they are incorporated into the general maintenance there will only be some additional costs where extra work relating to the SUDS feature needs to be undertaken above and beyond the cost for the general landscape. Items that are specific to a SUDS pond or wetland that will be carried out in addition to general landscape maintenance are highlighted in blue. The costs assume that access to the site is easy. Minimum costs are based on the cost to visit a site and the rates for larger areas are based on information in the SPON's External Works and Landscape Price Book 2008 and will be updated as necessary. There is no allowance for profit in the costs.

<table>
<tr><th rowspan="2">Item</th><th rowspan="2">Frequency</th><th rowspan="2">Comments</th><th colspan="2">Cost</th></tr>
<tr><th>Minimum cost for small areas of POS (based on fixed cost of a site visit)</th><th>£/100m^2 per visit for larger POS areas</th></tr>
<tr><td>Litter removal</td><td>1 per month</td><td>Litter quantity and characteristics will be dependant on the site
Litter may collect in ponds and wetland features
Litter collection may be part of the general landscape maintenance
Litter collection should be undertaken at each site visit and the beginning of any maintenance task, particularly grass cutting
All litter must be removed from site</td><td rowspan="2">1 site visit with 3 men, 1 light van, mower and ancillary equipment.
Half day visit comprises 3 hours on site and 1 hour travelling.
Half day maximum POS area including SUDS is about 4000 m^2 (including pond or wetland vegetation).
Cost per visit = £249</td><td>0.67</td></tr>
<tr><td>Inspect control structures to/from pond or wetland</td><td>1 per month</td><td>Surface control structures can be slot weirs, V-notch or gabion baskets with control in the stone fill. They can be inspected without removing covers or special keys</td><td>£5/ structure</td></tr>
<tr><td>Grass cutting on slopes around pond above temporary water level – amenity grass</td><td>1 per month</td><td>All grass cuttings managed on site in wildlife or compost piles</td><td rowspan="3">Full day visit comprises 7 hours on site and 1 hour travelling.
One day maximum POS area including SUDS is about 10000m^2 (including pond or wetland vegetation)
Cost per visit = £498</td><td>1.14</td></tr>
<tr><td>Scrub clearance from bankside</td><td>1 per year</td><td>Overhanging branches and encroaching growth will normally be undertaken as part of landscape maintenance</td><td>5.83</td></tr>
<tr><td>Cut 25% to 30% wetland vegetation and remove to site wildlife piles</td><td>1 per year</td><td></td><td>3.38</td></tr>
<tr><td>Remove planting and silt from 25% to 30% of base and place in site piles</td><td>1 per 5 years</td><td>Silt accumulation is slow if 'source control' features are located upstream in the 'management train'
Only required once every 5 years</td><td colspan="2">Assume 1 site visit with 3 men, 1 light van, small excavator and ancillary equipment. Total pond area up to 1200m^2
Cost per visit = £689
Disposal of silt by truck with mechanical grab (assuming it is not special waste) £51.18/m^3</td></tr>
<tr><td>Extra cost if silt, grass cuttings, etc are removed from site during routine maintenance</td><td>To suit other operations</td><td>Ideally all cuttings should be used on site to construct and maintain wildlife piles but this may not be the best option in public open space and removal from the site may be needed.</td><td colspan="2">£2.65/100m^2 cleared.
Assumes the waste is not classified as special waste and proportion of silt is minor (which should be the case if source control is in place upstream). Disposal of silt by truck with mechanical grab (assuming it is not hazardous or special waste) £55/m^3</td></tr>
</table>

= SUDS Specific Items

Ponds and Wetlands

No per year	General rates - cost per visit to site	No	Unit	Rate	Total per visit for site inc all SUDS 10000 m2 site	Page reference in SPON'S
	Item (10000 m2 site)					
12	Litter removal	10000	100m2	0.67	67	Pg 216 collection and disposal of litter from isolated grassed area
12	Inspect control structures to pond or wetland (assumes surface features and no special tools required)	4	No	5	20	Allow £5 per structure
12	Grass cutting on slopes around pond above temporary water level - amenity grass	10000	100m2	1.14	114	Page 214 self propelled rotary mower, 91cm cut width, removing arisings not exceeding 30 deg from horizonal (0.36 + 0.78 = 1.14)
1	Scrub clearance from bankside	10000	100m2	5.83	583	Page 216 use rate for clearing leaf and other debris from verges by hand
1	Cut 25% to 30% wetland vegetation and remove to site wildlife piles	2500	100m2	3.38	84.5	Page 214 cutting grass or light woody undergrowth using strimmer not exceeding 30 deg
1	Removal of all arisings (scrub clearance and wetland vegetation)	2500	100m2	2.65	66.25	Page 216 use rate for removal of arisings from areas containing shrub beds.
	Total per visit if all items completed				**934.75**	
	Total per visit for litter removal, inspection and gress cutting				**201**	
	Total annual cost				**3145.75**	
	Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow 15%				**471.86**	

Cost per visit based on labour rates

Item	No	Unit	Rate	Half day (4 hours)	Full day (8 hours)	Page reference in SPON'S
Labourers x 3	8	hour	15.5	186.00	372.00	Page 8 includes overheads, tools, site kit, etc but not profit
Light van (eg transit)	1	day	36	18.00	36.00	Page 8 includes fuel, insurance, etc
Small ride on mower	8	hour	8.75	35.00	70.00	Assumes rate for mower is same as for a mini excavator, self drive and no delivery charge or minimum hire
Ancillary tools and equipment	1	day	20	10.00	20.00	Allowance for tools such as strimmers, etc
Disposal of cuttings off site	1	Item	150	150.00	150.00	Cost based on small skip specific for disposal from a particular site - 6m^3 (The more sites that are maintained the less this cost may become)
Total per visit				**249.00**	**498.00**	
Total for 12 visits per year				**2988.00**	**5976.00**	
Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow one extra visit per year				**249.00**	**498.00**	

Pond silt removal every 5 years

Assume a specific visit is made for this work	No	Unit	Rate	Half day (4 hours)	Full day (8 hours)	Page reference in SPON'S
Labourers x 3	8	hour	15.5	186.00	372.00	Page 8 includes overheads, tools, site kit, etc but not profit
Light van (eg transit)	1	day	36	18.00	36.00	Page 8 includes fuel, insurance, etc
Small mini excavator, rubber tracks (self drive)	8	hour	8.75	35.00	70.00	Page 15, self drive and no delivery charge. Minimum hire 8 hours
Delivery charge in Cambridge from local hire company	1	Item	30	30.00	30.00	Assume £30 for both ways
Ancillary tools and equipment	1	day	20	10.00	20.00	Allowance for tools such as strimmers, etc
Disposal of silt for SUDS serving 1 Ha site (volume depends on catchment area)	0.63	m^3	51.18	161.00	161.00	Allow 0.63m^3 per year per ha of catchment area (impermeable), based on 755kg/ha/yr and density of 1200kg/m^3 from Darcy et al (2000). Cost from Page 106, wet clay
Total				**440.00**	**689.00**	

Notes
All rates and base costs taken from SPON'S External Works and Landscape Price Book 2008

Silt loading

Parameter	Units	Value	
Silt load (TSS)	kg/ha/yr	755	Maximum load for high density housing
Silt density in pond	kg/m^3	1200	
Silt accumulation pond	m^3/y/ha impermeable catchment area	0.63	

Maintenance requirements and costs of basins

Most of the maintenance will be required as part of the overall open space maintenance. The costs are based on the assumption that a specific visit to site is made to carry out the maintenance in the SUDS basin. If they are incorporated into the general maintenance there will only be some additional costs where extra work relating to the SUDS feature needs to be undertaken above and beyond the cost for the general landscape. Items that are specific to a basin that will be carried out in addition to general landscape maintenance are highlighted in blue. The costs assume that access to the site is easy. Minimum costs are based on the cost to visit a site and the rates for larger areas are based on information in the SPON's external works and landscape price book 2008 and will be updated as necessary. There is no allowance for profit in the costs.

Item	Frequency	Comments	Cost	
			Minimum cost for small areas of POS (based on fixed cost of a site visit)	**£/100m^2 per visit for larger areas of POS**
Litter removal	1 per month	Litter quantity and characteristics will be dependant on the site Litter may collect in ponds and wetland features Litter collection may be part of the general landscape maintenance Litter collection should be undertaken at each site visit and the beginning of any maintenance task, particularly grass cutting All litter must be removed from site	1 site visit with 3 men, 1 light van, mower and ancillary equipment. Half day visit comprises 3 hours on site and 1 hour travelling. Half day maximum area = 4000 m^2 (including pond or wetland vegetation) Cost per visit = £249	0.67
Inspect control structures to/from basin	1 per month	Surface control structures can be slot weirs, V-notch or gabion baskets with control in the stone fill. They can be inspected without removing covers or special keys. Maintenance of control structures in manhole chambers will be more expensive.		£5/ structure
Grass cutting on slopes and in bottom of basin – amenity grass	1 per month	All grass cuttings managed on site in wildlife or compost piles	Full day visit comprises 7 hours on site and 1 hour travelling. One day maximum area = 10000m^2 (including pond or wetland vegetation) Cost per visit = £498	1.14
Scrub clearance from bankside	1 per year	Overhanging branches and encroaching growth will normally be undertaken as part of landscape maintenance		5.83
Habitat mosaic 30% cut and remove to site wildlife piles (see Section on ponds and wetlands)	1 per year	Carry out September to November if possible to minimise disruption to wildlife		3.38
Scarify and spike base of infiltration basin if necessary at same time	1 per 5 years	This would typically be undertaken at the same time and as part of the visit to remove silt.	Inc in silt removal costs with nominal extra allowance for scarifying plant	1.29
Remove silt from base and place in site piles (see Section on ponds and wetlands)	1 per 5 years	Silt accumulation is slow if 'source control' features are located upstream in the 'management train' Only required once every 5 years	Assume 1 site visit with 3 men, 1 light van, small excavator and ancillary equipment. Basin area up to 1200m^2 Cost per visit = £689 Disposal of silt by truck with mechanical grab (assuming it is not special waste) £51.18/m^3	
Extra cost if silt, grass cuttings, etc are removed from site during routine maintenance	To suit other operations	Ideally all cuttings should be used on site to construct and maintain wildlife piles but this may not be the best option in public open space and removal from the site may be needed.	£2.65/m^2 cleared. Assumes the waste is not classified as special waste and proportion of silt is minor (which should be the case if source control is in place upstream). Disposal of silt by truck with mechanical grab (assuming it is not hazardous or special waste) £55/m^3	

= SUDS Specific Items

Basins

No per year	General rates - cost per visit to site Item	10000 m² site No	Unit	Rate	Total per visit for site inc all SUDS 10000 m2 site	Page reference in SPON'S
12	Litter removal	10000	100m²	0.67	67	Pg 216 collection and disposal of litter from isolated grassed area
12	Inspect control structures to basin (assumes surface features and no special tools required)	4	No	5	20	Allow £5 per structure
12	Grass cutting on slopes and in bottom of basin - amenity grass	10000	100m²	1.14	114	Page 214 self propelled rotary mower, 91cm cut width, removing arisings not exceeding 30 deg from horizonal (0.36 + 0.78 = 1.14)
1	Scrub clearance from bankside	10000	100m²	5.83	583	Page 216 use rate for clearing leaf and other debris from verges by hand
1	Habitat mosaic 30% cut and remove to site wildlife piles	3300	100m²	3.38	111.54	Page 214 cutting grass or light woody undergrowth using strimmer not exceeding 30 deg
1	Removal of all arisings (scrub clearance and vegetation)	3300	100m²	2.65	87.45	Page 216 use rate for removal of arisings from areas containing shrub beds.
	Total per visit if all items completed				**982.99**	
	Total per visit for litter removal, inspection and grass cutting				**201**	
	Total annual cost				**3193.99**	
	Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow 15%				**479.10**	

Cost per visit based on labour rates

Item	No	Unit	Rate	Half day (4 hours)	Full day (8 hours)	Page reference in SPON'S
Labourers x 3	8	hour	15.5	186.00	372.00	Page 8 includes overheads, tools, site kit, etc but not profit
Light van (eg transit)	1	day	36	18.00	36.00	Page 8 includes fuel, insurance, etc
Small ride on mower	8	hour	8.75	35.00	70.00	Assumes rate for mower is same as for a mini excavator, self drive and no delivery charge or minimum hire
Ancillary tools and equipment	1	day	20	10.00	20.00	Allowance for tools such as strimmers, etc
Disposal of cuttings off site	1	Item	150	150.00	150.00	Cost based on small skip specific for disposal from a particular site - 6m³ (The more sites that are maintained the less this cost may become)
Total per visit				**249.00**	**498.00**	
Total for 12 visits per year				**2988.00**	**5976.00**	
Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow one extra visit per year				**249.00**	**498.00**	

Basin silt removal, scarifying and spiking every 5 years

Assume a specific visit is made for this work	No	Unit	Rate	Half day (4 hours)	Full day (8 hours)	Page reference in SPON'S
Labourers x 3	8	hour	15.5	186.00	372.00	Page 8 includes overheads, tools, site kit, etc but not profit
Light van (eg transit)	1	day	36	18.00	36.00	Page 8 includes fuel, insurance, etc
Small mini excavator, rubber tracks (self drive)	8	hour	8.75	70.00	70.00	Page 15, self drive and no delivery charge. Minimum hire 8 hours
Delivery charge in Cambridge from local hire company	1	Item	30	30.00	30.00	Assume £30 for both ways
Ancillary tools and equipment to scarify and spike	1	day	40	20.00	40.00	Allowance for tools such as strimmers, pedestrian operated scarifying equipment, etc
Disposal of silt from SUDS serving 1 Ha catchment (volume depends on catchment area)	0.63	m³	51.18	161.00	161.00	Allow 0.63m³ per year per ha of catchment area (impermeable), based on 755kg/ha/yr and density of 1200kg/m³ from Darcy et al (2000). Cost from Page 106, wet clay
Total				**485.00**	**709.00**	

Notes
All rates and base costs taken from SPON'S External Works and Landscape Price Book 2008

Scarifying and spiking every five years

General rates - cost per visit to site, 10000m² site

Item	No	Unit	Rate	Total per visit for 4000m² site inc all SUDS	Page reference in SPON'S
Scarifying using pedestrian operated plant	10000	100m²	1.29	129	Pg 215 Scarifying mechanical
Removal and disposal of arisings	10000	100m²	11.41	1141	Pg 215

Silt loading

Parameter	Units	Value	
Silt load (TSS)	kg/ha/yr	755	Maximum load for high density housing
Silt density in basin	kg/m³	1200	
Silt accumulation basin	m³/y/ha impermeable catchment area	0.63	

Maintenance requirements and costs of swales and filter strips

Most of the maintenance will be required as part of the overall open space maintenance. The costs are based on the assumption that a specific visit to site is made to carry out the maintenance in the SUDS swale or filter strip. If they are incorporated into the general maintenance there will only be some additional costs where extra work relating to the SUDS feature needs to be undertaken above and beyond the cost for the general landscape. Items that are specific to a SUDS swale or filter strip that will be carried out in addition to general landscape maintenance are highlighted in blue. The costs assume that access to the site is easy. Minimum costs are based on the cost to visit a site and the rates for larger areas are based on information in the SPON's External Works and Landscape Price Book 2008 and will be updated as necessary. There is no allowance for profit in the costs.

Item	Frequency	Comments	Cost	
			Minimum cost for small areas of POS (based on fixed cost of a site visit)	£/100m^2 per visit for larger areas of POS
Litter removal	1 per month	Litter quantity and characteristics will be dependant on the site Litter may collect in swales Litter collection may be part of the general landscape maintenance Litter collection should be undertaken at each site visit and the beginning of any maintenance task, particularly grass cutting All litter must be removed from site	1 site visit with 3 men, 1 light van, mower and ancillary equipment. Half day visit comprises 3 hours on site and 1 hour travelling. Half day maximum area = 4000 m^2 (including pond or wetland vegetation) Cost per visit = £249 Full day visit comprises 7 hours on site and 1 hour travelling. One day maximum area = 10000m^2 (including pond or wetland vegetation) Cost per visit = £498	0.67
Inspect control structures to/from swale	1 per month	Surface control structures can be slot weirs, V-notch or gabion baskets with control in the stone fill. They can be inspected without removing covers or special keys. Maintenance of control structures in manhole chambers will be more expensive.		£5/ structure
Grass cutting in swale – amenity grass	1 per month	All grass cuttings managed on site in wildlife or compost piles		1.14
Scrub clearance from bankside	1 per year	Overhanging branches and encroaching growth will normally be undertaken as part of landscape maintenance		5.83
Remove planting and silt from 25% to 30% of base and place in site piles	1 per 5 years	Silt accumulation is slow if swale is design ed as a source control feature. Carry out September to November if possible to minimise disruption to wildlife. Only required once every 5 years	Assume 1 site visit with 3 men, 1 light van, small excavator and ancillary equipment. Pond area up to 1200m^2 Cost per visit = £689 Disposal of silt by truck with mechanical grab (assuming it is not special waste) £51.18/m^3	
Extra cost if silt, grass cuttings, etc are removed from site during routine maintenance	To suit other operations	Ideally all cuttings should be used on site to construct and maintain wildlife piles but this may not be the best option in public open space and removal from the site may be needed.	£2.65/100m^2 cleared. Assumes the waste is not classified as special waste and proportion of silt is minor (which should be the case if swale is designed as a source control feature). Disposal of silt by truck with mechanical grab (assuming it is not hazardous or special waste) £55/m^3	

= SUDS Specific Items

Swales and filter strips

No per year	General rates - cost per visit to site	No	Unit	Rate	Total per visit for site inc all SUDS 10000 m2 site	Page reference in SPON'S
	10000 m^2 site					
	Item	**No**	**Unit**	**Rate**	**Total per visit for site inc all SUDS 10000 m2 site**	**Page reference in SPON'S**
12	Litter removal	10000	$100m^2$	0.67	67	Pg 216 collection and disposal of litter from isolated grassed area
12	Inspect control structures to swale (assumes surface features and no special tools required)	4	No	5	20	Allow £5 per structure
12	Grass cutting on slopes and in bottom of swale - amenity grass	10000	$100m^2$	1.14	114	Page 214 self propelled rotary mower, 91cm cut width, removing arisings not exceeding 30 deg from horizonal (0.36 + 0.78 = 1.14)
1	Scrub clearance from bankside	10000	$100m^2$	5.83	583	Page 216 use rate for clearing leaf and other debris from verges by hand
1	Removal of all arisings (scrub clearance and vegetation)	3300	$100m^2$	2.65	87.45	Page 216 use rate for removal of arisings from areas containing shrub beds.
	Total per visit if all items completed				**871.45**	
	Total per visit for litter removal, inspection and gress cutting				**201**	
	Total annual cost				**3082.45**	
	Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow 15%				**462.37**	

Cost per visit based on labour rates

Item	No	Unit	Rate	Half day (4 hours)	Full day (8 hours)	Page reference in SPON'S
Labourers x 3	8	hour	15.5	186.00	372.00	Page 8 includes overheads, tools, site kit, etc but not profit
Light van (eg transit)	1	day	36	18.00	36.00	Page 8 includes fuel, insurance, etc
Small ride on mower	8	hour	8.75	35.00	70.00	Assumes rate for mower is same as for a mini excavator, self drive and no delivery charge or minimum hire
Ancillary tools and equipment	1	day	20	10.00	20.00	Allowance for tools such as strimmers, etc
Disposal of cuttings off site	1	Item	150	150.00	150.00	Cost based on small skip specific for disposal from a particular site - $6m^3$ (The more sites that are maintained the less this cost may become)
Total per visit				**249.00**	**498.00**	
Total for 12 visits per year				**2988.00**	**5976.00**	
Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow one extra visit per year				**249.00**	**498.00**	

Swale silt removal every 5 years

Assume a specific visit is made for this work	No	Unit	Rate	Half day (4 hours)	Full day (8 hours)	Page reference in SPON'S
Labourers x 3	8	hour	15.5	186.00	372.00	Page 8 includes overheads, tools, site kit, etc but not profit
Light van (eg transit)	1	day	36	18.00	36.00	Page 8 includes fuel, insurance, etc
Small mini excavator, rubber tracks (self drive)	8	hour	8.75	70.00	70.00	Page 15, self drive and no delivery charge. Minimum hire 8 hours
Delivery charge in Cambridge from local hire company	1	Item	30	30.00	30.00	Assume £30 for both ways
Ancillary tools and equipment	1	day	40	20.00	40.00	Allowance for tools such as strimmers, pedestrian operated scarifying equipment, etc
Disposal of silt assuming SUDS serves 1 Ha catchment (volume depends on catchment area)	0.63	m^3	51.18	161.00	161.00	Allow $0.63m^3$ per year per ha of catchment area (impermeable), based on 755kg/ha/yr and density of $1200kg/m^3$ from Darcy et al (2000). Cost from Page 106, wet clay
Total				**485.00**	**709.00**	

Notes
All rates and base costs taken from SPON'S External Works and Landscape Price Book 2008

Alternative rate per metre of swale

Clear vegetation from swale with strimmer	100	m	149.12	Pg 256 Ditching clear only vegetation from ditch not exceeding 1.5m deep. Dispose to spoil heaps width at top 2.5m to 4m
Disposal of vegetation off site	100	m	1193	Allow extra for disposal off site by truck. Use rate from page 216 for disposal of arisings from leaf clearance based on plan area of 1m length of swale - $4.5m^2$ and a rate of £2.65/m^2 typically if shallow as required in this guide. Deeper swales will be more expensive.
Total cost per 100 metre of swale			**1342.12**	

Silt loading

Parameter	Units	Value	
Silt load (TSS)	kg/ha/yr	755	Maximum load for high density housing
Silt density in swale	kg/m^3	1200	
Silt accumulation swale	m^3/y/ha impermeable catchment area	0.63	

Maintenance requirements and costs of filter drains

Most of the maintenance will be required as part of the overall open space maintenance. The costs are based on the assumption that a specific visit to site is made to carry out the maintenance in the SUDS filter drain. If they are incorporated into the general maintenance there will only be some additional costs where extra work relating to the SUDS feature needs to be undertaken above and beyond the cost for the general landscape. Items that are specific to a SUDS filter drain that will be carried out in addition to general landscape maintenance are highlighted in blue. The costs assume that access to the site is easy. Minimum costs are based on the cost to visit a site and the rates for larger areas are based on information in the SPON's External Works and Landscape Price Book 2008 and will be updated as necessary. There is no allowance for profit in the costs.

Item	Frequency	Comments	Cost	
			Minimum cost for small areas of POS (based on fixed cost of a site visit)	£/m per visit for longer lengths
Litter removal	1 per month	Litter quantity and characteristics will be dependant on the site Litter may collect on top of filter drains Litter collection may be part of the general landscape maintenance Litter collection should be undertaken at each site visit and the beginning of any maintenance task, particularly grass cutting All litter must be removed from site	1 site visit with 2 men, 1 light van and ancillary equipment. Half day visit comprises 3 hours on site and 1 hour travelling. Half day (including any other open areas or SUDS in site) Cost per visit = £152 Full day visit comprises 7 hours on site and 1 hour travelling. Full day (including any other open areas or SUDS in site) Cost per visit = £304	0.67
Inspect control structures to/from filter drains	1 per month	Surface control structures can be slot weirs, V-notch or gabion baskets with control in the stone fill. They can be inspected without removing covers or special keys Filter drains may well have control structures located in manholes or inspection chambers. Maintenance of control structures in manhole chambers will be more expensive.		£20/structure
Remove top 300mm of gravel, clean and replace. Remove silt from site	1 per 5 years	Silt accumulation is slow if filter drain is protected by a filter strip or other source control feature	Assume 1 site visit with 3 men, 1 light van, small excavator and ancillary equipment. Filter drain up to 100m length Cost per visit = £866 Disposal of silt by truck with mechanical grab (assuming it is not hazardous or special waste) £55/m^3	

= SUDS Specific Items

Filter drains

General rates - cost per visit to site **10000 m^2 site**

No per year	Item	No	Unit	Rate	Total per visit for site inc all SUDS 10000 m2 site	Page reference in SPON'S
12	Litter removal	10000	$100m^2$	0.67	67	Pg 216 collection and disposal of litter from isolated grassed area assume filter drain is maintained as part of wider management of area
12	Inspect control structures to filter drain (assumes surface features and no special tools required)	4	No	20	20	Allow £20 per structure as they are more likley to be in manholes for filter drains
	Total per visit if all items completed				**87**	
	Total per visit for litter removal, inspection and gress cutting				**87**	
	Total annual cost				**1044**	
	Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow 15%				**156.6**	

Cost per visit based on labour rates

Item	No	Unit	Rate	Half day (4 hours)	Full day (8 hours)	Page reference in SPON'S
Labourers x 2	8	hour	15.5	124.00	248.00	Page 8 includes overheads, tools, site kit, etc but not profit. Assume that if visit is specifically to maintain filter drain then a gang of 2 men will be used.
Light van (eg transit)	1	day	36	18.00	36.00	Page 8 includes fuel, insurance, etc
Ancillary tools and equipment	1	day	20	10.00	20.00	Allowance for tools
Total per visit				**152.00**	**304.00**	
Total for 12 visits per year				**1824.00**	**3648.00**	
Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow one extra visit per year				**152.00**	**304.00**	

Gravel removal by machine every 5 years

Assume a specific visit is made for this work	No	Unit	Rate	Half day (4 hours)	Full day (8 hours)	Page reference in SPON'S
Labourers x 2	8	hour	15.5	124.00	248.00	Page 8 includes overheads, tools, site kit, etc but not profit
Light van (eg transit)	1	day	36	18.00	36.00	Page 8 includes fuel, insurance, etc
Small mini excavator, rubber tracks (self drive)	8	hour	8.75	35.00	70.00	Page 15, self drive and no delivery charge. Minimum hire 8 hours
Delivery charge in Cambridge from local hire company	1	Item	30	30.00	30.00	Assume £30 for both ways
Disposal of gravel (top 300mm). This is worst case costs. Ideally the gravel would be cleaned and replaced. Only the geotextile would require replacement. Assume 100m length	18.00	m^3	26.77	240.93	481.86	Assume can excavate and replace 100m per day. Excavation = 0.3 x 0.6 x 100 = $18m^3$. 0.6m wide drain and disposal rate is for slightly contaminated material (majority will be the clean gravel pieces) Pg 105 disposal mechanical Recycled Materials Ltd
Install new geotextile assume 100m length	60.00	m^2	0.95	28.50	57.00	Pg 261 extra over for filter wrapping pipes with Terram or similar filter fabric. Replace top geotextile 0.6m by 100mm per metre length of drain
Replace gravel assume 100m length	18.00	m^3	40.7	366.30	732.60	Gravel = 0.3 x 0.6 x 100 = 18m3. 0.6m wide drain Page 137 Type 1 granular fill (rate /m^3 compacted material and compaction only)
Total				**447.93**	**865.86**	

Notes
All rates and base costs taken from SPON'S External Works and Landscape Price Book 2008

Alternative rate per metre of filter drain

Item	No	Unit	Rate	Page reference in SPON'S
Excavate gravel and replace	1	m	10.89	Pg 367 Excavate trench includes for excavation and filling with Type 2 (cost will be similar for filter drain material) and disposal of surplus soil. Not exceeding 0.5m depth.
Disposal off site	0.18	m^3	26.77	Allow extra for disposal as the gravel could be slightly contaminated.
Total cost per metre of filter drain			**37.66**	

Maintenance of canals, rills and treatment channels

Most of the maintenance will be required as part of the overall open space maintenance. The costs are based on the assumption that a specific visit to site is made to carry out the maintenance in the SUDS channels. If they are incorporated into the general maintenance there will only be some additional costs where extra work relating to the SUDS feature needs to be undertaken above and beyond the cost for the general landscape. Items that are specific to a SUDS channels that will be carried out in addition to general landscape maintenance are highlighted in blue. The costs assume that access to the site is easy. Minimum costs are based on the cost to visit a site and the rates for larger areas are based on information in the SPON's External Works and Landscape Price Book 2008 and will be updated as necessary. There is no allowance for profit in the costs.

Item	Frequency	Comments	Cost	
			Minimum cost for small areas less (based on fixed cost of a site visit)	**£ per visit for lengths greater than ??m**
Litter removal	1 per month	Litter quantity and characteristics will be dependant on the site Litter may collect on top of filter drains Litter collection may be part of the general landscape maintenance Litter collection should be undertaken at each site visit and the beginning of any maintenance task, particularly grass cutting All litter must be removed from site	1 site visit with 2 men, 1 light van and ancillary equipment. Half day visit comprises 3 hours on site and 1 hour travelling. Half day Cost per visit = £152 Full day visit comprises 7 hours on site and 1 hour travelling. Full day Cost per visit = £304	0.67 (general rate for litter removal on whole site)
Inspect control structures to/from filter canals, rills or treatment channels	1 per month	Surface control structures can be slot weirs, V-notch or gabion baskets with control in the stone fill. They can be inspected without removing covers or special keys Maintenance of control structures in manhole chambers will be more expensive.		£5/ structure
Remove silt. Remove silt from site	1 per 5 years	Silt accumulation is slow if canal is protected by source control feature Only required once every 5 years	Assume 1 site visit with 3 men, 1 light van and ancillary equipment. canal up to 100m length Cost per visit = £485 Disposal of silt by truck with mechanical grab (assuming it is not hazardous or special waste) £55/m^3	

= SUDS Specific Items

Canals and Rills

General rates - cost per visit to site **10000 m2 site**

No per year	Item	No	Unit	Rate	Total per visit for site inc all SUDS 10000 m2 site	Page reference in SPON'S
12	Litter removal	10000	100m2	0.67	67	Pg 216 collection and disposal of litter from isolated grassed area assume rill is maintained as part of wider management of area
12	Inspect control structures to swale (assumes surface features and no special tools required)	4	No	5	20	Allow £5 per structure
1	Scrub clearance and vegetation management in canals and rills	10000	100m2	5.83	583	Page 216 use rate for clearing leaf and other debris from verges by hand
1	Removal of all arisings (scrub clearance and vegetation)	3300	100m2	2.65	87.45	Page 216 use rate for removal of arisings from areas containing shrub beds.
	Total per visit if all items completed				**757.45**	
	Total per visit for litter removal, inspection and gress cutting				**87**	
	Total annual cost				**1714.45**	
	Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow 15%				**257.1675**	

Cost per visit based on labour rates

Item	No	Unit	Rate	Half day (4 hours)	Full day (8 hours)	Page reference in SPON'S
Labourers x 2	8	hour	15.5	124.00	248.00	Page 8 includes overheads, tools, site kit, etc but not profit. Assume that if visit is specifically to maintain canals or rills then a gang of 2 men will be used.
Light van (eg transit)	1	day	36	18.00	36.00	Page 8 includes fuel, insurance, etc
Ancillary tools and equipment	1	day	20	10.00	20.00	Allowance for tools such as strimmers, etc
Disposal of cuttings off site	1	Item	150	150.00	150.00	Cost based on small skip specific for disposal from a particular site - 6m^3 (The more sites that are maintained the less this cost may become)
Total per visit				**152.00**	**304.00**	
Total for 12 visits per year				**1824.00**	**3648.00**	
Contingency to allow for ad hoc work such as repairing erosion, vandalism, etc. Allow one extra visit per year				**152.00**	**304.00**	

Silt removal by hand every 5 years

Assume a specific visit is made for this work	No	Unit	Rate	Half day (4 hours)	Full day (8 hours)	Page reference in SPON'S
Labourers x 2	8	hour	15.5	124.00	248.00	Page 8 includes overheads, tools, site kit, etc but not profit
Light van (eg transit)	1	day	36	18.00	36.00	Page 8 includes fuel, insurance, etc
Ancillary tools and equipment to scarify and spike	1	day	40	20.00	40.00	Allowance for tools such as strimmers, pedestrian operated scarifying equipment, etc
Disposal of silt from SUDS serving 1Ha catchment (volume depends on catchment area)	0.63	m^3	51.18	161.00	161.00	Allow 0.63m^3 per year per ha of catchment area (impermeable), based on 755kg/ha/yr and density of 1200kg/m^3 from Darcy et al (2000). Cost from Page 106, wet clay
Total				**323.00**	**485.00**	

Notes
All rates and base costs taken from SPON'S External Works and Landscape Price Book 2008

Silt loading

Parameter	Units	Value	
Silt load (TSS)	kg/ha/yr	755	Maximum load for high density housing
Silt density in pond	kg/m^3	1200	
Silt accumulation pond	m^3/y/ha impermeable catchment area	0.63	

Minimum area for application of unit rates from SPONS
External works and landscape price book, 2008

Base minimum area on the area that can be covered by grass cutting

For half a day
Assume 1 hour travelling
Time on site = 3 hours
Assume slowest grass cutting speed around SUDS features and on small sites
Speed = 1mph
Width of cut - assume small mower 1m width
Capacity = 1529m^2/h
Area in 3 hours = 4587m^2
Say 4,000m^2 allowing for set up, etc
Note the actual rate could be lower or higher than this depending on mower width and the site layout

For full day
Assume 1 hour travelling
Time on site = 7 hours
Assume slowest grass cutting speed around SUDS features and on small sites
Speed = 1mph
Width of cut - assume small mower 1m width
Capacity = 1529m^2/h
Area in 7 hours = 10703m^2
Say 10,000m^2 allowing for set up, etc
Note the actual rate could be lower or higher than this depending on mower width and the site layout

For removing wetland vegetation and silt from ponds/wetlands, basins and swales
Assume 1 hour travelling
Time on site = 7 hours
Assume mid range excavation rate due to need for care around SUDS features and on small sites
Page 404 SPONS
Rate = 0.08m^3 per minute with 1.5 tonne mini excavator
Volume of material removed in 7 hours
33.6 m^3
Area covered in 7 hours, assuming 100mm silt per m^2 = 33.6/0.1 = 336m^2
Say 300m^2 allowing for set up, etc
This is 25% of pond area
Pond area total = 1200m^2

For removing gravel from filter drains
Assume 1 hour travelling
Time on site = 7 hours
Assume mid range excavation rate due to need for care around SUDS features and on small sites
Page 404 SPONS
Rate = 0.08m^3 per minute with 1.5 tonne mini excavator
Volume of material removed in 7 hours
33.6
Length covered in 7 hours, assuming 300mm deep layer per m = 33.6/0.3 = 112m
Say 100m allowing for set up, etc

C. Example of how to integrate SUDS into a development and showing where SUDS would be adopted by Cambridge City Council

The following example shows how imaginative design can provide a good quality SUDS that enhances the local environment, whilst at the same time reducing construction difficulties and costs.

The scheme is a housing development with an area of public open space around one side. It is located in the village of Cambourne, approximately 13km west of Cambridge.

The first stage in the SUDS design is to consider the natural flow routes across the site. On this site the contours show it would fall from the north-west to the south-east of the site and this is the general flow route that is adopted in the SUDS.

The development includes a substantial area of public open space that was incorporated as part of the SUDS scheme as shown on the plan of the scheme below. In developments in Cambridge the open space could be used to replicate the water meadows in the centre of Cambridge and also enhance the biodiversity provision within the SUDS. A series of very shallow swales and basins provide enhanced treatment and management of water flows across a wetland landscape around the outside of the development.

Summary of the Cambourne scheme technical details

The site was divided into two sub catchments based on the topography and layout of the development. The site is designed to attenuate runoff form the site based on a design rainfall event of 1 in 100 years with an extra allowance of 20% on the rainfall intensity to allow for climate change. The SUDS management train provides at least two levels of treatment to the runoff from the site, and more importantly at least one level of treatment is provided before water enters the ponds/wetlands on the site, therefore maximising the amenity and wildlife benefits.

Interception storage was provided by using permeable pavements, water butts and under-drained swales which should prevent runoff for small rainfall events.

The attenuation storage is provided in a series of basins, swales and wetlands or ponds that are incorporated into the open space around the development. At the time this system was designed the concept of long term storage was not well established. However. it would be easy to redesign the scheme to make one of the basins or wetlands an off-line area for long term storage, or to redesign the flow controls to achieve this.

Monitoring of the hydraulic performance of the scheme is currently being carried out. It would appear to be effectively managing runoff and the rate of runoff from the outfall shows reduced rates, overall volumes and frequency compared to a control site. It may appear to be over designed from a hydraulic point of view, but volumes were determined using recognised methodology, and this view would ignore the integration of important aspects of amenity, good landscape design and biodiversity provision within the scheme.

SUDS layout at Cambourne

A habitat survey has shown that the SUDS provide a greater diversity than normal open space. The maintenance of the SUDS has been incorporated into the day to day maintenance of the open space. The extra costs for maintaining the SUDS are minimal when compared to those for maintaining normal open spaces.

The adoption model originally agreed for this site was as follows:

- Swales and the basin within the site boundary – Cambridge Housing Society
- Permeable pavements – Cambridgeshire County Council
- Swales, wetlands and ponds in the greenway around the outside of the development are owned by Cambridgeshire County Council and were to be maintained by Cambridgeshire Wildlife Trust.

In practice the site is now entirely managed by the Housing Society, which has entered into an agreement with Cambridgeshire County Council to maintain the off site SUDS in the greenway and will arrange for suction sweeping of the permeable pavement (which are public road areas) until it is adopted by the Highways Department.

It is also important to note that the scheme was not ideal in that the SUDS were not considered at the development concept stage. Therefore the SUDS design was "bolted onto" an existing development layout that was intended to be drained using conventional drainage. Despite this, it does show how source control and green SUDS can be integrated into housing developments. It was also not subject to the rigorous verification procedures required by Cambridge City Council as detailed in Section 13 Adoption Requirements.

D. Checklist of adoption requirements

The following checklist can be used to confirm that the City Council's requirements for adoption have been met. This accreditation process follows advice in The SUDS Manual – CIRIA C697, London 2007 and Environment Agency guidance.

Ref No	Item	Date agreed with Cambridge City Council
1.	**Conceptual design**	
	The SUDS Manual requirements	
	• provide a clear explanation of the SUDS proposal following CIRIA C697 (The SUDS Manual) guidance	
	• Flow routes through development	
	• Attenuation storage locations identified	
	• Source control provision and interception storage identified	
	• Long term storage locations identified	
	• Landscape and ecology criteria defined	
	• Treatment levels identified	
	Cambridge specific requirements	
	• Mimic natural drainage patterns and landscape of Cambridge	
	• SUDS as shallow as possible	

2.	**Outline design**	
	The SUDS Manual requirements	
	• Drainage design criteria agreed with Environment Agency including greenfield runoff rates and frequency of volumes	
	• Source control and interception storage provided and volumes defined – no runoff from site for events up to 5mm (or stated value)	
	• Attenuation storage provided and volumes defined – storage for 1% and 3.3% annual probability	
	• Long term storage provided and volumes defined – storage for 1% annual probability, 6 hour duration event released to infiltration or at a rate of 2l/s/ha	
	• conveyance – describe flow routes, low flow recurrence intervals	
	• Control structures defined and sized	
	• Sufficient number of treatment stages provided	
	• Exceedance and overland flow routes	

3.	**Detailed drainage design**	
	General – The SUDS Manual	
	• Detail – check drainage pathways reflect natural drainage patterns	
	• Detail – check interception, attenuation and long term storage volumes provided	
	• Detail – check flow controls provided in correct place to ensure operates when required	
	• Detail – check sufficient treatment stages provided	
	• Detail – check biodiversity design requirements provided	
	Ponds and wetlands – Cambridge specific	
	• Design in accordance with The SUDS Manual	
	• Access provision for maintenance	
	• Side slopes less than 1 in 3 and safety bench	
	• Underwater slopes less than 1 I 3 and 150mm wet bench	
	• Biodiversity design considerations	
	Fencing provision appropriate (fencing not normally required)	
	• 150mm topsoil to slopes	
	• Interpretative boards	
	• If liner used is it covered by 300mm topsoil?	
	Retention and infiltration basins – Cambridge specific	
	• Design in accordance with The SUDS Manual	
	• Access provision for maintenance	
	• Side slopes less than 1 in 3	
	• Biodiversity design considerations	
	Fencing provision appropriate (fencing not normally required)	
	• 150mm topsoil to slopes	
	• Interpretative boards	
	• If liner used is it covered by 300mm topsoil?	
	• Root zone in base of underdrained swales	
	• Drainage to swale does not use gullies	
	Filter drains – Cambridge specific	
	• Design in accordance with The SUDS Manual	
	• Access provision for maintenance	
	• Drainage to filter drain does not use gullies	
	• Interpretative boards	

	Canals, rills and other channels – Cambridge specific	
	• Design in accordance with The SUDS Manual	
	• Access provision for maintenance	
	• Interpretative boards	
	Inlets, outlets and controls – Cambridge specific	
	• Design in accordance with The SUDS Manual	
	• Simple orifices or weirs located at surface wherever possible	
	• Overflow route provided to bypass control if it becomes blocked	

4.	**Health and safety**	
	• Provide CDM designer's risk assessment – for all SUDS features, inlets, outlets and controls.	
	• Hazards designed out wherever possible (e.g. entry to confined spaces eliminated, deep excavation eliminated)	

5.	**Construction - Verification**	
	• contractor method statement – control of silt and other contamination during construction	
	• Photographs of excavations and confirmation of soil conditions	
	• Photographs and details of as built inlets, outlets and controls	
	• Topsoil/rootzone sources, certificates and depths	
	• Planting list, method statement and initial maintenance regime	
	• Subsoil depth confirmed	
	• Filter drain material sources and certificates	
	• Source and test certificates for membrane liners (if used)	
	• Installation CQA sheets and test results for membrane (if used)	
	• Photos of completed feature	
	• As constructed drawings	

E. Glossary

Algae	Simple plants ranging from single cells to large plants.
Amenity	The quality of being pleasant or attractive; agreeableness. A feature that increases attractiveness or value, especially of a piece of real estate or a geographic location
Attenuation	Reduction of peak flow and increased duration of a flow event.
Balancing pond	A pond designed to attenuate flows by storing runoff during the storm and releasing it at a controlled rate during and after the storm. The pond always contains water.
Basin	A ground depression acting as a flow control or water treatment structure that is normally dry and has a proper outfall, but is designed to detain stormwater temporarily.
Berm	A mound of earth formed to control the flow of surface water.
Biodiversity	The diversity of plant and animal life in a particular habitat
Bioretention area	A depressed landscape area that is allowed to collect runoff so it percolates through the soil below the area into an underdrain, thereby promoting pollutant removal. Also known as a rain garden
Block paving	Pre-cast concrete or clay brick sized flexible modular paving system.
Bund	A barrier, dam, or mound usually formed from earthworks material and used to contain or exclude water (or other liquids) from an area of the site.
Catchment	The area contributing surface water flow to a point on a drainage or river system. Can be divided into sub-catchments.
Construction (Design and Management) Regulations 2007 (CDM)	Construction (Design and Management) Regulations 2007, which emphasise the importance of addressing construction health and safety issues at the design phase of a construction project.
Construction Quality Assurance (CQA)	A documented management system designed to provide adequate confidence that items or services meet contractual requirements and will perform adequately in service. CQA usually includes inspection and testing of installed components and recording the results.
Conventional drainage	The traditional method of draining surface water using subsurface pipes and storage tanks.
Conveyance	Movement of water from one location to another.
Curtilage	Land area within property boundaries.
Deposition	Laying down of matter via a natural process.

Retention basin	A vegetated depression that is normally dry except following storm events. Constructed to store water temporarily to attenuate flows. May allow infiltration of water to the ground.
Dewatering	The removal of groundwater/surface water to lower the water table.
Dry	Free of water under dry weather flow conditions.
Erosion	The group of natural processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is worn away from the earth's surface
Filter drain	A linear drain consisting of a trench filled with a permeable material, often with a perforated pipe in the base of the trench to assist drainage.
Filter strip	A vegetated area of gently sloping ground designed to drain water evenly off impermeable areas and to filter out silt and other particulates.
Filtration	The act of removing sediment or other particles from a fluid by passing it through a filter.
Forebay	A small basin or pond upstream of the main drainage component with the function of trapping sediment.
Formation level	Surface of an excavation prepared to support a pavement
Freeboard	Distance between the design water level and the top of a structure, provided as a precautionary safety measure against early system failure.
Geocellular structure	A plastic box structure used in the ground, often to attenuate runoff.
Geomembrane	An impermeable plastic sheet, typically manufactured from polypropylene, high density polyethylene or other geosynthetic material.
Geotextile	A plastic fabric that is permeable.
Green roof	A roof with plants growing on its surface, which contributes to local biodiversity. The vegetated surface provides a degree of retention, attenuation and treatment of rainwater, and promotes evapotranspiration. Sometimes referred to as an alternative roof.
Groundwater	Water that is below the surface of ground in the saturation zone.
Habitat	The area or environment where an organism or ecological community normally lives or occurs
Impermeable	Will not allow water to pass through it.
Impermeable surface	An artificial non-porous surface that generates a surface water runoff after rainfall.
Infiltration (to the ground)	The passage of surface water into the ground.
Infiltration basin	A dry basin designed to promote infiltration of surface water to the ground.
Infiltration device	A device specifically designed to aid infiltration of surface water into the ground.

Infiltration trench	A trench, usually filled with permeable granular material, designed to promote infiltration of surface water to the ground.
Open water	Clear water surface i.e. free from submerged or floating aquatic vegetation.
Pavement	The road or car park surface and underlying structure, usually asphalt, concrete, or blockpaving. Note: the path next to the road for pedestrians (the UK colloquial term of pavement) is the footway.
Permeable pavement	A permeable surface that is paved and drains through voids between solid parts of the pavement.
Permeable surface	A surface that is formed of material that is itself impervious to water but, by virtue of voids formed through the surface, allows infiltration of water to the sub-base through the pattern of voids, for example concrete block paving.
Pervious surface	A surface that allows inflow of rainwater into the underlying construction or soil.
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 is injurious to existing, intended, or potential uses of the resource.
Pond	Permanently wet depression designed to retain stormwater above the permanent pool and permit settlement of suspended solids and biological removal of pollutants.
Porous surface	A surface that infiltrates water to the sub-base across the entire surface of the material forming the surface, for example grass and gravel surfaces, porous concrete and porous asphalt.
Porous paving	A permeable surface that drains through voids that are integral to the pavement.
Public open space	The open space required under the City Council's open space & recreation standard is defined as any land laid out as a public garden or used for the purposes of public recreation. This means space which has unimpeded public access, and which is of a suitable size and nature for sport, active or passive recreation or children and teenagers' play. Private or shared amenity areas, for example in a development of flats, or buffer landscape areas are not included as public open space.
Rainfall event	A single occurrence of rainfall before and after which there is a dry period that is sufficient to allow its effect on the drainage system to be defined.
Rainwater harvesting or rainwater use system	A system that collects rainwater from where it falls rather than allowing it to drain away. It includes water that is collected within the boundaries of a property, from roofs and surrounding surfaces.
Recycling	Collecting and separating materials from waste and processing them to produce marketable products.
Risk	The chance of an adverse event. The impact of a risk is the combination of the probability of that potential hazard being

	realised, the severity of the outcome if it is, and the numbers of people exposed to the hazard.
Risk assessment	"A carefully considered judgement" requiring an evaluation of the risk that may arise from the hazards identified, combining the various factors contributing to the risk and then evaluating their significance.
Runoff	Water flow over the ground surface to the drainage system. This occurs if the ground is impermeable, is saturated or rainfall is particularly intense.
Sediments	Sediments are the layers of particles that cover the bottom of water-bodies such as lakes, ponds, rivers, and reservoirs.
Sewer	A pipe or channel taking domestic foul and/or surface water from buildings and associated paths and hard-standings from two or more curtilages and having a proper outfall.
Silt	The generic term for waterborne particles with a grain size of 4-63 µm, i.e. between clay and sand.
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.
Storm	An occurrence of rainfall, snow, or hail.
Sub-base	A layer of material on the sub-grade that provides a foundation for a pavement surface.
Sub-grade	Material, usually natural insitu, but may include Capping layer, below Formation level of a Pavement.
SUDS	Sustainable Urban Drainage Systems: a sequence of management practices and control structures designed to drain surface water in a more sustainable fashion than some conventional techniques.
Sump	A pit that may be lined or unlined and is used to collect water and sediments before being pumped out.
Surface water	Water that appears on the land surface, e.g. lakes, rivers, streams, standing water, and ponds.
Swale	A shallow vegetated channel designed to conduct and retain water, but may also permit infiltration. The vegetation filters particulate matter.
Treatment	Improving the quality of water by physical, chemical and/or biological means.
Vortex flow control	The induction of a spiral/vortex flow of water in a chamber used to control or restrict the flow.
Waste	Any substance or object that the holder discards, intends to discard, or is required to discard.
Wetland	Flooded area in which the water is shallow enough to enable the growth of bottom-rooted plants.

F. Cambridge SUDS Design Guide Consultees June 09

Name	Organisation
Sian Reid	Executive Councillor Cambridge City Council
Julie Smith	Executive Councillor Cambridge City Council
Alistair Wilson	Cambridge City Council
Debbie Kaye	Cambridge City Council
Guy Belcher	Cambridge City Council
Dinah Foley-Norman	Cambridge City Council
Alan Wingfield	Cambridge City Council
Jonathan Brookes	Cambridge City Council
Mark Parsons	Cambridge City Council
Ian Boulton	Cambridge City Council
Jo Clark	Countryside Properties
Nigel Borrell	Countryside Properties
Jo Whiteman	Countryside Properties
Andrew Carrington	Countryside Properties
Michael Lister	Countryside Properties
Marcia Whitehead	Bidwells
Guy Kaddish	BIdwells
Helen Thompson	Bidwells
Jason Tyers	Bidwells
David Banfield	Barratt Homes
Andrew Sharpe	Grovesnor
Neil Hardiman	USS
Ed Skeates	USS/Grovesnor
Richard Burton	Terence O'Rourke
Geoff Boulton	SRR Planning
Paul Milliner	Cambridge University
Ken Banfield	Anglian Water
Rob Morris	Anglian Water
Tony Wadhams	Environment Agency
Richard Taylor	Environment Agency
Jenny Gough	Environment Agency
Dan Curtis	Environment Agency
Daniel Clarke	Cambridgeshire Horizons
Tom Read	Cambridgeshire Horizons
Sheryl French	Cambridgeshire Horizons
Mark Vigor	Cambridgeshire County Council
Chris Capps	Cambridgeshire County Council
Richard Preston	Cambridgeshire County Council
Wendy Hague	Cambridgeshire County Council
Tom Barrance	South Cambridgeshire District Council
Rob Mungovan	South Cambridgeshire District Council
David Hamilton	South Cambridgeshire District Council
Richard Hales	South Cambridgeshire District Council
Pat Matthews	South Cambridgeshire District Council
Jonathan Dixon	South Cambridgeshire District Council
Paul Shaffer	CIRIA
Nancy Harrison	Anglia Ruskin University
Alvin Helden	Anglia Ruskin University
Dr Stuart Arnold	Ramboll
Alison Mallows	Halcrow
Simon Darch	Hannah-Reed
Mick Thurman	Cambridge Water
Janet Nuttall	Natural England
Vicky Dawe	DEFRA
Carolin Gohler	Cambridge Past, Present and Future
Coton Parish Council	
Fen Ditton Parish Council	
Fulbourn Parish Council	
Girton Parish Council	
Great Shelford Parish Council	
Histon & Impington Parish Councils	
Horningsea Parish Council	
Madingley Parish Council	