Water. People. Places.

A guide for master planning sustainable drainage into developments

Prepared by the Lead Local Flood Authorities of the South East of England

AECOM

ABOUT THE GUIDANCE

This guidance outlines the process for integrating sustainable drainage systems (SuDS) into the master planning of large and small developments. Consideration of the movement of water and its interaction with space at the earliest stage of design is crucial to the success of SuDS and allows the developer to maximise wider benefits. This guidance complements existing guidance on SuDS design, maintenance and operation which should be used to inform detailed design and delivery of SuDS.

The Flood and Water Management Act 2010 provides the legislative intention to require all new developments to incorporate SuDs.

The National Planning Policy Framework (NPPF) is also a key driver, stating that development should give "priority to the use of sustainable drainage systems". The NPPF also sets out key priorities for planning to address, including climate change, flood risk, water quality and biodiversity - all challenges that SuDS will help to address.

Who is this for?

This guidance should be used by developers and planners and other practitioners involved in the planning and design of the built environment in the South East of England.

How should the document be used?

The South East Lead Local Flood Authorities expect this guidance to be used as part of the initial planning and design process for all types of residential, commercial and industrial development. It has been developed through a partnership of South East Authorities and it intends to provide a consistent approach to best practice design of SuDS at the master planning stage. Specific local requirements for SuDS design and adoption may also be set by the Lead Local Flood Authorities.

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OUR VISION

OUR VISION

Sustainable drainage systems (SuDS) represent an opportunity to create great places and maximise the value and desirability of property schemes whilst managing water better. To capture this potential and ensure cost-effective solutions are delivered, SuDS must be considered from the very beginning of a project and integrated with design via the master planning process. As the Lead Local Flood Authorities in the South East, we expect to see SuDS as an integral element of all development and encourage planners and developers to use SuDS as a tool for place-making and good design.

The benefits of early consideration of SuDS are substantial for developers as well as the communities that will live in the development. When designed well, SuDS can increase property value, mitigate local flood risk, moderate microclimate, benefit ecology, provide new sources of water and create valuable amenity spaces for communities to enjoy. Furthermore, evidence shows that the cost of SuDS construction can also work out much cheaper than traditional drainage methods if planned properly and from the very start.

We acknowledge there can be challenges in delivering SuDS in some developments. However, we envisage that this guide will stimulate integrated working and cooperation between those involved in planning the built environment, helping to unlock pragmatic solutions to these challenges. This guide promotes a fresh and creative approach to the planning and design of SuDS, demonstrating that a drainage strategy which uses water to shape and celebrate place is one of the most effective tools a designer has to hand.

Image courtesy of CIRIA

02

SETTING THE SCENE IN SOUTH EAST

SETTING THE SCENE IN SOUTH EAST

Renowned for both its natural beauty and its economic vitality, the South East is a very popular place to live and work. It is the most populous region in England and is expected to see significant levels of growth in the future. The types of development that will accommodate this growth will range considerably, from new settlements and major urban extensions to small infill development in existing areas and lower density development in rural areas. This, along with the predicted impact of climate change will put considerable pressure on infrastructure and natural resources. The quality of the landscape in the South East is also exceptional, with over 37% of the region being designated as a 'protected landscape' for its outstanding natural beauty. Not surprisingly then, the delivery and management of green infrastructure and natural assets are incredibly important to the South East, not only to mitigate the impacts of climate change and maintain quality of life for communities, but also to showcase the extraordinary natural beauty it holds.

Good management of rainwater is vital to the South East, to protect the quality of water courses and coasts, to minimise the risk of flooding and to provide a reliable water supply to communities. The use of SuDS is essential for meeting these water management needs, and SuDS become even more advantageous where they can deliver green infrastructure and support high quality development.

The physiology of the South East, provides a range of opportunities for SuDS, where designers can tailor solutions to enrich and complement the local environment. Variations in soils, ecosystems, built and landscape character and community needs will all call for different benefits to be delivered through water management and urban design. Early consideration of SuDS provides the best chance for delivering these benefits.

Large swathes of chalk soils with good permeability in some parts of the South East provide excellent opportunities to use infiltration SuDS to reduce runoff and replenish groundwater supplies. Delivery of SuDS schemes in development areas, greenfield and brownfield, can also be used to reduce pressure on existing infrastructure and reduce surface water flooding which is a particular problem in and around urban areas. Using SuDS as an integrated system across a development will also support ecosystems by regulating flows, delivering habitat and filtering out sediment and pollutants that harm our treasured water courses and coasts. Importantly, as one of the driest parts of the UK, with some areas of the region receiving only 650mm of rain a year, the ability of SuDS to filter and store water for reuse will help build water security for the region.

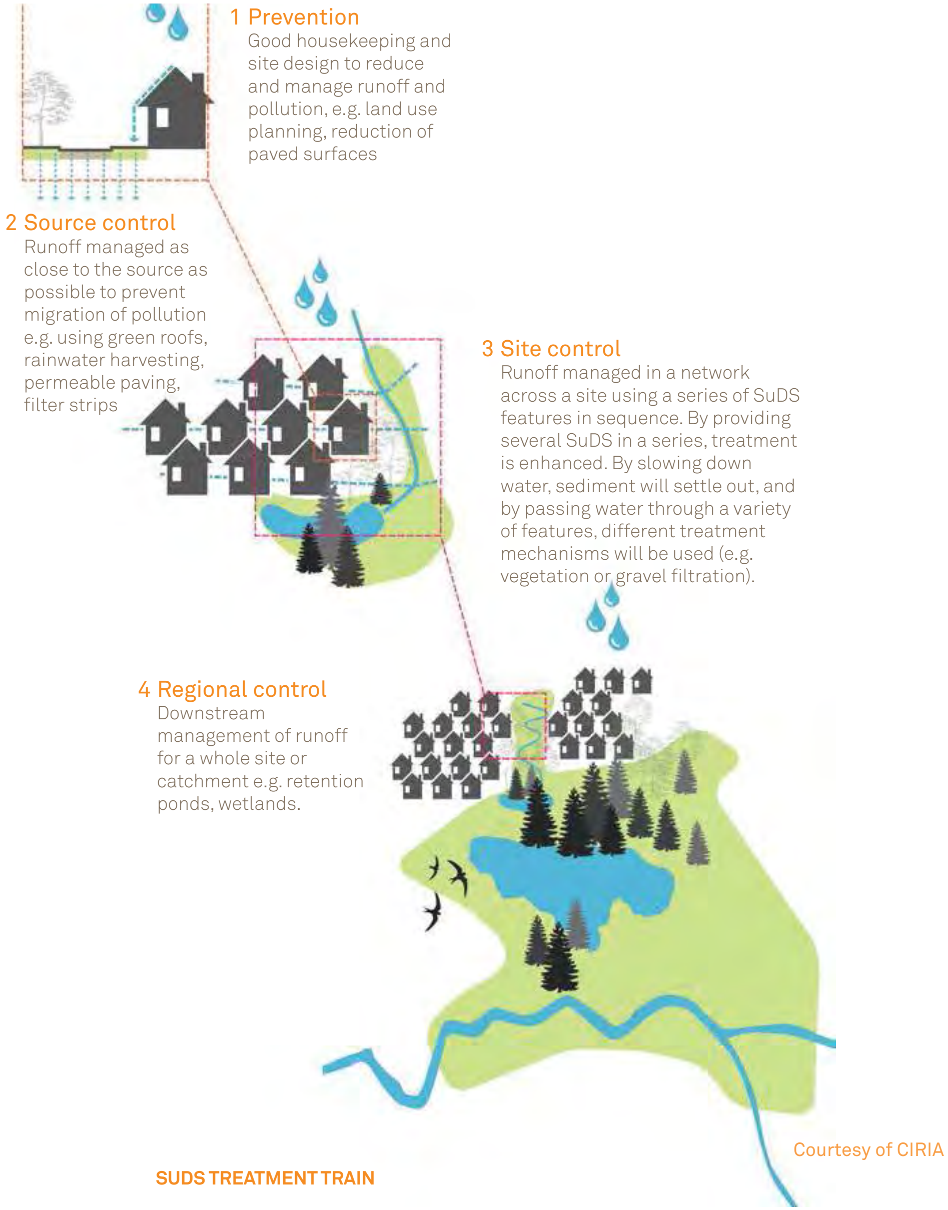
The delivery of SuDS is central to the future of the South East that we want to live and work in

03

DESIGNING SUDS TO DELIVER BENEFITS

SuDS should not be thought of as individual items, but as an interconnected system, where water slowly flows from where it falls to a soakage area or discharge point through a series of features that help to treat, store, re-use, convey and celebrate water. An important concept for the SuDS designer to follow is known as the 'treatment train'. By passing water through several stages of treatment, sediment and other pollutants will be removed more effectively, and maintenance costs are reduced as this minimises the risk of downstream SuDS features becoming clogged or blocked. The designer can use the treatment train to create green corridors and links, add opportunities for engagement and education and to match delivery of SuDS to phasing of development.

There are a wide variety of sustainable drainage systems which can be linked together in sequence, so that a designer can tailor surface water management to the local context. The following table presents common types of SuDS, their most suitable setting and their typical land take.



SUDS TREATMENT TRAIN

	Description	Setting	Required area
Green roofs	A planted soil layer is constructed on the roof of a building to create a living surface. Water is stored in the soil layer and absorbed by vegetation.	Building	Building integrated.
Rainwater harvesting	Rainwater is collected from the roof of a building or from other paved surfaces and stored in an overground or underground tank for treatment and reuse locally. Water could be used for toilet flushing and irrigation.	Building	Water storage (underground or above ground).
Soakaway	A soakaway is designed to allow water to quickly soak into permeable layers of soil. Constructed like a dry well, an underground pit is dug filled with gravel or rubble. Water can be piped to a soakaway where it will be stored and allowed to gradually seep into the ground.	Open space	Dependant on runoff volumes and soils.
Filter Strip	Filter strips are grassed or planted areas that runoff is allowed to run across to promote infiltration and cleansing.	Open space	Minimum length 5 metres.
Permeable paving	Paving which allows water to soak through. Can be in the form of paving blocks with gaps between solid blocks or porous paving where water filters through the block itself. Water can be stored in the sub-base beneath or allowed to infiltrate into ground below.	Street/open space	Can typically drain double its area.
Bioretention area	A vegetated area with gravel and sand layers below designed to channel, filter and cleanse water vertically. Water can infiltrate into the ground below or drain to a perforated pipe and be conveyed elsewhere. Bioretention systems can be integrated with tree-pits or gardens.	Street/open space	Typically surface area is 5-10% of drained area with storage below.

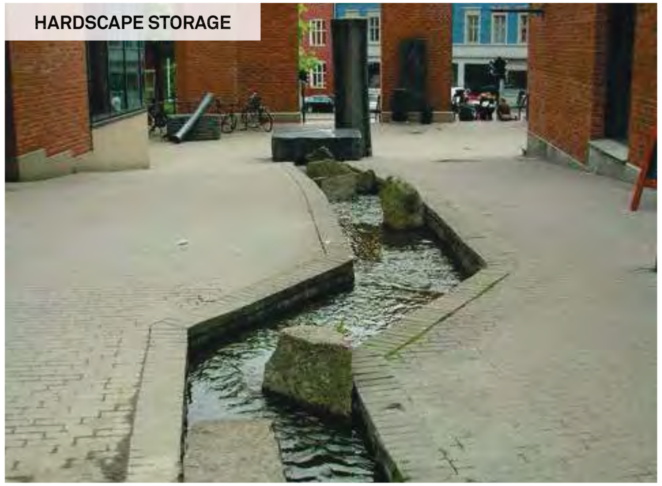
	Description	Setting	Required area
Swale	Swales are vegetated shallow depressions designed to convey and filter water. These can be 'wet' where water gathers above the surface, or 'dry' where water gathers in a gravel layer beneath. Can be lined or unlined to allow infiltration.	Street/open space	Account for width to allow safe maintenancce typically 2-3 metres wide.
Hardscape storage	Hardscape water features can be used to store run-off above ground within a constructed container. Storage features can be integrated into public realm areas with a more urban character.	Open space	Could be above or below ground and sized to storage need.
Pond / Basin	Ponds can be used to store and treat water. 'Wet' ponds have a constant body of water and run-off is additional, while 'dry' ponds are empty during periods without rainfall. Ponds can be designed to allow infiltration into the ground or to store water for a period of time before discharge.	Open space	Dependant on runoff volumes and soils.
Wetland	Wetlands are shallow vegetated water bodies with a varying water level. Specially selected plant species are used to filter water. Water flows horizontally and is gradually treated before being discharged. Wetlands can be integrated with a natural or hardscape environment.	Open space	Typically 5-15% of drainage area to provide good treatment.
Underground storage	Water can be stored in tanks, gravel or plastic crates beneath the ground to provide attenuation.	Open space	Dependant on runoff volumes and soils.

BIORETENTION AREA

WETLAND

SWALE

GREEN ROOF



HARDSCAPE STORAGE

POND

Designing SuDS to deliver benefits

Well-designed SuDS rarely function with only a single purpose (e.g. water attenuation). By using SuDS as part of an urban design toolkit and keeping water management above ground where possible, SuDS can be used to enhance their surrounding environment and provide a host of additional benefits. The following paragraphs outline a range of typical benefits that SuDS can be designed to provide.

Attenuation

Storing and slowly releasing runoff is one of the primary benefits SuDS offer. Rather than spilling off quickly into sewers or watercourses, increasing the risk of flooding and erosion, SuDS act as a sponge, soaking up excess water, storing it in plants, soils and constructed voids, before slowly releasing back into the surrounding environment through infiltration, plant up-take or controlled discharge. Areas with less permeable soils can incorporate SuDS features that are designed to hold and manage water on or near the surface for controlled discharge or re-use.

Water treatment

Pollution typically found in runoff including sediment, oils, metals, fertilizer, pesticides, and rubbish can be harmful to watercourses and coastal waters. The soils, gravels and vegetation present in many forms of SuDS act as filters, removing many pollutants before returning cleansed water to the natural environment.

Infiltration

SuDS can be used to first cleanse rainwater runoff then to promote infiltration into the ground to replenish groundwater, thereby letting water infiltrate which would have been prevented from soaking into the ground by impermeable development areas. This also helps to prevent soils from drying out.

Water reuse

South East England is a water stressed region. Many SuDS features can be used locally to capture, treat and manage water for re-supply of cleansed water to buildings or landscapes. Rainwater harvesting can be installed at a range of scales, from individual property scale to site-wide scale, by storing treated runoff at the end of a SuDS treatment train. Re-using rainwater for non-potable purposes such as irrigation and toilet flushing will help reduce potable water demand and deliver Code for Sustainable Homes, BREEAM and other sustainability targets.

Biodiversity and Habitat

SuDS can be designed to include a range of natural processes for managing and filtering surface water runoff. The inclusion of plants, trees, and other vegetation is often advantageous to slow and store water while providing filtration. These can be designed to support local biodiversity aims. SuDS treatment trains can be used to develop ecological corridors at the same time. They can also incorporate a range of vegetation species, ranging from wetland plantings to more common garden varieties. SuDS should be designed to complement and improve the ecology of the area, however consideration should be given to the effects of both species selection and maintenance requirements on the ability of existing habitats to continue functioning effectively.

Amenity

SuDS that integrate greenery or water features can improve the visual character of a development, and in doing so they can also increase property values. Access to green space, views of high quality public realm and street trees have all been shown to increase the resale value of properties. This is particularly the case in urban areas where these elements are not as common. Views of green space and water have been shown to increase commercial rents between 15 and 35%, while a view of a natural environment or high quality public realm can increase residential property values by as much as 15%[1].

Education

SuDS present an opportunity to educate and engage communities about water management and to grow a greater appreciation and respect for urban water. If schools incorporate SuDS on their premises, they can be viewed as a valuable learning and play opportunity for students and children.

Open space

Designing green space and public realm with SuDS that work well when both wet and dry can provide valuable community recreational space as well as important environmental infrastructure. Sports pitches, squares, courtyards, playgrounds, landscapes around buildings, urban parks, green corridors and woodlands are all popular types of open space which can be integrated with SuDS. SuDS can also contribute to development targets for open space where they are designed to be multi-functional.

Character

SuDS can be used to enhance and influence the character of development and its surroundings. As with all good design, SuDS design should respond to context, complementing the approach taken to landscape character and urban design. More rural areas often call for SuDS with a more natural feel and soft edges. Similarly, SuDS with hard edges and straight lines can be more appropriate in built up areas.

Microclimate

The inclusion of water and/or vegetation in the urban environment can help to regulate local temperatures and to mitigate the urban heat island effect. SuDS can be used to naturally irrigate trees and green areas, which help to provide shade, regulate heat and filter air.

1. Whitehead, Tim, Simmonds, David and Preston, John (2006) The effect of urban quality improvements on economic activity. Journal of Environmental Management, 80, (1), 1-12.

SUDS SELECTION MATRIX FOR BENEFITS

	unlikely benefit
○	benefit could be achieved in some cases with good design
●	likely benefit

	Green Roof	Rainwater Harvesting	Soakaway	Permeable Paving	Filter Strip	Bioretention area	Swale	Hardscape/ Modular Storage	Pond	Wetland	Underground Storage
Attenuation	○	○	●	●	○	●	●	●	●	●	●
Water Treatment	○	○	●	●	●	●	●		●	●	
Infiltration			●	○	●	○	○		○	○	○ Geocellular storage system
Water Reuse	○ Pre-storage treatment	●		○ Pre-storage treatment		○ Pre-storage treatment	○ Pre-storage treatment	○ Storage	○ Treatment and/or storage	○ Pre-storage treatment	○ Storage
Biodiversity and Habitat	●		○		○	●	●		●	●	
Education	●	○	○	○	○	●	●	○ If aboveground	●	●	
Amenity	●	○	○	○	○	●	●	○ If aboveground	○	●	
Open Space	○			○	○	○	○	○	○	○	
Character	○			○	○	○	○	○ If aboveground	○	○	
Microclimate	●			○		●	●	● If aboveground	●	●	

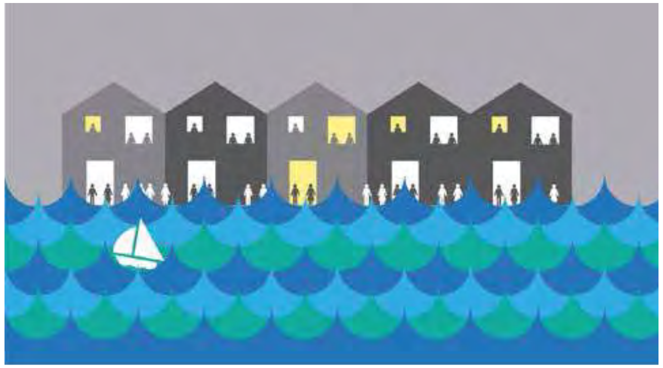
04

DESIGNING SUDS TO RESPOND TO COMMON SITE CONDITIONS

DESIGNING SUDS TO RESPOND TO COMMON SITE CONDITIONS

SuDS can be applied to any site. However, there are a variety of site conditions and constraints which could restrict the types of SuDS that are suitable, or which may trigger the need for bespoke design. Here are a few tips for designers.

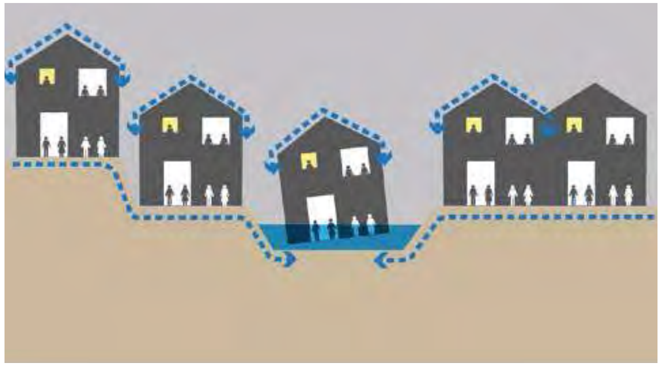
FLOOD CONDITIONS



I would like to include SuDS in the master plan, but how do I...

Design SuDS in a floodplain area?

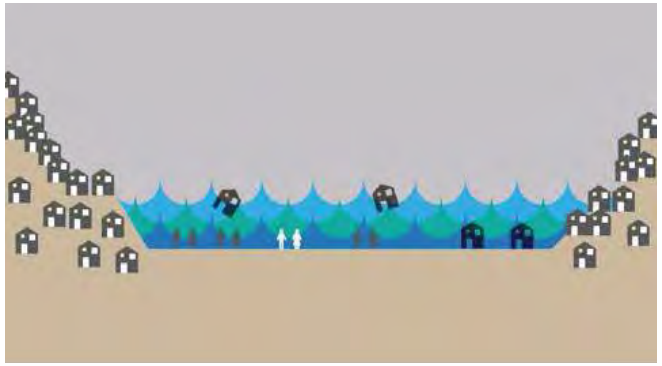
Floodplains should be used primarily to mitigate flood risk from rivers or tides. During storms and heavy rainfall these areas will naturally flood with river or coastal water, making them ineffective for storing surface water runoff. The presence of a floodplain, however, should not preclude the site from including SuDS as they could still be effective in managing routine rainfall. Given the likely high groundwater table and vulnerability to erosion, floodplain SuDS should be selected and designed accordingly. Design should limit grading and the creation of surface features (such as berms and un-reinforced channels) that could be washed out in a flood. Surface discharge from SuDS should be dispersed (allowed to shed off as sheet flow), and point discharges minimised or eliminated. Attenuation periods for SuDS should be designed so that SuDS empty within 48 hours of any rainfall.



I would like to include SuDS in the master plan, but how do I...

Prevent runoff from neighbouring sites flooding my site?

Some areas will experience existing runoff flows from neighbouring properties. Reducing flood risk requires an understanding of flows from elsewhere, and ensuring that buildings are located outside existing surface water conveyance routes. SuDS such as a swale could be used along the boundary to intercept and divert flows. Minimising flood risk in a wider area requires communication and collaboration among all stakeholders from the beginning of the master planning process with the aim to manage runoff at a catchment scale, rather than solely on individual properties.

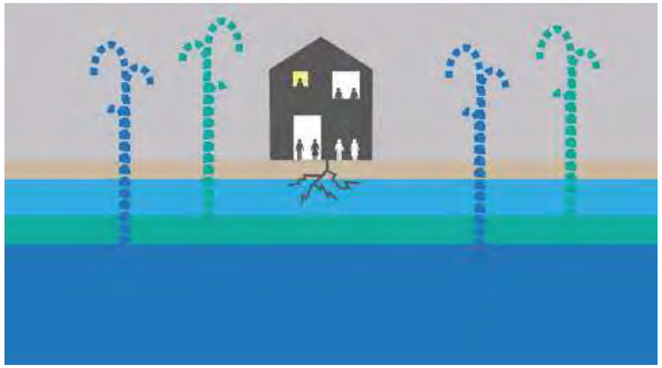


I would like to include SuDS in the master plan, but how do I...

Address local surface water flooding issues?

It is important at the initial design stage to understand if your site is in, or upstream of, local surface water flood risk areas as you may be subject to additional surface water runoff restrictions. This may influence the placement or design criteria for SuDS. Flow and attenuation requirements should be discussed with the Lead Local Flood Authority.

GROUNDWATER



I would like to include SuDS in the master plan, but how do I...

Design SuDS on a site with a high groundwater level?

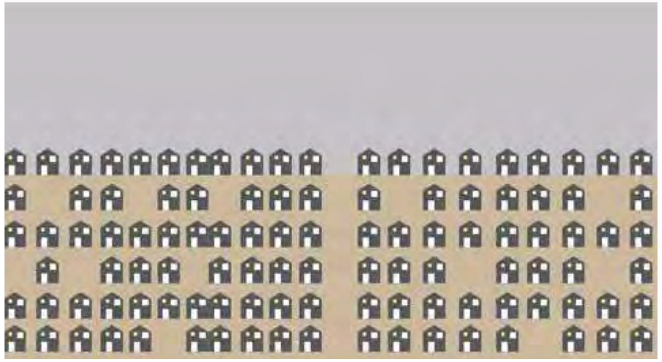
It is important to determine the depth of the water table below the ground. A water table near to the surface must be protected from contamination and high groundwater may also cause flooding or damage to deep SuDS features. In this instance, SuDS should be selected and designed to be on the surface or shallow in depth and to avoid infiltration. Those SuDS that normally allow infiltration can be lined with an impermeable liner (such as a water proof membrane or compacted native clay) to prevent infiltration.

I would like to include SuDS in the master plan, but how do I...

Design SuDS in a Groundwater Protection Zone?

Some areas may be designated as a groundwater protection zone to protect drinking water supply or otherwise. In these areas, SuDS proposals should be discussed with the Environment Agency. If infiltration is not allowed, SuDS can be lined. SuDS can also be used to provide treatment of water before infiltration to ensure contamination is avoided.

TOPOGRAPHY



I would like to include SuDS in the master plan, but how do I...

Incorporate SuDS on a flat site?

Managing surface water runoff on flat sites can be a challenge. A moderate slope is advantageous to move water around using gravity. If a piped system is being used to convey surface water on a flat site, downstream SuDS can become deep and unattractive due to the drop required for pipe cover and gradient. The best option on these sites is to keep surface water runoff on the surface as much as possible and to manage runoff close to its source. Water can be conveyed on the surface using roadside kerbs and shallow rills and swales. A designer should consider all alternatives before considering pumping as a last resort.

SOILS AND GEOLOGY

CONTAMINATED LAND

I would like to include SuDS in the master plan, but how do I...

Design SuDS on a site with a steep slope?

As steeper slopes will increase runoff velocity, these sites require additional attention when accommodating SuDS. Infiltration is not recommended near very steep slopes, as it might reduce slope stability. Check dams and staged storage, however, can be used to slow the runoff rates on steeper slopes. Another option is to design the site to convey runoff on platforms in a similar manner to switchback roads on mountainous terrain. Bioretention and wetland features can be staggered in a terraced arrangement on slopes.

I would like to include SuDS in the master plan, but how do I...

Use SuDS on a site with poor permeability?

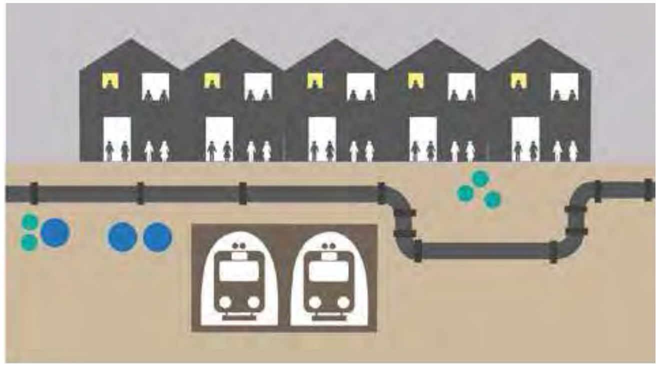
Poor permeability is a constraint for SuDS that promote infiltration, but there are still a range of design solutions to be explored. It is firstly worth understanding the vertical geology of an area, as it might be that a more permeable layer exists below shallow impermeable layers, where infiltration could occur at a greater depth. Where infiltration is not possible due to permeability or other ground conditions, SuDS should be designed to provide the required attenuation and treatment above ground or near the surface. In areas of poor permeability, the natural greenfield runoff rates are likely to be high, so requirements for attenuation should be relatively manageable.

I would like to include SuDS in the master plan, but how do I...

Use SuDS on contaminated land?

Some previously used sites will have contaminated soils. In these cases , SuDS can still be incorporated, although the use of infiltration may not be suitable as concentrated ground flow could lead to water-borne contaminants being transferred to deeper soils or sensitive aquifers. Accordingly, SuDS should be lined and designed to attenuate water on or near the surface.

EXISTING INFRASTRUCTURE

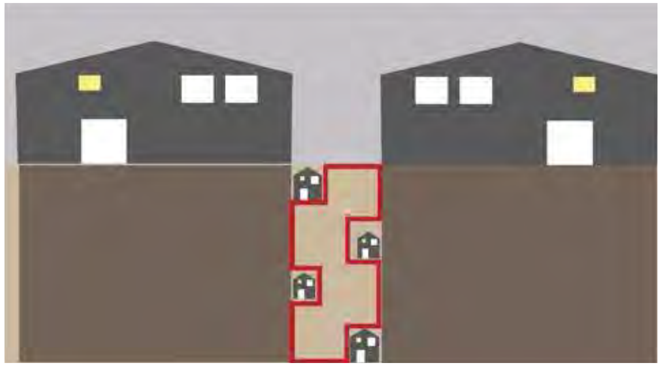


I would like to include SuDS in the master plan, but how do I...

Design SuDS on a site with existing infrastructure?

When building on brownfield or pre-developed sites, existing on-site infrastructure should be considered in SuDS design to find the most cost-effective solution. It will be important to understand the location and capacity of existing drainage to determine what infrastructure should be reused in the SuDS scheme. Other buried infrastructure, such as utilities, will need to be located and considered in SuDS design and construction. Using SuDS such as permeable paving and bioretention should be avoided in major service strips, as access will require disturbance and rebuilding of the SuDS system, but compatibility can be achieved by constructing dedicated and well-marked service strips that are designed with access in mind.

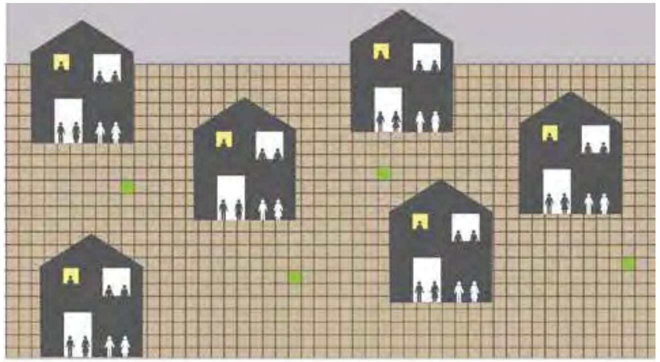
SPACE CONSTRAINTS



I would like to include SuDS in the master plan, but how do I...

Design for SuDS where space is limited?

SuDS are often associated with large green spaces, however, there are a range of SuDS features which can be easily designed into tight urban settings. Design forethought is required to build SuDS into multi-functional spaces and build up a network of SuDS that manage runoff close to its source to avoid the need for large storage areas. Space efficient SuDS include green roofs, bioretention gardens, permeable paving, rills, rainwater harvesting, hardscape storage, micro-wetlands, and bioretention tree pits.

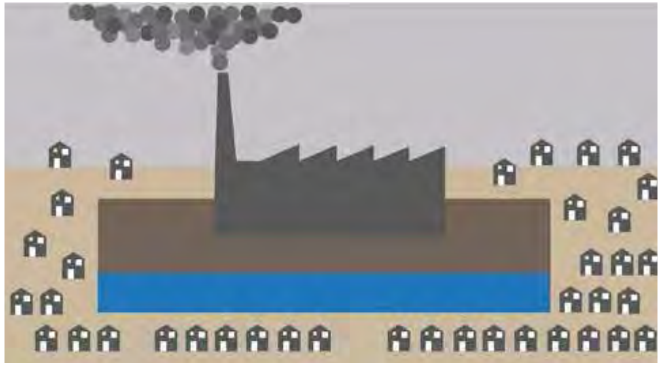


I would like to include SuDS in the master plan, but how do I...

Incorporate SuDS on a site that is mainly paved?

A number of different SuDS options can still be incorporated that will complement paved environments. Permeable paving can be used for part of the paved area to drain a larger area. The areas of permeable paving should be selected to be the least trafficked (e.g. parking and footpaths) and outside of service strips where possible. Hardscape depressions and rills can be used to provide aboveground storage and double as a water feature in courtyard and paved public realm areas. Underground storage is also an option, but one which won’t deliver amenity benefits. In areas where neighbourhood character will support additional greenery, bioretention gardens provide a small footprint while doubling as a landscaped area.

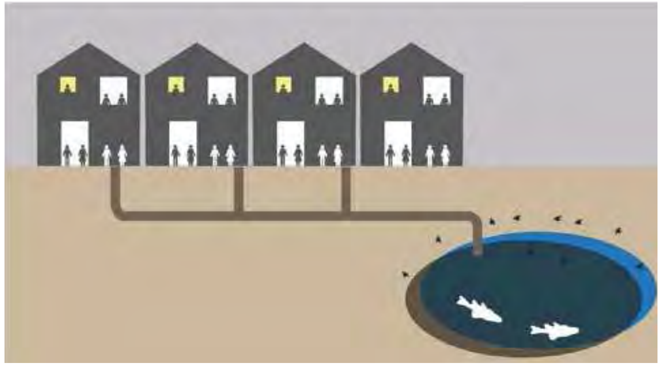
RUNOFF CHARACTERISTICS



I would like to include SuDS in the master plan, but how do I...

Ensure runoff from industrial sites is not contaminated?

Industrial sites that deal with chemicals, large trucks and machinery and other potential polluting uses need careful consideration in terms of SuDS design. Development of these sites can create surface water runoff with a high contamination risk. Managing runoff from these sites should be done by defining and isolating drainage sub-catchments so that high risk areas drain to separate systems while roofwater and general car park runoff drain to SuDS. Any runoff at high risk of contamination from chemicals or other serious water-borne pollution should be contained and treated as industrial waste.

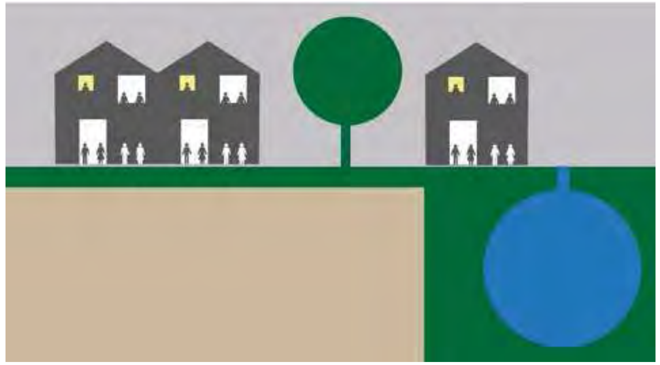


I would like to include SuDS in the master plan, but how do I...

Prevent runoff from reducing the quality of the receiving body of water?

When water is discharged into a water body, the quality of that receiving water needs to be considered. Different SuDS will provide different types of treatment, and a ‘treatment train’ of SuDS (see chapter 3) should be introduced to ensure water is exposed to a variety of filtration mechanisms and attenuated to allow pollutants to settle out. For example, runoff can be conveyed from permeable paving to a swale, before being treated in a wetland and discharged to provide three stages of treatment. Any water being discharged into a water body should be well treated to remove nutrients and sediments and a greater number of treatment stages is likely to be required when the receiving body quality is high.

PROTECTED SPECIES OR HABITAT



I would like to include SuDS in the master plan, but how do I...

Design SuDS to integrate with existing ecological areas?

SuDS can include vegetation and surface water that can contribute to biodiversity and enhance ecology in developed areas. However, SuDS are primarily water management features and their design should carefully consider existing ecological conditions. Initial site surveys should identify areas of interest, including designated areas for nature conservation, areas with protected species and locally important habitats. SuDS should be designed to protect or enhance these areas. While SuDS can include areas of habitat, these should be well thought out in terms of long-term maintenance to ensure that habitat is not harmed during maintenance activities.

OWNERSHIP AND MAINTENANCE

I would like to include SuDS in the master plan, but how do I...

Design SuDS for adoption?

Adoption discussions should be held early in the design process to ensure that SuDS are designed to the standards required by the adoption authority. Depending on the local provisions and context, the adopter could be the SuDS Approval Body (SAB) under the Flood and Water Management Act, a local authority, a highways authority, a land owner or a water company. Where adoption is uncertain, it is beneficial to ensure that design accommodates flexibility and favours simple solutions with low maintenance needs.

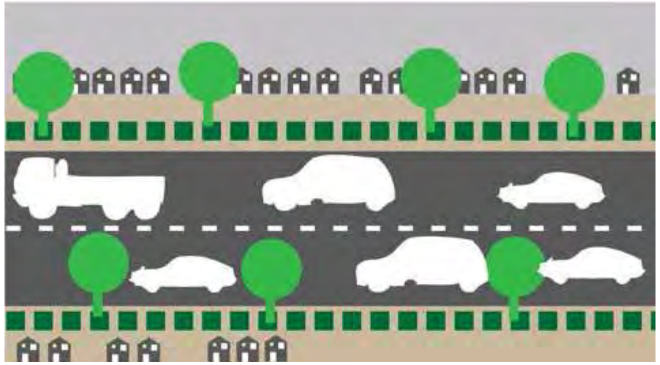
I would like to include SuDS in the master plan, but how do i...

Ensure SuDS costs are viable?

According to Defra[2], the capital costs for SuDS are generally considerably less than traditional drainage systems. By thinking about SuDS early in the design process, there is also a chance to limit long term maintenance costs. For example, developers can:

- Consider early, with all stakeholders, the management of surface water and its integration with the development;
- Maximise the use of simple, surface, vegetated systems, avoiding deep excavation and engineered structures;
- Develop a cost-effective construction programme to protect drainage;
- Design for low ongoing maintenance, integrated with general landscaping work;
- Include green waste and sediment disposal zones on-site; and
- Ensure effective community engagement, with the possibility of involving local people in SuDS maintenance.

Not only that, SuDS also have a number of benefits that can deliver value. This includes attractive views of green and water that people are willing to pay for.



I would like to include SuDS in the master plan, but how do I...

Manage runoff to/from Adopted Highways?

Specific design requirements and street design guidelines will exist for each authority area, and the local highways authority representative should be engaged early in the master planning process, as there may be potential for an efficient solution which benefits both private property owners and the highways authority. Adoption of SuDS in the roadway should also be discussed at this point.

2. Defra's Water Availability and Quality Evidence Programme

SUDS SELECTION MATRIX FOR SITE CONDITIONS

Key: (empty box) unsuitable; ● suitable

		Green Roof	Rainwater Harvesting	Soakaway	Permeable Paving	Filter Strip	Bioretention Area	Swale	Hardscape Storage	Pond	Wetland	Underground Storage
Flood Plain	Located in the floodplain?	●	●	●	●	●	●	●				
Groundwater	Groundwater less than 3 metres below ground surface?	●	●		● With liner and underdrain (no treatment)	●	● With liner and underdrain	● With liner	● If aboveground	● With liner	●	
Topography	Sited on a flat site (<5% gradient)?	● Source control	● Source control	● Source control	● Source control	● Source control	● With short kerb or rill length	● Careful to provide some gradient	●	● Try to keep flow above ground to	● Try to keep flow above ground to	●
	Sited on a steep slope (5-15% gradient)?	●	●		● If terraced		● If terraced	● If installed along contour	● If terraced		● If terraced	●
	Sited on a very steep slope (>15% gradient)?	●	●									●
Soils and Geology	Impermeable soil type (e.g. clay-based type)?	●	●		● With underdrain (no treatment)	●	●	●	●	●	●	●
Contaminated land	Are there contaminated soils on site?	●	●		● With underdrain (no treatment)	● With liner	● With liner and underdrain	● With liner	● With liner	● With liner	● With liner	● With liner
Existing Infrastructure	Are there underground utilities in the SuDS area?	●	●		● If possible relocated into a marked corridor for future maintenance	●	● Possible with structural grid in soil					●
Space constraints	Limited space for SuDS components?	●	●	●	●		●	Rill or channel more suitable	●		● Micro-wetland	●
Runoff characteristics	Suitable for inclusion in high risk contamination areas?	● Source control	● Source control		● With liner and spill isolation		● With liner and spill isolation	● With liner and spill isolation	● With liner and spill isolation		● If designed for treatment of predicted wastes	● With liner and spill isolation
Protected species or habitat	Proximity to designated sites and priority habitats?	●	●	●	●	●	●	●	●	● If designed and maintained appropriately	● If designed and maintained appropriately	●
Ownership and Maintenance	Can the feature be designed for adoption?	● Dependant on design and local adoption policies (all columns)										

05

THE MASTER PLANNING PROCESS

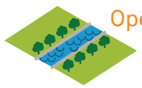
THE MASTER PLANNING PROCESS

A master plan is an overarching planning document and spatial layout which is used to structure land use and development.

'Master plan' is an all-encompassing term. Its scope can range from 10 year implementation at the regional scale, to an illustrative plan of small scale groups of buildings.

There is no formal process for master planning and every design team will have their own individual approach. In order to demonstrate the opportunities for maximising the benefits of combining SuDS with the design vision, a typical master planning process has been developed, and it is shown here.

Stages A – B form the preparation stages of the process, where the brief for the master plan is developed and the baseline analysis is conducted. Stages C – E step through the design process, moving from strategic land use arrangements to a concept design of streets and buildings. Broadly speaking, there are three key land use components to consider in the master planning process as design moves towards more detailed proposals:

1.  Buildings and built form
2.  The street network
3.  Open spaces and landscape areas

Prepare. Define. Design

A	AIMS AND OBJECTIVES	document aspirations
A	OUTLINE BUSINESS CASE	viability, feasibility, pragmatic
B	CONTEXT APPRAISAL	understanding the baseline and how a place works
B	SPATIAL FRAMEWORK	opportunities and constraints
B	ASSEMBLE MASTER PLANNING TEAM	the right range of skills for the team
C	INITIAL TESTING	
C	LAND USE & DESTINATION	land use distributions and relationships
C	KEY CONNECTIONS	strategic connections between destinations
C	OPEN SPACES	connected green infrastructure
C	MASTER PLAN OPTION TESTING	
D	PREFERRED STRATEGY	
D	BLOCK STRUCTURE	patterns of blocks and density areas
D	MOVEMENT FRAMEWORK	street hierarchies and the character of routes
D	OPEN SPACE NETWORK	functions and characters of open space
D	BUSINESS CASE	
E	DESIGN REFINEMENT	
E	CONCEPT ARCHITECTURE	character areas and building typologies
E	CONCEPT STREET DESIGN	highways and streets
E	CONCEPT LANDSCAPES	open spaces and public realm
E	DEVELOPER BRIEF OR GUIDELINES	

06

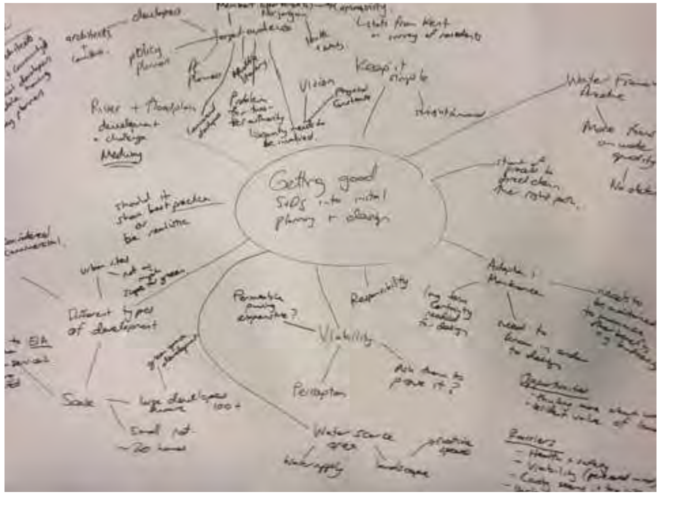
CONSIDERING SUDS THROUGH THE MASTER PLANNING PROCESS

CONSIDERING SuDS THROUGH THE MASTER PLANNING PROCESS

SuDS design should be fully integrated into a master plan as an essential part of land use and development planning, and considered in conjunction with other aspects of the design. This chapter outlines the tasks that should be considered in order to develop conceptual SuDS designs at each stage of the master planning process.

The process is designed to allow planners and designers to scope and embed opportunities for SuDS as land uses and design ideas evolve. The potential benefits outlined in chapter 3 should be prioritised and tailored through design. The site conditions in chapter 4 should also be appraised so that SuDS design is robust and responsive to context. These site-specific benefits and conditions should be identified during design stages A and B, then addressed through design stages C – E.

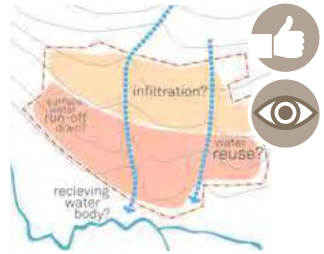
SuDS design tasks should be tailored to match the appropriate level of detail at each stage. As such, small developers may choose to customise and navigate the process more quickly to suit their needs.

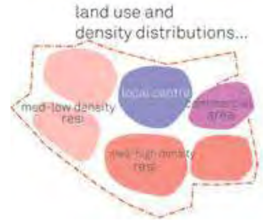
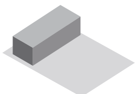
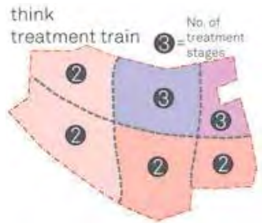
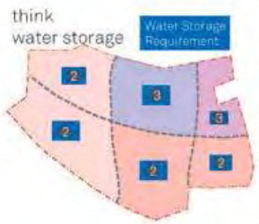


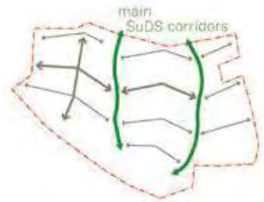
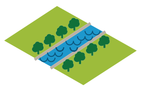
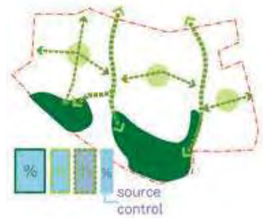
<table>
<tr><th colspan="2">Master planning process</th><th>Design process for SuDS</th><th></th></tr>
<tr><td rowspan="2">A. Prepare</td><td>AIMS AND OBJECTIVES
document aspirations</td><td>Identify targets and objectives

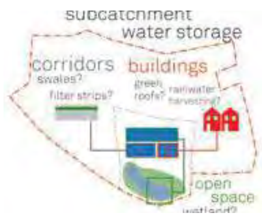
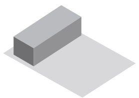
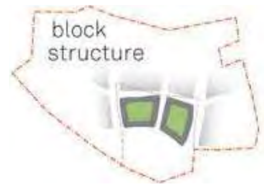
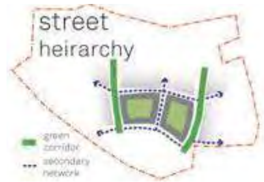
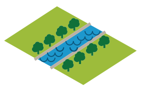
Identify relevant sustainability targets for water management, including local SuDS policy requirements and development specific targets.</td><td rowspan="2">
</td></tr>
<tr><td>OUTLINE BUSINESS CASE
viability, feasibility, pragmatic</td><td>Give forethought to likely synergies and challenges

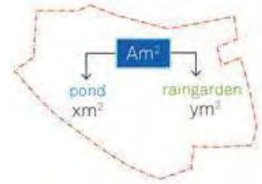
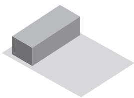
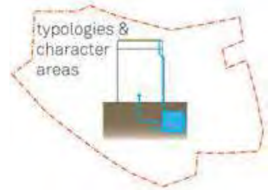
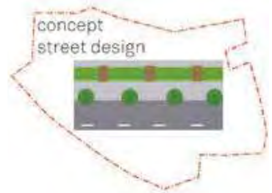
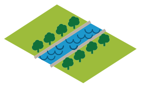
Ensure synergies and challenges are accounted for in the outline viability testing, particularly noting aspects that could influence the cost and benefits of the SuDS solution, including:
• position of the site within a wider catchment, its contribution to flood risk and its ability to support key movement and ecological corridors;
• green space and public space requirements where SuDS could be used as a multi-functional amenity feature;
• habitat and landscape needs that SuDS could influence;
• water recycling needs (often related to Code for Sustainable Homes or BREEAM targets) where SuDS can facilitate rainwater harvesting;
• the local planning requirements and stakeholders that may be involved in the adoption and maintenance of SuDS;
• likely change in permeability of the site which will influence attenuation needs; and
• risk of runoff contamination which will determine the level of water treatment needed through SuDS.</td></tr>
</table>

	Master planning process	Design process for SuDS	
B. Define	CONTEXT APPRAISAL understanding the baseline and how a place works	**SuDS baseline analysis** Conduct a baseline appraisal of the possible benefits of SuDS and the site conditions that could affect design. See chapters 3 and 4 for benefits and site conditions that should be considered. Identify desired benefits and challenging site conditions that will be considered in the design process.	
	SPATIAL FRAMEWORK opportunities and constraints	**Identify flow paths and low points** Existing drainage patterns and natural flow paths should be mimicked. Examine the existing topography (and note any substantial required changes to topography through development) to identify natural flow paths. Identify areas at the lowest points where water will naturally gather. This will help to maintain natural processes and eliminate the need for additional infrastructure or pumping. **Identify discharge options** Work through a hierarchy of options to determine where water should be directed: 1. water reuse – is there a local need for non-potable water? 2. infiltration – are ground conditions suitable for infiltration in some areas? 3. discharge to water body – is there a watercourse or water body on-site or near the site which could receive water? 4. discharge to surface water runoff drain – is there an above ground or below ground conveyance network for surface water only on-site or near the site? Could one be created? 5. discharge to combined drain – as a last resort, find connections to a nearby combined drain that carries both runoff and wastewater. On some sites there may be multiple discharge points and discharge types. **SuDS opportunities and constraints diagram** Include a high-level spatial diagram that identifies the possible benefits and constraining conditions for SuDS as part of the suite of baseline diagrams that make up the spatial framework for the site.	 
	ASSEMBLE THE MASTER PLANNING TEAM the right range of skills for the team	**Bring together the right skills** Identify skills that are needed in the master planning team to develop the best SuDS options. These should relate to the desired benefits to be developed and the site conditions that need to be addressed. A specialist with water management skills should be part of every team.	

	Master planning process	Design process for SuDS	
C. Design - Initial Testing	INITIAL TESTING	**Explore water movement** Design begins with an exploration of the relationship between the developed area and water. The placement and size of development will influence runoff rates and pollution risk and layout will influence the availability of opportunities for the introduction of sustainable drainage systems for amenity and biodiversity benefits.	
	LAND USE & DESTINATION Outline distributions and relationships 	**Identify SuDS sub-catchments (where suitable)** As the outline land use plan develops, a series of sub-catchments may evolve where distinct sets of SuDS treatment trains will be required. For example, on large developments which will be phased (built-out at different times) SuDS should similarly be phased to ensure each area is functional in itself. Also, there may be varying land uses on a site that give rise to different contamination risks, e.g. an industrial area within a wider residential development. SuDS in sub-catchments can join to regional SuDS systems downstream.	
		Allocate number of treatment stages All rainwater that falls on the site should generally be passed through at least two SuDS treatment stages to improve water quality before it is infiltrated into the ground or discharged (see chapter 3). The number of treatment stages should be scoped at this stage for each distinct drainage area or sub-catchment. **Estimate outline attenuation volumes** From the types of land use and density of the development, a general assumption can be made about the percentage of the area which is impermeable and will generate runoff. Using the local runoff-rate requirements this can be used to calculate a volume of runoff that needs to be attenuated for the site (and its component sub-catchments). This can be calculated manually or using modelling tools. A specialist member of the design team should be consulted at this time. The amount of source control (management where rain falls to prevent runoff such as rainwater harvesting, permeable surfaces and green roofs) should be estimated here through discussions with the design team to give a realistic estimate of runoff. The volume calculated does not need to be delivered as one storage area, and better solutions are often found by breaking down the storage volume into smaller parts and combining these with multi-functional spaces e.g. paved public areas, open spaces, roads, gardens).	 

Master planning process	Design process for SuDS	
KEY CONNECTIONS Strategic connections between destinations 	**Structure conveyance paths** At this stage of master planning, key routes and connections for vehicles and pedestrians will be established. Natural flow paths and 'man-made' connection routes (roads, green corridors) should be examined at this point to establish a structuring grid for surface water conveyance to storage areas and discharge points. Conveyance paths should work with topography to safely and effectively direct surface water to the desired location. Water should be kept above ground (not in pipes) where possible.	
OPEN SPACES Connected green infrastructure 	**Identify green space and public space locations** Most development types will include some form of open space, be it an urban park or a more informal public square. One of the key benefits of SuDS is their ability to be multi-functional - integrating into these spaces in an obvious or more subtle way. e.g. SuDS built into play spaces to prevent flooding. The master planning process may identify key locations for these spaces at this stage, which should be considered as locations for SuDS.	
MASTER PLAN OPTION TESTING	**Outline water management diagram** As early options for land use distribution are tested in the master plan, the location of SuDS conveyance paths, storage and treatment areas should also be outlined spatially and discussed with the design team and any relevant stakeholders who are involved with the overall master plan. Initial ideas for types of SuDS may be suggested at this stage.	

	Master planning process	Design process for SuDS	
D. Design - Preferred Strategy	PREFERRED STRATEGY	**Selection of SuDS portfolio** After the initial land use and spatial options testing, a preferred master plan option will be chosen for further detailing. At this stage, there is the opportunity for the design team to work together to develop the SuDS proposals to concept stage, selecting the possible types of SuDS and creating a SuDS network for the site. In any one area, several types of SuDS could be identified to provide flexibility for the developer in detailed design stage. SuDS components should be threaded together with the urban design vision to ensure they complement the development context and that they act as a treatment train, where water is conveyed from one SuDS component to another. Refer to the SuDS selection tables in chapters 3 and 4 to understand the relationship between site conditions, benefits and the various SuDS types and discuss options with the specialist in the team. Identify possible SuDS which can be used to make up the attenuation and treatment train requirements identified in the previous stage. It is often helpful to identify SuDS components that will be used in and around buildings (blocks), in roadways and in open spaces as described below. Solutions may vary by sub-catchment.	
	BLOCK STRUCTURE patterns of blocks and densities 	**SuDS portfolio – blocks** SuDS in these areas will predominantly take water from roofs and paved areas surrounding buildings. A general selection of suitable SuDS and source control measures should be identified at this stage that can be included on or around the building.	
	MOVEMENT FRAMEWORK street hierarchy and character of routes 	**SuDS portfolio – streets** At this stage, the width of major and minor routes (including green corridors) is likely to be decided. SuDS opportunities should be considered in tandem with requirements of the Highway Authority to allocate space that could be also used as verges, parking areas, or tree pits which could include a SuDS function.	
	OPEN SPACE NETWORK function and character of open space 	**SuDS portfolio – open space** A portfolio of possible SuDS components and their likely storage requirements can be defined at this stage.	
	BUSINESS CASE	**Create SuDS Concept Plan** As the preferred option is finalised, a business case for the master plan will be developed in more detail to underpin viability by estimating the number of units / floor area of development and the corresponding cost-benefit of the master plan proposals. At this stage, the portfolio of SuDS to be integrated into the development, and the general conveyance mechanisms between them should be decided. The outline amounts of attenuation for each sub-catchment should be indicated. This level of detail is appropriate for pre-application discussions or for a surface water management strategy submitted with an outline planning application. This is a good time to discuss adoption and maintenance and the target benefits to be delivered with stakeholders.	

	Master planning process	Design process for SuDS	
E. Design - Design Refinement	DESIGN REFINEMENT	**SuDS concept design and optimisation** At this final stage of master planning, the SuDS proposals can be developed to a concept level of design. Detailed design at a development plot scale will be completed at a later stage. This content will begin to build the detail required for a site specific surface water management plan. The solutions can be optimised to provide the best cost-benefit.	
	CONCEPT ARCHITECTURE character areas and building typologies 	**SuDS Concept Design - blocks and buildings** The final selection and concept design of SuDS should consider the roof type (flat, single slope, dual slope), building surroundings (gardens, forecourts), building uses and water demands. Outline sizing of specific features should be conducted at this stage.	
	CONCEPT STREET DESIGN highways and street 	**SuDS concept design – streets** In tandem with the development of street sections and visualisations the SuDS components should be selected and roughly sized. Overland conveyance such as swales should be given sufficient space here.	
	CONCEPT LANDSCAPES open spaces and public realm 	**SuDS concept design – open spaces** In tandem with the development of landscape concepts and visualisations the SuDS components should be selected and roughly sized.	
	DEVELOPER BRIEF OR GUIDELINES	**Create SuDS Brief** The vision for SuDS should now be integrated into the master plan. This vision can be integrated into developer briefs or design guides through the use of example designs and design criteria for SuDS. The SuDS brief should ensure the key benefits and site conditions are recognised as this will form the basis for further design at the plot scale. A selection of SuDS options could be presented if it is desired that more flexibility is provided for those conducting the detailed design stage.	

CONSIDERING SUDS THROUGH THE MASTER PLANNING PROCESS

07

DEMONSTRATION TYPOLOGIES

DEMONSTRATION TYPOLOGIES

Welcome to South East Waterbury, a ficticious but typical town in South East England. A range of developments types are shown here to demonstrate how SuDS can be intergrated at the master planning stage. Development 'typologies' include:

1. Education campus
2. Infill mixed-use development
3. Small residential mews
4. Medium scale residential development
5. Large scale urban extension
6. Business and industrial park

MAP OF SOUTH EAST WATERBURY

EDUCATION CAMPUS

DESIGN STAGE A

Site Plan

The education authority are working in partnership with a developer to deliver an educational campus on a Greenfield site. The campus includes a main primary school building, a nursery and play area, a playing field, a staff carpark and an outdoor basketball court.

DESIGN STAGE B

SuDS Constraints and Opportunities Diagram

- High point
- Low Point
- Biodiversity
- Less permeable geology
- More permeable geology
- Direction of flow
- Discharge location to watercourse

Site Benefits	Site Benefits Appraisal	Designer Reaction
Attenuation	Run-off rates need to be matched to Greenfield runoff rate.	Opportunity for small scale attenuation strategies such as filter strips or permeable paving.
Water Treatment	Water quality particularly important to minimise pollution on stream.	
Infiltration	Groundwater recharge considered beneficial.	
Water Re-use	The climate in the south-east is dry. Water re-use is a priority.	School rainwater harvesting strategy for pitch irrigation and toilet flushing.
Biodiversity and Habitat	Head teacher would like children to learn more about biodiversity.	Integrate natural observation and wet habitats.
Education	Education and natural learning is a priority. Health and safety of children is a concern.	Provide natural learning and spaces that are safe and functional when wet or dry.
Amenity	Visually attractive school.	
Open Space	School will contain playing fields and lots of informal recreation areas.	Opportunity to integrate recreation space with SuDS.
Character	No significant heritage features.	
Microclimate	Integration of trees important to provide shade for children.	Integrate trees with SuDS where possible.

SKILLSET

Education and Play · Water Engineering · Landscape Design · Ecology · Architecture · Planning

Site Condition	Site Conditions Appraisal	Designer Reaction
Flood Conditions	Not within a flood risk zone and no surface water flood risk area in immediate surroundings.	
Groundwater	Likely to be between 3 and 5 m below the ground surface for at least part of the year.	
Topography	Fairly flat site with gentle slope to the south and slight depression though the centre.	
Soils and Geology	No site bore hole information available at this stage. Soil map shows some areas of restricted permeability at the north of the site, with more favourable permeability to the south.	Infiltration SuDS would be good at southern end.
Contaminated land	None, greenfield site.	
Existing Infrastructure	Existing combined sewers along roadways to the east and south of the site draining to the local wastewater treatment plant. No existing drains or other utilities on site. There is ambition to change discharge to a stream on a neighbouring property to the south.	Opportunity to separate surface water to discharge to stream to south.
Space constraints	Fairly constrained school site.	
Runoff Characteristics	General urban runoff from buildings and minor roads. 50 percent impermeable surfaces anticipated - Roofs, pavements and play grounds.	
Existing Habitat	There is a site of metropolitan importance for nature conservation in the southeast corner of the site, and protected trees there and in the northwest.	
Ownership and maintenance	Will be owned and managed by the local education authority.	

EDUCATION CAMPUS

DESIGN STAGE C: INITIAL TESTING

Design Discussion

The low point of the site was identified as the south western corner, where there was also an opportunity to transfer flows to the watercourse on adjacent land to the south. This will require flow to pass through a culvert under the road but will avoid runoff entering the strained combined sewer network for the town. The baseline analysis also identified an existing biodiversity area to the south east of the site, so the southern boundary of the site became a focus for SuDS. There is also greatest permeability in the southern half of the site, making this more advantageous for SuDS features.

An appraisal of the land uses showed the major impermeable areas were the school building roof, the basketball court, the carpark and the nursery. The carpark is likely to give rise to most contaminants, and hence a three stage treatment train has been proposed. The suggested location for the car park is at the north of the site to allow the greatest scope to pass runoff through treatment stages as it flows towards the south west discharge point. Both the car park and the main school building require street frontage, and have been positioned fronting the road to the east. The playing field was a major permeable area which could also serve a drainage function. Accordingly, the playing field has been placed towards the south west of the site.

Space use and circulation strategy

Biodiversity + water flow corridor

Possible circulation spine

Impermeable and permeable space analysis

Outline Water Management Diagram

Indicative storage area at 0.5m depth

Number of treatment stages

EDUCATION CAMPUS

DESIGN STAGE D: PREFERRED STRATEGY

Design Discussion

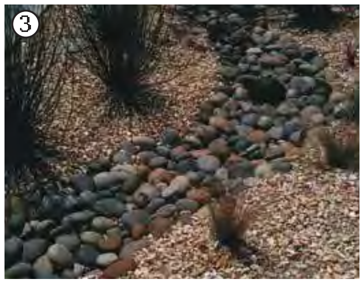
The two sources of the largest amount of runoff are located to the east of the site. There are no major internal routes to use for SuDS conveyance, but the site boundary provides an opportunity to incorporate a linear conveyance route which can transfer the bulk of the runoff from the main school building and carpark to the southern area. A swale is likely to be fitting in character and could provide a green edge to the school while providing an additional security measure around the perimeter. Discussions with the eduation authority identified the biodiversity area to the southeast as the best location for open water to be used for supervised teaching of older students and a pond or wetland were identified as preferred options here. Bioretention gardens or permeable paving with subsurface storage were identified as options for the car-park, with flow then transferring to the eastern swale.

SuDS Concept Plan

SuDS Ideas

Rain Chain for Nursery

Biodiversity Area



Dry Swale

CASE STUDIES

Building a school in a green belt – Riverhead Infant School

The Riverhead Infants School in Kent has an expansive sedum roof, which integrates the school building with its surrounding parkland setting located in a green belt. As the roof changes colours with the season it becomes a topic of discussion, presenting an opportunity to educate students about the importance of water conservation. The shape of the roof and the architectural quality of the building enhances the character of the surrounding development. Soakaways were utilised on site for additional surface runoff control.

Integrated water management at a school in Borough Green

The Grange Park School is designed to consider the requirements of the users and the constraints of the site. The curved north face is cut into the site slope and has a mono pitch roof rising out of the ground, designed to act as a noise deflector – minimising the sound of traffic from the M26. The roof is covered with grass and visually merges with the surrounding grassed areas and hedgerows. The south concave face of the building is a low rise combination of flat grass covered roofs which feature secluded/protected courtyards and acts to bring more light into the building.

Surface water from the green roof and play areas is collected for re-use in a grey water system within the building. The parking and vehicular access areas are paved with porous paving. Surface flows into the adjacent ditch are restricted to greenfield runoff rate.

DESIGN STAGE E: DESIGN REFINEMENT

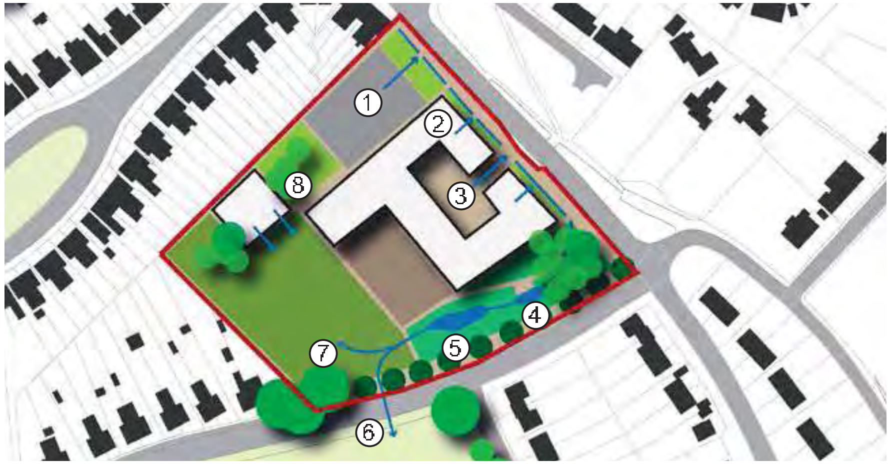
Design Discussion

The detailing of the school building resulted in a paved entry area to the school and a courtyard being added. Paved space needed to be maximised here to allow students to gather, however, the design team favoured the inclusion of an entry line of small trees. The tree pits have been designed as SuDS to provide bioretention using an undercroft layer of soil that provides storage and treatment of runoff from the courtyard area. The tree pits are underdrained by a perforated pipe which joins the boundary swale. A 3m corridor has been allocated for the swale with sufficient setback from the building. The swale has also been designed in conjunction with the access plan to minimise road crossings.

It was considered unsuitable to have open water in the nursery area around young children, but the teacher was still keen for children to see and hear water running. A 'rain chain' was suggested to transfer roof water down to a bioretention garden instead of a downpipe. The one-storey nursery roof was also identified as suitable as a green roof, which students could view from the upper stories of the main school building.

The swale was specified to be mostly 'dry' by having a layer of sandy soil on the surface which will promote sub-surface flow of water. Due to health and safety concerns, the biodiversity area was specified with a vegetated edge and a stepped entry bench.

Sub-catchment	SuDS Proposed for sub-catchment runoff	
	Within Sub-Catchment	In wider-site
School roof and courtyard	- Small underground rainwater harvesting tank for toilet flushing. - Eastern boundary swale. - Bioretention tree pits in courtyard.	- Eastern swale transfers to two-stage wetland in biodiversity area. - Wetland overflows to southern swale and culvert. - Overflow storage on school field.
Basketball court	- Permeable play surface (with infiltration).	- Overflow sheds across filter strip to southern swale. - Overflow storage on school field.
Car-park	- Permeable paving in eastern parking bay area (no infiltration). - Eastern boundary swale.	- Eastern swale transfers to two-stage wetland in biodiversity area. - Wetland overflows to southern swale and culvert. - Overflow storage on school field.
Nursery roof	- Green roof. - Rain chain from roof. - Bioretention garden at front of nursery (some infiltration).	- Overflow sheds to school field.



SuDS Brief

1. Car park to swale (via permeable surface)
2. Building to swale
3. Courtyard to swale (via bioretention tree pits)
4. Enter holding pond
5. Enter main pond
6. Discharge to watercourse 100m
7. Discharge overflow to recreation
8. Roof to bioretention garden. Discharge overflow to recreation area

Education Benefit: Water is a visible part of the school design, providing several opportunities for interaction and play.

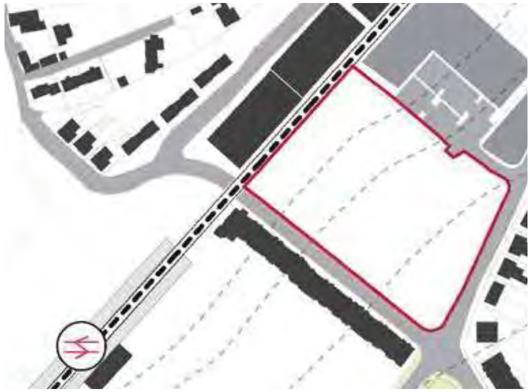
Biodiversity Benefit: An existing habitat area has been retained and enhanced, with an observational wetland for students.

Water Quality Benefit: The structure of the scheme includes a treatment train to ensure water is suitable for use in the biodiversity area. High quality water is also conveyed to the nearby water course, avoiding use of the sewer.

Attenuation Benefit: The playing pitch has been positioned as an exceedance storage area in major storms. It will be slightly depressed to be able to store water for regulated discharge to the stream via the culvert.

INFILL MIXED USE DEVELOPMENT

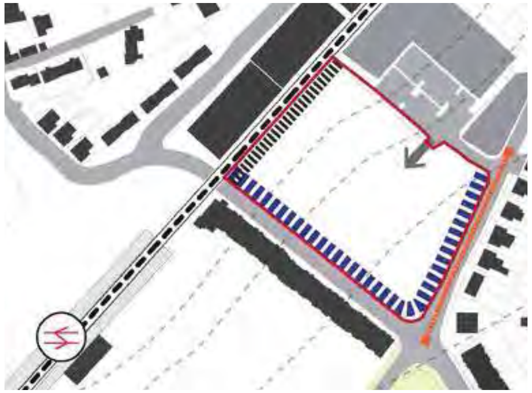
DESIGN STAGE A



Site Description

Private developers are looking to build a high density mixed use urban infill development on a site in central South East Waterbury. It will include office space, some retail frontage and a small number of flats.

DESIGN STAGE B



SuDS Constraints and Opportunities Diagram

- Retail frontage
- Railway fronting edge
- Existing combined sewers
- Entry to site
- Railway line
- Railway station

Site Benefits	Site Benefits Appraisal	Designer Reaction
Attenuation	Requirement for betterment of the brownfield runoff rate	
Water Treatment	Treatment of water required for reuse	
Infiltration	Low groundwater and infiltration would be beneficial	Use infiltration SuDS where possible
Water Re-use	Office accommodation has to meet high sustainability targets.	Opportunity to flush toilets with rainwater
Biodiversity and Habitat	Any improvement to urban ecology desirable	
Education	Employees can appreciate SuDS features in their place of work	
Amenity	The developer wants to create a high quality setting to attract businesses to the site.	Opportunity for water and landscape features in public realm
Open Space	Tranquil recreational areas for employees to relax in and take a break	Opportunity to integrate SuDS with seating and relaxation space
Character	The park should provide high quality office accommodation within an attractive green setting	
Microclimate	Very built up area where greenery and water for cooling is beneficial	

Site Condition	Site Conditions Appraisal	Designer Reaction
Flood Conditions	The site is not within a flood risk zone, but it is in a surface water flood risk hot spot.	Remove or attenuate runoff as far as possible.
Groundwater	The water table is over 10m below ground level	
Topography	Flat previously developed site with existing hard standing.	
Soils and Geology	Soils map shows that soil conditions have some permeability.	
Contaminated land	No contamination has been identified on site.	
Existing Infrastructure	Existing combined sewers along the roadways to the south.	
Space constraints	Space constraints are very high, with a desire to maximise floor space.	
Runoff Characteristics	Commercial use with no car parking, low pollutant hazard. Approximately 90 percent impermeable: including roads, pavements, car parking pavements, roof areas and a courtyard.	
Existing Habitat	None identified on site	
Ownership and maintenance	Private ownership	

SKILLSET

Water Engineering | Landscape Design | Architecture | Planning | Flood risk advice

INFILL MIXED-USE DEVELOPMENT

DESIGN STAGE C: INITIAL TESTING

Design Discussion

As a small site, optioneering mainly concerns the size of the buildings, the key frontages and split of uses. A general footprint was developed for the site, which maximises the retail frontage along the southern edges for ground level shops where footfall is likely to be the highest. Apartments will be developed in the floors above the retail uses. An office building is planned to be adjacent to the railway to shield noise from residents and to be close to the neighbouring car parking to the east of the site. This design has led to the allocation of buildings on three sides, with the eastern side reserved for access for deliveries and a small courtyard for office workers to eat lunch. The large roof area and the paved courtyard will comprise a highly impermeable area, leading to a significant generation of runoff.

Space use and circulation strategy

- Office use
- Residential use
- Open space
- Potential access
- Potential block evolution

Outline water management diagram

- Indicative storage area at 0.5m depth
- Number of treatment stages

INFILL MIXED-USE DEVELOPMENT

DESIGN STAGE D: PREFERRED STRATEGY

Design Discussion

The development also has planning requirements to provide private and amenity space for both residents and the office workers, but space is at a premium. The small courtyard area can be used by the office workers, but residents are likely to be limited to balconies for private space. The architect has proposed a roof garden to provide additional space for residents. Both the courtyard and the roof garden provide opportunities for SuDS to be included while also providing amenity in a dense urban context. The roof garden design has been developed to include green areas where possible that will absorb water, while also channelling excess water to bioretention tree-pits positioned over two of the weight-bearing pillars to ensure they are structurally sound. A small hardscape water feature, a bioretention garden or underground rainwater harvesting tank could be included in the courtyard to take excess roofwater, while the courtyard itself could be drained by a small area of permeable paving or a bioretention garden.

SuDS Concept Plan

CASE STUDIES

Appropriately using permeable paving in Hunter Avenue

Hunter Avenue in Ashford provides an example of the challenges faced in high density developments. Despite the constraints inherent in a 50 dwellings per hectare scheme, the development incorporates greenspace intelligently, improving the aesthetics and increasing the number of trees on site. Permeable pavement has also been included for surface water control with below ground attenuation. Overland flood flows are contained within the road curtilage and parking areas along the southern boundary of the site.

Building integrated SuDS in Brighton

The Keep is a 1 to 3 storey historic records and archive centre, including lecture and educational facilities, designed to meet BREEAM excellent standard. The site is located in a sensitive area, within a Groundwater Source Protection Zone 1 where there is strict control over discharge of water. The site incorporates three roof gardens, rainwater harvesting and an attenuation tank. The roof gardens contain a mix of grass and wild flowers to create a natural environment that requires minimal maintenance. The rainwater harvesting system provides water for toilets. Planning permission was conditional on there being a satisfactory maintenance regime for the system.

INFILL MIXED-USE DEVELOPMENT

DESIGN STAGE E: DESIGN REFINEMENT

Design Discussion

In appraising the SuDS options, it was decided that a bioretention garden would provide greenery and could be designed to take both runoff from the courtyard and excess runoff from the roofs. The client also liked the idea of rainwater harvesting to meet BREEAM and Code for Sustainable Homes targets, so a rainwater storage tank was placed underground and used in tandem with the bioretention garden, which provides pre-treatment of the water for re-use. Stored rainwater is distributed to buildings for reuse in flushing toilets and some additional storage is built into the tank for attenuation.

SuDS Brief

① Bioretention Garden

② Roof Garden

③ Underground storage for reuse

Recreation Benefit: A roof garden with green roof and bioretention features to provide greenery will absorb rainwater while providing a valued private space for residents.

Amenity Benefit: The courtyard bioretention garden provides a pleasant office design feature and garden space for office workers to eat lunch beside.

Water Reuse Benefit: Rainwater harvesting helps to meet sustainability targets, with the bioretention garden providing pre-filtration.

Attenuation Benefit: Some additional storage is provided in the rainwater tank to regulate flows to the combined sewer and help prevent sewer flooding.

SMALL RESIDENTIAL MEWS

DESIGN STAGE A

Site Plan

A local developer is proposing a minor residential development of approximately 10 units within South East Waterbury. The developer wants to build a mews-style development with a central paved area. There are no green space requirements. This brownfield site is a former cul-de-sac that is constrained by existing homes and roads in all directions.

DESIGN STAGE B

SuDS Constraints and Opportunities Diagram

- - - Existing combined sewer
▬ ▬ Site edge fronting back of houses
Potential contamination

Site Benefits	Site Benefits Appraisal	Designer Reaction
Attenuation	Run-off rates need to match or better existing conditions (disused grassland and hardcore)	
Water Treatment	Water quality especially important to enable local re-use of water.	
Infiltration	Groundwater protection zone.	Be careful with contamination.
Water Re-use	All units are required to meet code for sustainable homes level 4.	Rainwater harvesting will help to meet credits.
Biodiversity and Habitat	The site is currently an overgrown derelict site. Opportunity to enhance.	
Education	A lot of families expected, and should be suitable for children	Opportunity to teach people about water management and reuse using obvious features.
Amenity	Low maintenance environment, but the local families would like some space for plants and herbs.	Could integrate planter boxes in a formal arrangement.
Open Space	The cul-de-sac will be developed as a mews to allow children to play safely on the street.	
Character	Character will be fairly urban in nature. Typical brick work character.	
Microclimate	Greenery beneficial to provide a pleasant climate.	

Site Condition	Site Conditions Appraisal	Designer Reaction
Flood Conditions	The site is not within a flood risk zone	
Groundwater	Groundwater is likely to be between 3 and 5 m below the ground surface for at least part of the year.	
Topography	Site records show that the site is relatively flat, with a gentle slope to the south.	
Soils and Geology	A SuDS map requested from the British Geological Survey shows that the ground conditions have variable permeability.	
Contaminated land	It is a brownfield site, and contamination studies are inconclusive. Designers have been advised to err on the side of caution.	SuDS may need to be lined due to contaminated land risk.
Existing Infrastructure	Existing combined sewer in road junction entering the site.	
Space constraints	The site is highly restricted by space and existing development and infrastructure surrounding.	Space constraints may mean that SuDS features need to include underground storage.
Runoff Characteristics	General urban runoff from roofs and paved surfaces. 90 percent impermeable surfaces anticipated - roads, pavements, and roofs. Permeable surfaces include private gardens	Opportunity to reduce impact of large areas of hard surface by using features such as permeable paving or green roofs.
Existing Habitat	No protected species or designated ecological areas.	
Ownership and maintenance	Private mews	

SKILLSET

Water Engineering · Architecture · Highways Engineering · Planning

SMALL RESIDENTIAL MEWS

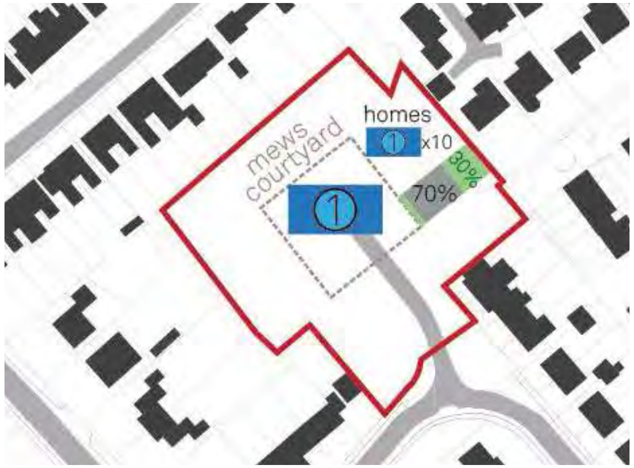
DESIGN STAGE C: INITIAL TESTING

Design Discussion

In the case of a small single use site such as this, no land use optioneering was undertaken by the master planning team. A mews development centred around a central courtyard was feasible and desirable. The land uses do not present any major pollutant risk, but source control will need to form an important part of the SuDS strategy to reduce runoff. There is some uncertainty around soil conditions on site, with some contamination expected in the central area and variable permeability across the site. Accordingly, it is expected some infiltration could occur around the edge of the site. This is the most likely location for private gardens which back onto neighbouring gardens. The possible contamination in the centre of the site, means that remediation will require some soil removal. This could be replaced with a gravel storage layer that could be used as part of the SuDS scheme. If contamination is found to be deep, the underground SuDS storage could be lined with a clay liner or geotextile.

Space use and circulation strategy

- Residential types
- Open space
- Potential access



Outline water management diagram

- Indicative storage area at 0.5m depth
- 2 Number of treatment stages

CASE STUDIES

Rainwater used to animate the landscape in Portsmouth

This Environment Agency funded pilot scheme in Portsmouth spans across two sites – one private residential block, and a housing development for the elderly. The private residential block at St. Faiths harvests and re-uses rainwater to animate and irrigate the landscape. Capturing roofwater, the design stores water to irrigate planting areas using a hand pump, with any overflow diverted to a rock feature. The nursing home at Nicholson Gardens captures roofwater in above ground attenuation tanks, and stores it underground. The captured water can be used for irrigation purposes as well.

Effective Maintenance Planning in Ore Valley

Sitting above Ore Valley Stream – a culverted stream – the site needed to design for exceedence in case the culvert became blocked. The swales and above ground pond selected not only mitigates flood risk from the stream, but also works to convey surface water runoff during routine rainfall events – promoting groundwater recharge, improving water quality and amenity value in the process. Perhaps the most impressive element of the Ore Valley scheme is the maintenance guidance created, which details how to maintain a wide variety of SuDS features so they continue operating as intended.

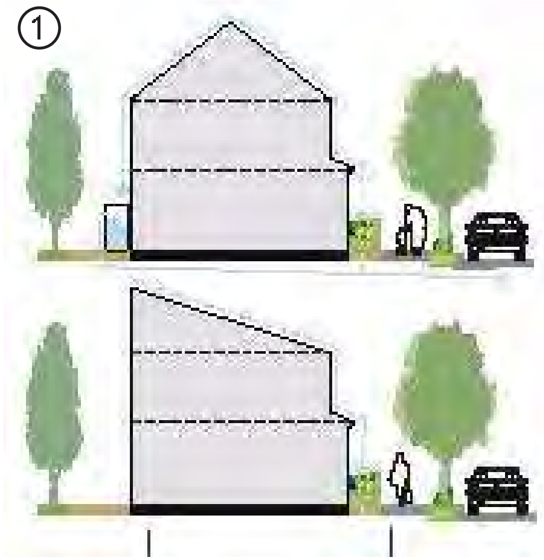
SMALL RESIDENTIAL MEWS

DESIGN STAGE D: PREFERRED STRATEGY

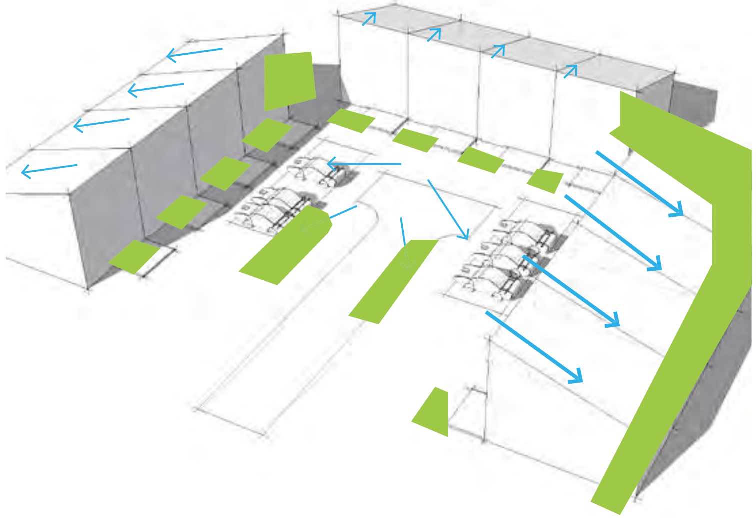
Design Discussion

There were two primary sources of runoff to be considered; residential roof water and runoff from the mews courtyard and parking area. At this point, it was important to develop the conceptual character of the development and test SuDS options to suit. In the mews courtyard, permeable paving or bioretention gardens could be used with underground storage in the sub-base to provide significant storage. The type of SuDS selected depended on the desirable character of the mews and the adoption and maintenance arrangements.

Lack of space was the key constraint for SuDS section. The roof styles of the housing will affect the drainage arrangements. Two styles were considered, either draining to the front and back, or just to the back. Several SuDS options were available for the front and back garden to provide initial treatment/removal of runoff before any excess water is then drained underground into the attenuation area beneath the courtyard. These options include green roofs, rainwater harvesting, bioretention gardens, bioretention planters (elevated in constructed planter box), soakaways or permeable paving.



Roof drainage and SuDS options



Possible runoff capture areas

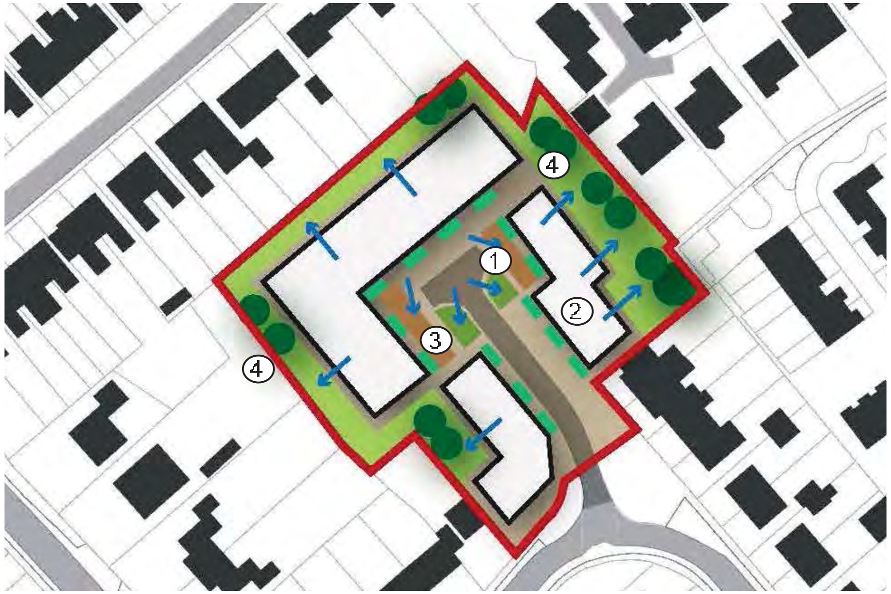
SuDS Concept Plan

SMALL RESIDENTIAL MEWS

DESIGN STAGE E: DESIGN REFINEMENT

Design Discussion

In this case, a low maintenance paved courtyard was favoured by the design team which will complement with brickface character of the dense development in this area of South East Waterbury. Accordingly, permeable paving was specified for the edges of the courtyard area, using a rule of thumb that permeable paving can drain twice its area of impermeable surface. A central planted bioretention area was also included to drain the central roadway. For efficiency, back sloping roofs have been selected, and a combined water butt and herb planter was favoured to provide growing space for residents. This also provides rainwater harvesting but avoids the installation of permanent features in the back garden which may be subject to change upon purchase.



SuDS Brief

① Parking with permeable paving

② Single side sloping roof

③ Lined bioretention areas

④ Water butts and bioretention planters

Attenuation Benefit: The inclusion of additional storage in the pavement sub-base under the courtyard area will allow peak flows to be stored, relieving pressure on the combined sewer.

Water Reuse Benefit: The installation of multi-functional water butts assists with the achievement of Code for Sustainable Homes level 4.

Amenity Benefit: The use of the planter / water butt in the back yard provides flexible greenery and food growing areas.

Heritage and Character Benefit: Local built character kept through use of permeable paving.

MEDIUM SCALE RESIDENTIAL DEVELOPMENT

DESIGN STAGE A

Site Plan

A small house builder is looking to build approximately 50 homes on a brownfield site within South East Waterbury. The development will include parking courts, a homezone style of street and a small community green.

DESIGN STAGE B

SuDS Constraints and Opportunities Diagram

High point — Direction of flows

Low Point — Existing combined sewer

Site Benefits	Site Benefits Appraisal	Designer Reaction
Attenuation	Local planning policy requires that run-off rates will show betterment from brownfield rates.	Opportunity to please planning authority if we can improve attenuation or infiltration.
Water Treatment	Water quality particularly important for infiltration SuDS.	
Infiltration	Groundwater recharge is a priority in this area.	Infiltration favoured.
Water Re-use	The climate in the south-east is dry. Water re-use is a priority.	Opportunity for community rainwater harvesting strategy for local garden square and allotment.
Biodiversity and Habitat	Opportunity to improve urban ecology and connections through to rural edge to the east.	Improvements to small scale biodiversity perhaps within the area of community green to include native grasses to complement rural edge.
Education	Inherent education opportunities.	
Amenity	Residents in area are fed up with the urbanity of the area and they want more greenery.	Integrate SuDS features into new community green.
Open Space	The proposal will contain small areas of recreation and play space for families to enjoy.	
Character	The development will reflect a suburban character	
Microclimate	Dispersal of greenery important for climate.	

Site Condition	Site Conditions Appraisal	Designer Reaction
Flood Conditions	The site is not within a tidal/fluvial flood risk zone, but is a large area which currently generates a lot of runoff causing surface water flood risk in the town.	Reduce runoff as much as possible
Groundwater	Groundwater is likely to be between 3 and 5 m below the ground surface.	
Topography	Site records show a fairly flat site with a small slope to the south.	On a flat site keep water on or close to surface to avoid deep SuDS
Soils and Geology	Local bore holes indicate good permeability.	Opportunity for infiltration SuDS
Contaminated land	Previous use was housing, and there is no contamination of concern.	
Existing Infrastructure	Existing combined sewers along the roadways surrounding the site and within the site.	
Space constraints	Being a brownfield site with development in all directions, space constraints are high.	
Runoff Characteristics	General urban runoff from buildings and minor roads. 70 percent impermeable surfaces anticipated - roads, pavements, roofs, parking courts and homezone. Permeable surfaces include private gardens and public recreation space.	Opportunity to design unique SuDS in homezone area
Existing Habitat	Existing use as housing, no designations or identified protected species.	
Ownership and maintenance	Homezone and minor roads to be adopted as public roads.	

SKILLSET

Water Engineering · Architecture · Highway engineering · Landscape Design · Ecology · Planning · Urban Design · Flood risk advice

DESIGN STAGE C: INITIAL TESTING

Design Discussion

Due to proximity of community facilities nearby, the land use of the site will be wholly residential in nature. Accordingly, urban design focuses on delivering homes efficiently while also creating a high value and desirable development for sale. Greenery has been identified as a key selling point and also a planning benefit in terms of urban biodiversity. This fits well with a SuDS strategy that maximises the use of vegetation. The site is also fairly flat, meaning that piped drainage networks are to be avoided as this will cause site-scale SuDS features to be very deep. Accordingly, the SuDS strategy here focuses on providing attenuation and infiltration close to where rain falls. This will maximise groundwater recharge, irrigate greenery and minimise the impact on the sewer system.

The inclusion of a community green provides an opportunity to integrate green space with SuDS features. The preferred design location for the green was the north of the site near the rural edge, while the natural low point was in the south. Discussions with the water engineer established that source control measures were most favourable, and hence it was not necessary to use the community green for the inclusion of site-wide SuDS.

Space use and circulation strategy

- Waterbury terrace
- Waterbury heights
- Waterbury gardens
- Green open spaces / gardens
- Key Access
- Rural Access

Outline water management diagram

- Indicative storage area at 0.5m depth
- Number of treatment stages

CASE STUDIES

Making use of natural drainage pattern in Singleton Hill

Singleton Hill is a development in Ashford which considered drainage from the outset of the master plan. As a result buildings were designed around the existing drainage pathways. Maintaining the natural drainage pattern eliminates the need to engineer conveyance routes. The main drainage channels were developed as a greenway for pedestrian and cycle access through the development to a local commercial area. This makes walking and cycling safer within the development, and reduces the need for residents and visitors to use cars.

Designing storage in Windmill View

Windmill View is a new residential development. Historically, the site has flooded due to overland flows from surrounding agricultural land. As there are no nearby watercourses to receive surface water discharge, the inclusion of a bund and additional drainage to an amenity pond has helped mitigate existing flood risk. Swales, porous paving, trapped gullies, and petrol interceptors assist in filtering surface water runoff, with the remaining runoff drained to an infiltration basin via a piped network.

MEDIUM SCALE RESIDENTIAL DEVELOPMENT

DESIGN STAGE D: PREFERRED STRATEGY

Design Discussion

The master plan was developed to include three 'character areas' which offer different housing styles to buyers. Each of these character areas has different SuDS opportunities as shown by the adjacent table.

SuDS Concept Plan

Character Area	SuDS Opportunities	
Waterbury Terrace: The area to the west is near the school and prioritises family housing at a medium density. It includes private gardens and a 'home zone' route to encourage pedestrian movement and play as well as necessary vehicle movement in a shared surface.	Home zone – could include distributed bioretention gardens and tree pits which are used as traffic medians to slow vehicles. Shared surface would suit block paving which could be permeable. Medium density terraced housing – Variety of SuDS suitable for front and back gardens. Inclusion of green back gardens for families will increase permeability.	
Waterbury Heights: The central area is centred around the primary through-route for the development, where there is a higher density of housing aimed at young professionals.	The central route - could be 'greened' through the use of a central or side formal swale, bio-retention tree planters or permeable paving strips along the side. Higher density apartment blocks - will drain to communal gardens that can include centrally managed bioretention gardens.	
Waterbury Gardens: The eastern end of the development offers a stronger community feel with a mix of units for older people and family housing. A community green and small allotment is favoured in this area to lend appeal to the development.	Development facing the green – can be treated as a 'pod' where all roofwater is intercepted by water butts for gardening supply, with excess channelled to the community garden area where it is filtered in a bioretention garden and allowed to infiltrate or directed to underground storage beneath a green area.	

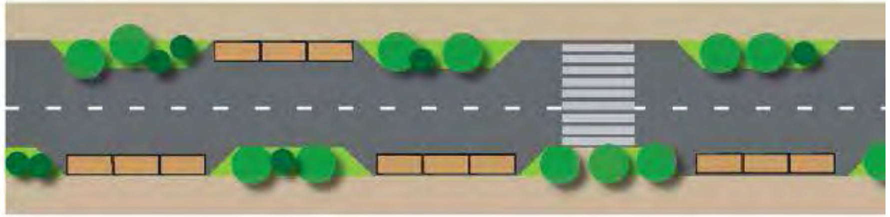
MEDIUM SCALE RESIDENTIAL DEVELOPMENT

DESIGN STAGE E: DESIGN REFINEMENT

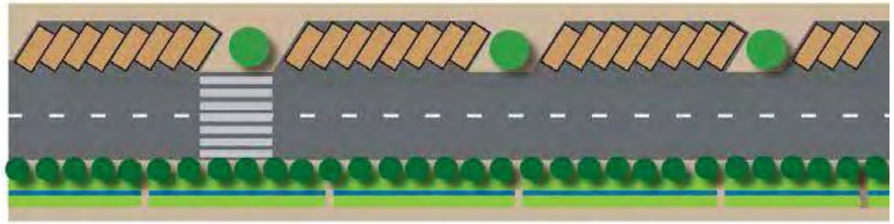
Design Discussion

The design of the specific SuDS features will prioritise infiltration, though in major events when features are overwhelmed, water may need to be conveyed elsewhere. There is a combined sewer in the area, but a separate discharge to the river is being constructed near the school. A separate surface water drainage system would be favoured to take overflows and minimise additional pressure on the existing sewers and wastewater treatment plant.

Detailed design of the homezone favoured the use of bioretention gardens to slow and discourage traffic while improving the look of the street through the addition of self-irrigated street trees. A formal swale was used in the central street (see Ashford case study) which also allowed integration of street greening. The local council favoured the delivery of allotments in the community garden, so all roof water draining to the front of the houses enclosing the garden will be directed to a central storage tank for irrigation with overflow to the bioretention garden.



Homezone with bioretention traffic medians and permeable pavement parking bays



Roadside swale

① Swale

② Tree pits and permeable parking area within homezone area

③ Source control in back gardens

④ Bioretention area in communal green

SuDS Brief

Water Reuse Benefit: Water is captured around the community garden for use in watering the allotments.

Biodiversity Benefit: The focus on green SuDS will promote urban ecology and help to achieve the planners objectives for the development. The greening of the development will increase house values.

Amenity Benefit: The use of SuDS in the homezone doubles as traffic calming measures.

Heritage and Character Benefit: The differing SuDS strategies for the character areas have been designed to suit the focus of the local area.

Water Treatment: Pre-treatment of all water is delivered before water is then encouraged to infiltrate, removing water from the town's sewers.

LARGE SCALE URBAN EXTENSION

DESIGN STAGE A

Site Plan

The local Council is looking to develop a 29ha greenfield site on the south western edge of South East Waterbury. They intend to develop a master plan and an accompanying developers brief for the site and release the land to several developers. The vision is to create a mixed use urban extension of approximately 500 units.

DESIGN STAGE B

SuDS Opportunities and Constraints Diagram

High point
Low Point
Direction of flows
Flood risk zone
Biodiversity areas

Site Benefits	Site Benefits Appraisal	Designer Reaction
Attenuation	Runoff needs to be matched to Greenfield runoff rates.	
Water Treatment	Environment Agency concerned about diffuse pollution to river.	
Infiltration	Good potential for groundwater recharge in the north.	
Water Re-use	The sustainability officer wants to meet Code for Sustainable Homes level 5.	Opportunity to use rainwater and surface water runoff harvesting to supply non-potable water to homes.
Biodiversity and Habitat	As a Greenfield site, there is a requirement to protect and enhance biodiversity and natural habitats.	Opportunity to integrate SuDS with large wild habitats to be more cost-effective.
Education	The development will mostly cater for families, creating a SuDS educational opportunity for a variety of ages.	
Amenity	The developer wants to maximise the desirability of homes and quality of living environment.	Use SuDS features to provide aesthetic value such as views of green space and water.
Open Space	The proposal will contain large areas of recreation space and play space for families to enjoy.	Integrate SuDS with recreational routes and play spaces.
Character	The area's rural landscape setting to be reinforced.	Well-designed road side swales can enhance the rural character of the scheme.
Microclimate	Opportunity for strategic blue-green corridors to naturally provide cooling and shelter	Think about ecological corridors.

Site Condition	Site Conditions Appraisal	Designer Reaction
Flood Conditions	Part of site falls within a tidal/fluvial flood risk zone in the south where it borders the Waterbury River.	Areas within the floodplain have a high groundwater table Development should limit grading and the development of surface features to avoid erosion.
Groundwater	Groundwater is likely to be less than 3 metres below the ground surface for at least part of the year across the site.	Some SuDS may require a liner.
Topography	Site records show a natural descent towards the river in the south. Two depressions run though the centre of the site. A gulley to the west has a relatively steep gradient.	Opportunity to align natural drainage corridors with key routes. Secondary routes could be angled to feed into these principal corridors.
Soils and Geology	The SuDS map requested from the British Geological Survey shows areas of restricted permeability to the south of the site although there are some areas of good permeability in the north.	Some areas may be suitable for infiltration in the north.
Contaminated land	No record of contamination on site.	
Existing Infrastructure	Existing combined sewers along the roadways to the north and west. No existing drains or other utilities on site.	
Space constraints	Space constraints are low.	Opportunity to provide multi-functional green open spaces.
Runoff Characteristics	General urban runoff from residential and commercial areas and minor roads. 60 percent impermeable surfaces anticipated - roads, pavements, roofs and squares. Permeable surfaces include private gardens and public recreation space.	
Existing Habitat	Hedgerows on site and a number of existing trees, especially around existing drainage corridors. May be water voles near river.	
Ownership and maintenance	Roads will be adopted as public roads by the Highways Authority, and open spaces to be adopted by Local Authority.	

LARGE SCALE URBAN EXTENSION

DESIGN STAGE C: INITIAL TESTING

Design Discussion

As a large master planned site, it is important to make good early decisions around land use distributions and drainage conveyance paths in order to maximise benefits. An allocation of green space was required for the site by the Council, and the development must include good pedestrian and cycle links as well as a local centre to provide community facilities for residents. At this scale, it is possible to build in a strategic SuDS network. The river is a prime attraction, and the urban designers were keen to bring connections from the town centre to the river. Riverfront property is also at a premium, but needed to be positioned outside of the flood zone to gain planning permission. Two broad options were developed for the site, by examining key routes, favoured locations for the community centre and landscape links:

Land use plan option 1 and option 2

Option 1: A basic grid system was put in place which will take advantage of the south-sloping site to maximise rows of housing that enjoy a river view. The open space allocation is focussed on the area in the flood zone and the area adjoining the Greenfield boundary to the southwest. Key connections run through and across the site to link the development with the surrounding area.

Option 2: Discussions between the urban designers and water engineer led to an alternative option which will make better use of natural drainage paths and open space to accommodate strategic SuDS for the site. There were clear benefits in maintaining the existing vegetation around the drainage paths, and the urban designers favoured the use of two linear parks. This could efficiently deliver open space which was better distributed through the development, while also raising property values by providing additional homes which overlook green areas.

Outline Water Management Diagram

Indicative storage area at 0.5m depth

(2) Number of treatment stages

Green Corridor

SKILLSET

LARGE SCALE URBAN EXTENSION

DESIGN STAGE D: PREFERRED STRATEGY

Design Discussion

Options were discussed with stakeholders and the developer group, and Option 2 was favoured due to the increased amenity value for the majority of the development provided by the green corridors. The green corridors were envisaged as key character features for the development, which would be flexible in use, and could accommodate play areas, allotments, pedestrian and cycle paths and SuDS. A business case analysis showed that a larger number of homes could be delivered under this option and that a higher proportion would enjoy green views. The end of the green corridors provided an ideal location for a 'destination' landscape feature that leads into the larger open space adjoining the river. This open space was favoured as an informal grassed space which is able to accommodate flooding as needed. In developing the block structure, the roads were aligned in a slight herringbone structure, so that topography will favour natural drainage towards the green corridors. Phasing discussions favoured the progression of development from east to west, with the green corridors being delivered similarly to provide phased drainage capacity.

Sub-catchments have been defined to mirror the phasing and land use pattern. The amount of attenuation that needs to be achieved in the northern areas is greater due to the infiltration opportunity with more permeable soils, leaving the site-wide features to manage more flow from the southern sub-catchments.

Street structuring for gravity surface drainage

SuDS Concept Plan

Percentage of attenuation provided in a designated area

Regional Storage

Within subcatchment

Within Corridor

CASE STUDIES

SuDS in a Groundwater Source Protection Zone

Augusta Park is a residential area situated on a major chalk aquifer in source protection zones 1 and 2, with restricted discharge of surface water runoff. The development's strategy is for all surface water to be managed through infiltration, in 26 distinct sub catchments designed for the 1 in 100 year flood event + 30% climate change allowance. The design includes shallow swales alongside highways and infiltration and detention basins at the lowest point of the site.

Raising property values in Elvetham Heath

Elvetham Heath is a large site, which due to the high water table, was limited in its ability to manage drainage with infiltration at source. Swales provide the main conveyance route to detention and retention ponds, where runoff is stored and treated. The retention pond is the central feature of the development, improving the amenity and value of surrounding homes. In fact, housing close to SuDS features have seen an estimated 10% increase in property value.

DESIGN STAGE E: DESIGN REFINEMENT

Design Discussion

While the large green space to the south provides a logical place for strategic-scale SuDS, the high groundwater table, sensitive ecology and flood risk zone requires some careful design consideration. The green corridors themselves can be designed to slow flow and provide significant storage. ‘Gateway’ features at the end of the corridors were designed as wetlands with horizontal flow and some storage provision. These were positioned outside of the flood zone, so that the SuDS system remains functional in times of flood. A controlled outflow from the wetland can regulate discharge to the river, and back up into storage areas in the green corridors when necessary. The wetland has been designed to be maintained in sections so that habitat can be protected. The western side of the development can make use of a bioretention basin as a landscape feature in the open space outside of the flood zone.

The design of the street hierarchy allocates three street typologies: streets alongside the green corridor swales, main routes which will include bioretention tree pits or permeable paving with shallow drainage that drain to the green corridors and smaller streets that have short kerb runs which connect to the main routes.

Discussion with the sustainability consultant has highlighted a need for a non-potable water source to meet Code for Sustainable Homes level 5. The filtered water from the wetlands and bioretention basin is to be stored in an underground tank for redistribution around the site. A water company has agreed to operate the scheme due to the number of homes requiring delivery of non-potable water.

The strategic SuDS are designed to provide a certain amount of attenuation and also store water for the reuse scheme. The developers brief will include requirements for runoff rate limits, attenuation requirements and treatment stages in each sub-catchment so that developers are clear on how much runoff can be transferred to the strategic SuDS, and what SuDS need to deliver within the development plots. Developers for the northern plots will be encouraged to explore infiltration techniques where soil conditions are more favourable.

SuDS Brief

1. Blue-green corridor with swale
2. Streets with bioretention tree pits/permeable parking area
3. Source control within the subcatchment
4. Bioretention area
5. Storage tank for recycled water

Runoff recycling scheme

Grovelands Farm, Hailsham

Water Reuse Benefit: A site-wide rainwater harvesting scheme uses SuDS to filter water for storage and reuse to meet sustainability targets in a cost-effective manner.

Attenuation Benefit: Storage is accommodated in the development plots and strategic features to store water outside of the flood zone.

Amenity Benefit: The maintenance of drainage paths increases land value by increasing the number of homes with a green space frontage.

Biodiversity Benefit: Existing landscape features were maintained through retention of natural drainage corridors.

Water Treatment Benefit: A treatment train is developed across the site by using strategic features as well as SuDS within the development areas.

Open Space Benefit: Multi-functional green space was distributed around the site, using SuDS as gateway landscape features and drainage pathways as key walking and cycling links.

BUSINESS AND INDUSTRIAL PARK

DESIGN STAGE A

Site Plan

Private developers are looking to develop a business and industrial estate on a site north-west of South East Waterbury. Half the site was previously developed as an industrial site, and the remaining part of the site is greenfield. The site is situated alongside the town's railway with direct access to the station.

DESIGN STAGE B

SuDS Opportunities and Constraints Diagram

- High point
- Low Point
- Direction of flows
- Railway Station
- Reasonably permeable zone
- Contaminated land
- Existing combined Sewers
- Entry to site
- Railway line

Site Benefits	Site Benefits Appraisal	Designer Reaction
Attenuation	Local authority wishes whole site to meet Greenfield runoff rates. Some runoff comes to site from the adjacent railway area.	Could intercept railway runoff with a linear swale to stop additional runoff migrating onto developable area.
Water Treatment	Runoff discharged to ground must not be contaminated.	Run off from the previously developed land could contain pollutants.
Infiltration	Groundwater recharge beneficial in Greenfield area.	
Water Re-use	Office accommodation has to meet high sustainability targets. Irrigation for the landscaped area.	
Biodiversity and Habitat	This edge-of-settlement location requires that biodiversity and wildlife habitats are enhanced.	Focus on biodiversity in western area.
Education	Employees can appreciate SuDS features in their place of work.	
Amenity	The developer wants to create an attractive setting to attract businesses to the site.	Use SuDS to create an amenity feature for offices.
Open Space	Tranquil recreational areas for employees to relax in and take a break.	Look to integrate SuDS features that can create a recreational opportunity such as a retention pond.
Character	The business park should provide high quality office accommodation within an attractive green setting.	Opportunity for water feature.
Microclimate	Workers will appreciate pleasant sheltered areas for sitting outside.	

Site Condition	Site Conditions Appraisal	Designer Reaction
Flood Conditions	The site is not within a flood risk zone, but is a surface water flooding hot spot due to a culverted watercourse beneath the site.	Opportunity to 'daylight' culverted watercourse and discharge directly.
Groundwater	Groundwater is likely to be more than 5 m below the ground surface throughout the year.	Groundwater levels are low and recharge is desirable in suitable areas.
Topography	Site records show a fairly steep slope in a southeast direction away from the railway line.	Opportunity to retain natural gully
Soils and Geology	Bore hole records show reasonable permeability across the site.	
Contaminated land	Contamination recorded in the eastern part of the site which was previously an industrial site. Greenfield area is contamination free.	Infiltration only suitable in western area
Existing Infrastructure	Existing combined sewers along the roadways to the south. Existing utility infrastructure located in the previously development plot. Culverted watercourse.	Design to consider existing utility trenches
Space constraints	Restricted by railway to north and existing properties to east, but otherwise has sufficient space.	
Runoff Characteristics	Industrial proposals include the handling of industrial chemicals and heavy vehicle movements. Business park has a lower pollutant risk. Approximately 70 percent impermeable: including roads, pavements, car parking pavements, large roof areas.	Need to segregate high risk industrial areas
Existing Habitat	Greenfield area required ecological survey, but protected areas identified.	
Ownership and maintenance	Site privately managed.	

BUSINESS AND INDUSTRIAL PARK

DESIGN STAGE C: INITIAL TESTING

Design Discussion

Runoff was a crucial factor to consider in the land use allocation of this site due to the variation in the pollutant risk associated with the mix of uses. A recycling centre is a land use which could give rise to contaminated runoff which will need to be treated as industrial waste. Warehousing and office buildings present a much lower pollutant hazard and surface water management should be separated in these areas from the recycling centre so that runoff can be gathered and filtered by SuDS features. Uncontaminated runoff can then be directed to a new separate surface water drainage network or allowed to infiltrate in the southern Greenfield area. The northern half of the site also has contaminated soils, meaning that infiltration SuDS need to be avoided and water should be managed on surface where possible. A contamination specialist and water engineer worked with the design team to position the recycling centre in the northern area of the site. The distribution warehouse was deemed to be the most suitable partner use on the brownfield portion of the site, while offices were allocated in the Greenfield section.

Outline water management diagram

Indicative storage area at 0.5m depth

② Number of treatment stages

Chiswick Business Park

SKILLSET

Urban Design | Architecture | Landscape Design | Contamination Advice | Water Engineering | Planning | Highway engineering | Flood risk advice

CASE STUDIES

Innovative and collaborative thinking in the Highways Authority

As part of Greater Ashford's regeneration effort, the Town Centre Development Frameworks determined that the one way ring road needed to be removed to increase safety and make the town centre more attractive. The design involved a radical plan to remove highway signage and markings to introduce an element of uncertainty so as to ensure that pedestrians, cyclists, and motorists had to negotiate their way through the city. Through using an interdisciplinary team of landscape architects, engineers, highways authority, and artists the final design combined creativity with functionality. In terms of drainage, West Street integrates sustainable drainage systems within a central linear park, which takes advantage of the existing topography and hydrology. The design showcases what is normally a hidden, engineered process of managing rainwater.

DESIGN STAGE D: PREFERRED STRATEGY

Design Discussion

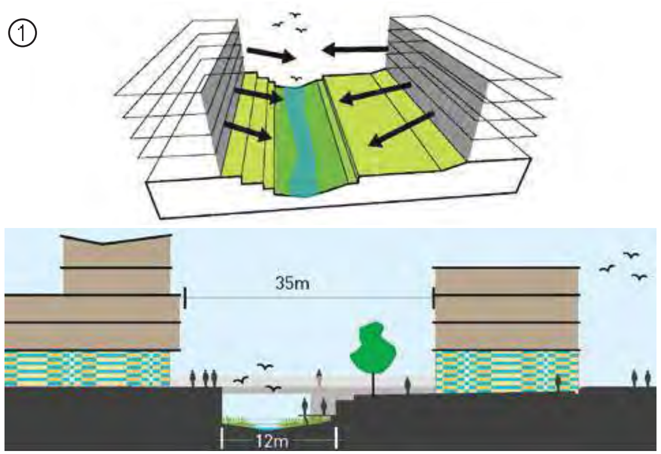
Key impermeable surfaces that will generate runoff are now distributed around the site and the structuring of SuDS features begin to take shape. The recycling centre has been separated from the drainage system. In the brownfield area, the emphasis is on reducing runoff and conveying it to the southern area where infiltration is more suitable. To avoid contact with contaminated soil, options such as a green roof or rainwater harvesting are favourable for the large warehouse roof, and additional runoff will be conveyed to the southern area using a lined swale or pipe. The business park developer favours the use of a central water feature for the business park to add prestige and character. This provides the opportunity to position a pond feature around the low point in the site which will act as an entrance feature for the business park. The business park requires a large amount of car parking, which has been positioned at the back of the site adjoining the railway, providing opportunities to capture and treat water at the north before transferring runoff to the southern pond. Options include permeable paving or integrated rain gardens.

The designers were also aware that runoff was shedding onto the site freely from the railway corridor. To intercept this flow, a swale has been placed along the back boundary of the site, also draining the back access road that links the carparks. A culverted watercourse exists on site running diagonally across the central southern area. Discussions were held with the architects to see if offices could be positioned to retain this as a central feature if it was 'daylighted' (deculverted) and it was seen as a unique design opportunity. The presence of a watercourse onsite also provides a discharge point for runoff following treatment and attenuation via the SuDS network.

SuDS Concept Plan

- Railway Station
- Roof drainage
- Parking runoff
- Swale
- Retention pond
- Parking with permeable paving
- Existing stream
- Railway line

SuDS Ideas



Daylighted water course

DESIGN STAGE E: DESIGN REFINEMENT

Design Discussion

The daylighted watercourse was designed sensitively to allow it to rise and fall with varying flow while maintaining useful public realm edges. Natural planting was included to help provide natural treatment of the watercourse. The watercourse itself maintains separation from the SuDS system until water is discharged from the ponds at a controlled rate at the southern end of the site. The SuDS options for each key sub-catchment were appraised to decide on the optimal selection of features.

Sub-catchment	SuDS Proposed for sub-catchment runoff	
	Within Sub-Catchment	In wider-site
Roofs	- Rainwater harvesting for toilet flushing - Bioretention gardens in forecourt - Rill connections	- Pond (with infiltration)
Back road and railway tracks	- Adjoining swale	- Pond (with infiltration)
Car-park	- Integrated bioretention rain gardens or permeable paving (with infiltration)	- Adjoining swale - Pond (with infiltration)
Warehouse	- Green roof	- Swale / Rill for overflow - Pond (with infiltration)

SuDS Brief

1. Pond
2. Daylighted water course
3. Swale
4. Permeable paving or bioretention
5. Warehouse green roof

Water Treatment Benefit: Runoff is managed to avoid contamination where possible.

Amenity Benefit: Central pond provides a selling point for the business park. Green roof on large warehouse provides improved view from elevated railway.

Attenuation Benefit: Existing runoff from railway tracks is gathered and treated by perimeter swale.

Biodiversity Benefit: Addition of pond and bioretention gardens in the southern area along with the green roof will promote integration of the development with its Greenfield surroundings.

08

FURTHER INFORMATION AND GUIDANCE FOR DETAILED DESIGN

FURTHER GUIDANCE

This document presents what needs to be considered when designing SuDS at the initial and concept design stage of a master plan. Guidance for detailed design of SuDS is available from a number of sources to inform the next stage of design. A list of resources is available from Susdrain: The Community for Sustainable Drainage.

There are also legislative requirements for the design of SuDS. Current requirements are provided by Defra and your Lead Local Flood Authority.

Brighton & Hove City Council

Kent County Council kent.gov.uk

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AECOM

East Sussex County Council

Medway Council Serving You

Surrey County Council

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