Sustainable Drainage Guide

February 2015

Leicester
City Council

Contents

Introduction

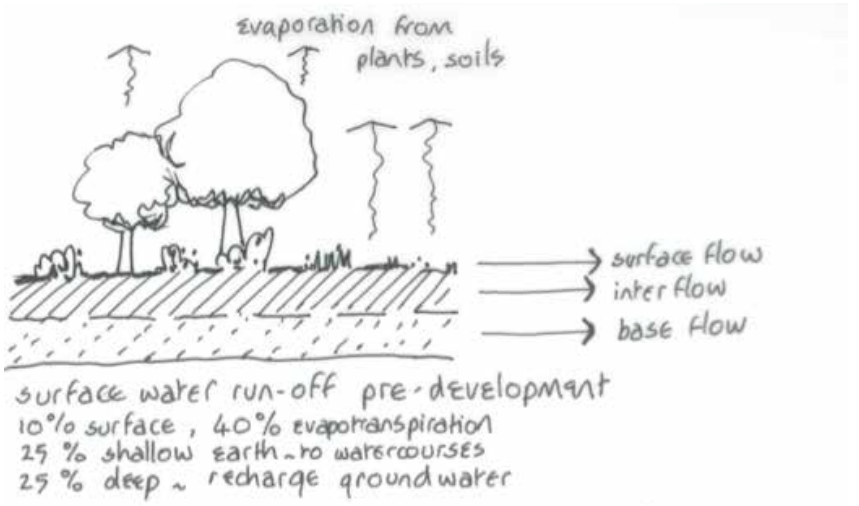
Flooding is a very real risk. Nationally and locally numbers of flood events are increasing; and even minor flood events cause problems which can affect us all.

This sustainable drainage guide has been produced to respond to these challenges by providing illustrations of techniques and local examples where suds have been used. It is aimed at anyone proposing to develop land; land owners, developers, professionals and the public. This easy to understand practical guide will result in better solutions to address this increasingly important issue.

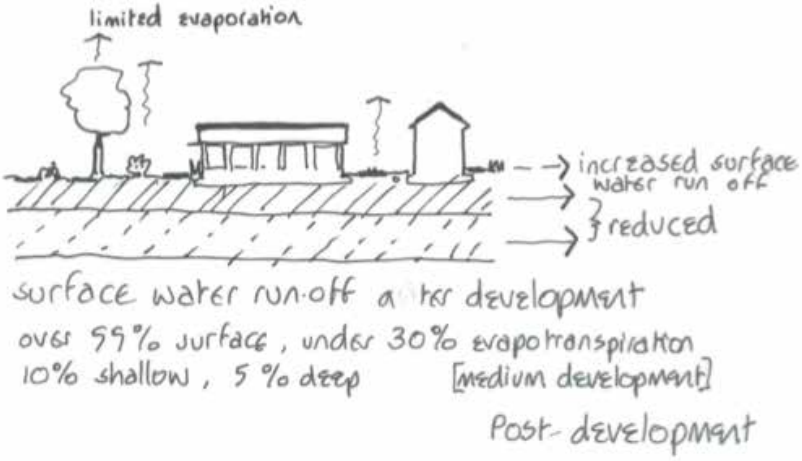
Increasingly it is recognised that it isn't just rivers breaking their banks that causes flooding; but the rate of surface water run-off and the capacity within existing conventional drainage systems to handle erratic weather patterns.

Built development and changes to agricultural patterns result in increased surface water run-off due to loss of land where water can soak naturally into the ground; or loss of rough ground slowing down the speed at which surface water can run off. This becomes a particular problem in times of heavy rainfall when existing rivers and land drainage systems are full to capacity.

There is continuing pressure for development within the city. Major developments present obvious risks for increasing flooding; but there are also cumulative impacts from the loss of 'soft' permeable land through piecemeal development; such as patios, driveways, shed bases etc. through to backland development where garden areas are converted into buildings, roadways etc. Areas previously developed; brownfield land; when redeveloped can result in the loss of permeable areas.



PRE - DEVELOPMENT



IMPACT OF URBANISATION ON RUN-OFF

Sustainable Drainage Principles

A SuDS (sustainable drainage systems) mimics natural drainage, having some storage capacity, slowing the movement of water and achieving a reduction in volume leaving the site during a storm.

The key difference between this and conventional piped drainage is that there is no one standard technique to be used universally. SuDS may take more time in the initial design but if thought through at the outset then there can be savings both in construction and longer term maintenance.

The term SuDS is a general term; made up of the use of a variety of techniques – either independently or as a collection of differing and complementary measures.

Overview; source, site and regional control

Source control; where rainwater falls

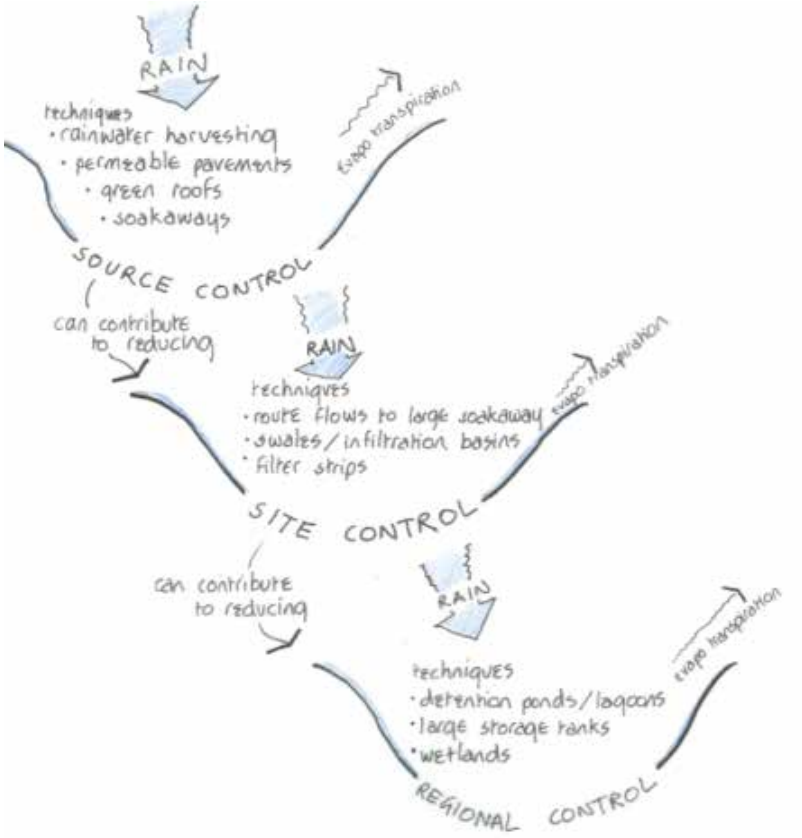
- Rainwater harvesting
- Soakaways
- Porous pavements
- Green roofs

Site control

- Infiltration devices-below ground or surface structures to drain water directly into the ground
- Such as - infiltration trenches, swales, infiltration basins, filter strips and swales
- Oversize storage tanks for use where underlying is impermeable or within flood zone.

Regional control

- Basins and balancing ponds; detention basins hold water temporarily, retention basins are designed to hold water permanently.
- Wetlands / reed beds can be significant nature areas.



DIFFERENT LEVELS OF CONTROL

Source control

The first control opportunity is where the rain falls. The aim for new development is 'where any increase in storm water run-off would result from development, mitigation must be incorporated to offset any impact by 100%.' (Core Strategy Policy 2 Addressing Climate Change) The first few millimetres of storm water washes off pollutants; if this can be treated at source it can reduce the pollutant load entering water bodies.

Wherever possible;

- Minimise hard surfacing
- Where paving is to be used look at using permeable paving
- Direct surface water run-off into soft areas.
- Value the contribution that planting can make; from gardens and open areas through to green roofs. This can also make a significant contribution to improving water quality.

These techniques will help in achieving the higher levels of Code for Sustainable Homes.

Relevant SUDs techniques for source control

- Trees and vegetation
- Bio retention and rainwater gardens
- Rainwater and greywater harvesting
- Soakaways
- Permeable paving (with possibility of reservoir storage below ground)
- Green roofs

Trees and vegetation

Trees break the impact of water hitting the ground; both reducing the quantity of water reaching the ground surface at any one time and reducing physical damage through soil erosion etc.

Low level planting slows down the rate at which water can run across a surface and will aid soil porosity making it easier for rain water to drain naturally.

Rain gardens and bio retention features

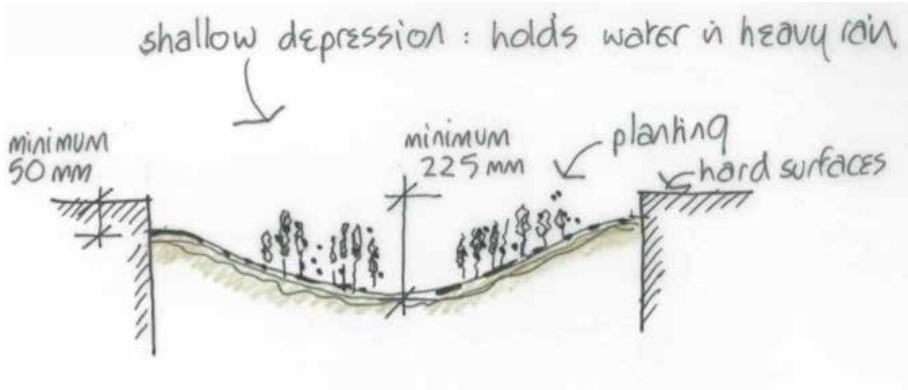
These are 'ornamental' features which are designed to store water. These can be used within built developments but can also be used alongside highways.

Other gains

Vegetation in built up areas can help to regulate air temperatures; and limit the use of air conditioning. Water holding planted areas may reduce irrigation demands and provide wildlife friendly areas.

Photo: John Brewington

Retrofit rain garden: Nottingham



BIO - RETENTION AREA

Source control

Rainwater harvesting

- Water butt; which is filled from rain water pipes. This provides water for gardens in long hot dry spells. Need to ensure that this can be achieved; check locations of downpipes
- Tanks; storing rainwater in tanks and using the filtered water to flush toilets and in washing machines. It actually displaces stormwater by diverting it for use and then discharging via the foul-water sewer. This could be applied at an individual house level through to apartments/high density developments where the most suitable approach would be to use modular cellular storm water tanks that provide large holding capacities for infiltration
- Reusing stored rainwater for drinking and cooking requires a greater degree of filtering and purification

Gains in addition to capturing rainwater

- Saving on mains water costs
- Can contribute to Eco-Homes rating points
- Can be applied at domestic and commercial scale Technology
- Storage generally below ground but can be above ground
- Needs a durable electric pump to supply water

Greywater

An extension of the rainwater harvesting is grey-water harvesting. Greywater comes from wash basins, bath tubs, showers and can be reused for flushing toilets, for garden use, cleaning. Potentially; collected rainwater can be used several times.

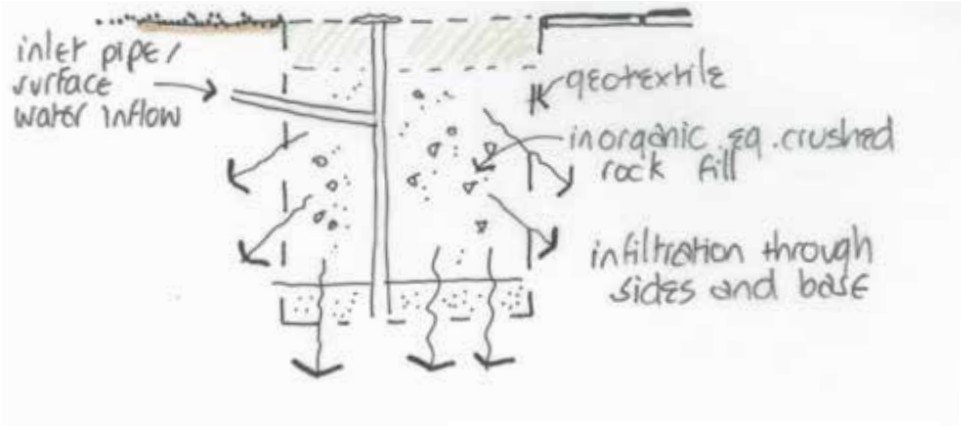
RAINWATER HARVESTING

Soakaways
These are sites underground where water can collect and gradually soak into ground layers. They can range from excavated areas filled with stone to fully engineered structures. Where land is impermeable – such as heavy clay or flood basin areas then consideration should be given to underground storage to attenuate peak run offs in storms.

In designing soakaways building control insist on percolation testing, which will determine the porosity of the ground, and from this the volume of the soakaway can be calculated, taking into account the rainfall intensity and the area to be drained. Design calculations in accordance with BRE Digest 365 are asked for; including percolation test data to be submitted.

Approved document H suggests that they should not be constructed within 5m of a building or road or within areas of unstable land. Although not stated, it is also recommended not to form a soakaway within 2.5 m of the boundary.

For smaller development, such as extensions less than 25m^2, a lesser standard percolation test can be adopted as cited in approved document H2, and a rainfall intensity of 10 mm in 5 minutes can be assumed. Ideally a soakaway should have an open void to receive a sudden surge of rainfall that can then drain away slowly into the ground.



TRADITIONAL SOAKAWAY

Simple soakaway; need correct sizing relative to catchment and long term maintenance.

Source control

Permeable pavements
Where the underlying soils are impermeable, providing limited opportunities for infiltration the use of permeable paving provides an opportunity to hold water allowing for any possible percolation and to delay storm water run-off.

The basic principle is that water is able to percolate through surface layers to storage at a lower level; this could be to soft ground or to crushed stone sub surfaces or to holding tanks.

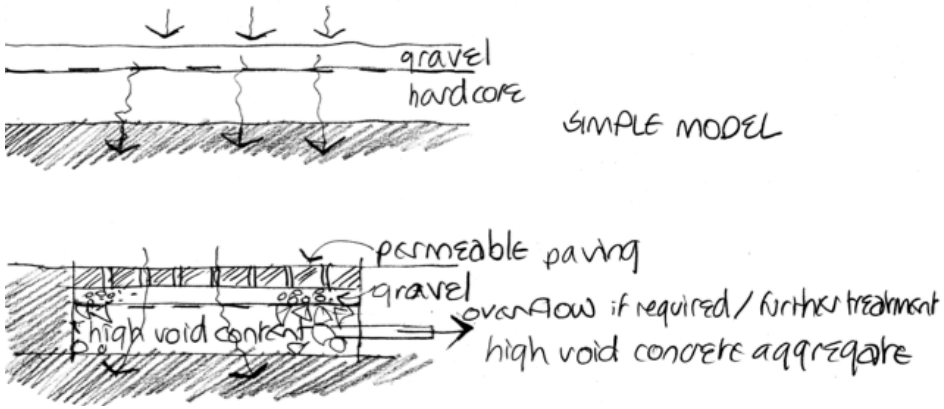
Water quality; the water is treated as it goes through gravels, geo textiles etc. improving the water quality. This could form a non-drinkable source of water.

Permeable paving surfaces include reinforced grass, gravelled areas, porous asphalts, paving blocks with voids filled with soil or gravel etc. In urban areas block permeable paving is one of the most space efficient SuDS methods. The blocks are similar to conventional blocks but the fill material is an open granular material which allows the water through. The system departs from traditional laying techniques; no sand or DoT type 1 is used; block manufacturers produce guidance on laying techniques.

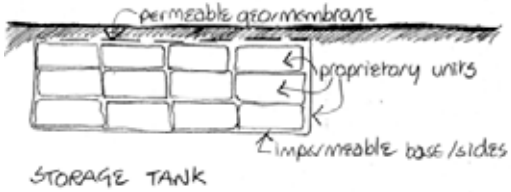
Note; to achieve a permeable solution the whole area does not need to be porous. It may be more appropriate to limit the permeable areas to more heavily trafficked areas; limiting the potential for vegetation build-up in joints.

Detail points to be considered include design on slopes, treatment of services and the longer term maintenance of these surfaces. Permeable paving will function with silt build up but ideally this is removed by brushing; major maintenance work would be to suck out joint filling material and replace.

PERMEABLE PAYMENTS



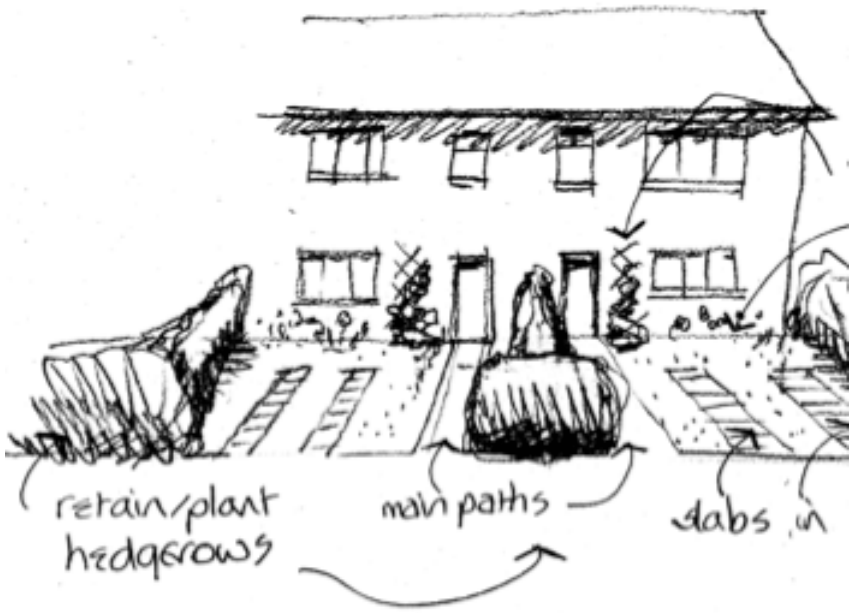
Storage tanks/permeable pavements
Storing water below ground slows down flood accumulation elsewhere. It can be via permeable pavements as before or into storage areas beneath open spaces



Source control

Open space at former Glenfield Laundry site Groby Road. Storage tanks beneath this area allow for playground/amenity use and stormwater attenuation.

Permeable paving in a city centre supermarket car park



Planning permission is now required for any impermable paving to front gardens exceeding 5m².

There are ways to provide for parking in front gardens without losing existing permeability; e.g. loose gravel plus 2 paved tracks to take the car wheels.

It is also possible to compensate for lost soft areas through planting; climbers and wall shrubs take up limited space and lower growing plants; such as herbs, low shrubs, annuals can seed into areas in the gravel.

Trees act as SuDS and can also limit the impact of storm water on ground surfaces. Careful selection of tree species can extend the areas where trees can grow happily.

Source control

Green roofs
They reduce the amount of surface water run-off, by holding onto storm water in the short term. Some rainwater will also evaporate back into the atmosphere. Green roofs can potentially retain up to 90% of the rainfall within the substrate; depending on the actual design.

Green roofs have a range of other benefits including;

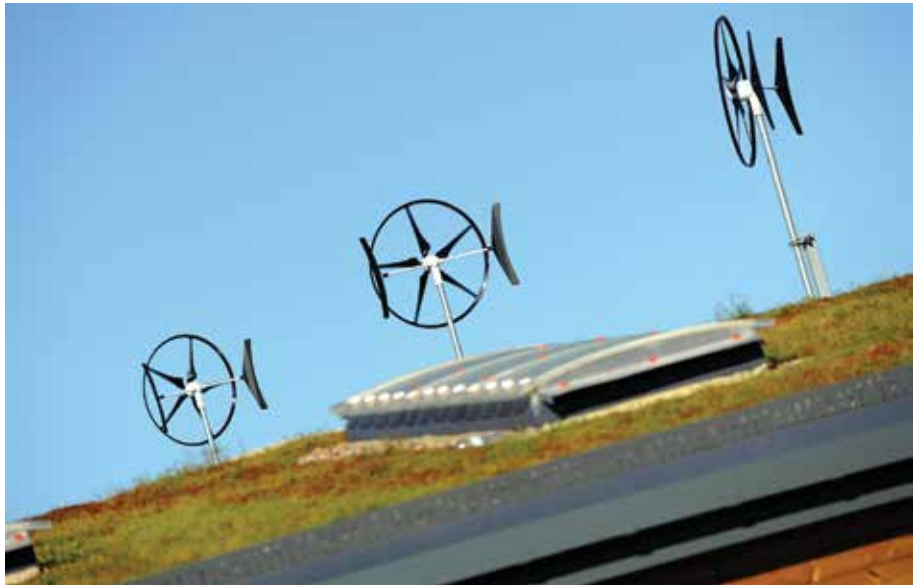
- Reducing air pollution
- Protecting the roof construction
- Contributing to reducing the urban heat island effect
- Biodiversity

There are 3 types
Intensive; can be walked on, essentially landscapes at roof level. These provide valuable green areas at a higher level but are more expensive both to construct and to maintain.

Extensive; can't be walked on and can have a pitch; see pictures to right.

Brown roof; where the design of the roof vegetation is wholly about promoting / conserving biodiversity. This can use the by-products of any development process / local substrates.

It can be seeded or allowed to colonise naturally. A brown roof aims to mimic a ground level habitat; to benefit biodiversity. This can provide habitat in areas lacking or losing habitat, or be used to encourage a particular species.

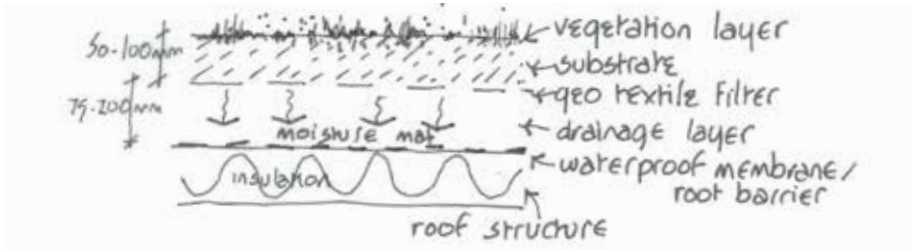


Industrial estate; Hinckley

Museum extension; South London

Warkworth; Northumberland; housing

Source control



GREEN ROOF ELEMENTS

Myths and challenges of green roofs

- Green roofs will leak; traditional flat roofs are often more vulnerable to damage; through impacts of diurnal temperature ranges, damage from ultra violet rays, water ponding on surfaces etc.
- New untried technology; there is increasing knowledge and experience.
- Maintenance will be a problem; on extensive green roofs very little maintenance is needed. Intensive green roofs can vary in amount according to design and intended uses. It is important to ensure that drainage routes are kept clear of establishing vegetation.
- Costs in use over the whole lifetime of the roof may offset additional initial costs. Also gains in biodiversity may mitigate for loss of pre-development biodiversity.

Green walls

At its simplest level a green wall has vertical planting; which will go some way towards protecting the building surface from intense rain events. There are a range of proprietary green wall systems that provide cells in which plants grow; achieving a higher height for plants. On some buildings this is by using high tensile steel cables that can support growing plants up to 25m.

These tend to be used for their visual rather than their environmental benefits.

Walls of a building present more surface area than a roof. Benefits can include improved amenity, biodiversity, thermal efficiency, amelioration of pollutants, reducing urban street temperatures, attenuating rainwater and supporting a different range of plant species.

Restaurant frontage Nottingham

Proprietary system Birmingham

Site control

Site control is managing the run-off from several sources. Typical techniques include infiltration trenches, swales and vegetated strips to provide temporary storage for storm water; helping to filtrate pollutants through microbial decomposition and allowing water to then infiltrate directly into ground or to be conveyed to a receiving water body.

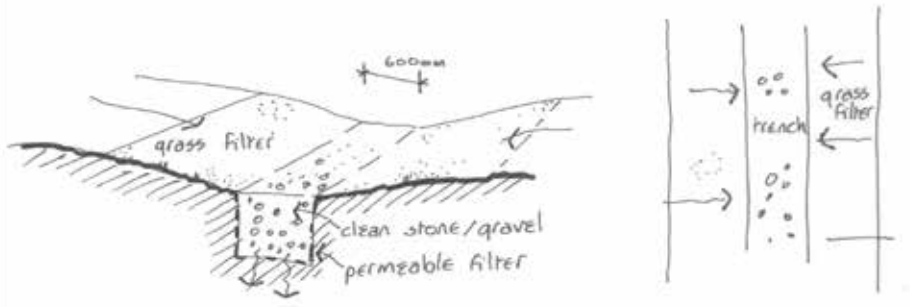
In greenfield areas SuDS can lead to cost savings; through using existing landscape features both for amenity and for water dispersal. There may also be some savings through reducing the need to connect to distant outfalls.

These features can form part of the amenity areas for new developments; providing open spaces and wildlife potential. Large areas of open green space can fulfil a dual role providing space for informal sport and recreation and acting as infiltration basins. Consider the details of construction to enable highways to act as flood carriers; taking storm waters away from properties to retention ponds etc. New development needs to show flood pathways plus storage areas (sacrificial land such as open spaces). Think about kerb heights and any potential breaches; such as dropped kerbs, property entrances; to prevent flood water entering properties; may need some improved resilience for properties or designs to allow flood water to travel around buildings.

Infiltration methods
Infiltration is the passage of surface water; either to ground or to a piped system. Infiltration potential is the rate at which water flows through a soil (mm/h). Infiltration techniques work best where they are close to the run-off source, rather than being used to hold/discharge large volumes of run-off.

Infiltration trench
A linear drain filled with a permeable material; generally shallow excavated trenches backfilled with stone. A French drain (terram wrapped gravel) is an example of a below-ground system. Water leaves the drain either through infiltration or via a perforated pipe at the base of the trench.

Infiltration basin
An infiltration basin is designed to promote infiltration of surface water to the ground.



INFILTRATION TRENCH

Site control

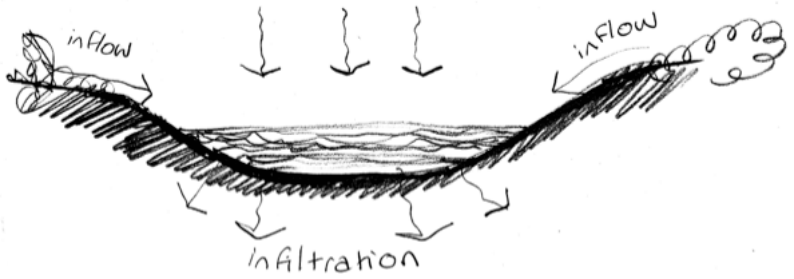
Filter strip
A vegetated area of gently sloping ground designed to drain water evenly off impermeable areas and filter out silt and other materials.

Swales
Swales are vegetated surface features that convey water evenly via long shallow channels. In essence they are a modified ditch; having a very broad base and gently sloping sides.

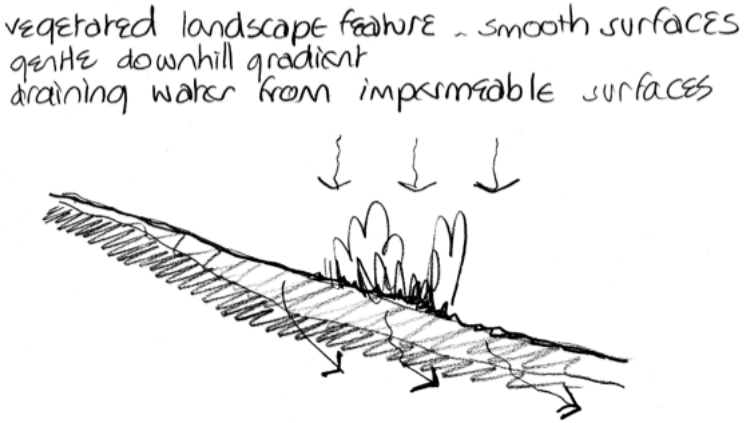
They work by mimicking natural drainage patterns. Rainwater runs through vegetation which slows and filters the flow.
Swales can treat polluted materials; removed through sedimentation and filtration. Vegetation traps organic and mineral particles, which are then incorporated into the soil, while the vegetation takes up any nutrients.

Swales and filter strips can contribute to the overall amenity of an area. Local species of grasses and flora can be used to benefit local biodiversity; this will be enhanced if small ponds and check dams are incorporated. These can be an attractive feature of swales.

Swale; in new housing area shows the amenity value of the system



SWALE



FILTER STRIP

Regional control

This is the downstream management of run off and should only be considered once source and site control opportunities have been taken.

Basins and ponds
These store water at the ground surface, either as temporary flooding of dry basins and flood plains, or as permanent ponds. These structures can be designed to manage water quantity and quality. They can store floodwater and release it slowly once the risk of flooding has passed.
The stored water level will fluctuate; so basins and ponds should be designed to function in both dry and wet weather.

The size of pond should also take into account the existing groundwater quality; and whether there are existing natural wetlands that could be affected through groundwater seepage.

Basins and ponds treat run-off in a variety of ways:

- Settlement of solids in still water - having plants in the water enhances the rate at which nutrients are removed and promotes settlement
- Absorption by aquatic vegetation or the soil
- Biological activity

Basins; or detention ponds; are free from water for most of the year. They are designed to collect storm run-off and hold it for a few hours. Any sediment within this storm water can settle out during the detention period. If they are designed to be marshes for most of the time this cuts down on maintenance and raises their wildlife value; this could be achieved by raising the level of the outfall.

Alternatively where a basin is largely dry for much of the year it could also be used for sport and recreation.

Their forms include:-

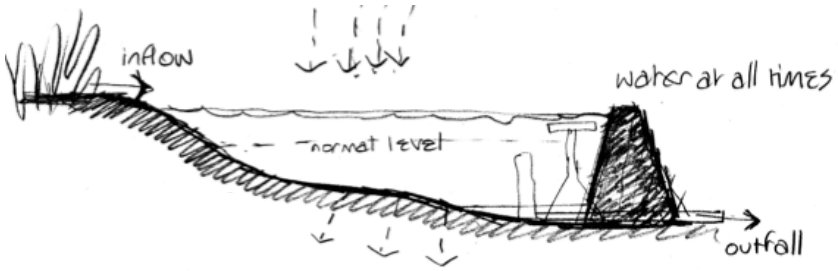
- Flood plain
- Detention basins
- Extended detention basins

Ponds; or retention ponds; contain water at all times. They can be an important amenity and wildlife feature.
Their forms include:-

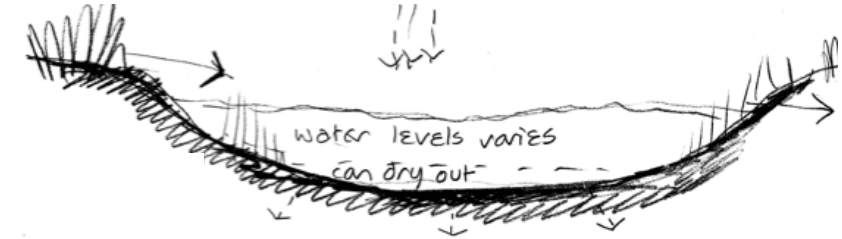
- Balancing/attenuation ponds
- Flood storage reservoirs
- Wetlands/reed beds

As with other groups of sustainable drainage measures all of these can be combined; e.g. by having a wildlife pond and an adjacent area that can be used as a basin for stormwater attenuation.

Regional control



RETENTION POND



BALANCING POND

WETLAND

water from : swales, filter drains, piped systems

stormwater feeds a pond, overflows into vegetated wetland area to form natural soakaway

ponds : enhance flood storage capacity
enable high levels of filtering through plants and algae

Hamilton retention basins; now a site for a diverse range of wildlife

Created wetland Castle Hill Country Park

Glenfrith housing area; a necklace of water retention areas; good for stormwater but not so good for wildlife and wetland benefit.

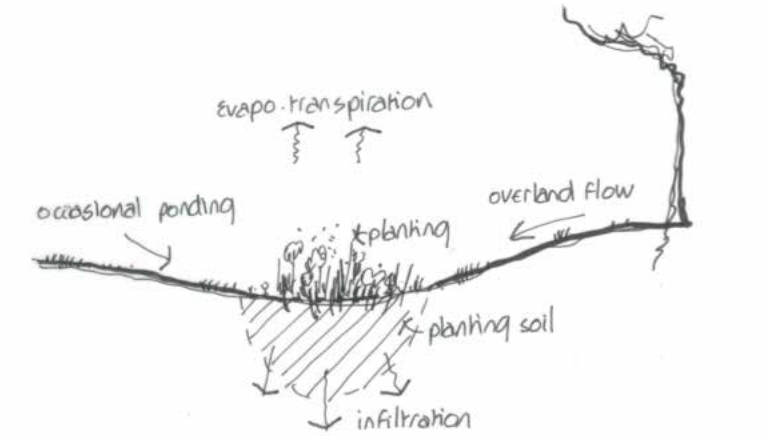
Biodiversity

Biodiversity
SuDS offer a positive way to have multifunctional and habitat enriching techniques. The aim of SuDS is to mimic nature and keep water flowing across surfaces.

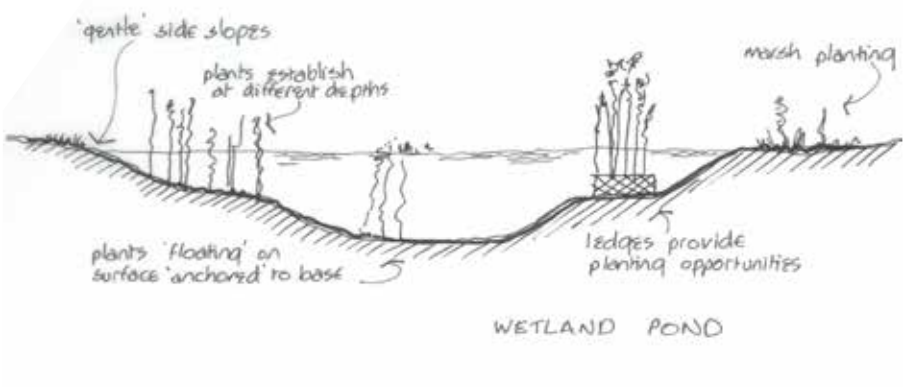
The need to increase wetlands within the city and beyond is recognised both nationally and locally. The River Soar and Grand Union Canal strategy (Nov 2009) recognises the importance of wet land corridors to provide multiple benefits; including flood attenuation. There is a constant need both to create new wetter areas but also to increase biodiversity within existing wetland systems. This could include changes to channel design, increasing vegetated areas or areas of open water through changes to water depths and flows.

The processes of development/ urban creep continue to result in loss of permeable /green areas within urban areas increasing the need to make green areas a multi-functional as possible.

Guidance
Choice of species and detailed design of wetland features will all have an impact on the value of the habitat. Look for opportunities to link to other habitats. Create a range of conditions from areas that dry out totally through marshland to wetlands; limit shading to water areas. Use sloping sides to drainage features. Do not over plant and aim to use native planting.



BIO RETENTION AREA



WETLAND POND

Illustration through typical pond profile

Wetland planting

Wetland areas include a range of conditions for plants; from plants that can survive submerged through to wetland grass species and even plants for drier conditions; for example at the tops of swales.

Consider the appropriateness of planting choices; some places may need a more ornamental approach rather than a more natural approach. Look at existing established ponds nearby for an indication of suitable plants.

Wettest areas; some of the floating plants that could be considered include; rigid hornwort (Ceratophyllum demersum), water starwort (Callitriche terrestris), frogbit (Hydrocharis morsus-ranae), willow moss (Fontinalis antipyretica).

Rooted plants include; spiked water milfoil (Myriophyllum spicatum), unbranched bur reed (Sparganium emersum), common water crowfoot (Ranunculus aquatilis), perfoliate pondweed (Potamegeton perfoliatus), brooklime (Veronica beccabunga)

Plants for pond edges include; branched bur reed (Sparganium emersum), sweet reed grass (Glyceria maxima), reed canary grass (Phalaris arundinacea), yellow flag iris (Iris pseudocorus), marsh marigold (Caltha palustirs), Purple loosestrife (Lythrum salicaria)

Talk to local ecologists; avoid importing species that could become invasive. Don't overplant; allow for natural colonisation (avoid plants such as reedmace, Norfolk reed, pendular sedge, greater or lesser pond sedge and bulrush).

Look for appropriate wet grass seed mixes; such as pond edge, wet meadow.

Maintenance

Who will look after the wetland feature?
Clear approx. 1/3 of any open water to maintain areas of open water and to prevent establishment of scrub.
Clear ditches one side at any time to limit disturbance to biodiverstiy.

Wetland adjacent to parking area, hospital site

Health and safety

It is important to take the risks associated with water seriously. Assess the impact of wetlands and other drainage features. Consider existing use of sites and whether there are existing routes which should be respected or existing wetter areas that can be exploited for wetlands.

Creating ponds can lead to fears for safety of children. Very small children are particularly at risk. Ensure that water areas can be seen and slopes are as gentle as possible and include 'benches' for deeper areas.

Information: Safety

A lot of SuDS features are only likely to have open water in periods of extreme rainfall. It is possible to combine amenity use with flood attenuation areas; particularly if there are some lower areas/ infiltration trenches to drain the area for most of the year; and providing that is easy to get into and out of any basins.

Design should take this into account through having gently sloping sides to ponds and/or having a shallow shelf for emergent plants on the pond edge.

The overall depth of ponds and wetlands are often dictated by inlet pipes; often due to the need to go beneath roads. If this level can be raised overall pond depths can be lessened.

Other fears; mosquitos, these are more likely to be a problem in areas of still water; such as rain water butts; ensure movement within water.

Involve people to help understanding the need for the ponds: this is a particularly an issue in design of any retrofit ponds. Designs need to be sympathetic to local settings.

Below; examples of created wetlands to help in flood attenuation/water quality on existing watercourses.

Bradford photo credit K Brakes

Abbey Meadows Leicester

Design of elements
Headwalls present a particular risk; which is often compounded by the addition of railings. Detail design of outfalls that are in line with slopes will help.

Siting of wetlands
Avoid obvious desire lines. Set at a distance from nearby paths. Design of side slopes 1:3 absolute maximum.

Look at including 'benches'; level areas to side slopes to provide safe areas to climb onto. In deeper ponds consider ditches around pond to provide a safe line of defence.

Fences and railings are to be avoided as these can trap people inside and limit rescue opportunities.

Car park outfall - ASDA

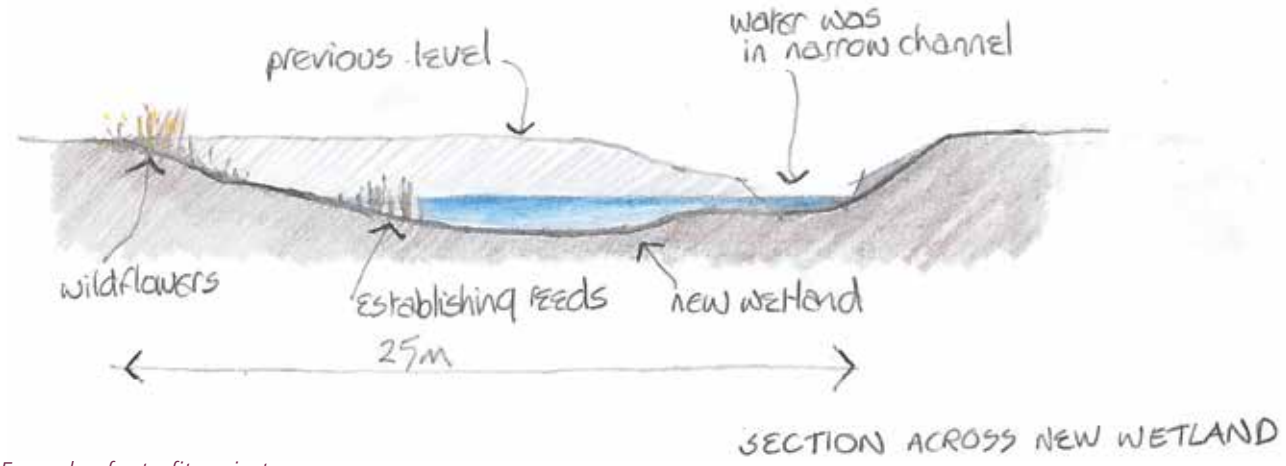
Open water areas should be visible, so they can be overlooked and provide local amenity. Research has shown that the presence of well designed ponds increases nearby house values.

Risk assessments
Prepare and talk about risk assessments at the outset.

Maintenance; what are the problems likely to be of the setting and also will be responsible for it? Loose materials may work well in some areas but could damage grass cutting equipment.

Enderby park and ride

Information; Retrofit case study



Example of retrofit project

This is Abbey Meadows wetland scheme; completed in November 2011. It provides a total flood capacity of 1000m³. It also helps to improve water quality entering the River Soar whilst also improving biodiversity and amenity.

Maintenance

Maintenance
SuDS need to be maintained over their lifetime. Many of the features are essentially landscape features; their maintenance is often a part of wider open space and landscape maintenance. On the plus side where SuDS schemes are above ground any maintenance problems should be recognised earlier than in underground drainage and be easier to remedy.

One possible method for maintenance is to use an independent land maintenance company. Each householder is covenanted to pay a contribution towards their upkeep.

Longer term solutions could be;- Surface water management plans; co-ordinating the differing agencies who currently have an interest This should also help in establishing clear lines of responsibility.

The extent of adoption will depend on the actual scheme Thinking about maintenance at the outset is essential; to ensure SuDS long term functioning and viability. Also good supervision on site will help to avoid later problems.

Who is to carry out maintenance? On green spaces it should not be presumed that parks will adopt SuDS features. Slopes over 1:5, engineering structures and constant deep water are outside their capability and remit to maintain. SuDS that can provide functional green space would be considered.

What is to be avoided is doubling up on maintenance; such as traditional gully emptying still required alongside management of soft SuDS features.

Maintenance is likely to be higher in early years of developing 'soft' solutions.

- Vegetated SUDS will require regular maintenance
- Regular grass cutting in swales and filter strips
- Annual meadow cutting; basins
- Longer term management of vegetation in ponds
- Initial and periodic safety assessments,
- De-silting and disposal of sediment will be required to maintain storm water capacity. Provision could be made on site for capacity to accommodate this. Might this material trigger Waste Reg considerations, especially if taken off site?

Hard features

- Management of silt
- Inlet and outlet features; keeping them clear and operational.

Checklist

Information to be provided with development applications

Baseline information
Site; context, habitats
Hydrology; catchments area, natural drainage; slope, infiltration rate, groundwater levels, soil attenuation, infiltration test details,
Ground stability
Contaminants; any risk of groundwater contamination
Wildlife/biodiversity; any status; particular features.

Pre application discussions
Potential for SuDS
Sub catchments
SuDS philosophy; description of proposed SUDs techniques
Figures – amount surface water to be retained on site – Greenfield recommendation 100%; brownfield 70%

Prevention methods
Minimise run off
Prevent pollution
Contain spillage
Manage silt

Source control
Attenuation and pollution control sequence on site
Conveyance

Site (or regional) control
– should be site first then region
Any regional proposed?
Any potential to over provide?
Description of flow rates.
Low flow routes, low flood recurrence intervals, extreme flood route
Include calculations – design return periods/ permitted rates and volumes of run off

Detailed design
Process
Check what baseline data used – eg rainfall criteria
Check design against natural drainage
Amenity; any community value
Biodiversity; habitat creation,
Timing of works
Health and safety; collection devices, inlets and outlets, storage features, wetlands and ponds

Construction
Site control measures through construction
Contractor method statement

Management
Management plan/landscape maintenance
Sustainability audit
Review design components, scheme design life, resilience in use, future management

Potential gains
- Flood risk attenuation
- Climate change adaptation policy
- Biodiversity
- Achieving BREAM standards / code for sustainable homes
- Amenity provision

References

There are lots of useful guides available including:

Case studies
http://www.susdrain.org/

Good wide ranging approach for SuDS design
https://www.cambridge.gov.uk/sustainable-drainage-systems

Guidance for more urban areas
http://www.islington.gov.uk/services/parks-environment/sustainability/sus_building/Pages/suds_buildings.aspx

UK - Flood Management – Improving Surface Water Drainage
http://www.defra.gov.uk/environ/fcd/policy/surfacewaterdrainage.htm

Toolkit for designing SuDs
http://geoservergisweb1.hrwallingford.co.uk/uksd/

Soakaway design BRE digest 365
http://www.yourspreadsheets.co.uk/soakaway-design.html

Surface water management plan Leicester City Council
http://www.leicester.gov.uk/your-council-services/ep/the-environment/flood-risk-management/flood-risk-studies/surface-water-management-plan/

Leicester's guide for Sustainable Drainage

Before and after; opening up a contained watercourse to alleviate flood issues and to improve amenity and biodiversity.

Leicester City Council Planning, Transportation and Economic Development

Leicester City Council