EA-Water Quality

SEPA

ENVIRONMENT AGENCY

protecting the quality

of our environment

Sustainable Urban Drainage
An Introduction

scottish environment protection agency

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INTRODUCTION

The Scottish Environment Protection Agency and the Environment Agency for England and Wales (referred to in this booklet as the Agency or Agencies) are working together to reduce pollution and flooding risk and to promote more sustainable drainage systems in Britain.

This booklet highlights problems caused by conventional urban drainage systems and identifies alternative approaches, referred to as Sustainable Urban Drainage Systems (SUDS).

A survey of the causes of poor river water quality in Scotland in 1995(1) found 20% of the poor quality waters resulted from runoff from urban areas. The causes included drainage from roads, industrial and residential areas. Unattenuated run-off from developments increases the risk of flooding from the receiving watercourse and can damage the river habitat. It will also decrease the amount of water soaking into the ground, reducing the available water resource.

The rain falling on these areas is normally drained to watercourses via surface water outfalls. These discharges are often thought of as being clean but in fact contain a range of contaminants including oil, organic matter and toxic metals. Cross connections of foul sewers into surface water drains are also endemic. As a result, urban rivers are often severely degraded.

The environmental impact can, however, be minimised through good design and practice. This booklet aims to raise awareness of the environmental problems arising from conventional urban drainage and to present some of the design options which have been found to be effective in reducing them. It is the start of the process of delivering more sustainable urban development.

The protection of rivers and groundwaters from the effects of these pollutants requires changes to the design of drainage systems and/or the provision of treatment facilities prior to discharge. A range of techniques, known as Sustainable Urban Drainage Systems, are available to achieve this. They are a flexible series of options which allow a designer to select those that best suit the circumstances of a particular site. This booklet gives an overview of the techniques and indicates where further information can be obtained.

The structural techniques described are effective for reducing the impact of surface water discharges. It is important to promote their inclusion in all developments at the earliest possible stage. Local planning authorities are encouraged to include reference to SUDS in strategic and local plans. Developers should consider SUDS in their land purchase negotiations.

The Salmon Brook in London is an example of an urban watercourse affected by urban drainage.

There is no need for the drainage from urban developments to damage our water resources. However, to protect our environment, the Agencies need the support and co-operation of a wide range of public and private organisation involved in urban development - including planning and highway authorities, sewerage undertakers and developers. By working together, it will be possible to ensure that drainage from roads and urban areas is designed in a cost effective and more sustainable manner.

DEVELOPMENT, DRAINAGE AND THE LEGAL BASIS FOR CONTROL

All developments require consideration of surface water drainage. For sustainable urban drainage to be effectively implemented at a site, the concept needs to be incorporated into a developer's plans at the earliest stage possible, not least because its use may influence land purchase and site layout decisions.

All proposals for development will require planning consent. The Town and Country Planning System has a key role to play in directing and shaping new developments and in protecting and enhancing the environment. It therefore plays a vital role in achieving sustainable development.

Sustainable Urban Drainage techniques were incorporated into this new roadside service area on the M40 from the earliest planning and design stage. SUDS provided the most economic means of protecting the local watercourse from flooding and pollution.

The Town and Country Planning System has a legal basis supported by national planning policy guidance statements. It is operated by local authorities and the two main components are development plans and the consideration of individual planning applications . through a development control process. Local authority Development Plans set out the main considerations on which planning applications are decided. Policies and proposals contained within them are of primary importance for shaping land use change and provide an opportunity to prevent future problems arising as a result of development. In addition local authorities may also produce separate site specific development briefs providing advice on a range of development issues, including appropriate means of surface water drainage. The Agency and sewerage undertaker will usually be consulted on major schemes, and will advise the local authority about appropriate surface water drainage systems and techniques. Specific requirements may be attached to any planning consent, as either a condition or as part of a legal agreement.

For certain types of development, the local authority will require an environmental assessment to be undertaken and an environmental statement to be produced. It is the responsibility of the developer to provide the statement; however, the local authority and the Agency are able to give guidance on drainage issues, particularly at the scoping stage.

DEVELOPMENT, DRAINAGE AND THE LEGAL BASIS FOR CONTROL

Many local authorities, sewerage undertakers and the Agencies are now committed to the promotion of SUDS, and planning policies are now being included in development plans. Developers should therefore consult the local authority about planning policies on sustainable urban drainage. For example, Reigate and Banstead Borough Council are promoting this approach at Horley in Surrey and West Lothian and Falkirk Councils in Scotland have adopted policies in local plans which support SUDS.

In addition to the development control process, discharges of site drainage may also be regulated by the Agencies under the law on water pollution. The legal basis of water pollution control differs between Scotland, and England and Wales. However, in practice the control of surface water discharges is achieved by the application of similar principles. The regulation of surface water discharges is a discretionary power and the Agencies seek to encourage the adoption of good practice so that smaller discharges need not be subject to a formal discharge consent. A system of Prohibition Notices enables control over the more significant discharges and can be used to require the formal consent of the Agencies where there has been a failure to agree suitable measures. Surface water discharges to soakaway systems are subject to control under Water Pollution Regulations including the Groundwater Regulations 1998, where List I or List II substances are present. Any discharges should be in accordance with the appropriate Code of Practice.

EXAMPLES OF SITES WHERE SUDS HAVE BEEN APPLIED

A site at Horley in Surrey is a major development included as an alteration in the local plan. Supplementary planning guidance is being provided on surface water drainage using source control techniques both within dwelling curtilages and for the site as a whole. This includes use of rainwater butts, grass swales, porous paths and driveways, wet and dry ponds and storm water wetlands. Guidelines on maintenance arrangements are also considered.

In Scotland a range of SUDS have been used at the Dunfermline Eastern Extension Area, with swales and small wetlands at individual sites and wet retention ponds serving large sections of the development. A major constraint on developing the site was the need to ensure there was no significant alteration to the runoff pattern.

THE ENVIRONMENTAL EFFECTS OF URBAN DRAINAGE

When the environment is modified by development, the effects can be seen in a number of ways.

Too many urban rivers are both culverted and polluted by surface water discharges. This reduces water quality and biodiversity in our urban areas.

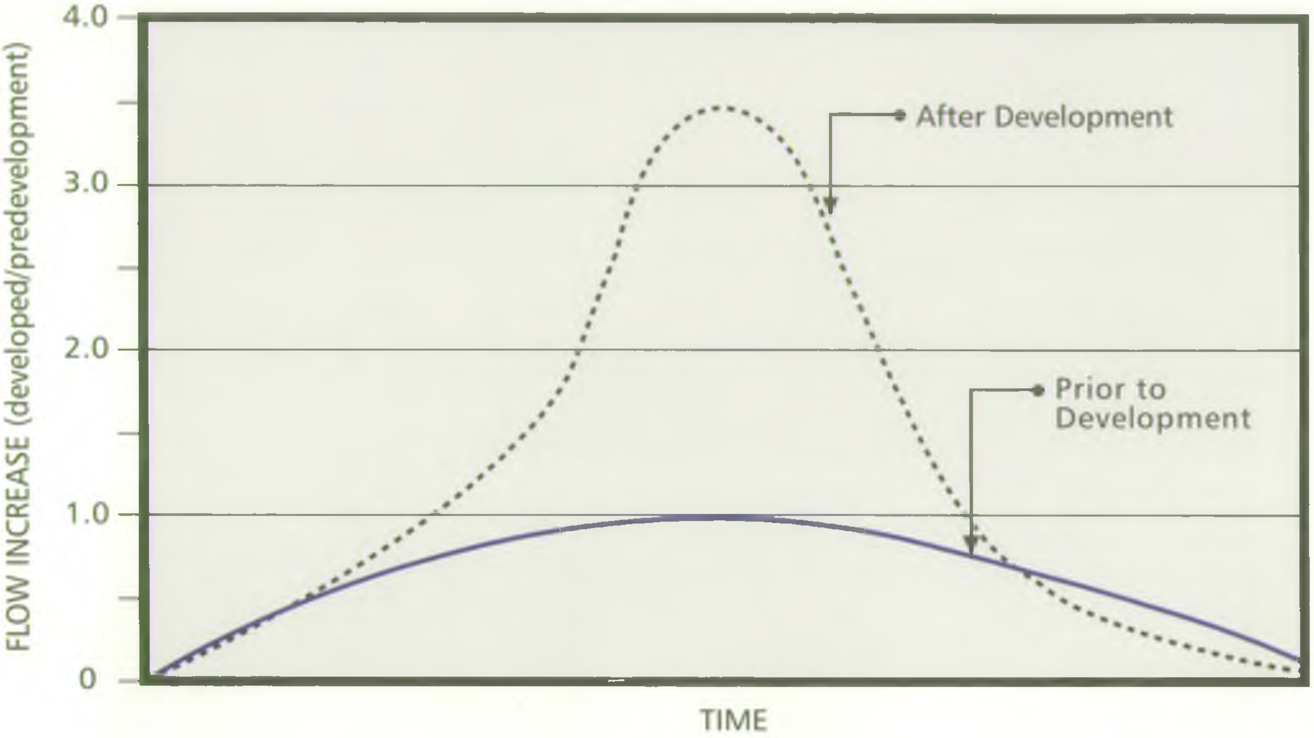
Flooding may occur for a number of reasons, including inadequately designed surface water drainage systems.

WATER QUALITY

Rain falling on impermeable surfaces rapidly picks up any contaminants present, such as dust, oil, litter and organic matter. The impact of this material being flushed into a watercourse can be dramatic, with high levels of silt blanketing stream life and a rapid reduction in oxygen levels. Numerous studies of the polluting nature of such runoff have been made (2,3). As a consequence of these repeated discharges, life in receiving streams may be severely restricted and any fish which do venture into them risk suffocation in the event of a storm. In addition, where discharges soak into the ground, the quality of the groundwater may be affected. Spillages from chemical and oil storage and tankers add to these pollution problems in both watercourses and groundwaters. A further problem arises because many people are unaware that most surface water drains discharge directly to a watercourse or a soakaway. As a result, used oil, garden chemicals, car washing water and other liquid wastes are often poured into these drains contributing to the polluting load.

A related problem is the connection of foul drainage, by accident or ignorance, to the surface water drain. Incorrectly plumbed toilets, washing machines and dishwashers are endemic in separately drained systems where the householder has no idea which drain is which, or even that two drains exist.

Figure 1: Impact of urbanisation on runoff quantity



FLOODING

As land is developed, natural drainage patterns are disrupted. In most cases development will result in an increase in the proportion of impermeable cover. Traditional drainage systems endeavour to remove the rainfall from these impervious surfaces as quickly as possible. This causes higher flow rates for shorter periods (see Figure 1) and can result in flooding further downstream. Balancing ponds or other similar measures are often required to compensate for this.

WATER RESOURCES

The increase in impermeable area which accompanies development also results in less water being available for infiltration into the ground. This can reduce the volume of water stored in the ground, depressing groundwater levels and base flows in streams.

HABITAT

The alteration of the flow pattern, with higher flow rates for shorter periods and reduced base flows can dramatically alter the river habitat. Increased flow rates can cause erosion of riverbanks and beds, resulting in deposition of material further downstream. These changes will destroy habitats and alter the natural flora and fauna.

Many existing urban drainage systems are damaging the environment and are not, therefore, sustainable in the long term. Techniques to reduce these effects have been developed and are collectively referred to as Sustainable Urban Drainage Systems (SUDS).

Sustainable urban drainage is a concept that focuses decisions about drainage design, construction and maintenance on the quality of the receiving environment and people. SUDS are physical structures built to receive surface water runoff. They typically include ponds, wetland, swales and porous surfaces. These structures should be located as close as possible to where the rainwater falls, providing attenuation for the runoff. They may also provide treatment for water prior to discharge, using the natural processes of sedimentation, filtration, adsorbtion and biological degradation.

SUDS can be designed to "fit" into almost all urban settings, from hard surfaced areas to soft landscaped features, as there are a range of design options available.

This variety of options allows designers to consider local land use and the needs of local people when undertaking the drainage design, as well as considering the traditional engineering components of the design, such as peak flow and capacity in the system.

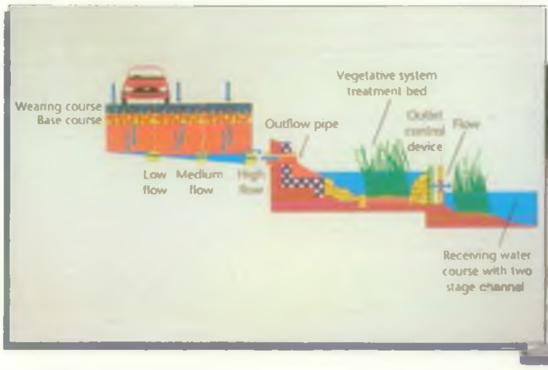
SUDS can be designed to improve amenity and biodiversity in urban areas. For instance, ponds can be designed as a local feature for recreational purposes and to provide valuable wildlife habitat in an urban setting.

SUDS provide a number of options for draining an area, and the designer or engineer is free to choose the best option(s) for any given site. SUDS fall into three broad groups which aim to:

I. Reduce the quantity of runoff from the site (source control techniques);

II. Slow the velocity of runoff to allow settlement filtering and infiltration (permeable conveyance systems);

III. Provide passive treatment to collected surface water before discharge into land or to a watercourse (end of pipe systems).



Car parks with impervious surfaces are a common feature in the urban environment. Porous paving can be used to reduce the impact of car parks on flooding and water quality, without compromising the car park's utility.
The design and construction of porous surfaces must be in accordance with the manufacturer's specification.

It should be assumed that measures to attenuate flow and reduce pollution should be incorporated at all new development sites, but it is not usually necessary or desirable to use designs from all three groups to solve a particular drainage problem. Where it may not be feasible to drain a whole site using SUDS, these systems may be incorporated into the drainage design to take a proportion of the runoff. Some SUDS fall into more than one group, for example attenuating flow and providing treatment.

In considering a drainage system it is beneficial to work through the options in the order presented above.

1. The scope for minimising the quantity of water collected should be considered first, since this determines the sizing of downstream systems and can provide the greatest savings. Infiltration is desirable if the site, soil conditions and groundwater protection considerations will permit it, and should be considered at an early stage.

2.Collected runoff should be removed from the site in a way that reduces the level of pollution and allows further infiltration and volume loss.

3. Finally, and only if necessary, passive treatment can be installed to improve water quality before final discharge to a watercourse.

Sustainable urban drainage systems offer a number of benefits that conventional drainage systems do not provide. For instance:

* SUDS may protect and enhance water quality and biodiversity in urban streams;

* SUDS may maintain or restore the natural flow regime in urban streams;

* SUDS may protect people and property from flooding, now and in the future;

* SUDS may protect urban watercourses from pollution caused by accidental spillages and misconnections;

* SUDS may allow new development in areas where sewerage systems are already at full capacity, encouraging new development within existing urban areas and protecting greenfield sites;

* SUDS can be designed in a way that is sympathetic to their environmental setting and the needs of the community;

* SUDS can allow natural groundwater recharge where this is considered appropriate.

* SUDS may also simplify construction. Porous paving will allow the construction of flat car parks, eliminating gullies and puddles. In low lying areas the need for pumps may be eliminated.

In order to ensure that SUDS are successfully designed, built and maintained, developers need to include them in their plans at the earliest stages of the process. Where SUDS are being considered it is important for developers to consult with planning authorities, highway authorities, the sewerage undertaker and the regulator (as appropriate) early in the development process,

A range of organisations concerned with sustainable urban drainage have worked with CIRIA to produce technical design guidance on SUD techniques. A design manual for Scotland and Northern Ireland (4), and a separate manual for England and Wales (5), are due for publication in mid-1999. CIRIA are also publishing a best practice guide (6) to examine some of the development and planning issues in more detail.

SEPA and the Environment Agency have also worked with IAWQ (International Association on Water Quality) to produce a video and booklet (7) entitled "Nature's Way". These explain the problems associated with existing drainage systems and illustrate many of the Best Management Practices (BMPs) for urban drainage which are the basis for sustainable urban drainage systems.

The following pages describe in more detail examples of these Sustainable Urban Drainage Systems.

SOURCE CONTROL TECHNIQUES

These techniques are designed to counter increased discharge from developed sites, as close to the source as possible and to minimise the quantity of water discharged directly to a river. This can have benefits in reducing flood risk and the impact on water quality, enhance recharge of underground water resources and help to maintain flows in surface watercourses during dry weather. The amount of polluting matter flushed into a watercourse is also reduced, further increasing the water quality benefit. These systems work best when dealing with small quantities of water, and are most effective when distributed throughout a catchment at the point where runoff arises. For example, uncontaminated water from roofs can be fed directly into soakaways and infiltration trenches where soil conditions permit.

Source control techniques are concerned with capturing rainwater at or near the point where the rain falls and often involve directing runoff into the ground by the use of shallow infiltration systems. Some of these techniques are familiar, for example use of water-butts in gardens to collect the runoff from a roof. At times of rainfall the water-butt fills (the water is collected at / near the place of the rainfall, hence it is collected at source), and the water is used on the garden during dry periods. This principle is applied for all source control techniques. However, in some circumstances, for example on contaminated land, close to water supply boreholes or in vulnerable aquifer areas, infiltration may not be appropriate, so consultation with the Agency is advisable.

In any development, some areas, such as gardens and parklands, will continue to drain naturally. Other areas, such as drives, access roads and car parking areas will require drainage. For these, porous materials can reduce the need to collect runoff in drains, therefore cost savings can be made through the reduction in size, or even elimination, of off-site surface water sewers.

Providing there is no danger of increasing downstream flooding risks, such installations need not be designed to receive very large storms. A system which is designed to accept a twice per year storm before an overflow or bypass takes effect will still have significant environmental benefits. It will greatly reduce the frequency of discharge, provide protection from the highly polluting "first flush" and delay the time of discharge, allowing time for the flow in the receiving watercourse to increase. In most urban developments downstream flooding will be a concern and additional storage will need to be provided.

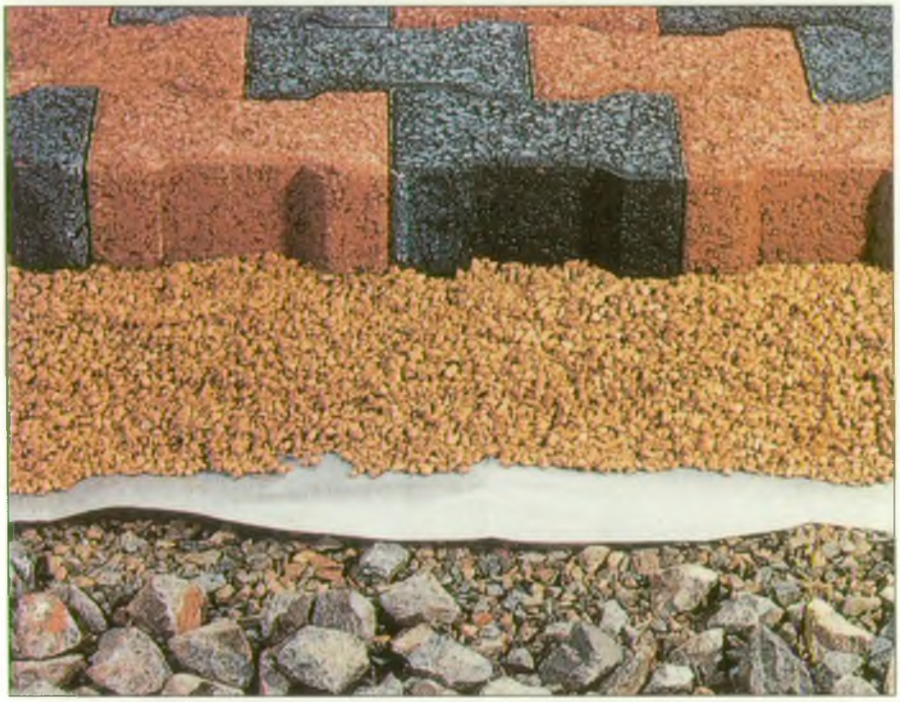
It may also be worth considering the option of allowing a part of a development site to be flooded under some circumstances. For example, it may be acceptable to allow shallow flooding of a car park once or twice a year rather than building a larger drainage system to cater for such events.

With good source control techniques runoff from new developments need have little impact on the hydrology of a catchment.

POROUS PAVEMENTS

Porous pavement is an alternative to conventional paving in which water permeates through the paved structure rather than draining off it. Both the surface and the sub-grade need to be designed with this function in mind. Where the conditions are suitable the water may be allowed to infiltrate directly into the subsoil. Alternatively, it can be held in a reservoir structure under the paving for subsequent infiltration or delayed discharge. The porous paving can be materials such as gravel, grasscrete, porous (no fines) concrete blocks or porous asphalt.

The photograph on page 10 shows a supermarket car parking area where a porous covering overlies a storage reservoir filled with graded stone. Rainwater passes through the pervious surface and



UK manufactured porous blocks, being laid on a bed of ground and crushed stone. Porous surfaces are particularly appropriate for lightly contaminated runoff, close to source. The underlying materials provide a useful storage volume for peak storm events, for new or existing developments.

is stored in the sub-grade reservoir, which need only be about one metre deep. The stored water can then slowly discharge to a nearby stream. The access routes have been constructed using conventional asphalt which can be clearly seen in the photograph.

Overflows can be constructed on all these systems where a surface must be kept free of water in all conditions or where the base needs to be sealed to protect the aquifer. Even if the overflow operates, some storage and filtering of the runoff water has occurred, and environmental benefits accrue. The

In this supermarket car park in Wokingham, Berkshire, the porous paving of the parking area is clearly visible.

overflow can lead into a permeable conveyance system to increase further the benefit and reduce the need for pipe systems.

Pollutant removal rates have been shown to be high, with some pollutants being held within the pavement material where this is asphalt. With other materials the majority of the removal occurs as a result of the infiltration of the water and the subsequent absorption and filtering within the subsoil. Removal of up to 80% of sediment, 60% of phosphorus and 80% of nitrogen has been measured, as well as high removal rates for trace metals and organic matter.

Porous pavements need to be protected during installation from the excessive mud usually present on construction sites.

Here the parking area at a motorway service has been built with porous blocks for the parking bays. The rainfall from the tarmac access roads runs onto these bays.

INFILTRATION TRENCHES

An infiltration trench is a shallow, excavated trench that has been backfilled with stone to create an underground reservoir. Stormwater runoff diverted into the trench gradually infiltrates into subsoil. An emergency overflow may be provided for extreme rainfalls which exceed the capacity of the reservoir.

The performance of the trench depends largely on the permeability of the soil and the depth to the water table. In common with other source control techniques, infiltration trenches usually serve small catchment areas, perhaps up to 2-3 hectares. The closer they are to the source of the runoff the more effective they will be.

The longevity of the trench may be enhanced by providing pre-treatment for the inflow, such as a filter strip, gully or sump pit, to remove excessive solids. Regular maintenance will be required for most pre-treatment designs.

This infiltration trench is incorporated into the landscape areas on a road embankment. The trench has an overflow into a stream.

Pollutant removal mechanisms include adsorption, filtering and microbial decomposition in the soil below the trench and trapping of particulate matter within pre-treatment areas. Properly constructed and maintained, infiltration trenches

Infiltration trench at the edge of a minor road. Water is taken into the trench via off-let kerbs.

can significantly reduce levels of solids, coliforms, trace metals and organic matter. Levels of phosphorus and nitrogen can also be reduced.

This gravel car park area in Fife has an infiltration trench in the centre. Water soaks into the ground, but during high rainfall, the overflow pipe takes excess flow from the trench to a nearby stream.

Design guidance for infiltration systems can be obtained from the Building Research Establishment(8) and CIRIA(9).

INFILTRATION BASINS

Infiltration basins are shallow, surface impoundments where stormwater runoff is stored until it gradually infiltrates through the soil of the basin floor. An emergency overflow may be provided for extreme rainfall events which exceed the capacity of the reservoir.

The performance of the basin depends largely on the permeability of the soil and the depth to the water table. Infiltration basins can serve larger catchment areas than infiltration trenches because a larger volume of water can be stored on the surface. They can probably serve catchments of up to 10 hectares.

As with the infiltration trench, the longevity of the infiltration basin may be enhanced by providing runoff pre-treatment, such as a filter strip, gully or sump pit to remove excessive solids. With larger basins these traps will require careful design to prevent scour of collected sediment during storm events. Regular maintenance will be required for most pre-treatment designs.

Pollutant removal mechanisms include adsorption, filtering and microbial decomposition in the soil below the basin and trapping of particulate matter within pre-treatment areas. Properly constructed and maintained, infiltration basins can be expected to remove a large proportion of solids and a lower proportion of soluble pollutants.

PERMEABLE CONVEYANCE SYSTEMS

FILTER (OR FRENCH) DRAINS

These move runoff water slowly towards a receiving watercourse, allowing storage, filtering and some loss of runoff water through evaporation and infiltration before the discharge point. There are two main types: underground systems, such as filter drains (or French drains) and surface water swales.

The underground systems are known as filter (or French) drains. They comprise a trench, filled with gravel wrapped in a geotextile membrane into which runoff water is led, either directly from the drained surface or via a pipe system.

A filter drain at the edge of a road in Stirling. There are no kerbs or gullies incorporated into the design.

The gravel in the filter drain provides some filtering of the runoff, trapping organic matter and oil residues which can be broken down by bacterial action through time. Runoff velocity is slowed, and storage of runoff is also provided. Infiltration of stored water through the membrane can also occur and some filter drains need not lead to a watercourse at all.

Filter drain systems have been widely used by the highway authorities for roads drainage and feature in the Design manual for Roads and Bridges, Volume 11 (10).

Hybrid infiltration systems and filter drains have been used for a variety of developments, including both residential and industrial sites.

Swale on A8000 near Edinburgh. No kerbs or gullies are required.

SWALES

Swales are grassed depressions which lead surface water overland from the drained surface to a storage or discharge system, typical using the green space of roadside margins. When compared to a conventional ditch a swale is shallow and relatively wide, providing temporary storage for storm water and reducing peak flows. They are appropriate close to source and can form a network within a development scheme, linking storage ponds and wetlands

A swale is dry during dry weather but during a rainfall event water flows over the edge and slowly moves through the grassed area. The flow of surface water is retarded and filtered by the grass. Sediment is deposited and oily residues and organic matter retained and broken down in the top layer of soil and vegetation. Swales can be lined below the soil zone where necessary, to protect the underlying aquifer.

During a rainfall event a proportion of the runoff can be lost from the swale by infiltration, and by evaporation and transpiration. If necessary, overflows can be placed at a high level to prevent flooding in times of exceptionally heavy rainfall. Swales should be designed to be dry between storm events to enhance their pollutant removal capability.

Swales work best with small gradients both for their side slopes and longitudinally. Performance can be enhanced by placing check dams across the swale to reduce flow velocities, which in turn reduces the risk of erosion in a swale. Even where swales discharge directly to a watercourse a considerable reduction in pollution load can be achieved. In addition, where runoff is conveyed via surface channels, wrong connections become obvious and can be fixed without the need for the expensive surveys required with traditional piped systems.

Swales avoid the need for expensive roadside kerbs and gullies and for their ongoing maintenance. They also reduce risk to amphibians such as toads and newts, which are often trapped in gully pots. Some regular maintenance is required to keep a grassed swale operating correctly, chiefly mowing during the growing season. The optimum grass length is around 150mm.

PASSIVE TREATMENT SYSTEMS

Passive Treatment systems use natural processes to remove and break down pollutants from surface water runoff. Small scale systems such as filter strips, can be designed into landscaped area, and are sited upstream of other SUDS. Larger, "end of pipe" systems usually involve storage of water in constructed ponds where natural purification processes can be encouraged. Constructed wetlands and ponds also provide the opportunity to improve wildlife habitat in urban areas. Additionally, ponds can be made into amenity features for the local community.

FILTER STRIPS

Filter strips are vegetated sections of land designed to accept runoff as overland sheet flow. In order to be effective they should be 5 – 15 metres wide and they may adopt any natural vegetated form, from grassy meadow to small wood. The wider the strip and the more dense the vegetative cover the better the pollutant removal.

Filter strips are best employed at the upstream end of the drainage system, accepting runoff from small areas (up to around 2 hectare) directly, i.e. before it is concentrated in a drainage system. Road runoff can also be treated in this manner, provided the road/filter strip boundary is designed so that it does not become blocked by sediment or vegetation.

Filter strips can be used effectively to remove excess solids and pollutants before discharge to an infiltration system. They may preserve the character of riparian zones and prevent erosion along stream banks by reducing flow velocities and spreading the flow across a wide area. Used in this way they also provide an excellent urban wildlife habitat.

This picture shows a filter strip that has been integrated into the pond design. The gravel filter strip provides a rooting medium for plants between the two sections of the pond. This pond serves an industrial estate in Livingstone.

DETENTION BASINS

Detention basins are designed to hold back storm runoff for a few hours to allow the settlement of solids. By-passes may be included to ensure the "first flush" is detained. Detention basins drain via an orifice or similar hydraulic structure into a watercourse or surface water drainage system.

This large detention area provides attenuation and flow control for a retail park near Dunfermline.

Detention basins are dry outside of storm periods. They are designed to retain flood events, reducing peak flows and limiting the risk of flooding.

Highway junctions provide land between slip roads that can be used for ponds or wetlands. In this case, land in the centre of a roundabout has been used as a detention basin, which releases rainwater at a fixed maximum rate, providing storage at times of intense rainfall.

The entire contents of the basin are drained down, and therefore they have a low level outlet orifice, which can lead to clogging by sediment. Careful design of the basin inlet and outlet will maximise the performance of the basin by preventing scour and short-circuiting. The performance can be enhanced by including small pools at the inlet and outlet to act as sumps to collect sediment.

Solids removal is the chief feature of detention basins, and high removal rates are possible. Nutrient and trace metals removal is more modest. Extended detention basins incorporate a small permanent pond or wetland which can enhance the appearance of the basin.

Pollutant removal can be maximised by allowing up to 24 hours detention and seeking to treat a modest volume of runoff. It may be better to treat the "first flush" of runoff from the catchment and by-pass the rest, rather than to scour out settled silt by passing the full storm flow through the basin. Performance is further enhanced with retention ponds and wetland pond systems.

Stenton Ponds in Glenrothes acts as both a flood control system and a water treatment pond.

RETENTION PONDS

Retention Ponds retain a certain volume of water at all times. This can avoid possibly unsightly exposure of banks of collected sediment and enhance performance in removing nutrients, trace metals, coliforms and organic matter. Allowance for a considerable variation in water level during storms should be incorporated in the design, so that a significant storage volume can still be provided.

The permanent water may be visually more attractive, although elevated nutrient concentrations may result in algal blooms. To be successful as an amenity, a retention pond should have a catchment of at least 5 hectares and/or a reliable source of baseflow. Inlet and outlet sumps will, as for detention basins, enhance performance by trapping sediment and preventing clogging of the outlet. Removal of collected sediment from the inlet sump may be needed, although typically this is not required at a frequency greater than once every seven years.

Ponds can be fed by a swale system, a filter drain network or a conventional surface water system. The last option will result in much larger peak flows reaching the pond and consequently require a bigger area. A typical retention pond will have at least 20 days retention time, to permit biological degradation of pollutants. For industrial sites, a pond provides a final opportunity to catch oils and chemicals from accidental spillages around the estate.

WETLANDS

These are a further enhancement of retention ponds, and incorporate shallow areas planted with marsh or wetland vegetation. These provide a much greater degree of filtering and removal of nutrients by algae and, to a lesser extent, by incorporation into plant material. Inlet and outlet sumps, as with detention basins and retention ponds, will enhance performance and might be considered almost obligatory since excessive sediment can quickly overwhelm the shallow area.

Only specially constructed wetlands should be used to treat surface water. It is not normally an acceptable practice to lead surface water into an existing, natural, wetland area.

In many developed countries constructed wetlands have been proven to be effective, providing moderate to high levels of pollutant removal throughout the year. Design of constructed wetlands by specialist consultants will maximise their performance and longevity. A review of constructed wetlands was published by CIRIA in 1997 (11).

This wetland serves an industrial estate in Livingston. It acts as both a water treatment facility and provides wildlife interest.

SUDS such as ponds and wetlands provide additional green areas and interesting water features within the urban environment, useful for urban recreation and pollution tolerant wildlife. They can provide a network of varied habitats threading through the urban environment.

Water features can be incorporated into both rural and urban settings to improve amenity value.
Roof water from the site flows to this attractive water feature at the Wheatley Service Area on the M40.

This newly constructed pond forms part of the treatment system for a major site in Southern England, which will provide a haven for local wildlife as the plants become established.

CONCLUSION

The traditional approach to draining developed areas is having a damaging impact on our environment and is not sustainable. Sustainable Urban Drainage Systems offer a wide range of techniques which can be adopted for most new and redeveloped sites to give a reduced environmental impact from surface water drainage. To implement SUDS techniques effectively, developers need to consider their use at the earliest possible stage, as this may influence decisions on land purchase and the overall layout of the development. They should consult with planning authorities, the Agencies and sewerage undertakers at the earliest stage of the development process. Widespread adoption of these techniques in new developments would see a long-term improvement in the quality of our urban rivers, contributing to a more varied and attractive urban environment built on a sustainable basis.

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