Gloucester, Cheltenham & Tewkesbury Joint Core Strategy

Sustainable Drainage Systems for
Local Development Framework
FINAL REPORT – Volume 3
October 2011

Halcrow Group Limited

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Contents Amendment Record

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2	0	Revised Draft Following Comments	Feb 11	RD
3	1	Final Report with LA comments addressed	July 11	JRP
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Glossary of Terms

DEFRA - Department for Environment, Food and Rural Affairs Development.

Department for Communities and Local Government (DCLG) - Department responsible for launching the Code for Sustainable Homes in 2007 which sets the standards for sustainability in new homes.

Environment Agency - The leading public body for protecting and improving the environment in England and Wales. Flood management and defence are a statutory responsibility of the Environment Agency; it is consulted by local planning authorities on applications for development in flood risk areas, and also provides advice and support to those proposing developments and undertaking Flood Risk Assessments. The Environment Agency reports to DEFRA.

Environment Agency Flood Zones - Nationally consistent delineation of 'high' and 'medium' flood risk, published on a quarterly basis by the Environment Agency.

Flood and Water Management Act 2010 - The Act takes forward some of the proposals in three previous strategy documents published by the UK Government - Future Water, Making Space for Water and the UK Government's response to the Sir Michael Pitt's Review of the summer 2007 floods. The Act also takes forward parts of the draft Flood and Water Management Bill and takes into account pre-legislative scrutiny of the draft Bill by the Environment, Food and Rural Affairs Committee.

Ground Source Protection Zone (GSPZ) - The GSPZ represents the groundwater catchment for the local water supply and is split into Inner Zones, Outer Zones and Total catchment areas which represent areas of varying sensitivity to contaminants.

Hydrology of Soil Type (HOST) classes - The Institute of Hydrology's soil classifications for UK soils.

Local Planning Authorities (LPA) - Local body responsible for future development control within the administrative boundary.

'Making Space for Water' (DEFRA 2004) - The Government's original strategy to manage the risks from flooding and coastal erosion by employing an integrated portfolio of approaches, so as: a) to reduce the threat to people and their property; b) to deliver the greatest environmental, social and economic benefit, consistent with the Government's sustainable development principles, c) to secure efficient and reliable funding mechanisms that deliver the levels of investment required.

Planning Policy Statements - The Government has updated its planning advice contained within Planning Policy Guidance Notes (PPGs) with the publication of new style Planning Policy Statements (PPSs), which set out its policy for a range of topics.

Previously Developed (Brownfield) Land - Land which is or was occupied by a building (excluding those used for agriculture and forestry). It also includes land within the curtilage of the building, for example a house and its garden would be considered to be previously developed land. Land used for mineral working and not subject to restoration proposals can also be regarded as Brownfield land.

Standard Percentage Runoff (SPR) value - These values are associated with each soil HOST class and represent the percentage of rainfall that does not permeate through the soil layer and causes the short-term increase in flow seen at the catchment outlet.

Sustainable Development – “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (The World Commission on Environment and Development, 1987).

Sustainable Drainage Systems (SUDS) – Surface water drainage systems which manage runoff in a more sustainable way than conventional drainage, through improved methods of managing flow rates, protecting or enhancing water quality and encouraging groundwater recharge. A variety of types are available and can be chosen as appropriate for the location and needs of the development, and many have added benefits such as enhancement of the environmental setting, provision of habitat for wildlife and amenity value for the community. The philosophy of SUDS is to replicate, as closely as possible, the natural drainage from a site before development.

Winter Rain Acceptance Potential (WRAP) - A classification representing soil permeability across the UK. Shown on maps produced as part of the Wallingford Procedure.

Executive Summary

In April 2010, Halcrow was commissioned by the Gloucester, Cheltenham and Tewkesbury Joint Core Strategy Consortium to produce a Sustainable Drainage System (SUDS) overview and advise the most appropriate techniques applicable to future developments, both allocated and windfall, within the administrative boundary of the planning authorities.

The findings of the Pitt Review, DEFRA, DCLG, PPS25, EU Water Framework Directive and other government consultation documents have culminated in the Flood and Water Management Act, which received Royal Assent in April 2010. The Act encourages the use of sustainable drainage in new developments and re-developments to ensure urban flood risk and water quality is adequately managed. It does this by requiring drainage systems to be approved, against a set of National Standards (under production), before building can commence and a connection to the sewer can be allowed (if needed). The Act establishes a SUDS approving body (SAB) at county or unitary local authority level. The SAB has responsibility for the approval of proposed drainage systems in new developments and re-developments, subject to exemptions and thresholds. The SAB is also responsible for the adoption and maintenance of SUDS which serve more than one property, where they have been approved. Highways authorities will be responsible for maintaining SUDS in Public Roads, to National Standards. A basic understanding of the various techniques will aid the local planning departments in consultation with developers.

For all Greenfield sites, it is recommended that the developer attenuates runoff so as to not exceed the corresponding greenfield rates generated by a range of storm events with the probability of occurring up to and including once in 100 years. An allowance must be made for the additional flow generated by up to the climate change event, to take account of future climate change. For brownfield sites, SUDS devices should reduce the proven current instantaneous runoff rate by a minimum of 5% wherever possible.

In areas of identified surface water flood risk and/or where the receiving watercourse has insufficient channel capacity, a greater reduction in surface water runoff should be required. In all instances, opportunities to improve runoff rates from a site and reduce flood risk should be sought.

It is recommended that land-raising is not undertaken to ensure overland flow paths are kept clear. This will involve the use of SUDS techniques which should take into account the local geological and groundwater conditions (see Volume 3 for further details on appropriate SUDS techniques for the JCS area).

The local soil permeability and Groundwater Source Protection Zones (GSPZ) have been mapped and provide a general overview of the Joint Core Strategy Area. These are used to provide an overview of the most suitable SUDS techniques. The local soil permeability has been assessed using the Hydrology of Soil Type (HOST) classification and the Environment Agency's GSPZ represent the sensitivity of the local water supply to contaminants. Analysis of this data shows that the Joint Core Strategy Area is predominantly made up of low permeable soils situated outside of the GSPZ.

There are vast arrays of SUDS techniques and the report has placed the most suitable devices with their corresponding HOST classes. Appendix A provides a User Guide which enables the user to easily identify suitable SUDS for any given site based on the local ground conditions identified in the maps in Appendix C.

Sites with HOST classes corresponding to high permeability will be more suited to infiltration devices than sites on less permeable soils. The natural treatment of contaminants and pollutants seen with the majority of SUDS techniques should be sufficient to allow discharge into all but the most sensitive zone of the GSPZ. Attenuation storage is required to enable greenfield or, for previously developed sites, agreed runoff rates to be maintained during extreme rainfall events. Where the GSPZ is highly sensitive or high levels of contamination are likely the SUDS system will require an impermeable lining to protect the receiving groundwater.

Micro-Drainage (WINDES) software and Environment Agency approved methodology have been used to estimate the greenfield run-off and corresponding storage area required to attenuate flow to Greenfield rates, for each of the HOST classes found in the Joint Core Strategy Area. This enables the LPA to make a preliminary assessment as to whether developers are limiting discharge from the site to suitable rates and to see whether SUDS techniques have been afforded adequate space in their design.

1 Background Information

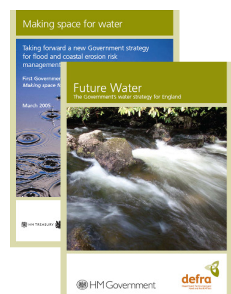
1.1 Terms of Reference

1.1.1 In April 2010, the Gloucester, Cheltenham and Tewkesbury Joint Core Strategy Consortium commissioned Halcrow to produce a Sustainable Drainage System (SUDS) overview and advise the most appropriate SUDS techniques applicable to future developments within the administrative boundary of the planning authority. A basic understanding of the various techniques will aid the local planning departments in consultation with developers.

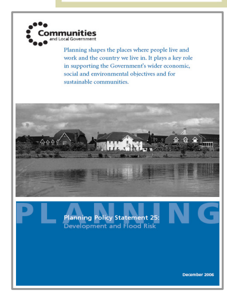
1.2 The Need for SUDS

1.2.1 SUDS is a term which encompasses the use of a variety of drainage elements to manage surface water in a way which is more sympathetic to the natural and human environment than conventional drainage systems. The overarching philosophy of SUDS is to replicate, as closely as possible, the natural drainage of a site before development. Traditional drainage systems comprising surface water sewers are designed to convey the water as quickly as possible to the receiving watercourse. They also, directly transfer urban runoff pollutants to the outfall. SUDS are designed to reduce the volume and rate of runoff and improve water quality through a range of processes that mimic the natural regime.

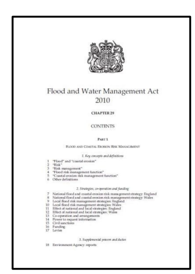
1.2.2 In February 2008, DEFRA launched the **Future Water: The Government's Water Strategy for England** which followed on from the consulting document, **Making Space for Water: Developing a New Government Strategy for Flood and Coastal Erosion Risk Management in England (2004).** Both documents set out the Government's proposals for future sustainable practices, including SUDS, and management objectives under the increased pressures of climate change and the increasing requirement for new housing.



1.2.3 **Planning Policy Statement 1 (PPS 1): Delivering Sustainable Development and Planning Policy Statement 25 (PPS 25): Development and Flood Risk** requires LPAs to promote the use of SUDS and states that the use of infiltration drainage systems should be given priority over sewers discharging to watercourses. The interim conclusion of the **Pitt Review: Learning Lessons from the 2007 Floods** is that PPS25 should be rigorously applied by local planning authorities to manage flood risk.



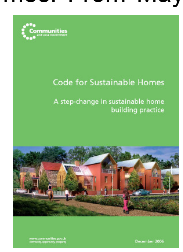
1.2.4 The findings of the Pitt Review, DEFRA, DCLG, PPS25, EU Water Framework Directive and other government consultation documents have culminated in the **Flood and Water Management Act**, which received Royal Assent in April 2010. The Act encourages the use of sustainable drainage in new developments and re-developments to ensure urban flood risk and water quality is adequately managed. It does this by requiring drainage systems to be approved, against a set of National Standards (under production), before building can commence and a connection to the sewer can be allowed (if needed). The Act thus ends the automatic right to connect surface water drainage to the public sewer. The Act establishes a SUDS approving body (SAB) at county or unitary local authority level. The SAB has responsibility for the



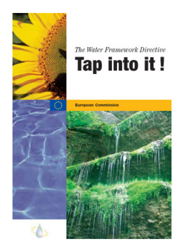
approval of proposed drainage systems in new developments and re-developments, subject to exemptions and thresholds. The SAB is also responsible for the adoption and maintenance of SUDS which serve more than one property, where they have been approved. Highways authorities will be responsible for maintaining SUDS in Public Roads, to National Standards.

1.2.5 In June 2009, the latest set of UK climate projections (UKCP09) was released. This is based on a new methodology designed by the Met. Office and provides the latest understanding and assessment of the likely effects of climate change. This suggests little change in annual rainfall, but by the 2080s, around 30% increases in the winter along the western side of the UK and corresponding decreases in the summer. Temperatures are expected to rise, with the greatest increases predicted in southern England. The impact of this is to increase the demand on future drainage systems through increased volumes and rates of runoff. Temperature rises have implications on water quality and treatment requirements.

1.2.6 The Department for Communities and Local Government (DCLG) launched the **Code for Sustainable Homes in 2007** which sets the standards for sustainability in new homes. From May 2008 all new homes are required to have a minimum Code rating of level 3. Surface The Department for Communities and Local Government (DCLG) launched the Code for Sustainable Homes in 2007 which sets the standards for sustainability in new homes. From May 2008 all new homes are required to have a minimum Code rating of level 3. Surface water runoff management is a mandatory element and provides 2 ‘credits’ towards the Code rating and represents the use of SUDS techniques in all new developments.



1.2.7 The **European Union Water Framework Directive (European Commission, 2000)** was transposed into UK national legislation in December 2003. The Directive includes a specific condition relating to the control of surface water discharge. Urban runoff has to be managed so that the impact on the receiving environment is mitigated. Mitigation cannot be adequately provided by traditional surface water sewers and therefore requires the use of SUDS.



1.2.8 The inference of the Pitt Review, DEFRA, DCLG, EU Water Framework Directive and UK law is that SUDS techniques are to be a mandatory requirement in all future developments to ensure urban flood risk and water quality is adequately managed.

1.3 Effects of Using SUDS

1.3.1 SUDS may improve the sustainable management of water for a site by:

- controlling or reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- reducing volumes of water flowing directly to watercourses or sewers from developed sites;
- improving water quality, compared with conventional surface water sewers, by removing pollutants from diffuse pollutant sources;

- reducing potable water demand through rainwater harvesting;
- improving amenity through the provision of aesthetic elements and varied habitat within the public open space;
- replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

1.3.2 To meet the requirements of PPS25 to reduce flood risk:

- the surface water drainage arrangements for any development site should be such that the volumes and peak flow rates of surface water leaving a developed site are no greater than the rates prior to the proposed development, unless specific off-site arrangements are made and result in the same net effect. For previously developed (brownfield) sites there should be a reduction in the current instantaneous runoff rate (not including any impacts of climate change), commonly by a minimum of 5%. However many Local Authority and Environment Agency officers are calling for 20 – 30% betterment on brownfield sites or in areas where existing flooding problems occur;
- the design runoff rate must include for the anticipated effects of climate change, e.g. a 30% increase in rainfall intensity is to be used to calculate the runoff rate for housing developments;
- there should preferably be a reduction in the volume of runoff. This may be achieved by the use of infiltration systems in accordance with the Building Regulations Part H3.

1.3.3 If this methodology is applied across a catchment, the cumulative benefit, particularly in the future following the impacts of climate change, from a n umber of sites is likely to be significant.

Surface SUDS elements

1.3.4 The most commonly found surface elements of a sustainable drainage system are described below (pictures from www.ciria.org):

Pervious surfaces: Surfaces that allow inflow of rainwater into the underlying construction or soil, such as porous surfacing – gravel, permeable hard surfacing – permeable block paving, porous tarmac and porous concrete. The storage can be created within the sub-base of these surfaces given careful selection of the stone fill or use of plastic box systems. They may also permit infiltration.

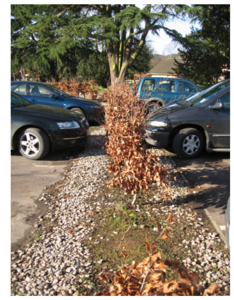
Green roofs: A vegetated roof which provides retention, attenuation and treatment of rainwater, and promotes evaporation and local biodiversity.

Brown roofs: Similar to green roofs, but the permeable layer is made from crushed material which provides a good void ratio and does not contain any contaminates.

Rainwater harvesting: A system that collects rainwater from where it falls rather than allowing it to drain away. It includes water that is collected within the boundaries of a property, from roofs and surrounding surfaces and can reduce the risk of flash flooding. Rainwater harvesting systems are not included in the calculation of attenuation storage provision due the fact that they may be full at the start of a storm event.

Filter trenches/ drains: Linear drains consisting of trenches filled with a permeable material, often with a perforated pipe in the base of the trench to assist drainage, to store and conduct water. They may also permit infiltration.

Filter strips: Vegetated areas of gently sloping ground designed to drain water evenly off impermeable areas and to filter out silt and other particulates.



Sand Filters: Structural controls designed to treat surface water by passing runoff through a filter bed of sand. Temporary storage can be provided by ponding above the filter layer and they can be used where high pollutant removal is required.

Swales: Shallow vegetated channels that conduct and can retain water in larger storm events. The vegetation filters out particulate matter in the flow thus providing treatment and improving water quality. They may also permit infiltration.

Basins: Ponds, depressions and wetland areas that may be utilised for surface runoff storage.

Bio-retention areas: Vegetated areas designed to collect and retain runoff and permit settlement of suspended solids and biological removal of pollutants before discharge via a piped system or infiltration to the ground.

Roadside water

Sub-surface SUDS elements

1.3.5 The most commonly found sub-surface elements of a sustainable drainage system are described below. These are particularly useful where there is limited open space on the site.

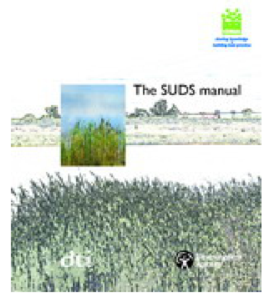
Geocellular/ Modular Storage: Sub-surface storage structure that has a very high void ratio and thus occupies a reduced space compared to other options, e.g. stone filled trenches. These are particularly useful where there is limited open space in the site and can also be used as a very effective infiltration device due to the very large areas in contact with the ground.

Pipes and accessories: A series of conduits and their accessories, normally laid underground, that convey surface water to a suitable location for treatment and/or disposal (these drainage elements should generally only be considered where at surface SUDS techniques are not practicable, e.g. under a road crossing).

Pre-treatment devices: These include vortex separators, proprietary filtration systems, sediment sumps, catch basin inserts and oil separators. These remove silt, sediment and debris to prevent downstream clogging and provide pollutant capture from runoff. These devices require regular maintenance to work efficiently.

Large diameter pipes, culverts or tanks: Provide a volume of below ground storage with a high void ratio and good man entry provision to allow for future maintenance and cleaning. These would generally be suitable for adoption by the statutory water company (e.g. Severn Trent Water Ltd).

1.4 Effective application of SUDS techniques



1.4.1 A hierarchical approach is recommended for selection of SUDS techniques to dispose of surface runoff. The SUDS Manual (CIRIA 697) states that 'wherever possible, stormwater should be managed in small, cost-effective landscape features located within small sub-catchments rather than being conveyed to and managed in large systems at the bottom of drainage areas'. This is illustrated by the SUDS Management Train (see Figure 1.1).

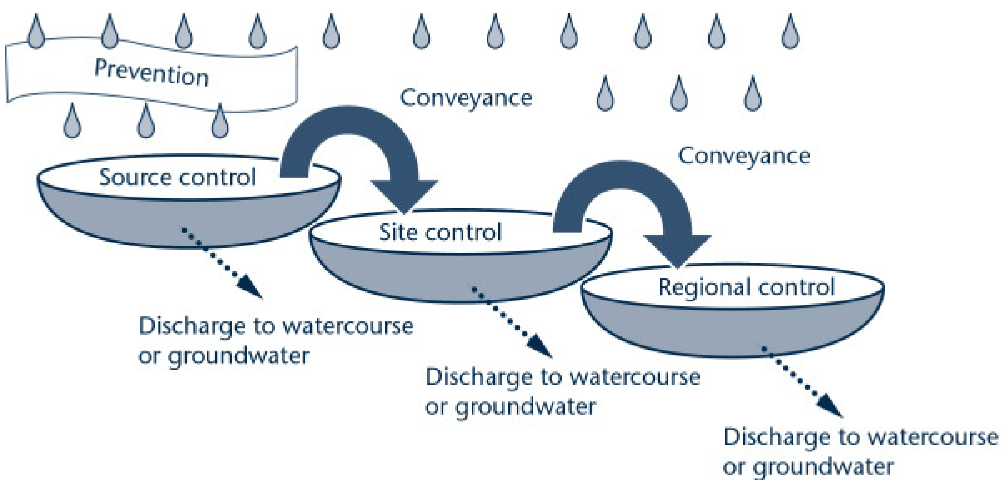


Figure 1.1: SUDS Management Train (from the Environment Agency website).

1.4.2 As well as the management train, all SUDS schemes should address the issue of Quantity, Quality and Amenity. This scheme must show that Greenfield (or better) discharge has been achieved, that water quality is not compromised (either groundwater or surface water), that the SUDS devices implemented perform efficiently and are sympathetic to the surrounding environment and are attractive to wildlife. As such, devices such as under ground storage tanks should be seen as a last resort.

1.4.3 The first stage, 'Prevention' stresses the benefit of avoiding runoff in the first place, and also refers to the need to prevent pollution. Prevention of runoff can be achieved by maintaining a permeable area. This can be achieved by avoiding paving where possible or by using permeable materials which allow rainfall to soak directly into the ground. It may also be possible to allow roof water to discharge straight onto a lawn in order to soak into the ground, but infiltration must avoid pollution of the soil and groundwater. This includes ensuring minimal use of herbicides on lawns, secure storage of oils and chemicals to avoid leakage, and dog litter policies.

1.4.4 If prevention methods are not sufficient to avoid runoff, the next preferred option is to store and dispose of it on site. This includes measures such as permeable paving or rainwater harvesting. Rainwater harvesting has the added benefit of reducing demand on public water supply and can reduce costs for the user of the rainwater (if they purchase water using a water meter). However, it cannot be included as part of the required storage provision as it must be assumed to be full at the start of a storm event. Where water cannot be directly infiltrated into the ground, it may be conveyed some distance before infiltration or, alternatively discharged into a watercourse. As the runoff is conveyed further, the SUDS classification moves from source control to site control and then regional control.

1.4.5 Infiltration is preferred over disposal to a watercourse or the public sewer system as this more commonly deals with runoff nearer to source and serves to replenish groundwater. This recommendation is reinforced by the requirements of the Building Regulations Part H3. If infiltration is not viable (due to a high water table, local impermeable soils, contamination issues including source protection zones etc), then the next option of preference is for the runoff to be discharged into a nearby watercourse. Only if neither of these options is possible should the water be discharged into the public sewer system.

1.4.6 The protection of groundwater quality is a factor in determining how SUDS are implemented (see Chapter 2.3). It should be noted that where soakaways are proposed, their use will only be acceptable to the Environment Agency subject to the following conditions:

- Soakaways shall not be constructed through contaminated material;
- The depth of any soakaway should normally not exceed 2.0 meters and under no circumstances shall be permitted to intersect the water table;
- A minimum of a 1.0 metre unsaturated zone shall be maintained between the base of any soakaway and the maximum seasonal water table for that site;
- Soakaways intended to drain highway or parking areas will usually require additional safeguards such as seal-trapped gullies or a suitably sized oil/grit separator;
- Soakaways designed to receive clean roof water should be kept separate from those receiving surface water runoff from highway or parking areas;
- The use of borehole soakaways will only be acceptable subject to written agreement from the Environment Agency.

1.4.7 It is important to note that it is an offence to discharge list 1 substances (petroleum, hydrocarbons etc) to groundwater. This would require a lined SUDS system where the runoff could not permeate into the ground and may require discharge to the local public sewers. In particular this may restrict the use of infiltration from swales for the drainage of car parks, in some areas where groundwater is likely to occur at shallow depth.

1.4.8 Depending on the final use, a number of treatment stages may be required. The number of stages is determined by the risk of pollution from a development. For example, roofs and school playgrounds which are by their nature unpolluted will only need one treatment stage; whilst industrial sites will need more. A treatment stage is typically a component of the management train. For example a permeable paving discharging into a swale which feeds into an attenuation basin before discharging will need three stages.

1.4.9 All SUDS devices should be positioned in flood risk Zone 1, as defined in PPS25, as any attenuation positioned in the other zones will reduce existing floodable storage capacity and the site runoff would be contributing directly to river flooding during severe events.

1.4.10 Large increases in impermeable areas contribute to significant increases in surface runoff volumes and peak flows and could increase flood risk unless adequate SUDS techniques are implemented. This even applies to developments which are at low risk of river (fluvial) flooding themselves, such as sites in Zone 1. These sites, although not susceptible to river flooding, may still be at risk themselves to pluvial (surface water) flooding whereby the drainage network cannot accommodate the rainfall runoff. These sites may also cause an increase in risk of flooding elsewhere, particularly downstream of the point of discharge.

1.4.11 A critical situation could be that of building a new large development just upstream of an existing development which already suffers from frequent flooding. In this case an effective SUDS technique could be to have large areas of pervious surfaces (pervious paving etc, where natural surfaces are not possible) combined with infiltration and rainfall harvesting techniques. The use of large attenuation areas may not be the appropriate SUDS technique, as whilst these reduce peak flows they do not affect flood volumes. Infiltration methods and/or long term storage provision may therefore need to be considered as appropriate.

1.4.12 The developer should investigate the most appropriate SUDS techniques at the master-planning stage to ensure that the most effective options are used and sufficient space is made available from the outset.

1.5 Future maintenance of SUDS

1.5.1 The Flood and Water Management Act 2010 places a duty on local authorities to adopt and maintain SUDS that serve more than one property and that have been constructed to national standards. The SUDS system will be adopted when it has been completed to the satisfaction of the SUDS Adopting Body, which will be the unitary or county council for the area. The SUDS Adopting Body will have the right to insist on a financial bond before work can begin on the SUDS. This will be released on satisfactory completion.

1.5.2 Until the processes for implementing the 2010 Act have been finalised and the SUDS Adopting Body established, the maintenance responsibility must be given to durable and accountable bodies which have the resources to meet the long term needs of the system. The future management and costs of maintaining SUDS devices will be dependent on the types of system used and this should be considered by the developer at an early stage.

1.5.3 A criticism of traditional drainage systems is that problems are often hidden underground and take time to eventually be discovered. The majority of SUDS devices are at the surface and pollution or silt build up can be observed as it happens. This means that any issues can be dealt with as they occur, but requires a regular monitoring regime and suitable body to provide the maintenance support.

1.5.4 As the majority of SUDS are at the surface elements, they are best incorporated into local landscape maintenance regimes where possible. An advantage of this is that the site managers and landscape contractors will have a good knowledge of the site through regular maintenance operations such as grass cutting and litter removal. This should also ensure regular monitoring and a quick response to any maintenance needs.

1.5.5 Water companies such as Severn Trent Water Ltd will only adopt hard structures which are to form part of the public sewer network. Developers will have to demonstrate to the SUDS approving body that they have met national standards for the application of SUDS techniques before they can connect any residual surface water drainage to a public sewer either directly or via a new section of adoptable public sewer. This amends Section 106 of the Water Industry Act 1991.

1.5.6 It is strongly advised that early consultation with the adopting authorities is sought to determine the most suitable design for future adoption and maintenance.

1.5.7 A CIRIA case study of the new development in Lamb Drove, Cambridgeshire concluded that the most cost-effective SUDS measures are within the soft landscaped areas, as the long-term management and maintenance could be incorporated into landscape and wildlife management regimes.

1.5.8 The need to keep SUDS simple was also raised as this ultimately reduced maintenance costs and increases the likelihood of future maintenance. Surface-based SUDS also allowed problems to be observed and dealt with as they arose. (Pictures from www.ciria.org)

2 Analysis of the Geology & Ground Source Protection within the Joint Core Strategy Area

2.1 Introduction

2.1.1 The Joint Core Strategy Area covers an approximate area of 501 km2. In order to achieve a general assessment of the most suitable SUDS techniques for proposed development sites within the area the following underlying factors are considered:

- Permeability of the soil;
- Location of GSPZs.

2.1.2 The permeability of the soil determines the infiltration potential for a site and is used to calculate the greenfield runoff value (see Chapter 4). The local GSPZs will determine the sensitivity of the groundwater to contaminants and will determine whether infiltration techniques are appropriate or an impermeable lining is required.

2.1.3 There are a number of other factors that will require site specific investigation to allow selection of the most suitable SUDS techniques. These include:

a) current land use (Greenfield vs. Brownfield sites);

b) location of the development relative to other urban areas;

c) type of land use proposed and layout of the development;

d) presence of contaminated land;

e) local fall of the land;

f) depth to permeable layer beneath a more impermeable layer;

g) normal and maximum height of groundwater table;

h) willingness of the water authority to adopt part of the drainage network.

2.1.4 Infiltration devices require a minimum of 1m soil depth between the base of the device and the maximum expected groundwater level. During severe storm events the groundwater can rise significantly in localised areas so local levels must be considered when selecting SUDS. Steep slopes may prevent the use of certain SUDS and suitable techniques should be based on the local gradients.

2.1.5 Elevation differences are required for some techniques and if the required head is not available naturally then local excavations or re-profiling may be necessary. SUDS need suitable areas to operate efficiently and the local availability of space will have an affect on the most suitable devices to use. The proposed land use will affect the amount of impermeable land to be attenuated and the level of contamination and health and safety requirements for the drainage systems.

2.2 Soil Permeability

2.2.1 The appropriate SUDS techniques for each site are highly dependent on the underlying soils. More permeable soils can have a positive effect for some SUDS, but a negative effect on others, for example wetlands rely on a pool of water or saturated sub-soils to provide the basis of water quality treatment and impermeable soils would provide this naturally, while permeable soils would require a liner to be installed. For this reason the local soil classifications for the entire Joint Core Strategy Area have been analysed.

2.2.2 Data on the permeability of local soils are contained within the HOST classifications produced by the Institute of Hydrology. Each HOST class is assigned a specific Standard Percentage Runoff (SPR) value, which is the percentage of rainfall that does not permeate through the soil layer and causes the short-term increase in flow seen at the catchment outlet. Therefore a low SPR value represents a highly permeable soil and a high SPR value represents a low permeable soil. Using the available information Table 2.1 was created showing the proportion of the Joint Core Strategy Area within each HOST class. Each class has been coloured as they appear on the HOST maps in Appendix C.

Table 2.1: HOST Classification for the Joint Core Strategy Area

HOST Class	SPR Value (%)	Permeability	Area (km^2)	Area (%)
2	2	High	68.0	13.6
5	14.5	Medium	49.0	9.8
8	44.3	Low	6.4	1.3
9	25.3	Medium	53.0	10.6
18	47.2	Low	15.1	3.0
20	60.0	Low	5.0	1.0
21	47.2	Low	26.2	5.2
23	60	Low	188.6	37.7
24	39.7	Low	33.8	6.7
25	49.6	Low	56.0	11.2
		Total	**501**	**100**

2.2.3 Table 2.1 shows that the majority of the Joint Core Strategy Area (66%) has a soil classified with a low permeability. 20% of the Joint Core Strategy Area has soil with a medium permeability and only 14% has a highly permeable soil classification.

2.2.4 Further confirmation of the local soil permeability is shown in The Wallingford Procedure 'Winter Rain Acceptance Potential' (WRAP) map published by the National Water Council. This shows that the majority of the Joint Core Strategy Area is located over areas with a WRAP Class of 3 and the minority has a Class of 1. Table 2.2 below shows that WRAP Class 3 represents relatively impermeable soils or permeable soils with shallow groundwater, while WRAP Class 1 represents relatively permeable soils. The two classes have been coloured as they appear on the WRAP map.

Table 2.2: WRAP Values taken from The Wallingford Procedure Map

WRAP Class	General Description
1	(i) Well drained permeable sandy or loamy soils and shallower analogues over highly permeable limestone, chalk, sandstone or related drifts. (ii) Earthy Peat soils drained by dikes and pumps (iii) Less permeable loamy over clayey soils on plateaux adjacent to very permeable soils in valleys
3	(i) Relatively impermeable soils in boulder and sedimentary clays, and in alluvium, especially in eastern England. (ii) Permeable soils with shallow ground-water in low lying areas (iii) Mixed areas of permeable and impermeable soils in approximately equal proportions

2.2.5 In summary, the majority of the Joint Core Strategy Area has either impermeable soil or soils where groundwater levels are high. This means that infiltration techniques will not be very efficient. Therefore more emphasis will have to be placed on storage areas to contain the peak flow. Greenfield runoff rates will be higher on the majority of sites for the same reasons, and developers will therefore have to provide less attenuation than would be required on sites with higher permeability (see Chapter 4).

2.3 GSPZ Catchments

2.3.1 The GSPZs represent the groundwater catchment for the local water supply and areas of varying sensitivity to contamination. The Environment Agency has provided GSPZ information for the Joint Core Strategy Area. Groundwater Source Protection Zones are split into Inner Zones (**red**), Outer Zones (**green**) and Total Catchment Areas (**blue**). The GSPZ classification will determine the type of SUDS system the proposed development site will have to use and the level of filtration and protection required.

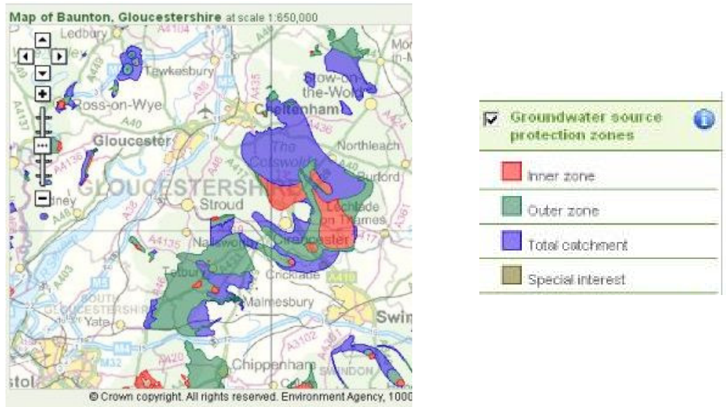


Figure 2.1: Groundwater Source Protection Zone; Baunton GSPZ shown for illustrative purposes

2.3.2 Figure 2.1 shows the different zones of the GSPZ. The Inner Zone is the most sensitive to contaminants, has a minimum 50m radius from the source and is based on biological decay criteria. It is designed to protect against the transmission of toxic chemicals and water-borne disease. The Outer Zone is based on the minimum time required to provide delay, dilution and attenuation of slowly degrading pollutants. The Total Catchment is defined as 'the area needed to support the protected yield from long-term groundwater recharge (effective rainfall)' (Environment Agency Groundwater Source Protection Zones publication) and is the least sensitive of the zones.

Table 2.3: Distribution of GSPZ in the Joint Core Strategy Area

GSP Zones	Area (m^2)	Area (%)
Inner Protection Zones	0	0
Outer Protection Zone	0	0
Total Catchment	8.0	1.6
Not in the GSPZ	493.0	98.4
Total	292	100.0

2.3.3 The GSPZ Zones in Table 2.3 have been coloured as they appear on the Environment Agency maps. The table shows that the vast majority of the Joint Core Strategy Area (98.4%) is situated outside the GSPZ. Only 1.6% of the Joint Core Strategy Area is situated over a GSPZ and this is over the Total Catchment.

2.3.4 This means that virtually all SUDS techniques will be situated in low risk sites and the level of filtration and contaminant removal naturally found with SUDS will provide adequate water quality control before discharge.

2.3.5 Runoff from certain sources have a high potential for contaminate discharge and such areas will however, require treatment before discharging downstream. Table 2.4 was populated using information from The SUDS Manual (CIRIA 697) and shows the sites which will require such treatment. This is a general overview and each site will require suitable investigation to determine the potential for contamination.

Table 2.4: Runoff Sources and their Requirement for Treatment

Source	Requirement for Treatment
Roof drainage	No
Residential areas, amenity soakaway area	No
Car park	No
Lorry park, service yard, garage forecourt - outside canopy	Yes
Local Roads	No
Major Roads (Motorway/ Trunk Road)	No/ Yes *
Industrial site, major commercial site	Yes

**Major roads will require an assessment to determine if treatment is required. This will be dependent on the traffic volumes and estimated pollutant loads.*

2.4 Conclusion

2.4.1 The analysis of local soil permeability and GSPZ areas provides a general overview of the key factors determining suitable SUDS selection for the Joint Core Strategy Area. The percentage run off within the Joint Core Strategy Area was found to be predominantly high due to either low permeability soils or high groundwater levels. These factors will inhibit the use of infiltration SUDS as the soil is inefficient at absorbing runoff. The most suitable techniques for low permeable soils/high groundwater levels will be storage devices that capture and attenuate rainwater run-off to suitable discharge rates.

2.4.2 The majority of the Joint Core Strategy Area is outside the GSPZ and therefore the requirements to filter and remove contaminants are not as stringent. SUDS techniques naturally reduce the level of contaminants by enhancing dilution, settlement and degradation by the attenuation of peak flows, but sites with potential for contamination such as service yards or industrial areas may still require filtration or pollution control, even if they are located outside the GSPZ.

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3 Selection of SUDS for the Joint Core Strategy Area

3.1 Introduction

3.1.1 This chapter provides a guide to the SUDS techniques most suited to the Joint Core Strategy Area. The local soil permeability and GSPZ information reviewed in Chapter 2 is used to provide a list of the most suitable SUDS techniques for sites with specific characteristics. The total catchment area of the GSPZs can be used for sites completely outside the GSPZs as they both have a low sensitivity to contamination. Appendix A presents these findings in flow diagram User Guide format.

3.1.2 While this document provides a useful tool to strategically identify suitable SUDS techniques across the Joint Core Strategy Area, the available GIS information is only accurate to a 1km2 scale and it is strongly advised that developers undertake site specific investigation. This will provide more accurate soil permeability information, identify any local water bodies or source protection issues and identify any other local factors that may affect the selection of the most suitable SUDS techniques. Where the site contains two or more separate HOST classifications, site investigation should also be undertaken to determine the most suitable locations and selection of SUDS devices for that site. A further factor to consider is that SUDS techniques require maintenance in order to remain effective so it is necessary to ensure that a suitable, durable authority agrees to maintain the system.

3.1.3 The amount of space available for the development will affect the choice of technique as some, such as swales and ponds, take up more space than others. Infiltration techniques need to be located suitably as they may affect the ground stability and pose a risk to nearby buildings. The land use of the site and surrounding area will affect the type of pollution that occurs, and different SUDS techniques are better at dealing with different types of pollution.

3.1.4 Runoff from heavily contaminated surfaces will always require a lined system to prevent contamination of the local ground and may require discharge into the public sewer system for full treatment if suitable pre-treatment cannot be provided within the SUDS system.

3.1.5 If the local soil is contaminated then a lined system is generally required. This may include a drainage design which allows infiltration in the upper layer, but should incorporate an impermeable layer at its base and sides to prevent contamination before discharging into the local watercourse. Where infiltration devices are to be used the design must comply with the Environment Agency's policy on infiltration and groundwater protection (see Chapter 1.4).

3.1.6 Environment Agency approval must be sought for discharge within all areas of the GSPZs. If it can be shown that there will be no contaminants in the runoff (e.g. from roofwater) then the discharge could go directly into the local groundwater even within the Inner Zone of the GSPZ.

3.1.7 The following sections provide information on suitable SUDS for each different HOST class within the Joint Core Strategy Area. There is only a small area that is within a Groundwater Source Protection Zone and this is within the Total Catchment rather than either the more sensitive outer or inner zones. The area as a whole is therefore at low sensitivity to contamination. Water from SUDS devices has improved quality due to treatment, such as filtration and biodegradation, and also because the attenuating effect on the peak flow enhances the dilution, settlement and degradation of any remaining pollutants. Due to this natural treatment the downstream water quality should be sufficient for discharge into the local watercourse, or where soil conditions are appropriate, to the ground. Special measures to protect groundwater quality such as the lining of SUDS devices with an impermeable membrane and an imposed requirement to discharge to a public sewer are not likely to be necessary.

3.2 HOST Class 8, 18, 20, 21, 23, 24 & 25

8

18

20

21

23

24

25

3.2.1 Soils with a HOST class of 8, 18, 20, 21, 23, 24 and 25 represent the most impermeable soils in the Joint Core Strategy Area. Infiltration devices will be highly inefficient and require very large volumes to encourage infiltration. Storage devices will be required to deal with the majority of runoff. However, because the greenfield runoff will be naturally high, the volume required to contain runoff and limit flow during the severe event will be correspondingly smaller than in areas with more permeable soils. (see Chapter 4).

3.3 HOST Class 8, 18, 20, 21, 23, 24, & 25, outside or within the Total Catchment Area of the GSPZ

8

18

20

21

23

24

25

3.3.1 Sites located within the total catchment area of the GSPZ or outside the GSPZ have a low sensitivity to contamination. Most SUDS systems naturally involve some form of treatment which is likely to ensure the water quality is sufficient to enter the local watercourse at the end of the system.

3.3.2 The most suitable SUDS techniques are:

- **Green or brown roofs**: to reduce runoff rates and volumes at the source.
- **Rainwater harvesting and water butts:** to collect runoff close to the source for re-use. (Not included as attenuation storage provision.)
- **Filter strips:** to capture silts and prevent the blockage of SUDS systems downstream.
- **Filter trench/ drain:** to convey runoff along a trench filled with permeable material and a filter drain at the base.
- **Swales:** to convey water and to remove silts.

- **Bio-retention areas:** to reduce runoff velocities, provide temporary surface water storage and filter particulates.
- **Detention basins:** to provide surface storage areas for attenuated runoff and allow the settlement of solids.
- **Ponds and wetlands:** to provide surface water storage and treatment.
- **Geocellular/modular:** for use as below ground storage structures.

3.4 HOST Class 5 & 9

5

9

3.4.1 Soils with a HOST class of 5 and 9 have a higher permeability than those with HOST classes 8, 18, 20, 21, 23, 24 and 25, but are less permeable than HOST class 2 Infiltration devices will be more efficient, but storage for the extreme events will require greater volume as the greenfield runoff is lower in more permeable sites (see Chapter 4).

3.5 HOST Class 5 & 9 outside or within the Total Catchment Area of the GSPZ

5

9

3.5.1 Sites located within the total catchment area of the GSPZ or outside the GSPZ have a low sensitivity to contamination. Most SUDS systems naturally involve some form of treatment which is likely to ensure the water quality is sufficient to enter the local water course at the end of the system or infiltrate into the more permeable soil.

3.5.2 The most suitable SUDS techniques are:

- **Green or brown roofs**: to reduce runoff rates and volumes at the source.
- **Rainwater harvesting and water butts**: to collect runoff close to the source for re-use. (Not included as attenuation storage provision.)
- **Soakaways**: to allow infiltration and stormwater treatment.
- **Filter strips**: to allow infiltration, capture silts and prevent the blockage of SUDS systems downstream.
- Filter trench/ drain: to allow infiltration and convey runoff along a trench filled with permeable material and a filter drain at the base during severe events.
- **Swales**: to allow infiltration, convey water and to remove silts.
- **Bio-retention areas**: to reduce runoff velocities, provide temporary surface water storage and filter particulates.
- **Pervious pavements**: to allow infiltration and remove urban runoff pollutants. The pavement design may incorporate storage within the sub-base.
- **Detention basins**: to promote infiltration, provide surface storage areas for attenuated runoff and allow the settlement of solids.

- **Ponds and wetlands**: to provide surface water storage and treatment. These may require an impermeable base if they are to remain water filled due to the more permeable soils.

- **Geocellular/modular**: for use as below ground infiltration sites and storage structures.

3.6 HOST Class 2

2

3.6.1 Soils with a HOST class of 2 represent the most permeable soils in the Joint Core Strategy Area. Infiltration devices will be highly efficient and require relatively small volumes to contain runoff and encourage infiltration. Storage devices will require a large volume to contain the extreme event as the greenfield runoff rate will be very low due to the highly permeable soil (see Chapter 4).

3.7 HOST Class 2 outside or within the Total Catchment Area of the GSPZ

2

3.7.1 Sites located within the total catchment area of the GSPZ or outside the GSPZ have a low sensitivity to contamination. Most SUDS systems naturally involve some form of treatment which is likely to ensure the water quality is sufficient to infiltrate into the permeable soils or enter the local water course.

3.7.2 The most suitable SUDS techniques are:

- **Green or brown roofs**: to reduce runoff rates and volumes at the source.

- **Rainwater harvesting and water butts**: to collect runoff close to the source for re-use. (Not included as attenuation storage provision.)

- **Soakaways**: to allow infiltration and stormwater treatment.

- **Filter strips**: to allow infiltration, capture silts and prevent the blockage of SUDS systems downstream.

- **Filter trench**: to allow infiltration and stormwater treatment.

- **Swales**: to allow infiltration, convey water and to remove silts.

- **Lined Bio-retention areas**: to provide surface water storage and treatment. These will require an impermeable lining due to the more permeable soils.

- **Pervious pavements**: to allow infiltration and remove urban runoff pollutants. The pavement design may incorporate storage within the sub-base.

- **Infiltration basins**: to allow infiltration and store runoff.

- **Detention basins**: to allow infiltration, provide surface storage areas for attenuated runoff and allow the settlement of solids.

- **Lined Ponds**: to provide surface water storage and treatment. These will require an impermeable base if they are to remain water filled due to the more permeable local soils.

- **Lined Stormwater wetlands**:

- **Geocellular/modular**: for use as below ground infiltration sites and storage structures if lined with an impermeable membrane.

3.8 Conclusion

3.8.1 The Joint Core Strategy Area has a mixture of low, medium and high permeability soils. The less permeable soils will be highly inefficient at infiltrating runoff and will have to provide suitable storage areas to deal with the majority of stormwater runoff events. The medium and highly permeable soils will be more efficient at infiltrating runoff and more emphasis should be placed on infiltration techniques.

3.8.2 The current design standard is to build infiltration devices capable of containing up to the 1 in 10 year storm event. In more extreme events the infiltration devices are left out of the storage area calculations (unless they are specifically designed to contain the more severe events) as they are likely to be saturated and will provide minimal attenuation. Therefore, to attenuate severe events (with a probability of occurring less than once every 10 years) the more permeable sites will require greater volumes of storage than the less permeable sites because the greenfield runoff rate will be lower.

3.8.3 Areas over the total catchment of the GSPZ, or outside the GSPZ entirely, should have suitable water quality at the end of the SUDS system to discharge into the local water course or permeable geology. Within the Joint Core Strategy Area there are no areas within the Inner or Outer Zones of the GSPZ so there should be no requirements to either line SUDS devices or to incorporate pre-treatment. The natural treatment provided by SUDS techniques has a beneficial impact on groundwater by improving the water quality leaving the system.

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4 General Size Guide for SUDS in the Joint Core Strategy Area

4.1 Introduction

4.1.1 This chapter provides greenfield runoff rates and corresponding pond area requirements for sites with different soil permeability in the Joint Core Strategy Area of Gloucestershire. This will provide the Councils with discharge rates that developers should achieve for the different sites and general estimates of the area developers should be providing to make space for SUDS techniques. This should assist during a site's Master Planning stage

4.1.2 For sites where there is no previous development, the developer must attenuate runoff so as to not exceed the corresponding greenfield rates generated by a range of storm events with the probability of occurring up to and including once in 100 years. An allowance must be made for the additional flow generated by up to the climate change event, to take account of future climate change. Where development will take place on brownfield land, SUDS devices should reduce the proven current instantaneous runoff rate by a minimum of 5% betterment wherever possible.

4.1.3 In areas of identified surface water flood risk and/or where the receiving watercourse has insufficient channel capacity, a greater reduction in surface water runoff should be required. In all instances, opportunities to improve runoff rates from a site and reduce flood risk should be sought.

4.1.4 It is recommended that land-raising is not undertaken to ensure overland flow paths are kept clear. This will involve the use of SUDS techniques which should take into account the local geological and groundwater conditions.

4.2 Greenfield Runoff Rates and Storage Areas

4.2.1 Where soils have a low permeability (HOST Classes 8, 18, 20, 21, 23, 24 & 25) the greenfield runoff rate will be relatively high because less runoff will naturally percolate through the soil. Areas with highly permeable soils (HOST Class 2) will conversely have the lowest greenfield runoff rate because more runoff would naturally be absorbed into the soil.

4.2.2 Infiltration devices are usually designed to contain the 1 in 10 year event and are assumed to be saturated during more severe events. The storage areas are therefore designed to attenuate the entire extreme event runoff. For this reason the required storage volume will be greater in areas with a higher permeability than in areas of less permeability, because the greenfield runoff rate will be lower.

4.2.3 Table 4.1 gives a rough guide to SUDS storage sizing for each of the HOST classes found in the Joint Core Strategy Area and is based on attenuation to greenfield rates. The greenfield runoff rate is calculated using the Institute of Hydrology Report 124 method as recommended by DEFRA/Environment Agency in the R&D Technical Report W5-074/A/TR/1, Preliminary rainfall runoff management for developments. The Micro-Drainage software, WinDes, is used to calculate the preliminary storage requirement.

4.2.4 To avoid calculation of excessive storage volumes in areas with high permeability soils, the minimum value to be used for greenfield runoff is 1.0 l/s/ha. The IH124 method was derived using SPR values up to 50% and is not strictly applicable above this range. The greenfield runoff rates for HOST classes

20 and 23 have therefore been calculated using an SPR value of 50%. Storage estimates are based on a 1ha site and have been calculated for a range of impermeability values. 60% impermeability represents a typical 'worst case' estimation for mid-density housing developments with approximately 50 houses per hectare. (See Appendix B for details).

Table 4.1: Greenfield Runoff Estimate and Storage Areas for Given HOST Classifications

Soil Classification			Greenfield Runoff (l/s/ha)		Storage Pond Area – 1m deep (m^2/ha) 1 in 100year +30% for Climate Change Event		
HOST Class	SPR Value (%)	Permeability	Mean annual peak flow (Qbar)	1 in 100 year event	60% impermeable	70% impermeable	80% impermeable
2	2	High	1.0	1.0	500	600	710
5	14.5	Medium	1.0	1.0	500	600	710
8	44.3	Low	4.2	10.9	270	330	390
9	25.3	Medium	1.3	3.2	370	450	530
18	47.2	Low	4.9	12.5	260	310	370
20	60	Low	5.5	14.2	250	300	360
21	47.2	Low	4.9	12.5	260	310	370
23	60	Low	5.5	14.2	250	300	360
24	39.7	Low	3.3	8.6	290	350	410
25	49.6	Low	5.4	13.9	250	300	360
Environment Agency (5 l/s/ha)			5.0	5.0	330	400	470

4.2.5 Existing sites which have a high permeability would naturally allow a significant proportion of runoff to infiltrate through the soil layer and reduce the amount of runoff which passes as overland flow. Therefore lower greenfield runoff values are seen at highly permeable sites as shown in Table 4.1 and Figure 4.1.

4.2.6 The opposite occurs at existing sites with low permeability as the proportion of runoff infiltrating through the soil layer is reduced and the amount of runoff as overland flow is higher. Therefore higher greenfield runoff values are found at lower permeable sites as seen in Table 4.1 and Figure 4.1.

4.2.7 Table 4.1 shows that in order to reduce runoff from a development to greenfield rates, a greater storage area will be required where the existing permeability is high. As the site is developed and surfaces become less permeable, water that would normally infiltrate away now becomes surface runoff and will have to be attenuated on site. However; sites with high permeability will provide more opportunity for the use of infiltration techniques which may be used to reduce the storage requirements.

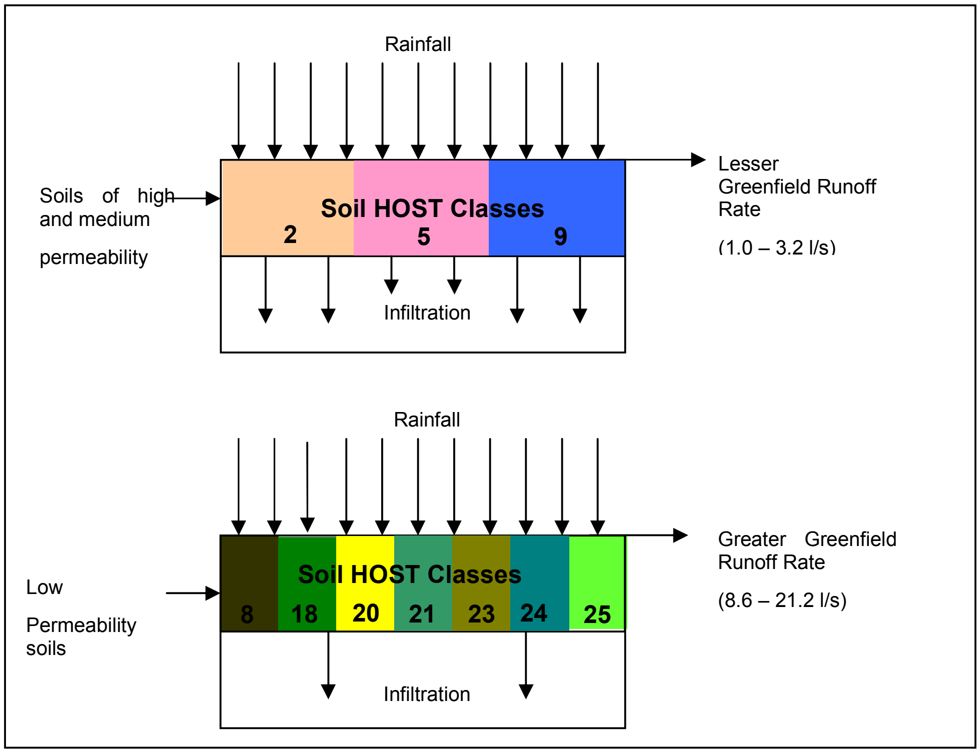

Figure 4.1: Greenfield Runoff for low and high permeability soils

4.2.8 Where no site specific ground investigation is undertaken the Environment Agency recommends that a discharge rate of 5 l/s/ha is not exceeded during a storm event with a probability of occurring only once in 100 years. An allowance for climate change should be applied by increasing the predicted rainfall intensities by 30%. Maximum permitted discharge rates are therefore likely to be as follows:

- 5.0 l/s/ha for sites with HOST classes 8, 18, 20, 21, 23, 24 and 25
- 3.2 l/s/ha for sites with HOST class 9
- 1.0 l/s/ha for sites with HOST classes 2 and 5.

4.2.9 Table 4.1 gives the approximate storage requirements for a limiting discharge of 5 l/s/ha.

4.2.10 1.0 l/s/ha is a small discharge and may be difficult to achieve on site. The Environment Agency should be consulted to see if the more achievable value of 3.2 l/s/ha is acceptable for sites with HOST classes 2 and 5. A practical minimum limit on the discharge rate from a flow attenuation device is 5l/s. For small sites in particular, the Environment Agency's advice regarding an acceptable discharge rate should be sought at the earliest opportunity.

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5 Summary of Principal Recommendations

5.1.1 This report has been produced to advise The Joint Core Strategy Consortium on the most suitable SUDS techniques applicable for developments within the administrative boundaries of Gloucester City Council, Cheltenham Borough Council and Tewkesbury Borough Council.

5.1.2 SUDS are being strongly promoted and legislation is coming into force which will make them compulsory elements of future developments. A basic understanding of the various techniques will aid the local planning departments in consultation with developers and help enforce the requirement for such devices.

5.1.3 For sites where there is no previous development, the developer must attenuate runoff so as to not exceed the corresponding greenfield rates generated by a range of storm events with the probability of occurring up to and including once in 100 years. An allowance must be made for the additional flow generated by up to the climate change event, to take account of future climate change. Where development will take place on brownfield land, SUDS devices should reduce the proven current instantaneous runoff rate by a minimum of 5% betterment wherever possible.

5.1.4 In areas of identified surface water flood risk and/or where the receiving watercourse has insufficient channel capacity, a greater reduction in surface water runoff should be required. In all instances, opportunities to improve runoff rates from a site and reduce flood risk should be sought.

5.1.5 It is recommended that land-raising is not undertaken to ensure overland flow paths are kept clear. This will involve the use of SUDS techniques which should take into account the local geological and groundwater conditions.

5.1.6 The local soil permeability and GSPZ locations are the most effective indicators for providing a general overview of the Joint Core Strategy Area, and have been mapped in Appendix C. The local soils have been categorised using the HOST classification and the corresponding SPR values represent permeability. The Environment Agency's GSPZ mapping breaks down the areas contributing to local water supply into areas of varying sensitivity.

5.1.7 Analysis of this data shows that the Joint Core Strategy Area has a mixture of low, medium and high soil permeability, but is predominantly made up of low permeability soils. The GSPZ mapping again shows a small area of total catchment locations, but the majority of the Joint Core Strategy Area is situated outside of the GSPZ.

5.1.8 There are vast arrays of SUDS techniques and the report has split the most suitable types into corresponding HOST classifications of soils in the Joint Core Strategy Area. The User Guide presented in Appendix A facilitates this process and provides a quick and user friendly reference tool.

5.1.9 HOST classes with associated high permeability will be more suited to infiltration devices than sites with low permeability soils. The natural treatment of contaminants and pollutants seen with the majority of SUDS techniques should be sufficient to allow discharge into all but the most sensitive zone of the GSPZ. Storage SUDS are required for the extreme event to enable greenfield runoff rates to be maintained. SUDS systems will require an impermeable lining in sites where the GSPZ is highly sensitive or contamination is likely. However, this is not anticipated within the Joint Core Strategy area.

5.1.10 It is advised that developers undertake a thorough site investigation to confirm the most suitable SUDS techniques as local factors may require different approaches. The long term maintenance of SUDS devices must also be considered at an early stage as their effectiveness can be greatly reduced by neglect and could pose future flooding or contamination issues.

5.1.11 A general estimation of runoff and required storage volumes has also been provided. This will enable planners to enforce the relevant discharge rates for sites within a given HOST class if site investigation is not undertaken by the developer. The storage estimation can also be used to check that development master planners are considering suitable areas for installing SUDS techniques.

6 Reference Documents

6.1.1 For more guidance on SUDS, the following documents are recommended as a starting point:

- C967 The SUDS Manual, Woods Ballard B; Kellagher R et al, 2007 – available from CIRIA bookshop www.ciria.org.uk
- Interim Code of Practice for Sustainable Drainage Systems, National SUDS Working Group, 2004 – available from CIRIA bookshop www.ciria.org.uk or Environment Agency website www.environment-agency.gov.uk
- Preliminary rainfall runoff management for developments, DEFRA/Environment Agency R&D Technical Report W5-074/A/TR/1 Revision D, July 2007, - Free download from EA website www.environment-agency.gov.uk
- C625 Model Agreements for Sustainable Water Management Systems, Shaffer et al, 2004, – available from CIRIA bookshop www.ciria.org.uk
- C539 Rainwater and greywater use in buildings – best practice guide, Leggett et al, 2001, – available from CIRIA bookshop www.ciria.org.uk
- C582 Source control using constructed pervious surface: hydraulic, structural and water quality performance issues, Pratt et al, 2002, – available from CIRIA bookshop www.ciria.org.uk
- C635 Designing for exceedance in urban drainage – good practice, Digman et al, 2006, – available from CIRIA bookshop www.ciria.org.uk
- Report 156 Infiltration drainage – manual of good practice, Betess R, 1996, – available from CIRIA bookshop www.ciria.org.uk
- Harvesting rainwater for domestic uses: an information guide, Environment Agency, 2003, - Free download from Environment Agency website www.environment-agency.gov.uk
- Planning Policy Statement 25 (PPS25) Development and flood risk, Department for Communities and Local Government, 2010, - Free download from CLG web site http://www.communities.com
- Development and flood risk: A Practice Guide Companion to PPS25, - Department for Communities and Local Government, updated 2009, - Free download from CLG web site http://www.communities.com

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Appendix A

Quick Guide to SUDS Selection for all HOST classes in the Joint Core Strategy Area

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Attenuation Requirements Table

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Appendix B

Greenfield Runoff Estimation

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WinDes Storage Estimation

Greenfield runoff estimation:

Greenfield runoff rates for the different HOST classes across the Joint Core Strategy Area were calculated using the Institute of Hydrology Report 124 method as recommended by the DEFRA/Environment Agency R&D Technical Report W5-074/A/TR/1, Preliminary rainfall runoff management for developments. This method comprises a regression equation based on area, annual rainfall (SAAR) and SPR soil values that correspond to the HOST classes, to calculate an estimate of the mean annual peak runoff rate (Qbar). Growth curves related to the relevant region of the UK are used to calculate the corresponding peak runoff rate for a 1 in 100 year return period storm event. The equation is only valid for SPR soil values within the range of 15% and 50%. Below 15% a minimum value of 1 l/s/ha is used and the maximum value is limited to that derived for a SPR of 50%.

WinDes Storage estimation:

The Micro-Drainage software WinDes was used to calculate the general estimates for storage volumes. The ‘Source Control’ application was used for the outline design of a pond storage structure with an orifice controlled outfall to restrict outflows to the 1 in 100 year greenfield runoff rates. The 60% impermeability for a 1ha site represents a typical, mid-density residential development with 50 houses. This was input as a contributing area of 0.6ha to the pond. The 1 in 100 year event with rainfall intensities increased by 30% to allow for climate change was used to calculate the corresponding storage volume required. The pond was sized based on a 1m water depth to provide a simple area calculation. Storage volumes for higher percentage impermeabilities have also been included for guidance.

Brownfield runoff

Brownfield runoff must be calculated based on proved existing impermeable areas connected to the public sewer system. Betterment should be provided in the form of a minimum reduction in agreed peak runoff of 5%, but the Environment Agency normally require a 20% reduction over agreed existing runoff rates.

Appendix C

Maps showing HOST Classifications and Ground Source Protection Zones for the Joint Core Strategy Area

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