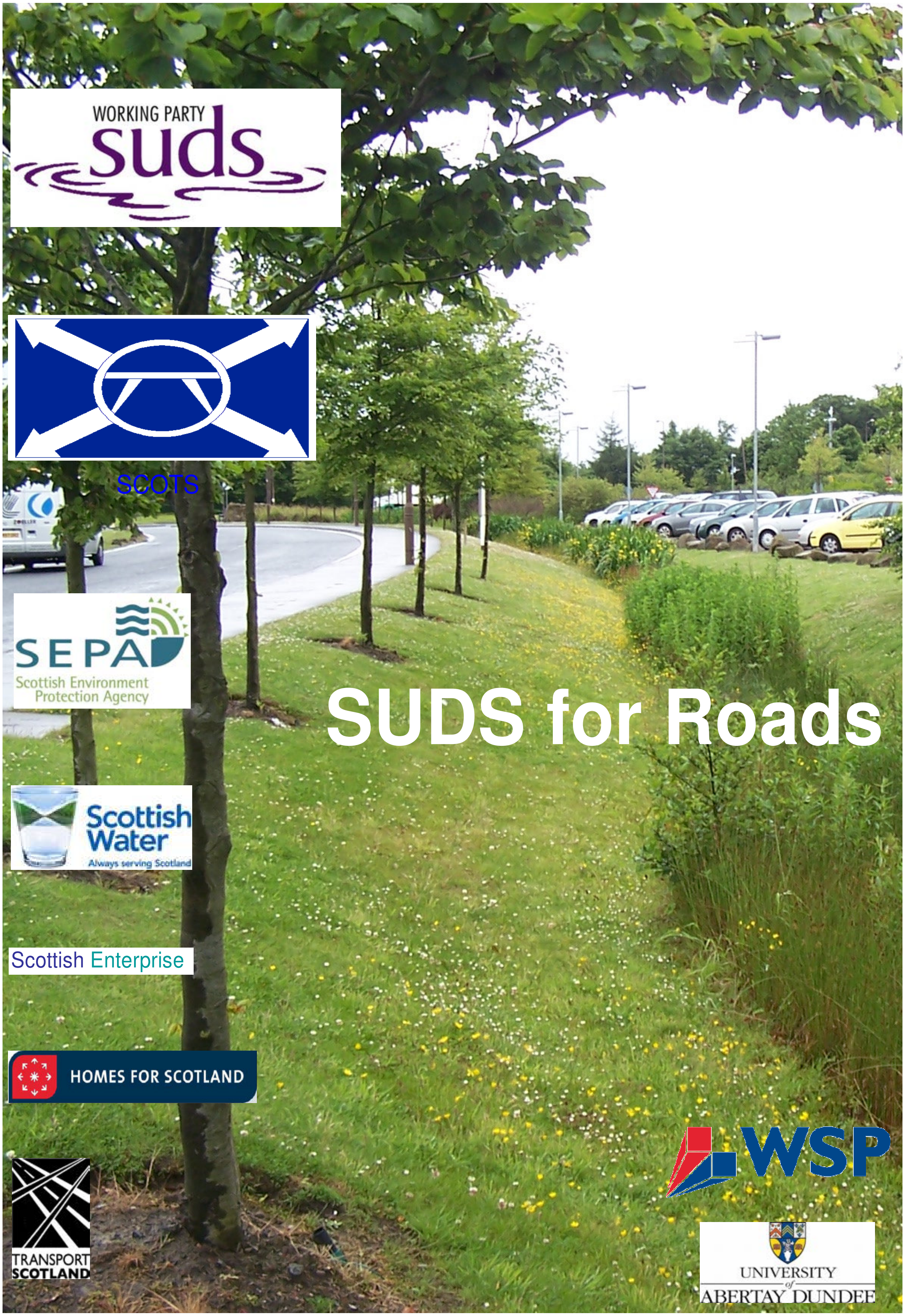

SUDS for Roads

QM

Issue/revision	Issue 1	Revision 1	Revision 2	Revision 3
Remarks	First draft	Second draft	Third draft	Consultation
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FOREWORD

As a consequence of their military conquest, the Romans constructed roads in the UK with what is still recognised as durable technology. Later designers such as Macadam brought us our modern roads and attempted to address the problems of drainage. Since then drainage has been uppermost in designers' minds in protecting the structural integrity of the road.

'SUDS for Roads' is now intended to further advance our knowledge of the interaction between roads and drainage within an urban context where roads are now multifunctional and must provide much more than sealed surfaces for wheeled vehicles.

SUDS (Sustainable Urban Drainage Systems) were introduced to the UK more than 10 years ago and much of the early work developed here in Scotland concentrated on the hydrology and water quality aspects of SUDS. Roads designers have been required to adapt to this new strategy without apparently having input to the processes. Equally, legislation has advanced significantly in the area of water management and, arguably, roads legislation has not kept up.

The design of roads now incorporates SUDS systems and together provides long term environmental and social factors.

This recent growth and accrued benefits from the use of SUDS has been supported by the work of a range of public and private sector organisations, and facilitated by a series of documents. While many of these documents describe the suitable design of SUDS, few have provided appropriate advice and direction for practitioners involved in the design approval and adoption of SUDS within the road network boundary.

Early in 2008 the SUDS Scottish Working Party, guided by practitioners, took ownership of this disconnect and, from then on, a committed group of professionals, from a variety of industry stakeholders have worked collaboratively to resolve this issue.

This document, commissioned and guided by SCOTS and SUDS Working Party, and authored by WSP, is the result of careful partnership working between a range of public and private sector organisations including the Scottish Government, Scottish Water, Scottish Enterprise, Homes for Scotland, University of Abertay Dundee and Transport Scotland.

The document is supported by robust research, and evidence gathering, and provides a guide for all professionals involved in the road design process. It is anticipated the primary readership of SUDS for Roads will be Local Authorities and Private Developers however the principles contained herein apply equally to designers in other disciplines such as Architecture and Landscaping.

The purpose of the document is to guide the reader through the design of roads incorporating SUDS that are suitable as best practice at reasonable cost.

The Sustainable Urban Drainage Scottish Working Party believe,

"SUDS can be incorporated into every new development in Scotland if all those involved

in the decisions about drainage work together."

Colin Bayes, Chair of SUDS Working Party   Ian Bruce, Chair of SCOTS

STRUCTURE OF THE GUIDANCE MANUAL

The following chapter descriptions identify where key information is located within the guidance document:

Chapter 1 **Introduction** describes the traditional and historical context of road drainage design. It describes the responsibilities of the roads drainage adopting authorities and provides an over view of concepts of SUDS and its relationship with road pavement construction. It also looks at surface water management plans and their importance in providing an integrated regional drainage strategy.

Chapter 2 **SUDS Applications for Roads** deals with details of road hierarchy and site classification and will set out the hydrological criteria requiring consideration in the design process, the principles of water quality enhancement by utilising SUDS for roads drainage, and the environmental risk addressed by applying these principles. It will introduce the types and applicability of SUDS features for roads at pre-treatment, source control and site control and will outline the framework enabling design and detailing of these features taking into account of structural integrity of the road, hydraulic considerations, water quality, amenity and ecological performance objectives associated with various road types. A selection matrix and flow chart for the selection of SUDS for various roads applications is described within this chapter.

Chapter 3 **Practical Guidance for Construction, Operation and Maintenance of Road SUDS** will outline practical guidance for particular SUDS features for use in roads taking cognisance of particular issues associated with construction detailing and installation/ construction guidelines. It will also provide an overview on the maintenance of completed SUDS, why and when they need to be maintained and by who.

Chapter 4 **Procedure for Adoption** sets out the current position, relevant at the time of writing, with respect to legislation and statutory obligations, ownership and maintenance responsibilities. It will outline the adoption process from the land use planning system to Road Construction Consent, adoption agreements and maintenance responsibilities. The importance of Building Control related issues will also be considered.

Chapter 5 **Un-adopted SUDS and Retrofitting** summarises the retrofitting options available for existing un-adopted SUDS, their applicability and technical feasibility to a required standard where they can be adopted. It will also consider the introduction of SUDS to roads where they have been previously drained solely by conventional piped drainage techniques.

Chapter 6 **Factors affecting Cost** presents the initial and long-term costs that are likely to be required to support the SUDS scheme from ‘cradle to grave’. It will present a framework for whole life costing of the SUDS features including an assessment of the environmental costs and benefits.

Contents

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1 Introduction

1.1 SCOPE OF THE GUIDANCE

WHO SUDS FOR ROADS IS FOR

This technical guidance document is intended for use by roads engineers within local authorities, Transport Scotland, consulting engineers and by other professionals within the built environment involved with planning, design, construction, operation, adoption and maintenance of roads, surface water drainage and associated SUDS for new and existing developments.

WHICH ROADS ARE COVERED BY THE GUIDANCE

1.1.1 The document provides guidance on the design, construction, adoption, maintenance, performance, applicability and whole life cost of SUDS associated with the treatment and attenuation of surface water runoff from roads and footways linked with the local authority road hierarchy outlined in Figure 1.1. It also covers the application of SUDS in rural areas and references are made to trunk road applications.

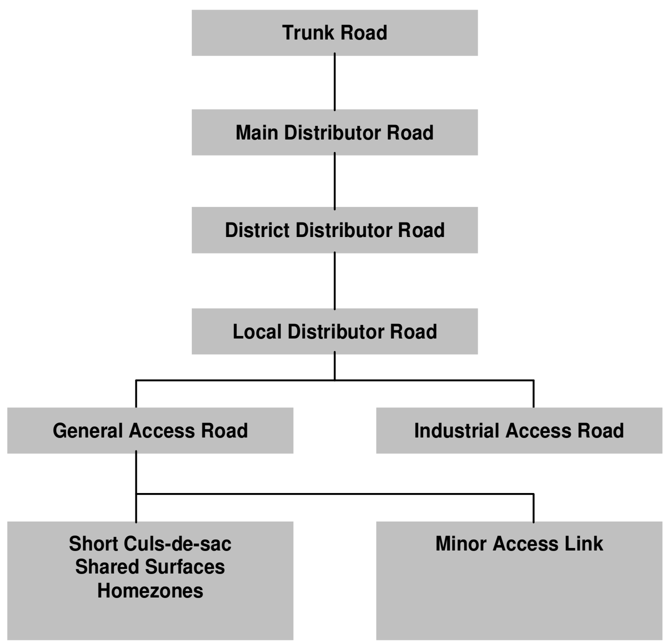

Figure 1.1 Typical Road Hierarchy [1]

Note: Emerging policy on future street layout will be dominated by layout and geometry focussing on the character of the development, and will vary greatly from the traditional road hierarchy.

1.2 BACKGROUND

HISTORICAL CONTEXT OF ROAD AND DRAINAGE DESIGN

1.2.1 Guidance for the design of road pavements was introduced through Road Note 29 – A Guide to the Structural Design of Pavements for New Roads[2]. The principles within this guidance, for the design of flexible and rigid pavements, were based on the subgrade and traffic conditions, linked to the percentage California Bearing Ratio (CBR) and cumulative numbers of vehicle standard axles. The approach taken within Road

Note 29 to drainage of the subgrade or any other permeable layer within the road construction was to provide sub-surface piped drainage solutions such as filter drains to remove water from these layers during construction and throughout the design life of the road. Drainage systems were designed generally to prevent the water table from rising to within 600mm of the formation level.

1.2.2 Subsequent guidance, summarising over thirty five years of research in road pavement design, was prepared by the Transport and Road Research Laboratory (TRRL) in the form of TRRL Laboratory Report 1132 – The Structural Design of Bituminous Roads[3]. This research document broadly follows the principles outlined in Road Note 29 in terms of drainage of the subgrade and other permeable layers and indicates that the water table should be maintained at a depth of at least 300mm below the formation level.

1.2.3 The traditional purpose of providing drainage for roads is to convey water as quickly as possible from the running surface, thus ensuring a clear safe path for road traffic, and to prevent water ingress to the road pavement structure to avoid potential damage to the structure of the road. Traditional road surface water drainage techniques involved collecting runoff in roadside gullies, drainage kerbs or other collection devices which convey runoff to underground closed pipe systems.

1.2.4 Historically, many road and other surface water drainage systems in urban areas were combined with foul sewage in a single combined sewer; a sewer being drainage that is adopted by a water authority. During significant rainfall events overland flows would enter the combined sewer network, leading to spills of untreated sewage into receiving watercourses via combined sewer overflows.

1.2.5 More recent theory encouraged the use of separate surface and foul water drainage systems to reduce this burden. However, conventional road and surface water drainage systems still conveyed water away as quickly as possible which in turn altered natural flow patterns leading to potential problems elsewhere. This approach to drainage design in urban development led to flooding and disruption of the water cycle to the detriment of water resources and the natural environment.

1.2.6 Most surface flooding of traditional road drainage is directly linked to the specified design capacities which do not require the system to cope with extreme rainfall events.

1.2.7 Conventional road drainage for local roads has been designed in accordance with local authority development guidelines which specify the use of Road Note 35[4]. Road Note 35 recommended the use of the Rational (Lloyd-Davies) formula for small areas such as housing estates or villages where the diameter of the largest surface water drain is unlikely to exceed 600mm. Road Note 35 states that suitable design frequency for design of road drainage is 1 in 1 year for separate surface water drainage in estate roads.

1.2.8 Surface water drainage associated with trunk roads is covered within the Design Manual for Roads and Bridges (DMRB), Volume 4, Section 2, HD33/ 06[5]. This guidance suggests that longitudinal sealed carrier drains must be designed to accommodate a one year storm, with a 20% increase in rainfall intensity of the design storm to allow for climate change, without surcharge, and the design should be checked to ensure the five year surcharge levels do not exceed the chamber cover levels. Where the risk of potential flooding has been identified, consideration should be given to the use of controls and vegetated drainage systems as described in DMRB, Volume 4, Section 2, HA 103/ 06[6].

1.2.9 Recent legislative changes, through the introduction of The Water Environment (Controlled Activities) (Scotland) Regulations 2005, commonly referred to as CAR, require that surface water runoff from areas constructed after 1 April 2007 must be drained by SUDS so that all reasonable steps are taken to ensure the discharge will not result in the pollution of the receiving water environment.

DRAINAGE RESPONSIBILITIES FOR ROADS AND CURTILAGE

Transport Scotland

1.2.10 The trunk road network, including strategic roads and motorways, and associated surface water drainage, are the responsibility of Transport Scotland. Guidance on the selection of types of surface and sub-surface drainage for trunk roads is given in DMRB Volume 4 Section 2 HD 33/06 'Surface and Sub-surface Drainage Systems for Highways'[5]. Guidance on how vegetated systems, similar to SUDS, may be used to convey, treat and store runoff from highways is given in DMRB HA 103/06 'Vegetated Drainage Systems for Highway Runoff'[6].

Local Authorities

1.2.11 The provision of new roads for developments is controlled and consented by the roads authority through the Road Construction Consent (RCC) process, governed by Section 21 of the Roads (Scotland) Act 1984[7]. Under the terms of a RCC application, the developer is obliged to construct roads, over which there is a public right of passage, to an agreed standard, having first secured technical approval for the design from the roads authority. The design would also include details of how the road surface is to be drained and what SUDS measures are to be incorporated.

1.2.12 Roads authority development guidance generally advocates that the provision of permanent drainage of the road subgrade and any other permeable layer within the pavement construction requires to be designed to prevent the water table from rising to within 600mm of the formation level.

1.2.13 Under Section 31 of the Roads (Scotland) Act 1984 the roads authority may construct or lay drains, erect and maintain barriers for diversion of surface waters, scour, cleanse and keep open all drains, and drain surface water into any inland waters or tidal waters for the purpose of draining a public or proposed public road.

Scottish Water

1.2.14 The Sewerage (Scotland) Act 1968[8] requires Scottish Water to effectively drain surface water from roofs and paved areas within the curtilage of premises.

1.2.15 Scottish Water has no obligation to drain roads, footways or paved surfaces out with the curtilage of premises, or to drain groundwater or accept land drainage connections. Scottish Water may choose to accept road runoff into their surface water drainage system through agreement with the roads authority under the terms outlined in Section 7 of the Sewerage (Scotland) Act 1968.

SUDS OVERVIEW

1.2.16 The road surface and its associated drainage provides a conduit for both the storage and conveyance of runoff and, by its nature and its impact on the environment, the management of this runoff is a more complex matter than dealing with foul water.

1.2.17 Historically, surface water drainage systems have not been designed with sustainability in mind, with most paying insufficient regard to water quality, catchment flooding, water resources, site amenity and potential for habitat enhancement.

1.2.18 Increased urbanisation through time has led to the modification and/ or deterioration of watercourses, water bodies and groundwater through release of untreated pollutants, resource depletion and the loss of natural floodplains to development.

1.2.19 The introduction of Sustainable Urban Drainage Systems (SUDS) is seen as a means to redress the balance and manage surface water runoff within the urban environment in a fashion that minimises the impacts of development on the quality and quantity of road runoff, whilst maximising amenity and biodiversity opportunities. The three-way urban drainage triangle is illustrated in Figure 1.2.

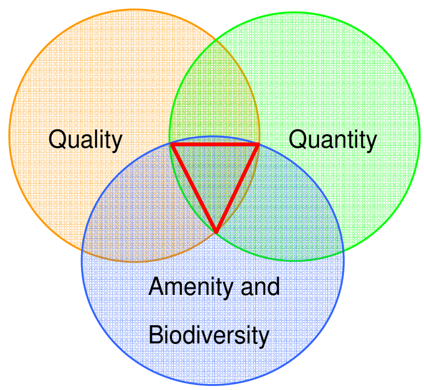

Figure 1.2 Urban Drainage Triangle

1.2.20 In order to mimic the natural catchment processes as closely as possible within a development drainage system, the concept of a surface water management train should be followed.

1.2.21 The concept begins with prevention, such as gully emptying, road sweeping and other maintenance tasks, and progresses through source control, where the control and treatment of runoff is at or very near to its source, to larger site controls where management of surface water is undertaken for a site area, then on to estate regional controls where surface water management can be provided for an individual or multiple site scenario. This process is illustrated in Figure 1.3.

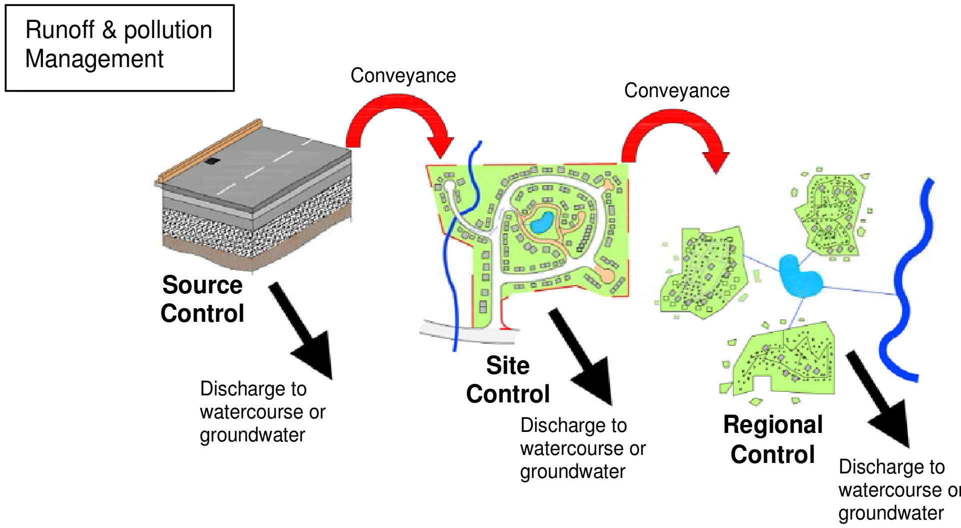

Figure 1.3 Surface Water Management Train

1.2.22 The challenges now being faced in positive road drainage and SUDS design are not only restricted to the 1 in 1 year return period storm, having an annual probability of exceedance of 100%, but are extended to ensure that a minimum 1 in 30 year 3.3% annual probability of exceedance level of service against flooding is provided for surface water sewers adopted by Scottish Water, as stated in Sewers for Scotland 2nd Edition[9].

1.2.23 When considering the management of surface water runoff through attenuation storage and controlled conveyance, recognition of design for exceedance for various return period storms up to the 200 year event and various storm durations up to 24 hour, including an allowance for climate change, is required to ensure there are no detrimental effects to people or property. The parameters for this analysis are provided by the local authority and are often linked to the vulnerability of the receiving watercourse in terms of flood risk and water quality.

> The road surface may provide an important contribution in providing a drainage path for flood risk management by overland flood flow where the return period of the storm exceeds 30 years.

1.2.24 Detailed guidance on overland flood flow analysis is provided in CIRIA C635 – ‘Designing for Exceedance in Urban Drainage – Good Practice’[10]. This document sets out good practice for the design and management of urban sewerage and drainage systems to reduce the impacts from drainage exceedance. Information on effective design of both underground and overland flood conveyance is included, and advice on risk management to reduce the impacts that extreme events may have on people and property. A schematic illustrating the potential water level for 30 year and 200 year return period storms is shown in Figure 1.4.

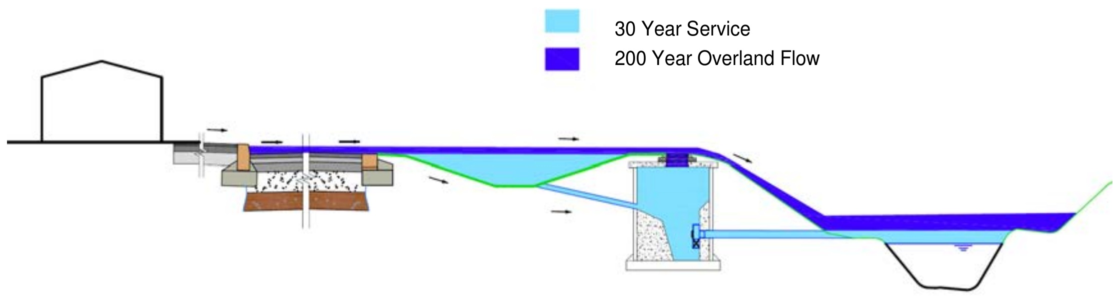

Figure 1.4 Levels of Service

ROAD RUNOFF POLLUTANTS

1.2.25 Road pavements and other impervious surfaces associated with vehicular movements including driveways and car parks can contribute as much as 70% of the total impervious areas in an urban catchment[11], and are all recognised as sources of various pollutants to the water environment.

> Runoff from roads is a major contributor to 'urban diffuse pollution', a term used to describe pollution that does not arise from a single source or activity, and the source of many pollutants which can have a serious adverse effect on water quality in receiving waters.

1.2.26 The pollutants that occur in road runoff originate from a wide variety of sources. Their concentration in road runoff can be highly variable and dependant on a wide variety of factors including location, traffic volumes, extent of dry period before a rainfall event, frequency of sweeping and nature of the road surface. Further details relating to pollution and the concept of first flush are discussed in Chapter 2.

1.3 SURFACE WATER MANAGEMENT PLANS

IMPORTANCE OF AN INTEGRATED REGIONAL DRAINAGE STRATEGY

1.3.1 Surface water flooding frequently develops quickly and can be difficult to predict. Flooding occurs when man-made and natural drainage systems have insufficient capacity to cope with the amount of rainfall. The critical factors for surface water flooding are the volume of rainfall, the rainfall intensity and the permeability of the surface onto which the rainfall falls. In urban areas where the ratio of impermeable surfaces to vegetated areas is high, sudden and intense rainfall drained through conventional drainage piped systems designed to remove surface water from a site as quickly as possible, can lead to downstream flooding problems.

1.3.2 The urban drainage system is a complex interaction of the urban landscape including buildings, roads, public sewers, private sewers and watercourses. The integrated approach by partners and stakeholders in the preparation of Surface Water Management Plans (SWMPs) gives the roads authorities clear roles where the roads form a key part of the drainage or alleviation of flood risk, namely:

- Retain data relating to location and serviceability of existing road drainage
- Design road drainage to minimise surface water runoff
- Plan exceedance routes using roads surfaces for overland flow

SUDS offer a sequence of surface water management features and control structures designed to drain surface water in a sustainable fashion, and serve to mitigate the extent of potential surface water flooding through the control of surface water runoff at source.

1.3.3 SWMPs are referred to in planning policy as a tool to manage surface water flood risk on a local basis by improving and optimising coordination between relevant stakeholders. SWMPs build on Strategic Flood Risk Assessments (SFRAs) and provide the vehicle for local organisations to develop a shared understanding of local flood risk, including setting out priorities for action, maintenance needs and links into local development frameworks and emergency plans[11].

1.3.4 The purpose of the SWMP is to make sustainable urban surface water management decisions that are evidence based, risk based, future proofed and inclusive of stakeholder views and preferences[12].

1.3.5 The key aims of the SWMP are:

- Ensuring that development allocations within an area are properly supported by adequate surface water management
- Providing a common framework for stakeholders to agree responsibilities for tackling existing drainage problems and preventing future problems
- Where development pressures are high it can be part of a Water Cycle Strategy
- Demonstrating how capital investment, infrastructure and maintenance can deliver the required surface water management

1.3.6 The SWMP considers the regional management of surface water under a full range of rainfall events, from short, high intensity rainfall events that impact on water quality to the longer duration infrequent events that may generate overland flood flows.

1.3.7 Central to a risk based surface water management approach is the prediction of the occurrence and frequency of flooding events. The Flood Risk Management (Scotland) Bill 2009[13] as passed by the Scottish Parliament makes provision in relation to the following areas:

- Coordination and cooperation within the domain of flood risk management
- Assessment of flood risk and preparation of flood risk maps and flood risk management plans
- Amendments to local authority and SEPA functions for flood risk management
- A revised statutory process for flood protection schemes
- Amendments to the enforcement regime for the safe operation of reservoirs

1.3.8 Local flood risk management plans will be prepared by local authorities as the lead authority and they may require the roads authority to participate under the terms of the Bill as ‘a responsible authority which has flood related functions exercisable in or in relation to the local plan district to which the plan relates’.

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2 SUDS Applications for Roads

CHAPTER AIMS

- Describe the current and emerging guidance on road hierarchy and site classification
- Set out the design principles requiring consideration, starting with key road design parameters including California Bearing Ration (CBR), subgrade strength and porosity of road pavement materials
- Recognise the difference between pervious and impervious pavements in terms of structural design and performance
- Introduce the guiding criteria for the design of road Sustainable Urban Drainage Systems (SUDS) including hydrology and water quality
- Introduce the principles associated with providing levels of treatment and how these are linked to pre-treatment, source control and site control SUDS features
- Provide detailed methodology on road SUDS selection utilising flow chart and SUDS matrix tools
- Provide examples of proprietary systems

2.1 ROAD HIERARCHY

CURRENT GUIDANCE

2.1.1 Local standards determined by local authorities have often referred to Design Bulletin 32 ‘Residential Roads and Footpaths – Layout considerations. 1977. 2nd Edition 1992, (DB32) [1], and its companion document ‘Places, Streets and Movement – A companion guide to Design Bulletin 32 Residential roads and footpaths’. DB32 has been widely used as a reference on the layout of roads and footpaths in new residential developments to provide advice which allows a sensible balance to be struck between planning, housing and road considerations in the design of new residential schemes and improvement of existing developments.

2.1.2 Currently, across the 32 road authorities in Scotland there are no standardised development guidelines. Some of the road authorities may have their own road development guidelines, whilst others use the former Strathclyde Regional Council guidelines last published in 1996[2].

2.1.3 Current standards for road design provide a hierarchy for the road network which both facilitate the movement of traffic from one location to another and provide access to individual premises.[2].

2.1.4 Five types of road have traditionally been identified when considering road infrastructure, although the terminology used can vary within different local authorities:

- **Trunk roads** – provide a system of strategic routes of national importance that caters for the through movement of long distance traffic, and includes motorways and all-purpose 'A' roads
- **Main distributor roads** – provide links between major residential and commercial districts and provide traffic movements into and out of a town
- **District distributor roads** – provide for major traffic movements within a town or district
- **Local distributor roads** – link district distributor roads to access roads and distribute traffic within a district
- **Access roads** – provide a link from premises and their associated parking areas to local distributor roads

2.1.5 For development purposes the category of access roads is split further into the following categories:

- **General Access roads** – provide the link between dwellings and their associated parking to local distributor roads
- **Industrial Access roads** – provides the link from industrial/ commercial premises and associated parking to local distributor roads
- **Minor access links** – interconnect short Culs-de-sacs and general access roads
- **Short Culs-de-sacs / shared surfaces and Homezones** – link dwellings and their associated parking to minor access links or general access roads

2.1.6 A typical hierarchy of roads is outlined in Figure 2.1, and illustrated in plan layout form in Figures 2.2 and 2.3.

2.1.7 The above hierarchy includes both urban and rural roads as described below:

- Urban – Non-trunk road, generally low speed
- Rural – Non-trunk road, generally lower speed

2.1.8 When considering the context of SUDS associated with roads, the road geometry, layout and vehicle speed associated with the category of the road requires to be taken into consideration when selecting the SUDS feature. This is discussed in more detail in §2.6.

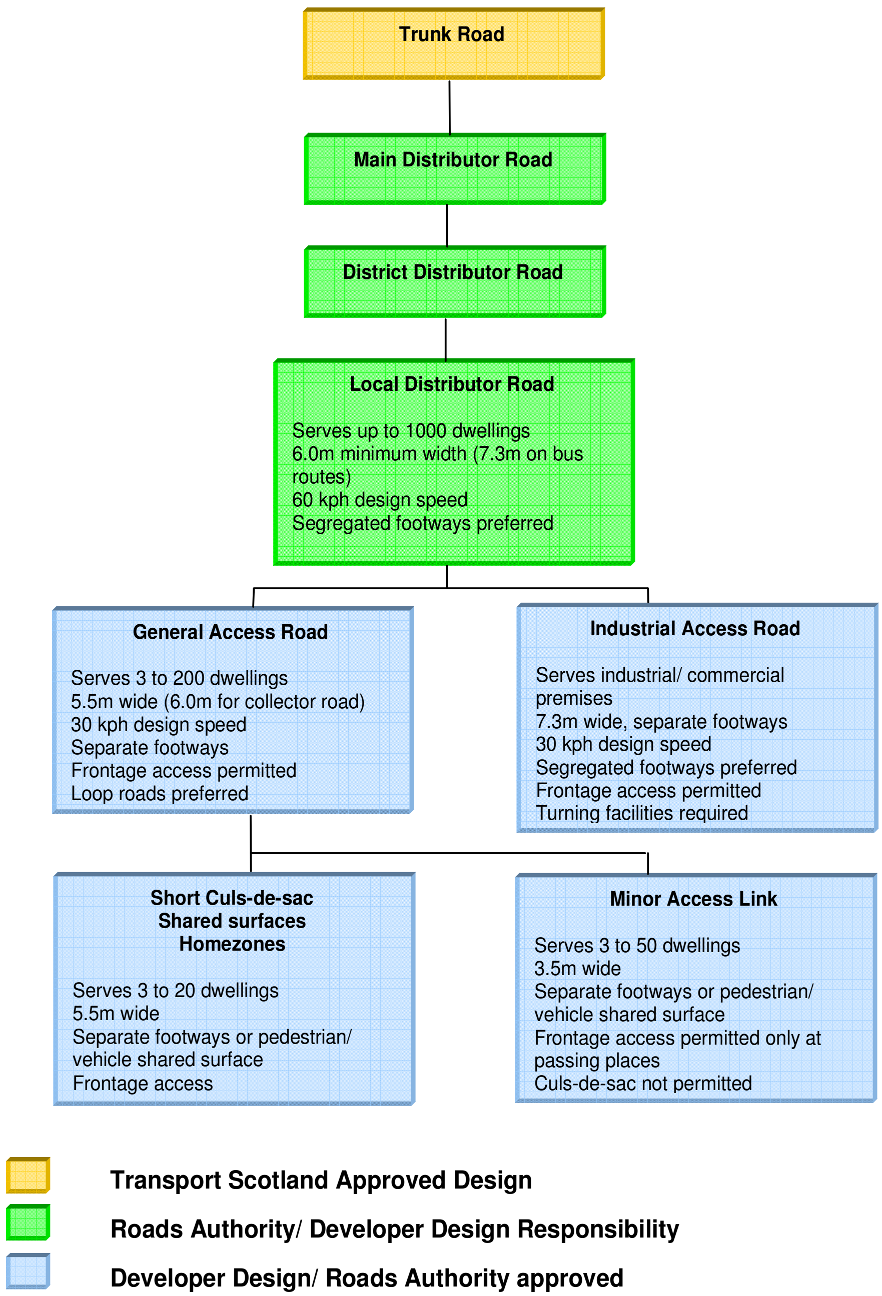


Figure 2.1 Current Example of Typical Road Hierarchy[2]

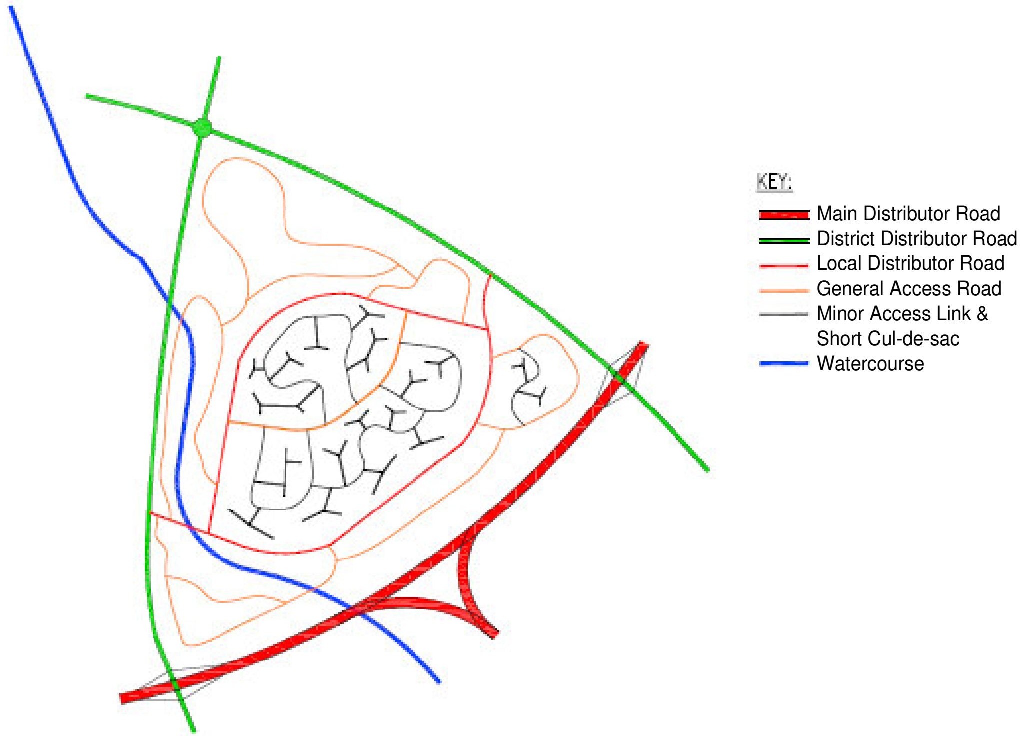


Figure 2.2 Residential Layout Showing Current Prescribed Road Hierarchy

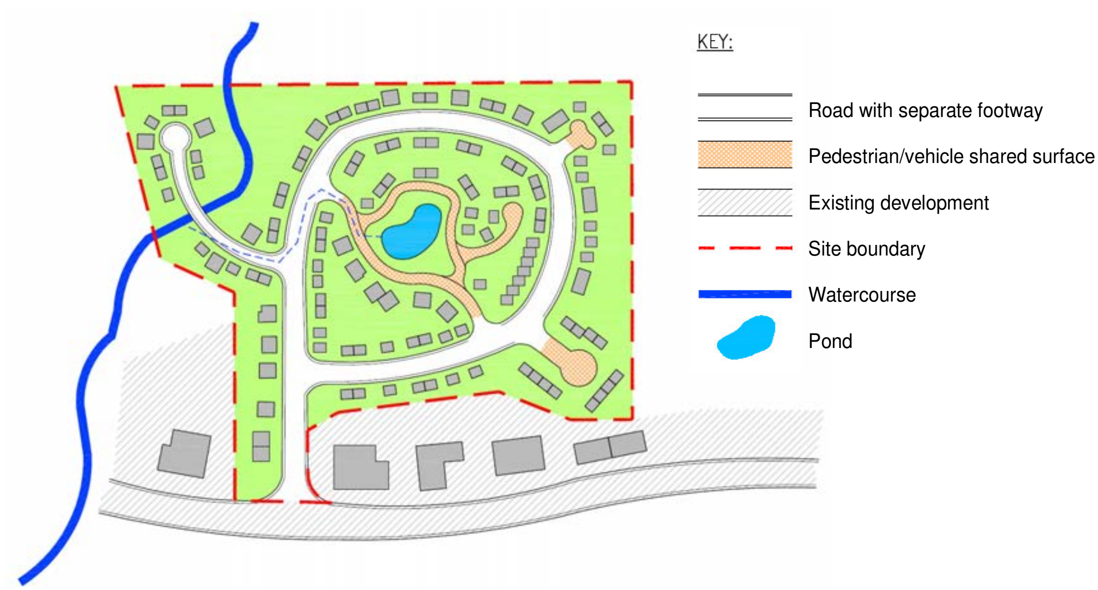


Figure 2.3 Conventional and Shared Surface Access Roads in Residential Development.

EMERGING POLICY

2.1.9 The Scottish Government has commissioned the preparation of 'Designing Streets' a new policy document which embraces the principles of Manual for Streets[3], and previous guidance contained within PAN76 New Residential Streets[4].

2.1.10 Designing Streets is expected to be used predominantly for the design, construction, adoption and maintenance of new streets, but is also applicable to re-design of existing streets.

2.1.11 The future design challenges to be faced by road engineers will vary greatly from the traditional categories of road they are familiar with. Future street design may be very much focussed on character influenced by layout and geometry.

2.1.12 The change in approach to layout and geometry will promote lower vehicle speeds, and may also restrict the space made available for the provision of utilities and drainage by increasing the density of development. These factors will require due consideration by the roads engineer in the SUDS selection process.

2.2 ROAD CONSTRUCTION CONSENT

2.2.1 Where development requires the provision of a new road, with the intention to have it adopted by the roads authority and added to the register of public roads, an application for Road Construction Consent (RCC) will be required in accordance with The Roads (Scotland) Act 1984. The key stages associated with the RCC process are outlined in Figure 2.4:

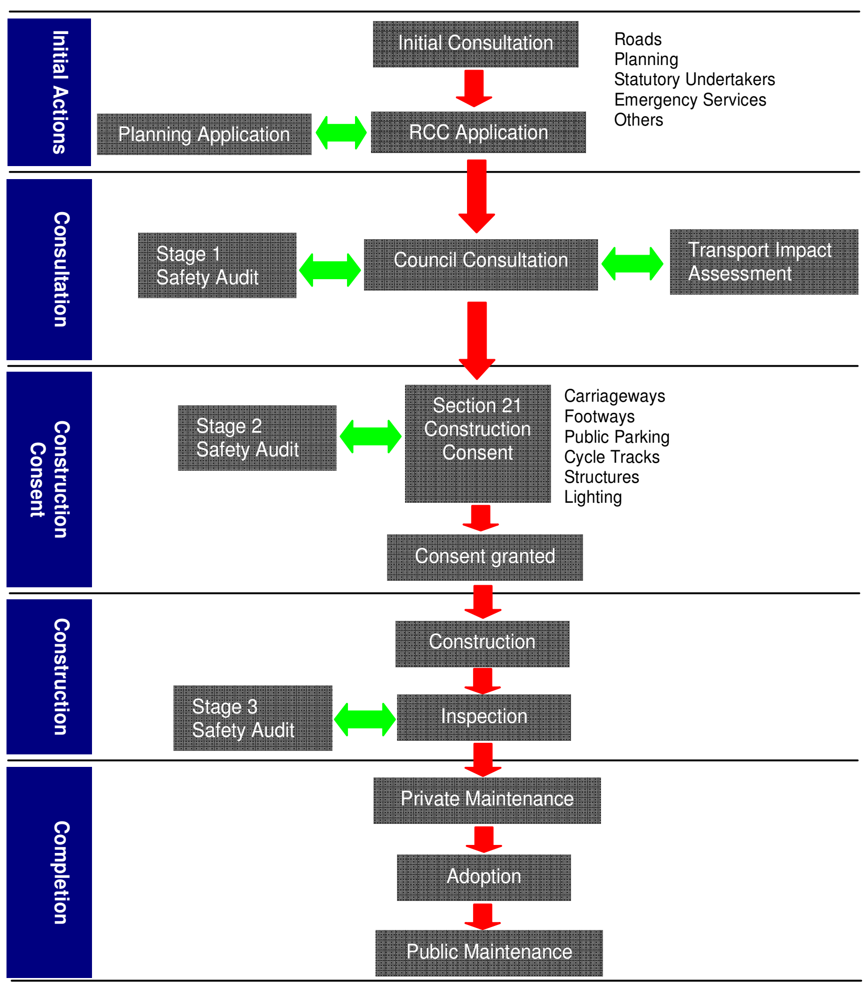


Figure 2.4 Road Construction Consent Process

2.2.2 Each of the key stages of the construction consent process are described in detail in §4.2.

2.3 DESIGN CRITERIA

ROAD PAVEMENT - IMPERVIOUS

2.3.1 The design of road pavements requires consideration of the following elements, detailed in Figure 2.5:

- Foundation soils including the subgrade and any capping layers upon which the structural layers are placed
- Structural layers, for example base, binder, concrete slab and sub-base
- Surface course which may include asphalt, porous asphalt, concrete slab, concrete block paving and permeable concrete block paving

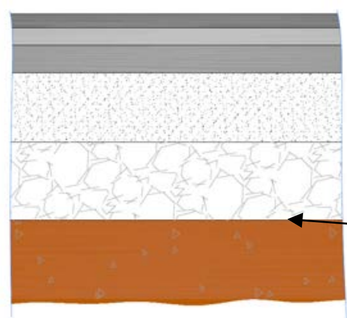


Figure 2.5 Impervious Road Pavement Construction

2.3.2 The design of each element of the road pavement above will depend on the required operational life of the road and traffic loadings. Structural design for trunk roads and motorways is undertaken using the guidance provided in the Design Manual for Roads and Bridges [5] (DMRB). Pavement designs for estate roads, distributor roads and roads in residential areas and industrial estates are usually based on prescriptive guidance provided by the roads authority.

2.3.3 The basic method of pavement design as outlined in Transport and Road Research Laboratory (TRRL) Report 1132 [6] is related to the traffic loading and subgrade strength expressed in terms of California Bearing Ratio (CBR). Using this method, the thicknesses of bituminous materials, sub-base and capping layers, on weaker subgrades, can be determined using a series of graphs.

ROAD PAVEMENT – PERVIOUS

2.3.4 Roads authority development guidelines, at the time of writing, do not include guidance on the selection or use of pervious pavement materials for use on roads within the hierarchy. There is however valuable guidance within CIRIA C582 – Source Control using Constructed Pervious Surfaces [7], BS 7533-13: 2009 Pavements constructed with clay, natural stone or concrete paviours – Part 13: guide for the design of permeable pavements constructed with concrete paving blocks and flags, natural stone slabs and setts and clay pavers[8], and the DMRB Volume 7 Pavement Design and Maintenance

Section 2 Pavement Design and Construction Part 3 HD26/06 – Pavement Design and Section 5 Pavement Materials Part 1 HD36/06 Surfacing Materials for New and Maintenance Construction.

Where pervious pavements or SUDS features adjacent to the road formation are being considered, it is essential that accurate measurements of CBR values are obtained for the saturated foundation soils unless an impermeable membrane preventing infiltration is provided.

2.3.5 Where infiltration pervious pavements are being employed or where infiltration SUDS are located adjacent to the road foundation, the presence of water in the pavement structure may lead to saturation of the subgrade, which may lead to loss of strength and stiffness. The severity of these effects depends on the sensitivity of the soil types to increased moisture content. Typical sensitivity details and CBR values for various soil types are outlined in Table 2.1[7]:

Soil Type	Sensitivity	Typical range of CBR values
Clay	Very sensitive, rapid loss of strength an stiffness through small increases in moisture content	2 – 5
Silt	Very sensitive, rapid loss of strength an stiffness through small increases in moisture content	1
Fill materials	Moderate to very sensitive, depending on soil type	variable
Well graded sands and gravels	Low to moderate, depending on proportion of cohesive materials present	10 – 40
Rock	Very low to moderate sensitivity. Weak or highly weathered material will be most susceptible to changes in moisture content	> 20
Made ground	Variable sensitivity dependant on constituent materials.	Not considered

Table 2.1 Typical Sensitivity and Soil CBR Values

2.3.6 When considering pervious pavement design or SUDS features adjacent to roads, the CBR value should be measured for the saturated subgrade condition, unless an impermeable geomembrane is proposed to prevent infiltration, allowing the designer to protect weak subgrades with either a capping layer and/ or geogrid. Equally, maintaining the depth to subgrade at a minimum of 450mm mitigates against frost action during winter conditions.

2.3.7 The choice of gravel media materials for use in capping and sub-base layers, within pervious pavements, providing the necessary strength, treatment and storage, will require the following criteria to be determined:

- Permeability
- Void space
- Stiffness

2.3.8 Although the presence of water within a Type 1 sub-base may affect the strength and stiffness due to the relatively high fines content and sensitivity to change in moisture content, it is a common misconception that the same principle applies to the presence of water in all types of unbound layers. The stiffness of a single size granular media used in pervious pavements, with a low fines content, will not be significantly reduced further by the introduction of water, providing sufficient friction between the particles is maintained when the material becomes saturated[9].

2.3.9 The design should ensure that pavement materials do not suffer excessive rutting from the influence of traffic. This can be controlled in practice by limiting the applied stress imparted on the subgrade by providing a capping layer and/ or geomembrane to ensure adequate stiffness and internal shear strength can be achieved. This should be evaluated for the saturated foundation soils.

IMPORTANCE OF INFILTRATION

> Infiltration SUDS features provide an opportunity to discharge surface water runoff from the road directly into the underlying superficial soil deposits, promoting groundwater recharge, and reducing or eliminating peak flow discharge to the receiving watercourse or waste water treatment works. Infiltration should normally be encouraged below roads.

2.3.10 Infiltration SUDS provide treatment of runoff at source, and are most suited to be preceded by a form of pre-treatment such as a silt trap to remove sediments and pollutants before entering the infiltration device. Where pervious pavements are used, the SUDS feature itself provides the treatment prior to infiltration. Infiltration systems will also remove pollutants from runoff if a geotextile and/ or other filter media is provided to trap sediments and hydrocarbons before they enter the ground.

2.3.11 Typical examples of SUDS infiltration features include:

- Infiltration trenches
- Dry swales
- Infiltration pervious pavements
- Infiltration basins

2.3.12 The performance of infiltration SUDS is dependent on the capacity of the underlying soils, in which they are constructed, to infiltrate water. The rate at which infiltration occurs is determined by the infiltration coefficient, which is evaluated by infiltration testing during site investigation works, and is related to the soil's permeability. Guidance on the completion of infiltration testing is provided in CIRIA Report 156[10] and BRE Digest 365[11]. Typical values of infiltration coefficients are detailed in Table 2.2:

Soil type	Typical infiltration coefficient (m/h)
Good infiltration media	
Gravel	10 – 1000
Sand	0.1 – 100
Loamy sand	0.01 – 1
Sandy Loam	0.05 – 0.5
Loam	0.001 – 0.1
Chalk	0.001 – 100
Sandy clay loam	0.001 – 0.1
Silt loam	0.0005 – 0.05
Poor infiltration media	
Silty clay loam	0.00005 – 0.005
Till	0.00001 – 0.01
Rock	0.00001 – 0.1
Clay	<0.0001

(green) An infiltration coefficient of 0.001 is generally considered the lowest value which should be used for infiltration systems[10].

(orange) Potential range of infiltration coefficient requires site specific data required to assess suitability

(red) Considered unsuitable for infiltration

Table 2.2 Typical Infiltration Coefficients

2.3.13 Where infiltration is being considered, infiltration testing at the time of a detailed site investigation should be undertaken, not only in dry conditions where artificial results may lead to poor design, but the effects of antecedent rainfall should also be taken into account with appropriate factors of safety being applied to the resultant infiltration coefficients used in the design of infiltration SUDS components[12]

2.3.14 Research has shown that the antecedent water table level can exert significant control on the infiltration coefficient. If the antecedent conditions are not considered, then this may lead to an overestimation of the infiltration coefficient. As a result of uncertainty of the water table height in estimating the infiltration coefficient it is suggested that factors of safety are introduced to reduce the design infiltration coefficient, as summarised in Table 2.3[12]:

Factor of safety	Consequence of failure
3	None
5	Minor
15	Major

Table 2.3 Factors of Safety

2.3.15 The design of infiltration systems is primarily based on accurate determination of the infiltration coefficient, by either method referred to in 2.3.12. This will allow the capacity of the infiltration system to be determined ensuring that infiltration allows the system to be half empty within 24 hours, to provide capacity for subsequent storms.

2.3.16 Where consideration is being given to using infiltration techniques, the risk associated with pollution of groundwater requires to be taken into account based on the pollutant load within the surface water runoff. Where groundwater vulnerability is considered greatest, for example if the groundwater is being used as a resource, then infiltration should not be used. Elsewhere, it is advised that there is at least 1m of unsaturated soil beneath an infiltration system[10].

2.3.17 The advantages and factors requiring consideration for using of infiltration SUDS is summarised in Table 2.4 [10]:

Advantages	Factors Requiring Consideration
Reduction in volume of runoff to watercourse or Waste Water Treatment Works (WWTW)	Soil and groundwater conditions should be shown to be suitable
Groundwater recharge	Prior treatment of runoff is required at groundwater recharge zones. (2.3.18)
Can be used where there is no outfall to sewer or watercourse	Do not provide any amenity benefits
Construction is simple, understood and rapid	May be legal liabilities if pollution of groundwater occurs
Provides treatment and attenuation at source	

Table 2.4 Advantages and Disadvantages of Infiltration

2.3.18 Where there is a risk of plausible pollutant linkages with respect to pollution of the water environment, an assessment consistent with the guidance and methods specified in Technical Advice to Third Parties on the Pollution of the Water Environment of Part IIA of the Environmental Protection Act 1990[13] requires to be undertaken.

2.3.19 The European Community Directive on Groundwater (80/68/EEC)[14] requires that measures are to be taken to prevent pollution by chemicals in two categories:

- List 1 substances should be prevented from entering groundwaters, directly or indirectly
- List 2 substances should be prevented from causing pollution in groundwaters or deterioration in the quality of groundwater

2.3.20 Details of List 1 and 2 groups are presented in Appendix A.

HYDROLOGY

2.3.21 The SUDS hydrology principles are based on the rate of rainfall, and the ability to mimic pre-development greenfield runoff conditions, designed to agreed standards recognising hydraulic, water quality, amenity and ecological objectives that require to be met.

2.3.22 When rainfall falls on greenfield sites some 80 to 100 per cent can be lost to infiltration, depending on the permeability of the underlying soils and soil slope, and evapotranspiration, a combination of evaporation and vegetative absorption[15]. The remainder is classed as surface water runoff. In contrast, when rainfall falls on impervious surfaces such as roads and their associated features the capacity for infiltration and evapotranspiration are reduced significantly as the contributing surface area is predominantly impervious, giving rise to an increase in peak flows to the receiving watercourse. This effect is made worse as the proportion of impervious area increases.

2.3.23 The pre-development greenfield runoff rates require to be calculated to assess the acceptable rate of discharge from a development site to the receiving watercourse and will guide the designer in determining the control and storage requirements. In certain circumstances where discharge to a watercourse is not practicable, for example, in a dense urban environment distant from a watercourse, then connection to a Scottish Water surface water or combined sewer may provide a solution. The agreement of the discharge rate to that sewer must be agreed with Scottish Water.

2.3.24 The methods by which greenfield runoff rates are estimated for developments are outlined in Table 2.5.

Development Area	Method of Estimation
0 – 50 ha	Institute of Hydrology Report 124 (IoH 124). Flood Estimation for Small Catchments. 1994. [16] to determine mean annual peak greenfield runoff rates for QBAR. For smaller catchments the flow rate should be linearly interpolated based on the ratio of the size of the site to 50 ha.
50 – 200 ha	Institute of Hydrology Report 124 (IoH 124). Flood Estimation for Small Catchments. 1994, to determine mean annual peak greenfield runoff rates for QBAR, with application of regional growth factors
Greater than 200 ha	Institute of Hydrology Report 124 (IoH 124). Flood Estimation for Small Catchments. 1994 may be used for developments with catchments greater than 200 ha but the use of the Flood Estimation Handbook [17] is recommended.

Table 2.5 Greenfield Runoff Methods of Estimation

2.3.25 For development sites up to 200 ha in size the following IoH 124 equation is used to determine the mean annual peak flow rate:

$$QBAR_{rural} = 0.00108AREA^{0.89}SAAR^{1.17}\ SOIL^{2.17}$$

Where:

$QBAR_{rural}$ = Mean annual flood flow for the development catchment area. (m^3/s)

AREA = Development catchment area. (km^2)

SAAR = Standard average annual rainfall. (mm) *

SOIL = Soil index from the WRAP maps *

* Values for SAAR and SOIL can be obtained from The Wallingford Procedure[18]

DESIGN RAINFALL

2.3.26 The design rainfall return periods and climate change allowances used for the design of road drainage for local roads, trunk roads and Scottish Water assets are outlined below in Table 2.6 for each of the adopting authorities:

Adopting Authority	Design Rainfall Return Period	Allowance for Climate Change
Local authority – Local roads	1 in 1 year, or as agreed with the roads authority.	10 – 20%
Transport Scotland – Trunk roads	1 in 1 year with design check to ensure the 5 year surcharge levels do not exceed chamber cover levels.	20 % increase in the rainfall intensity.
Scottish Water	1 in 1 year event demonstrating that no flooding occurs to a minimum of a 1 in 30 year event.	10 % increase in the rainfall intensity.

Table 2.6 Design Rainfall Return Periods and Climate Change Allowance

2.3.27 The design rainfall return period is linked to the annual probability of exceedance of that particular storm. For example, a storm with a probability of exceedance of 50% can be expected to be equalled or exceeded every two years, whilst a 1 in 30 year storm will have a 3.3% probability of being equalled or exceeded.

2.3.28 The selection of the design rainfall return period is an economic decision rather than meteorological[18]. The choice of longer return periods will lead to drainage systems with greater capacities, providing a greater level of service and protection, which may be at a higher cost.

2.3.29 The adopting authority prescribes the levels of service required, which influences the design of drainage systems to ensure no flooding occurs. For example, Sewers for Scotland 2nd Edition[19] states that the design of all storm water drainage should ensure that a minimum 1 in 30 year level of service is provided.

2.3.30 BS EN 752:2008 – Drain and Sewer Systems Outside Buildings[20], offers specific conveyance criteria for simple design methods where the pipes are usually designed to run full bore, without surcharge, for relatively frequent storms. Specific criteria are also offered for complex methods where the developments are larger and the risks to public health and/ or the environment are significant. The figures outlined in Table 2.7 may be considered for use for both simple and complex design methods in the absence of specific design criteria specified by the relevant authority:

Location	Return Period (Years)
Simple Design Method	
Rural	1 in 1
Residential	1 in 2
City centre	1 in 5
Complex Design Method	
Rural	1 in 10
Residential	1 in 20
City centre	1 in 30

Table 2.7 Drainage Design Return Periods

STORAGE AND OVERLAND FLOW

2.3.31 Storage within the SUDS components fulfils two essential functions. Firstly, to provide extended detention of flows to provide the necessary treatment and secondly to attenuate the peak flows to agreed greenfield runoff rates for flood protection downstream of the development area.

2.3.32 Attenuation storage requires some form of hydraulic control structure which limits the outflow prior to discharge to the receiving watercourse or sewer. Figure 2.6 illustrates the extended detention and attenuation storage in ponds, basins and pervious pavements.

2.3.33 When assessing the attenuation storage requirements, an assessment is usually made on storms up to the 30 year return period, although some roads authorities may impose less stringent criteria.

2.3.34 As a result of extreme rainfall events, it is inevitable that the capacities of drainage systems, watercourses and other drainage features will become exceeded on occasion. Periods of exceedance occur when the rate of surface water runoff exceeds the drainage system capacity.

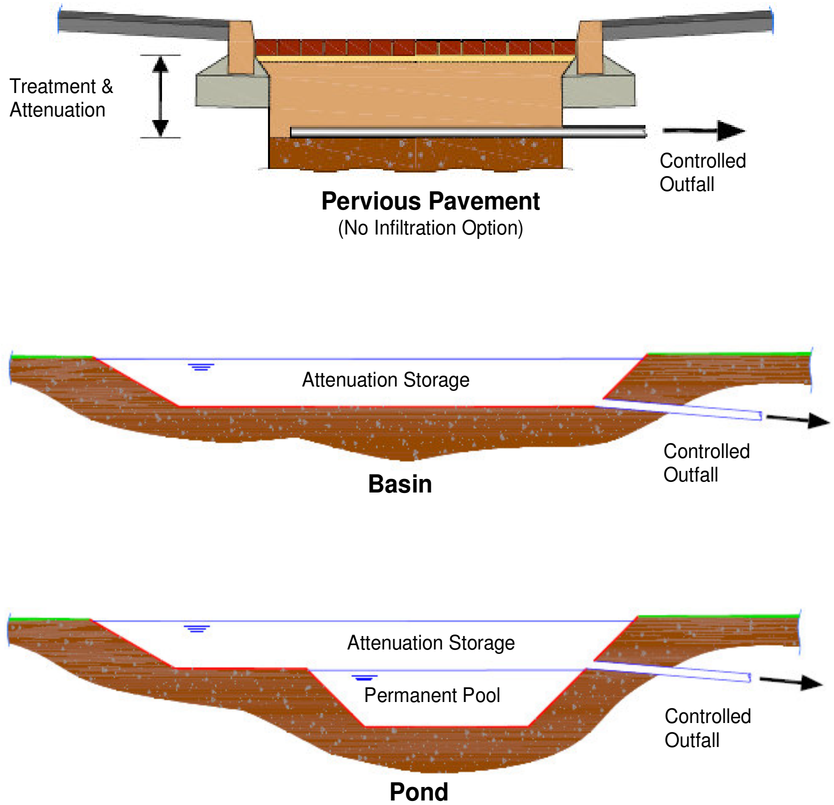


Figure 2.6 Attenuation and Treatment

Note – Overland flow upon pervious pavements is not recommended as it may reduce performance through excessive clogging.

2.3.35 Generally conveyance beneath ground cannot be economically or sustainably constructed to the scale required for the most extreme rainfall events. This will result, on occasion, to the surface water runoff exceeding the capacity of the drainage network, resulting in the excess water (exceedance flow) being conveyed above ground. Overland flow should be routed along roadways, footways and open spaces to avoid flooding of property.

2.3.36 During the detailed design a review of overland flood conveyance should be undertaken, based on the proposed surface water drainage and SUDS system, ensuring that flood flows are directed along routes where the risk of property flooding and the risk to health and safety is minimal. The sensitivity analysis undertaken for overland flow is typically up to and including the 200 year return period storm, but may require to be increased to 1000 year return period storms in areas of high risk, as defined in Scottish Planning Policy 7 (SPP7)[21], currently under review. Further detailed guidance on designing for exceedance may be found in CIRIA C635[22].

WATER QUALITY

2.3.37 Road surfaces collect a wide range of pollutants from a variety of sources, which individually fall under six general categories, as listed below[9]:

- Sediments
- Hydrocarbons
- Metals
- Salts and nutrients
- Microbial
- Others

2.3.38 The sources of pollutants contained within road runoff are categorised in Table 2.8.

Source	Pollutant type
Vehicle Exhausts	Include Poly Aromatic Hydrocarbons (PAH's), unburnt fuel and particles from catalytic convertors [hydrocarbons, cadmium, platinum, palladium, rhodium]
Vehicle wear and corrosion	Tyre wear, sediments and deposits of heavy metals. [lead, chromium, copper, nickel , zinc]
Roadside vehicle washing	Deposition of sediments. [phosphorous, nitrogen, detergents]
Vehicle leaks and spillages	Engine oil leaks. Accidental spillages of oil, fuel, hydraulic fluids, and de-icing fluids can occur at the roadside. [hydrocarbons, phosphates, heavy metals, glycols, alcohols]
Road Traffic Collisions	Fire suppressants, oil / fuel dispersants, fuel.
Landscape maintenance	Fallen leaves and grass cuttings. Application of herbicides and pesticides for weed and pest control. [phosphorous, nitrogen, herbicides, insecticides, fungicides, organic matter]
Litter, animal faeces	Deposits can contain tin cans, paper, plastics, glass, food, animal excreta, and dead animals. [bacteria, viruses, phosphorous, nitrogen]
Soil Erosion	Sediment deposits from poorly designed landscaped areas. [sediment, phosphorous, nitrogen, herbicides, insecticides, fungicides]
De-icing activities	De-icing salt used on road pavements and footways. [sediment, chloride, sulphate, iron nickel, lead, zinc, cyanide, phosphate]
Atmospheric deposition	Industrial activities, traffic air pollution and agricultural activities can contribute to atmospheric pollution which can be deposited on road pavements when rain absorbs pollutants.

Table 2.8 Sources of Pollution

Studies have shown that high intensity storms produce the majority of surface runoff and consequently generate most of the pollution[23].

2.3.39 For less frequent events on small catchments the rainfall that runs off the road surface in the early stages of a storm is more polluted than later runoff because of the cleaning effect of the runoff. This phenomenon is termed the first flush.

2.3.40 Studies have suggested that the first 10% of the total runoff for a particular storm will be much more polluted than the remaining 90% of the runoff [24]. In Britain it is generally accepted that the most detrimental type of storm in pollution terms is the frequent summer short duration high intensity storm, which has high abrasive quality to mobilise a higher percentage of pollutants and limited volume of water to create a concentrated effluent.

2.3.41 Where SUDS features discharge to sensitive water resources, or in close proximity to points of extraction, additional treatment measures may be required to ensure that discharging waters are of the highest quality and free from contamination. Guidance in Technical Advice to Third Parties on the Pollution of the Water Environment of Part IIA of the Environmental Protection Act 1990[13] requires to be followed.

2.3.42 To quantify the treatment volume required for the road catchment, an empirical formula has been developed linked to the M5-60 rainfall depth for the area, equivalent to approximately 10-15mm rainfall depths, based on the following parameters:-

- D = rainfall depths of five year return period storm of 60 minutes duration *
- SOIL = soil index broadly describes the infiltration potential *
- i = impervious fraction

$$Vt = 9D[SOIL/2 + (1-SOIL/2)i] \quad m^3/hectare$$

* Values for D (M5-60) and SOIL can be obtained from The Wallingford Procedure[18].

CONTAMINATED LAND

2.3.43 Where roads are to be constructed through brownfield sites an intrusive geochemical and geotechnical site investigation will be required, as well as a hydrogeological assessment prior to the final design of the SUDS system.

2.3.44 The interpretative report of the findings of the site investigation will indicate whether the introduction of SUDS will result in an increased risk to the wider environment. It will:

- Quantify the risk of mobilising existing contaminants and define their leachability
- Describe the probable effects of increased water volumes on underlying water sources
- Confirm whether the use of liners is appropriate, and whether liners resistant to chemical attack are necessary
- Advise on suitable disposal or remediation of material arising from SUDS and road excavations

2.3.45 Where SUDS features discharge to sensitive water resources, or are in close proximity to points of water extraction, additional treatment measures may be required to ensure that water discharged is of the highest quality and free from contamination.

TREATMENT PROCESSES IN SUDS

2.3.46 The design of SUDS can incorporate various mechanisms that retain pollutants or prevent the pollution of controlled waters through one or more of the following techniques:

- Sedimentation – whereby suspended solids are settled out of solution by reducing the velocity of flow through the SUDS component. The design should take into account the risk of re-suspension of solids during extreme rainfall events
- Filtration – where pollutants conveyed with sediment are trapped either within the soil or gravel media matrix, or on geotextile layers that form part of the SUDS construction
- Biodegradation – provides a biological process that allows the creation of microbial communities to be established within the soil or gravel media to degrade organic pollutants including hydrocarbons
- Adsorption – occurs when pollutants attach themselves or bind to soil, gravel media particles or to other media
- Uptake by vegetation – provides a mechanism for removal of nutrients such as phosphorous and nitrogen

2.4 LEVELS OF TREATMENT

2.4.1 It is generally accepted that roads typically require two levels of treatment, although for smaller developments residential roads may require only one level. The philosophy of the surface water management train, introduced in Chapter 1, provides a technique whereby one or more SUDS techniques are linked together to give a number of forms of treatment thus assuring that a higher level of overall treatment is provided.

PRE-TREATMENT

2.4.2 Pre-treatment can provide an opportunity, at or close to source, for silt and debris removal prior to road runoff entering the downstream SUDS component. Pre-treatment can prevent clogging and reduce maintenance requirements of the downstream SUDS.

2.4.3 The pre-treatment features described within this section provide effective management, if well maintained, of silt, sediment and debris by settlement, of road runoff and include:

- Road gullies
- Silt traps

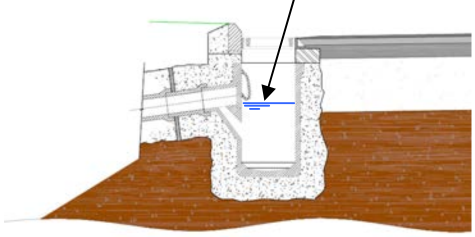
2.4.4 These pre-treatment features are familiar to roads engineers and are specified within roads authority development guidelines and project specifications.

> It is important to recognise that pre-treatment features do not generally have the capability to provide any treatment of dissolved pollutants and must not be confused with a source control SUDS feature, providing treatment.

2.4.5 Where there is difficulty incorporating SUDS at source the use of a sub-surface piped system may be considered the only method for conveyance of runoff to a SUDS feature. Using pre-treatment methods in this situation provides an effective method for sediment removal, minimising sediment deposition within the piped system, when the required frequency of maintenance is applied.

2.4.6 Pre-treatment features should be located where straightforward access by maintenance plant can be achieved. Where possible, pre-treatment features should incorporate easily removable grated covers reducing the risk of unseen blockages and allowing for a simple approach to monitoring of performance and determination of maintenance requirements.

PRE-TREATMENT



Typical Section

Description

Road gullies usually comprise a small sump which is permanently full of water, intended to trap silt and sediments

Road Applications

- Trunk roads
- All distributor roads
- General access roads
- Industrial access roads
- Short Culs-de-sac
- Minor access link

Design Criteria

- The type of road gulley is specified within the traditional local authority development guidelines. Equally the spacing of road gullies indicated within these guidelines is generally dictated by the longitudinal road gradient, cross sectional profile and road width
- Detailed design of road gullies is outlined within DMRB Volume 4 Geotechnics and Drainage Section 2 Drainage Part 3 HA 102/00 Spacing of Road Gullies[5]

Pollutant Removal

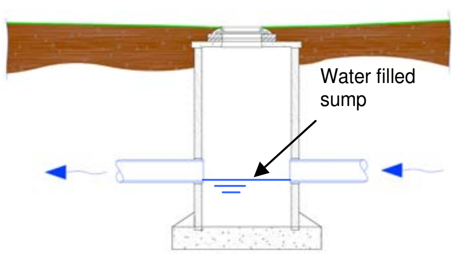
- Low. Dissolved pollutant concentrations within the sump wet well may increase during periods of dry warm weather
- Settled sediment and pollutants may be washed out of the sump during periods of turbulent high runoff flow

Maintenance

- Cleansing annually. Frequency increased in areas of known trouble spots and through experience
- Refer to §3.4 for further details

Limiting Factors

- No treatment provided.
- Where gullies are used in conjunction with swales, the swale depth increases due to the depth of the gulley outlet



Typical Section

Description

Silt traps, also often referred to as catchpits are chambers constructed within a piped system at changes in direction and gradient and often prior to discharge of a piped system to a SUDS component. Provision is made for collection of silt by a sump which provides a permanent wet well

Road Applications

- Trunk roads
- All distributor roads
- General access roads
- Industrial access roads
- Short Culs-de-sac
- Minor access link

Design Criteria

- The size of chamber will be determined by the size, depth and position of incoming and outgoing pipes
- The design should follow good hydraulic practice with an undisturbed flow as possible with mean velocities less than 0.3m/s[15]
- Details of the arrangements of these features may be found within the Specification for Highway Works Volume 1 and drawing no.s F11 and F12 in volume 3[25]

Pollutant Removal

- Low. Dissolved pollutant concentrations within the sump wet well may increase during periods of dry warm weather
- Settled sediment and pollutants may be washed out of the sump during periods of turbulent high runoff flow

Maintenance

- Cleansing annually. Frequency increased in areas of known trouble spots and through experience
- Refer to §3.4 for further details

Limiting Factors

- No treatment provided

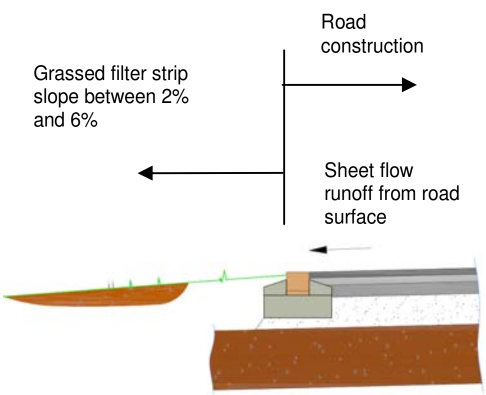
TYPES OF SOURCE CONTROL

2.4.7 Source control is the preferred option in the use of SUDS and should be considered before any other approaches, for example, 'end of pipe'. This is because the control of runoff close to the point of precipitation results in relatively small road contributing catchment areas where the volume of runoff and pollution are not concentrated into the receiving watercourse, and as a result the consequence of failure is lower[15]. The first surface water runoff which contains an unusually high contaminant loading as pollutants that have accumulated during the antecedent dry period is generally termed the first flush. Source control provides the first level of treatment and in the case of permeable paving and dry swales provides the first and second levels of treatment. The source control features, described in detail within this section, which provide the effective management of first flush runoff include:

- Filter strips
- Pervious pavements
- Swales
- Filter drains
- Infiltration trenches
- Bioretention areas

2.4.8 Further detailed information on all the above SUDS source control features may be found in the The SUDS Manual.[26]

SOURCE CONTROL



Typical Section

Description

Wide relatively gently sloping areas of grass or other vegetation, draining water evenly, that treat runoff from the road surface and footways

Road Applications

- Trunk roads
- All distributor roads
- General access roads
- Industrial access roads
- Minor access link
- Rural roads

Design Criteria

- Flow across the filter strip can be determined using Manning's formula
- Sheet flow depth should be maintained to depths less than 50mm
- Minimum residence time of 5 minutes
- Design details – The SUDS Manual [26]

Pollutant Removal

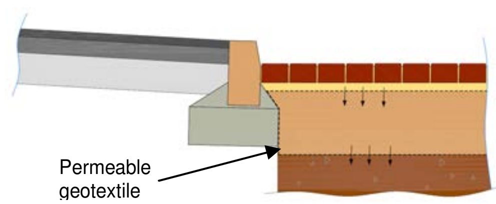
- Medium
- Single level of treatment provided

Maintenance

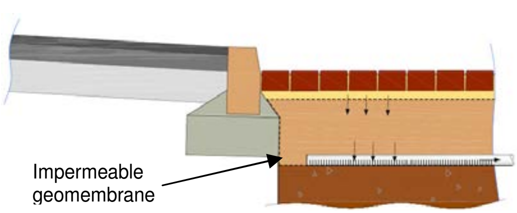
- Monthly inspections
- Litter removal following inspections, as required
- Mowing dependent on grass type, and following inspection, as required
- Scarifying and spiking as required following inspection
- Remove silt and replace vegetation as required following inspection
- Refer to §3.4 for further details

Limiting Factors

- Require a large area of space



**Typical Section
(With Infiltration)**



**Typical Section
(Without Infiltration)**

Description

Pavement construction that allows road runoff to infiltrate through the surface layer to underlying treatment and storage media

Road Applications

- Short Culs-de-sac
- Minor access link
- Homezones/ shared surfaces

Design Criteria

- Structural design methods as conventional road pavements adjusted for different material properties and the presence of water in the sub-base and saturated subgrade where infiltration possible
- Hydraulic design to provide storage based on design rainfall and outflow restriction
- Design details – The SUDS Manual [26], CIRIA C582[7], BS7533 - 13: 2009 [8]

Pollutant Removal

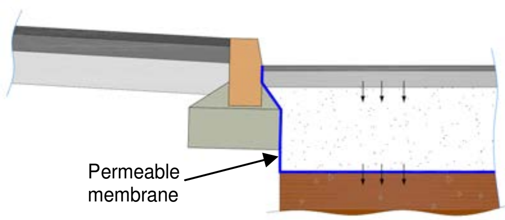
- High
- Permeable block paving provides two levels of treatment

Maintenance

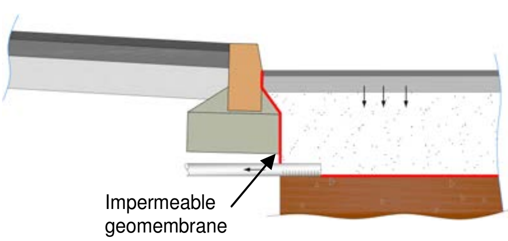
- Monthly inspections for clogging and ponding on surface
- Vacuum sweeping, as required following inspection
- Refer to §3.4 for further details

Limiting Factors

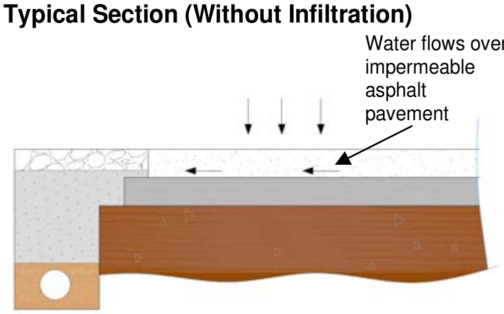
- Gradient of road may require check dams
- Membranes may be required to protect weak subgrades
- Unsuitable to provide route for overland flow due to potential clogging



Typical Section (With Infiltration)



Typical Section (Without Infiltration)



Typical Section Showing Flow Through Porous Surface across Impermeable Binder and Base

Description

Pavement construction that allows road runoff to infiltrate through the surface layer to underlying treatment and storage media, or through the top surface and over the surface of the impermeable binder to a filter drain

Road Applications

- Short Culs-de-sac
- Minor access link
- Homezones/ Shared surfaces

Design Criteria

- Structural design methods as conventional road pavements adjusted for different material properties and the presence of water in the sub-base and saturated subgrade where infiltration possible
- Hydraulic design to provide storage based on design rainfall and outflow restriction
- Design details – The SUDS Manual [26], CIRIA C582[7]

Pollutant Removal

- Medium
- Reduced surface spray leading to reduction in pollutants washed off underside of vehicles

Maintenance

- Monthly inspections for clogging and ponding on surface
- Jet washing and vacuum sweeping, as required following inspection
- Refer to §3.4 for further details

Limiting Factors

- Membranes may be required to protect weak subgrades
- Unsuitable to provide route for overland flow due to potential clogging

Description

Shallow vegetated channels designed to convey road runoff and treat pollutants

Road Applications

- Trunk roads
- All distributor roads
- General access roads
- Industrial access roads
- Short Culs-de-sac
- Minor access link
- Homezones/ Shared surfaces

Swale Types

- Standard swale – broad shallow vegetated channel
- Dry Swale – vegetated channel to include a filter bed
- Wet Swale – as a standard swale but designed to encourage wet and marshy conditions

Design Criteria

- Design using Manning's equation
- Limiting velocity to prevent erosion to 1 – 2 m/s
- Maintain flow height below the top of vegetation during frequent rainfall events to max 100mm
- Minimum side slopes 1:3
- Design details – The SUDS Manual [26]

Pollutant Removal

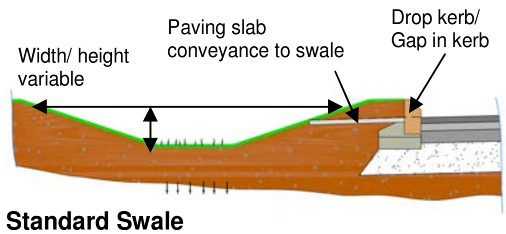
- Medium
- Provides single level of treatment
- Dry swale provides two levels of treatment

Maintenance

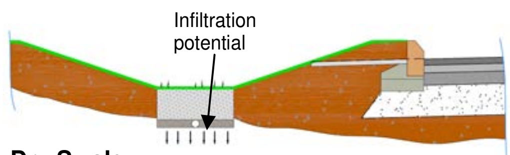
- Monthly inspections to identify mowing requirements
- Monthly litter removal
- Scarifying and spiking as required following inspection
- Repair damaged vegetation as required following inspection
- Refer to §3.4 for further details

Limiting Factors

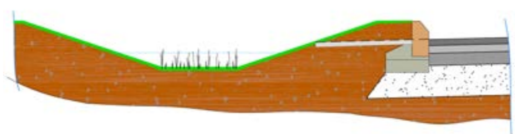
- Not suitable in very flat steeply sloping sites
- Not suitable where groundwater close to surface
- Land take may not be available
- Use with gullies may increase depth of swale



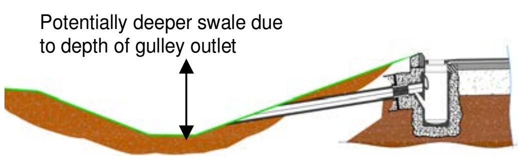
Standard Swale



Dry Swale

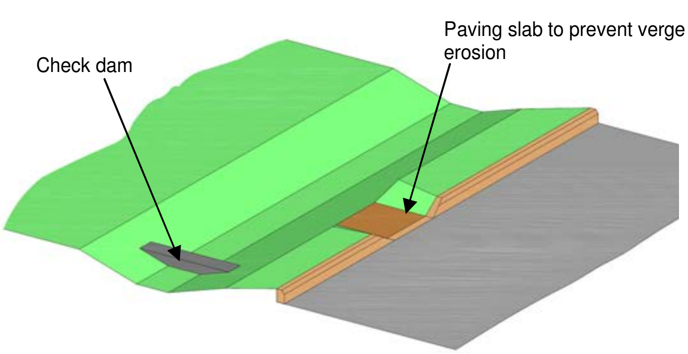


Wet Swale

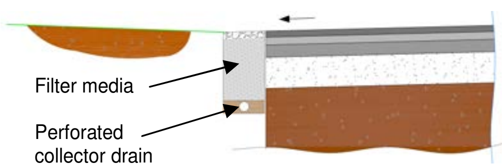


Swale with Gulley Connection

Swale Collecting Sheet Runoff



Check Dam to control flow velocity



Typical Section

Description

Roadside trenches filled with a permeable media to provide treatment and temporary storage of runoff before either infiltration or conveyance to downstream SUDS features

Road Applications

- Trunk roads
- All distributor roads
- General access roads
- Industrial access roads
- Minor access link

Types

- Allowing infiltration [Infiltration trenches]
- Downstream conveyance to SUDS feature

Design Criteria

- Storage of water based on void ration of filter media
- Infiltration rate of surrounding soils requires to be determined for infiltration trenches
- Percolation through media using Darcy's law
- Design details – The SUDS Manual [26]

Pollutant Removal

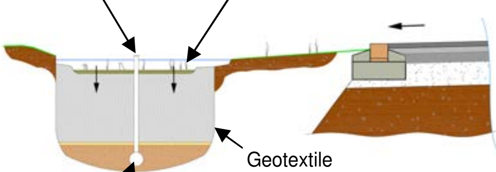
- Medium to high
- Single level of treatment provided

Maintenance

- Monthly inspections
- Weed control, as required, following inspections
- Replace clogged material, as required, following inspections
- Refer to §3.4 for further details

Limiting Factors

- Pre-treatment features required to prevent clogging



Typical Section

Description

Shallow landscaped depressed areas that are under drained and rely on enhanced vegetation and filtration to reduce runoff volumes and remove pollutants

Road Applications

- All distributor roads
- General access roads
- Short Culs-de-sac
- Homezones/ shared surfaces
- Minor access link

Design Criteria

- Provide sufficient area for temporary storage of the treatment volume Vt at a depth not exceeding 150mm
- Infiltration rate of surrounding soils to be determined
- Half drain down time should be within a 24 hour period to ensure adequate capacity for multiple rainfall events
- Design details – The SUDS Manual [26]

Pollutant Removal

- High
- Single level of treatment provided

Maintenance

- Monthly inspections
- Weed control, as required, following inspections
- Annual replacement of top mulch layer
- Replace damaged vegetation, as required following inspection
- Spiking or scarifying every 3 years
- Refer to §3.4 for further details

Limiting Factors

- Catchment area limited to around 0.1 ha to avoid clogging

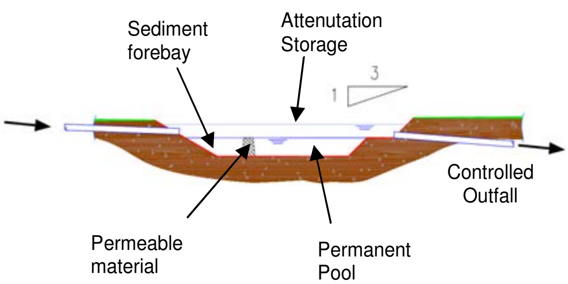
TYPES OF SITE CONTROL FOR ROADS

2.4.9 The second level of treatment within the surface water management train, following source control is termed site control. Where source controls cannot be implemented then site controls should be used to provide the first level of treatment and attenuation. Consideration should be given, during the design process, to increased runoff volumes and increased pollutant concentrations when using site control SUDS features without source control SUDS, particularly where runoff is collected from a number of sub-catchments. The site control features, described in detail within this section include:

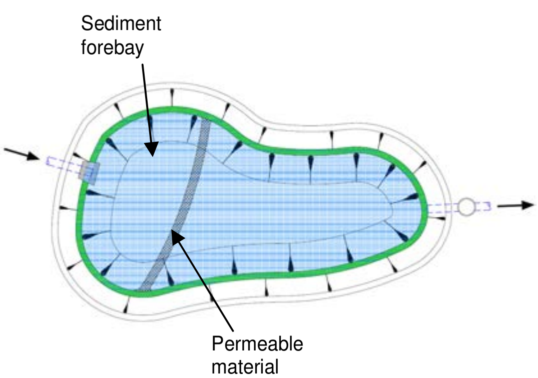
- Ponds
- Detention basins
- Infiltration basins
- Wetlands
- Sand filters

2.4.10 Further detailed information on all the above SUDS site control features may be found in the The SUDS Manual [26].

SITE CONTROL



Typical Section



Typical Plan Layout

Description

Ponds are basins that embody a permanent pool of water in the base. These may be formed within natural depressions or formed by excavation. The permanent pool provides the required treatment with temporary storage above providing flood attenuation for the required rainfall events

Road Applications

- Trunk roads
- All distributor roads
- General access roads
- Industrial access roads

Design Criteria

- Permanent pool equivalent to Vt, increased up to 4Vt in industrial settings
- Side slopes 1:3 minimum
- 20% volume of permanent pool as sediment forebay
- Irregular shape
- Length to width ratio 1.5:1 to 4:1
- Space requirement for temporary storage above permanent pool
- Residence time between 24 and 48 hours
- Inlet velocities 0.3m/s to 0.5m/s to minimise re-suspension of solids
- Minimum depth of open water 1.2m, maximum depth of permanent pool 2m
- Design details – The SUDS Manual [26]

Pollutant Removal

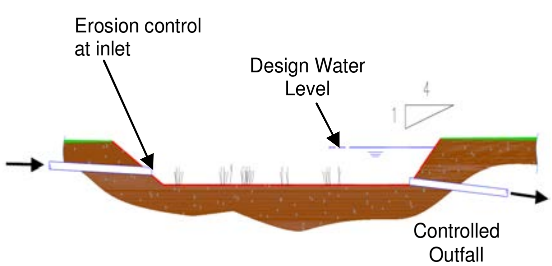
- High
- Single level of treatment provided

Maintenance

- Monthly inspections to determine frequency of maintenance activities
- Grass cutting following inspection, if required
- Bank clearance annually following inspection, if required
- Manage and repair landscaping following inspection, as required
- Forebay sediment removal, as required
- Sediment removal from main pond area, typically 25 years or greater
- Refer to §3.4 for further details

Limiting Factors

- Land take requirements high, therefore limited use in dense urban environments
- Not suitable for steep sites
- Perceived health and safety risk



Typical Section

Description

Basins are either naturally occurring vegetated depressions, or excavated depressions in the ground designed to retain surface water runoff for the required period of time to allow treatment and attenuation to take place

Road Applications

- Trunk roads
- All distributor roads
- General access roads
- Industrial access roads

Design Criteria

- Storage volume required for design rainfall events
- Maximum side slopes 1:4
- Minimum length to width ratio 2:1
- Design details – The SUDS Manual [26]

Pollutant Removal

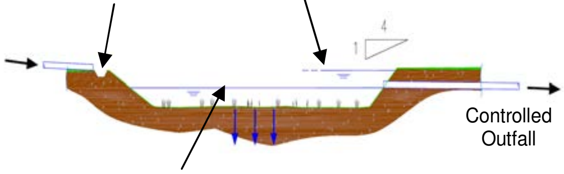
- Medium
- Single level of treatment provided

Maintenance

- Monthly inspections to determine frequency of maintenance activities
- Grass cutting following inspection, if required
- Bank clearance annually following inspection, if required
- Manage and repair landscaping following inspection, as required
- Removal of sediment as required following inspection
- Refer to §3.4 for further details

Limiting Factors

- Land take requirements high, therefore limited use in dense urban environments
- Not suitable for steep sites



Typical Section

Description

Infiltration basins are vegetated depressions, formed either naturally or artificially that are designed to retain surface water runoff and allow in to infiltrate into the ground

Road Applications

- Trunk roads
- All distributor roads
- General access roads
- Industrial access roads
- Short Culs-de-sac
- Minor access link

Design Criteria

- Based on site investigation data with infiltration potential of underlying soils
- Maximum side slopes 1:4
- Basin half drain down time in 24 hours
- Maximum storage depth 0.8m
- Complete drain down in less than 72 hours to prevent emergence of nuisance insects
- Design details – The SUDS Manual [26]

Pollutant Removal

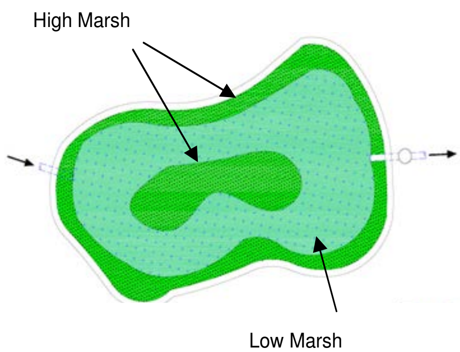
- High
- Single level of treatment provided

Maintenance

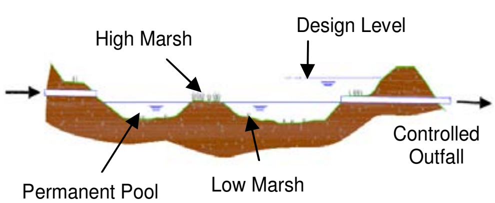
- Monthly inspections to determine frequency of maintenance activities
- Grass cutting following inspection, if required
- Replace clogged material, as required, following inspections
- Manage and repair landscaping following inspection, as required
- Removal of sediment as required following inspection
- Refer to §3.4 for further details

Limiting Factors

- Not suitable in areas where groundwater vulnerable
- Land take requirements high, therefore limited use in dense urban environments



Typical Plan Layout



Typical Section

Description

Wetlands are shallow depressions, either naturally or artificially formed, comprising marshy areas and shallow ponds, and are almost entirely covered with wetland vegetation

Road Applications

- Trunk roads
- All distributor roads
- General access roads
- Industrial access roads

Design Criteria

- Retention time 16 – 24 hours
- Length to width ratio 1.5:1 to 4:1
- Surface area = 1% catchment area
- Continuous baseflow to ensure wetland does not dry out
- Combination of deep and shallow areas
- Shallow side slopes
- Design details – The SUDS Manual [26]

Pollutant Removal

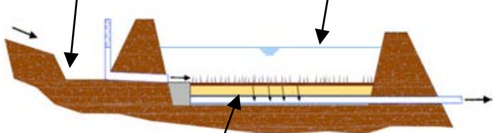
- High
- 3 x Vt required
- Provides single level of treatment

Maintenance

- Monthly inspections to determine frequency of maintenance activities
- Grass cutting following inspection, if required
- Manage and repair landscaping following inspection, as required
- Removal of sediment as required following inspection (Typically 25 years)
- Refer to §3.4 for further details

Limiting Factors

- Land take requirements high, therefore limited use in dense urban environments
- Needs impervious soils or liner



Typical Section

Description

Sand filters are above or below ground structures comprising single or multiple chambers with a sand bed as a filter medium providing treatment of runoff. Can be formed as earthworks depression with infiltration if soil conditions allow, or concrete structures. Storage is provided above the sand bed

Road Applications

- All distributor roads
- General access roads
- Industrial access roads
- Short Culs-de-sac
- Minor access link
- Homezones/ Shared surfaces

Design Criteria

- Filter depth 0.45 – 0.6m
- Sand particle size 0.5 – 1.0 mm
- Maximum depth of treatment volume of 150mm dictating filter bed area
- Chamber length to width ratio 2 to 1
- Pre-treatment required for >25% of Vt and 40%Vt for high sediment loads
- Recommended treatment percolation time 40 hours
- Design details – The SUDS Manual [26]

Pollutant Removal

- High
- Provides single level of treatment

Maintenance

- Monthly inspections to determine remedial works and establish frequency for future inspections
- Litter/ debris removal following inspection
- Removal of sediment as determined by inspection
- Refer to §3.4 for further details

Limiting Factors

- High capital cost
- Limited benefit in areas with high sediment content in runoff

2.5 DESIGN CONSIDERATIONS

DESIGN STANDARDS

2.5.1 The following, non-exhaustive, list of key standards are available for the design of roads, drainage and SUDS:

- Local Authority Development Guidelines – Guidance to the design and construction of roads for adoption
- The Design Manual for Roads and Bridges
- TRRL LR1132 – The Structural Design of Bituminous Roads
- BS 7533 – 1: 2001 Pavements constructed with clay, natural stone or concrete pavers. Guide for the structural design of heavy duty pavements constructed of clay pavers or precast concrete paving blocks. BS 7533 – 2: 2001 provides structural design guidance for lightly trafficked pavements
- CIRIA C697 The SUDS Manual
- CIRIA C582 Source Control using Constructed Pervious Surfaces
- Sewers for Scotland 2nd Edition. Scottish Water
- The Wallingford Procedure – Design and analysis of urban storm drainage. Hydraulic Research Limited
- BS EN 752: 2008 – Drain and sewer systems outside buildings

Well designed, constructed and maintained road SUDS will protect against the increased risk of flooding and/ or risk of pollution to the downstream receiving watercourse.

2.5.2 It is considered that the design of road SUDS are completed by design teams with the necessary skills and experience to execute this type of design work.

2.5.3 To ensure a consistent approach to the design of roads and their associated SUDS, the completion of a design checklist is recommended. An example design checklist is outlined in Table 2.9.

Description	Project Site Details	Source Of Information
Existing Site Parameters		
Topography		Site survey
Contributing area		Road/ footway alignment
Soil type		Site investigation
Infiltration potential		Site investigation
CBR		Site investigation
Former land use		Local authority, Ordnance Survey maps, local library
Environmental Considerations		
Contamination of soils		Site investigation, local authority, Ordnance Survey maps, local library
Environmental sensitivity of the site		SEPA, local authority, Scottish Natural Heritage
Details of receiving water		SEPA
Groundwater vulnerability		SEPA
Road Design		
Layout		Development plans
Traffic flow		Transport assessment
Road geometry		Local authority development guidelines, DMRB
Pavement design		Local authority development guidelines, DMRB

Table 2.9 Design Checklist. **Continued overleaf**

SUDS Design		
Rainfall data		Meteorological office, Wallingford Procedure
Hydrology and storm return period		Local authority, Scottish Water, Wallingford Procedure
Flood risk		Local authority, SEPA
Design discharge flow rate		Local authority, Scottish Water
Quality of design discharge		SEPA
Storage requirements and infiltration potential		Site investigation, manufacturers specifications
Overland flow routes		Development plans
Climate change allowance		Local authority, Scottish Water
Temporary SUDS during construction phase		Development plans, SEPA
Design Specific Parameters		
Development type		Development plans
Potential areas for SUDS		Development plans
Riparian rights for overflow routes		Legal team
Utilities		Utility companies
Health and Safety		All parties

Table 2.9 Design Checklist

2.5.4 The roads engineer will require to engage, at an early stage, with a number of stakeholders to ensure successful delivery of a road scheme incorporating SUDS for surface water runoff treatment and attenuation. These will typically include:

- SEPA
- Scottish Water
- Utility companies
- The client
- Architects
- Planners
- Roads authorities
- Public
- Maintenance team
- Contractor

2.5.5 The hydraulic criteria – return periods, climate change, greenfield runoff, allowable runoff, retention times, used in the design of the SUDS will be agreed with the local authority, and or Scottish Water dependent on the receiving asset being either a watercourse or sewer. The water quality criteria will require to be agreed with SEPA. However, it is generally understood the runoff from roads require two levels of treatment, and one level of treatment for smaller residential developments.

2.5.6 Where practicable, source control within design of road runoff management should be optimised, so that treatment can be provided where the pollutant load is greatest.

> The design of the road and SUDS components should take into account the operation and maintenance required by both individually and when considered together, to ensure design performance is not compromised during maintenance activities.

2.5.7 The design should ensure easy vehicular access is provided to site control SUDS components which are remote from the road, to enable maintenance works to be undertaken. The design of accesses should be in keeping with the natural appearance of the SUDS feature.

2.5.8 Maintenance activities should be easy to understand and facilitate, and be able to be undertaken without risk to the health and safety of maintenance staff and the public.

DETAILING STANDARDS

2.5.9 Guidance on detailing road SUDS features is limited in current SUDS design publications. Standard dimensional criteria for SUDS components are outlined in CIRIA C697 – The SUDS manual [26], and for pond and basins in Sewers for Scotland 2nd Edition[19] where appropriate. Whilst roads authority development guidelines provide comprehensive, dimensioned details for carriageways, footways and associated road features, they are deficient in detail associated with SUDS and how they would be incorporated within or adjacent to the road corridor.

2.5.10 Chapter 3 focuses on particular areas where attention is required during the construction process to ensure that the integrity of the SUDS feature is not compromised.

SUSTAINABLE CONSTRUCTION CONSIDERATIONS

2.5.11 The design of the road and SUDS should consider sustainable construction throughout the design process. Some of the key construction aspects which may affect the road and SUDS construction and influence the design process include:

- Energy consumption for both road and SUDS components
- Loss of habitat through construction
- Potential impact of flooding during the construction process
- Use of recycled materials
- Use of materials with low embodied energy
- Reduction of materials removed from site
- Re-use of existing assets

- Impact of aggregate and landfill taxes
- Permanent design to mitigate against sediment contamination of SUDS from landscaped areas
- Requirements for temporary SUDS for mitigation and management of pollutants from the site
- Prevention of damage and erosion control
- Sediment control procedures to prevent contamination of the permanent SUDS features
- Minimise nuisance and disruption

SUDS PERFORMANCE STANDARDS

2.5.12 The performance of the SUDS component can be measured against key criteria:

- Flow attenuation and storage
- Pollutant removal and water quality
- Environmental and amenity
- Community acceptance
- Safety

2.5.13 The standards associated with flow attenuation and storage are generally prescribed by the local authority where the discharge of runoff is to a watercourse, and flow is limited to a variable greenfield runoff related to the various return period storms being considered. Exacting constraints may be imposed where there is a high flood risk, for example, resulting in attenuation storage and controls being required to limit higher return period storm peak flow to the 1 in 2 year return period storm flow.

2.5.14 Where the discharge of runoff is to an adopted sewer, Scottish Water will define the allowable peak flow to the sewer.

> Within new developments it is generally accepted that two levels of SUDS treatment are required for surface water runoff from roads, although a single level of treatment may be acceptable for smaller residential developments. Some individual components provide two levels, such as permeable pavements and dry swales. Where consideration of alternative SUDS is being given, two or more components linked in series may be required, depending on the type of development on the site.

2.5.15 Well designed SUDS can provide a valuable wildlife habitat, with ponds and wetlands offering the greatest opportunity. Where above ground SUDS features are proposed, such as swales, they provide a green corridor adjacent to the road linking wildlife habitats. The design of SUDS should encourage the use of local grasses and vegetation, where possible and avoid the use of invasive species.

2.5.16 Engaging with the local community at an early stage in the decision making process regarding the type and use of SUDS for treatment and attenuation of road runoff, and education relating to the philosophy of SUDS may lead to increased chances of the SUDS component performance and value in the longer term.

2.5.17 Detailed information relating to performance standards can be found within CIRIA C697 – The SUDS Manual[26].

SAFETY

There is a general misconception that site control ponds and wetlands are unsafe and pose a risk of drowning. At the time of writing there is no recorded evidence of such an incident, and properly designed SUDS should pose little or no risk.

2.5.18 Properly designed SUDS features should pose little or no risk when the principles of safety by design are embraced by the designer. The Construction (Design and Management) Regulations 2007 (CDM)[28] will apply to most road and SUDS construction work with the exception of very small projects. Accordingly, it will be incumbent on designers to ensure that all foreseeable risks during design, operation and maintenance are managed by:

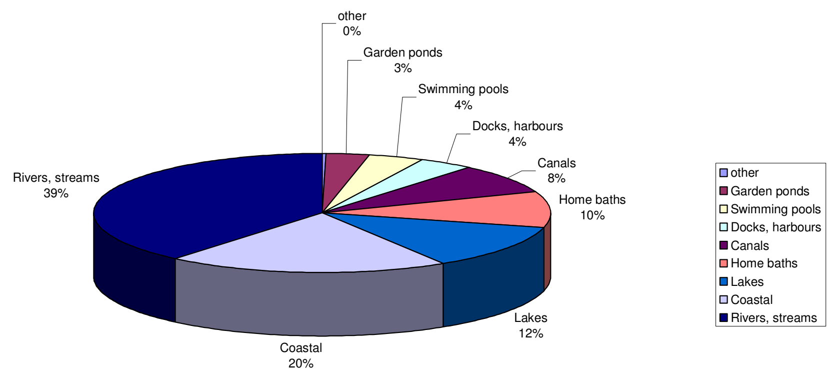
- Elimination, where practicable
- Reduction
- Identification and mitigation of residual risks
- Control

2.5.19 The risks associated with road and SUDS design, construction, operation and maintenance managed within the context of CDM should be designed out as far as is practicable. In road design this is carried out through the Road Safety Audit process, which comprises a four stage audit procedure completed at various stages from Stage 1 design to Stage 4 accident monitoring. Details of the Road Safety Audit process can be found within the DMRB Volume 5 – Assessment and Preparation of Road Schemes, Section 2 – Preparation and Implementation, Part 2 HD 19/03 Road Safety Audit.[5] A similar process of safety audit for risks associated with provision of road SUDS should also be undertaken. An example layout of some of the hazards that could be identified is detailed in Table 2.10.

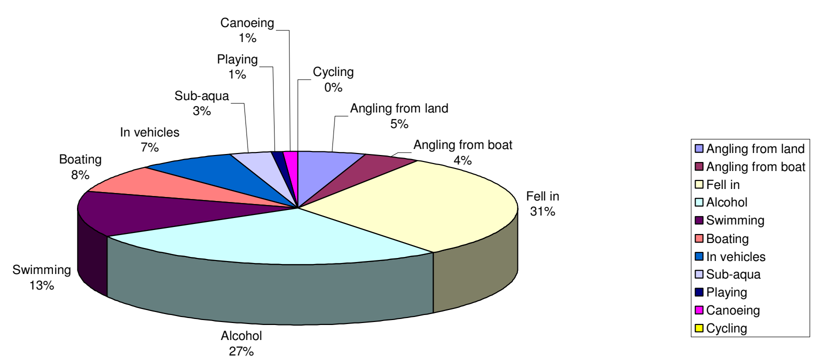
Hazard	Risk target	Eliminate	Reduce	Mitigate	Residual risk
Drowning	Construction workers Maintenance staff Public	Provide barriers/ fencing to prevent entry	Shallow banksides to allow easy escape	Vegetation to act as barrier, warning signs, life jackets	Very low
Falling from inlet structure	Maintenance staff Public	Design inlet structure without walls	Provide barrier	Warning signs	Very low
Entry to inlet or outlet pipes	Public	Design smaller diameter pipes to prevent entry	Provide grills	Warning signs	Very low
Sudden inflow of water	Maintenance staff Public	Design controlled flow to avoid sudden inflows	Shallow banksides to allow easy escape	Vegetation to act as barrier, warning signs, life jackets	Very low

Table 2.10 Pond Example of Hazard and Risk Assessment Process

2.5.20 Figures published by The Royal Society for the prevention of Accidents (RoSPA) of UK drowning statistics for 2002[27] by location and activity/behaviour are illustrated below:



By Location



By Activity/ Behaviour

2.5.21 The above statistics highlight that there is a similar risk of drowning from bathing at home to that of drowning in a loch. Equally the highest risk by activity is when people fall in, and are under the influence of alcohol, and swimming to a lesser extent.

2.5.22 With the introduction of gentle side slopes to above ground SUDS features, generally not steeper than 1 in 3, shallow shelves within ponds and wetlands, these risks can be minimised or designed out, and pose less of a hazard than many of the ditches with steep side slopes that line many miles of roads throughout Scotland and the UK.

2.5.23 Other misconceptions associated with above ground SUDS features are that standing water within ponds and wetlands can provide breeding grounds for mosquitoes and allow growth of toxic variants of blue green algae. Well designed above ground SUDS features with moving water, limited residence time, deeper permanent pools and vegetative growth will prevent the formation of stagnant water to deter mosquito breeding and the formation of algal blooms.

2.5.24 Other associated health and safety benefits that can be gained from the introduction of road SUDS include:

- Reduction in the number of manholes within the carriageway and footways reducing the risk of skids and slips by motorcyclists, cyclists and pedestrians
- Introduction of pervious surfaces reduces the risk of accumulation of standing water and ice formation
- Provision of appropriate warning signage at open bodies of water
- Introduction of 'toddler proof' fencing at open bodies of water where access may be gained by the public

2.5.25 With the water safety experience and knowledge that RoSPA possess, their consultancy team are able to conduct site specific audits for all water locations in urban and rural locations.

2.5.26 Further safety enhancement measures could include a programme of education through an integrated approach with RoSPA to reassure stakeholders of the lack of risk through risk management and community engagement.

2.6 SELECTION CRITERIA

SUDS SELECTION FLOWCHART

2.6.1 SUDS should be selected by using appropriate selection criteria which serve to identify the capabilities and limitations of each SUDS for use on roads. These notes outline a generic process for the selection of the most appropriate road SUDS option.

2.6.2 Factors requiring to be considered for any given site are evaluated using the selection tool. Selection is classified into three main processes of scoping, evaluation and final selection and these processes are further divided into six main stages.

2.6.3 The SUDS selection tool comprises the following parts:

- Roads SUDS Selection Flowchart
- SUDS Options Matrix
- SUDS Performance Matrix
- SUDS Maintenance Matrix
- SUDS Site Factors Scoring Worksheet

2.6.4 The SUDS selection tool uses a simple scoring system which is intended to enable options to be ranked. It is not intended set definitive rules as to which SUDS components should be used but it provides a common basis for discussion and negotiations in deciding the most appropriate solution for a location.

2.6.5 The process outlined in the flowchart represented in Figure 2.7 should be seen as being an iterative rather than a linear process which has been developed to aid the selection of sustainable options. The selection tools are presented in Appendix B.

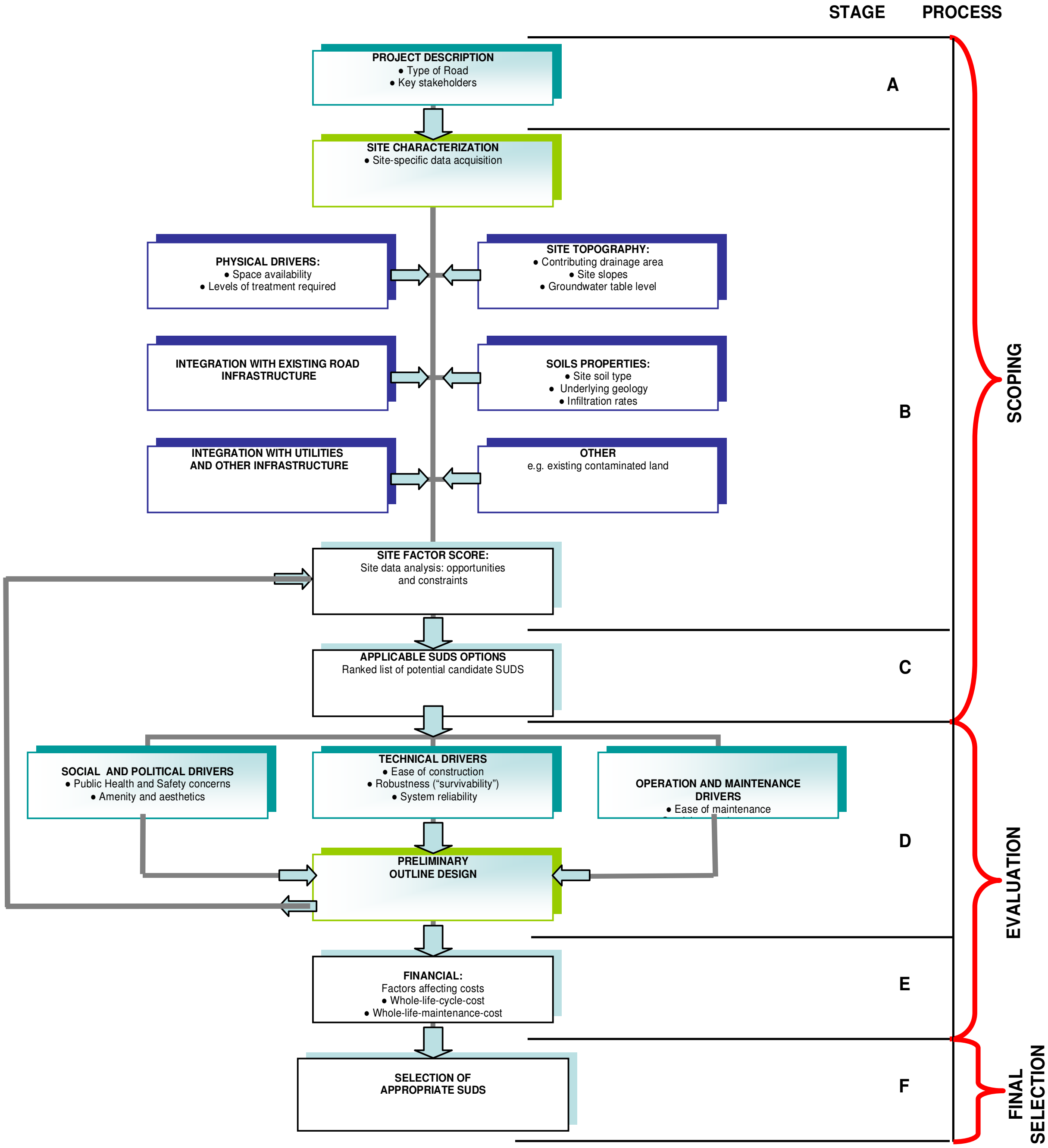


Figure 2.7 Road SUDS Selection Flowchart

SITE FACTOR SCORING

2.6.6 A scoring system to assist in the selection of the most appropriate SUDS for a location has been developed for SUDS for Roads. This is a binary scoring system (where each factor has a score of one or zero) and is intended to be a basis to rank the different options for a location. The factors included in the scoring are given in Table 2.11 and guidance on the scores to be used is given in the following pages.

	Permeable Block pavements	Porous Asphalt	Bioretention area	Sand filter	Modular Storage System
Land / Space requirement	1	1	1	0	1
Contributing Drained area	1	1	1	1	1
Site Gradient	1	1	1	1	1
Groundwater level	1	1	1	0	0
Soil Type	1	1	1	1	1
Contaminated land	1	1	1	0	1
Underlying geology	1	1	1	0	1
Surface Water abstractions	1	1	1	1	1
Integration with existing road Infrastructure	1	1	1	1	1
Integration With Utilities and other Infrastructure	1	1	1	0	0
Functional requirements*					
Level of treatment provided	2	2	1	1	0
Flow attenuation	1	1	0	0	1
SITE FACTOR SCORE	13	13	11	6	9

Table 2.11 Site Factor Scoring Table (with typical values from Worked Example 1)

* Each SUDS option must meet the functional requirements of the location in terms of treatment and flow attenuation. These are scored even though a component would not be acceptable if the functional requirement was not met.

2.6.7 Each of the range of options initially selected using the selection matrix is scored on the basis of whether they meet the particular criteria/factor in question. When they meet an individual site-specific criterion, they are given a score of 1, otherwise the score is zero. For example, if a particular SUDS option meets the space criteria it is given a “yes” which equated to a score of 1; otherwise if the option is not feasible based on that criterion, (i.e. a “no”) it is given a score of 0 (i.e. 1 = yes/ ok and 0 = not ok). The exception to this is the level of treatment criteria, the level of treatment score is based on each level i.e. for each level of treatment, the score is a 1, therefore, if an option provides two levels of treatment, has a score of 2. The site factor score is the sum of the individual scores.

2.6.8 The cumulated site factor score is determined at the end of STAGE B.

STAGE A: PROJECT DESCRIPTION

2.6.9 This initial stage is to determine and clarify the type of road to be developed. Once that is known, the designer uses the matrix to select a range of SUDS options which are potentially suitable for that particular road type. This gives a list of applicable SUDS options. The SUDS in this list may be more attractive to some stakeholders and less to others and is effectively the starting point for selection. For example, the most attractive option for a developer might have a very low above-ground footprint with a form of hard surfacing whereas the adopting authority might be drawn to another solution which would have lower maintenance costs and be easier to inspect. The purpose of drawing up the selection flowchart and process is to assist in resolving these differences.

STAGE B: SITE CHARACTERIZATION

2.6.10 For any given site, it is important to review and assess the site characteristics and check for any site constraints which may cause a preference for the use of certain options over others. A particular SUDS component should only be used in areas where the physical site characteristics are suitable, although some overcome unfavourable site conditions by incorporating particular design features. For example, the bottom of a detention pond can be sealed to prevent seepage into permeable soils at a site where a permanent pool is desired.

2.6.11 In this stage, the designer screens the initial list/ range of SUDS options derived from stage A and determines which factors apply; available space, site topography, soil characteristics, existing road assets, utilities and other infrastructure. Different site factors or combinations of factors might limit the use of any of the SUDS options selected initially.

Stage B – Physical Drivers:

2.6.12 Physical site drivers include space availability and cutting and grading requirements etc. Development is normally constrained by land availability but appropriate SUDS selection can help remove constraints and release developable land. In the road environment, space may be limited and even when open space exists but this does not necessarily mean that that space is available for surface water. Selecting the most appropriate type of SUDS is essential to remove space constraints.

2.6.13 In some exceptional instances, the only option for highly constrained urbanised areas may be to use pre-treatment and/or proprietary devices be located within the storm drain system, such as gully/ water quality inserts, silt traps, hydrodynamic devices or media filters. These types of devices generally provide only limited treatment and may be more difficult to monitor and maintain than other conventional SUDS types. In contrast, large pond or wetland SUDS usually require a larger footprint than other options.

2.6.14 At virtually all locations, the volume required to store water will be critical and often there is pressure to store this surplus water below ground in pipes or cellular structures. It should be remembered that underground storage does not provide treatment which must be provided in another way for pipes or cellular storage devices.

Stage B - Site Topography:

2.6.15 Site factors here include contributing drained area, site slope, and depth to seasonal high water table. Note that the scores (1 or 0) relate to the scoring matrix in Table 2.11.

Contributing drained Area (0 = too big an area for the component)

2.6.16 This indicates the recommended minimum or maximum area that is considered suitable for any particular SUDS component (see CIRIA C697 [26]). If the area drained at a site is slightly greater than the maximum allowable drainage area for a practice, some leeway may be permitted or more than one SUDS component might be included to give at least two levels of treatment. The minimum drainage areas indicated for ponds and wetlands are flexible depending on water availability (baseflow or groundwater) or the mechanisms employed to prevent clogging.

Site Gradient (0 = steep and 0 = flat; 1 = otherwise)

2.6.17 The site gradient must be considered when selecting any SUDS option. Steep slopes can restrict the use of several SUDS options and a slope that is not steep enough may cause ponding and backwater effects, which in turn may cause premature sedimentation and clogging of inlet pipes. For example, swales must have sufficient longitudinal slope to avoid ponding but on the other hand a slope that is too steep may cause scour at the inlets and outlets of some particular device and reduce their functionality. Frequently, steep slopes are often addressed by using small rock dams to create steps.

Groundwater level (1 = low; 0 = high for infiltration and filtration systems)

2.6.18 The elevation of the Groundwater (water table) frequently has a significant influence on the type of SUDS selected, particularly infiltration SUDS. A high groundwater level may lead to the risk of contamination of the groundwater and also cause the SUDS component to fill with water thus rendering the volume useless or even worse, causing excessive infiltration into the surface water drainage system.

2.6.19 The best guidance is the depth to the (wet or winter) seasonal high groundwater level. This indicates the minimum recommended depth to the seasonally-high water table from the bottom or floor of a SUDS component. An incorrectly estimated seasonal high water table may cause SUDS to fail, decrease in effectiveness and increase maintenance cost. It is good practice to allow at least 1metres between the bottom of the SUDS component and the seasonal high water table. The depth to groundwater should be measured in Winter and may require a series of measurements over a period of time.

2.6.20 In contrast, wetland treatment systems are at their most efficient with a groundwater level or irrigation to maintain permanent pools and aquatic vegetation.

Stage B - Site Soil Properties:

2.6.21 In addition to the general topography of the site; soil properties such as the type(s) of soil, geological formation, hydraulic conductivity and water storage capacity at a site may dictate the SUDS type to be used. Since soil characteristics may vary even for locations just a few metres apart, the importance of local, site-specific measurement of soil properties cannot be overemphasized. A site soil investigation is needed to determine the hydrologic soils groups at the site, the underlying geology and potential infiltration rates. Soil permeability has an enormous impact on SUDS effectiveness, particularly for systems which rely on infiltration and filtration as they must have well-drained underlying soils, and the depth to bedrock must be sufficient to avoid excessive ponding. This also applies to swales and basins which, although they do not rely on infiltration, should dry out relatively quickly for best performance and poorly drained soils mitigate against this.

Soil type (0 if poorly draining, 1 if well drained)

2.6.22 There are many soil classification systems but the most appropriate for this use is the WRAP value (Wallingford Procedure [18]). WRAP = 1 or 2 indicates a free draining soil which will permit infiltration and is generally good for permeable paving or infiltration systems. WRAP = 3,4 or 5 will only permit limited downward movement of water but may be very good for basins, ponds or wetlands.

2.6.23 The ability of surface soil layers to infiltrate and their capacity to store stormwater are important parameters which are usually represented by two soil properties: hydraulic conductivity and water storage capacity. The hydraulic conductivity is the rate at which water flows through the soil pore structure and is expressed as a velocity, e.g., mm/hr or mm/day. The hydraulic conductivity is measured on site by an infiltration test (BRE Digest 365 [22]). Soil infiltration tests should be conducted at various locations on the site and at various depths in order to evaluate respective soil strata characteristics. These rates are then logged for future reference during design.

Underlying geology (0 if solid rock near surface, 1 otherwise)

2.6.24 Similar points apply to the solid geology. Many types of bedrock layers may impede downward infiltration of runoff or make pond excavation expensive or impossible. It may also be useful to access the depth to bedrock/ impermeable layer as well as the existing ground water flow direction and gradient.

Stage B - Integration with Existing Infrastructure

Road Infrastructure (1 = fully compatible; 0 = poor integration)

2.6.25 The existing infrastructure should be taken into account fully when considering the SUDS options for a site. Urban road projects are often constructed in stages and/or are reconstruction of existing roads. Retrofit of new SUDS into an existing drainage system built in an earlier stage presents different challenges from new construction. Existing road or bridges may also inhibit the particular SUDS selected and installed. Furthermore, concerns over the structural integrity of some road infrastructure such as footings, bridge abutments, and retaining walls may discourage certain roadside infiltration/ exfiltration approaches.

Utilities and other Infrastructure

2.6.26 Existing or proposed utilities and other infrastructure assets may inhibit the SUDS selected. For example, it is very important that a dedicated service strip is included where there is extensive pervious paving since any remedial work by utilities might not be satisfactory and may compromise the efficiency and function of the pavement.

2.6.27 Setbacks to existing building foundation, other property lines, water supply pipes, sewers etc, places of interest etc are generally required by local regulations and should also be considered.

Stage B - Site Factor Score:

2.6.28 The purpose of the site factor score is to provide a common assessment of the different opportunities and constraints offered by the SUDS options for a site. The scores for different options are used to rank the options so that the different technical merits can be openly considered. The costs of the different options are considered later since it is only worth costing options which are technically viable.

STAGE C: APPLICABLE SUDS OPTIONS

2.6.29 A ranked list of applicable SUDS options which are appropriate for the location is drawn up for further evaluation on the basis of the site factor score. Typical examples can be seen in Table 2.11 and in Worked Examples 1 and 3.

STAGE D

2.6.30 Here the range of SUDS alternatives for the site is further evaluated. In this stage, the designer narrows the SUDS list and selects the best alternatives based on their site factor scores. These are further evaluated and screened using other site specific as well as non-site specific factors such as operation and maintenance requirements; social and ecological benefit and other technical issues such reliability and robustness of the selected options.

Stage D - Social and Ecological Benefits

2.6.31 In this step, the ranked SUDS options are further evaluated for their habitat creation potential, public health and safety concerns, community acceptance, etc.

<u>Public health and safety concerns</u>

2.6.32 The consideration of public health and safety is included at this stage of the screening process because liability and safety could be prime factors in some residential road settings and SUDS devices should not create the perception of hazards. Informing the public of the location and purpose of project SUDS raises awareness and encourages local participation.

2.6.33 Good safety design using appropriate slopes, barrier planting and/or toddler fences should be promoted at all SUDS. Designs incorporating gentle side slopes and shallow basin depths should be considered so that the use of fencing might be avoided. It will be necessary to take into account the proximity of local schools and playgrounds when undertaking a safety risk assessment.

2.6.34 However, roads are essentially hazardous locations and the dangers of intermittent inundation of a swale or a basin should not be overstated.

<u>Habitat creation potential</u>

2.6.35 This evaluates the selected SUDS options for their ability to provide wildlife or wetland habitat. Some SUDS options such as pond and wetlands offer the greatest opportunity for wildlife creation. Grassed options such as swales and filter strips can be integrated into the general landscape and can be use to create green corridors, linking to wildlife habitats elsewhere.

<u>Aesthetics</u>

2.6.36 In an urban environment, the aesthetic and associated amenity values of a SUDS option are important considerations for gaining public acceptance. In some cases, components such as detention ponds can be a visual asset to the surrounding area. Some grassed and underground SUDS, such as biofilters and bioretention areas, are unobtrusive and in general tend to look more natural and be more easily disguised than other SUDS. In contrast, litter and rubbish accumulating in detention and infiltration basins together with the accumulation of sediment may have a more negative aesthetic impact which would require good landscaping and regular maintenance.

Community Acceptance

2.6.37 Most well designed and maintained SUDS will be an asset to the community.

Stage D - Technical Drivers

2.6.38 In this step, the ranked SUDS options are further evaluated as regards to their relative ease of construction, the system's reliability, and the system's robustness.

Stage D - Operation and Maintenance Drivers

2.6.39 In this step, the ranked SUDS options are further evaluated for their relative ease of maintenance, and any servicing requirement. Maintenance is an important part in the operation of any SUDS system and the maintenance effort needed for any of the SUDS option should be evaluated.

2.6.40 It should be noted that all SUDS options require routine inspection and maintenance. Maintenance should not only be evaluated in terms of effort such as the relative frequency and ease of inspection, but also the evaluation should be based on issues such as the ease of obtaining any specific components, access to maintenance equipment and/ or the need for specialist maintenance skills or techniques.

STAGE E - FINANCIAL CONCERNS

2.6.41 The cost is an important consideration in the final selection of any SUDS solution. To properly compare alternatives, all costs expected during the life of the SUDS options should be included. The construction cost alone is not of particular relevance. The costs which should be considered are expressed in two ways;

- The whole-life-cycle-cost including construction, operating and periodic rehabilitation costs throughout the life of the SUDS
- The whole-life-maintenance-cost which considers the costs only from the point of view of the maintaining body

2.6.42 The whole-life-cycle-cost includes the expected long-term maintenance costs as well as the initial costs for land, engineering and construction etc.

2.6.43 It is also appropriate in order to create a true picture of the "cost" of an option, benefits other than water quality and flood attenuation may also be considered. Some benefits such as opening up of otherwise undevelopable land and increases in land values are direct economic benefits. Other benefits are intangible and include such factors as recreation, health or wildlife benefits. They are more difficult to quantify but should be considered.

STAGE F: SELECTION OF APPROPRIATE SUDS

2.6.44 When all the options have been evaluated using the above factors/ criteria, a final decision can be made on the appropriate SUDS option to be used for the particular site.

2.7 WORKED EXAMPLES

2.7.1 Four worked examples are included with this guidance document in Appendix C. The purpose of the worked examples is to give the roads engineer assistance in developing compliant SUDS designs which are both efficient and adoptable. The worked examples specifically address the SUDS required for the roads component of a development, even though the roads drainage may be a relatively minor part of the drainage of the full site. They are intended to show the type of approach which can be used to develop a design to adoptable standards. They cover the hydrological and hydraulic design but, more importantly, the design details required for adoption.

2.7.2 Very frequently the roads SUDS will be part of a larger scheme for a larger site and the examples indicate how the roads SUDS fit into the larger sites. A range of different SUDS options are addressed in the worked examples, in each case their concept and design follows the process outlined in the Roads SUDS Selection flowchart. The examples are based around installations which have been completed and have either been adopted by the local roads authority or are to adoptable standard.

2.7.3 The worked examples cover the following:

1. Permeable Paving in the City of Edinburgh.
2. A detention basin and permeable paving serving roads and parking at a school in South Lanarkshire.
3. A filter strip roadside and swale on an access road to a distribution hub in West Lothian. The SUDS are part of a three level treatment train.
4. Permeable paving in a small development.

2.8 USE OF PROPRIETARY SYSTEMS

GUIDELINES FOR USE

2.8.1 In order to assess the suitability of a proprietary SUDS component, the following proforma, Table 2.12, has been developed as a guide for the engineer for selection of an appropriate system for a particular road type and specific design criteria:

	Details/ description	Yes	No	Comments
Manufacturer Name				
Product Name				
Type				
Road Suitability				
Trunk road				
Main distributor road				
District distributor road				
Local distributor road				
General access road				
Industrial access road				
Short Cul-de-sac				
Minor access link				
Designing Streets geometry				
Retrofit				
Installation				
Space required				
Complexity				
Time required				
Ease of commissioning				
Adoptability				
Power requirements				

Table 2.11 Proprietary SUDS Selection Proforma. **Continued overleaf**

Performance/ Pollutant Removal				
Flow and volume reduction				
Total suspended solids				
Nutrients				
Heavy metals				
Bactria				
Hydrocarbons				
Fine sediment/ dissolved pollutants				
Operation and Maintenance				
Inspection frequency				
Specific requirements				
Waste management requirements				
Annual waste volumes				
Timescales for completion of maintenance				
Replacement parts availability				
Costs				
Supply and installation				
Annual operation and maintenance				
Replacement parts				
Whole life costs				
Supporting Evidence				
Independent research				
Technical approvals e.g. BBA certification				
Compliance with British and European Standards				
Compliance with Codes of Practice				
Other				

Table 2.11 Proprietary SUDS Selection Proforma

2.8.2 Where manufacturers of proprietary systems make claims in support of their products then independent evidence must be provided. Manufacturer's claims or research carried out on their behalf endorsing their product is not considered sufficient.

GENERIC EXAMPLES OF PROPRIETARY SYSTEMS

MODULAR SYSTEMS

2.8.3 Modular systems are used for the underground storage, attenuation and infiltration of surface water runoff. These systems typically have a crate-like structure which can be constructed to a range of depths and sizes. The systems have a flow control device restricting the outflow allowing the water to accumulate within the modular structure during storm events, which then gradually discharges as the storm subsides.

2.8.4 The modular systems are surrounded by a layer of granular material and wrapped with an impermeable membrane for attenuation of the water, or a permeable geotextile for infiltration, if ground conditions allow. Many of the systems available are suitable for use beneath trafficked areas; however some are designed only to be used below landscaped areas. Figure 2.8 shows a typical arrangement for attenuation of road runoff.

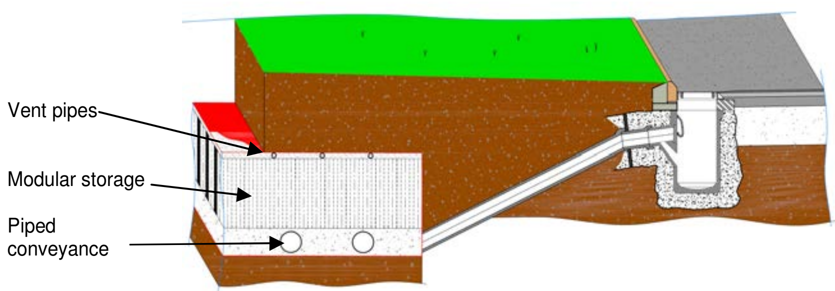


Figure 2.8 Modular Systems

HYDRODYNAMIC SYSTEMS

2.8.5 Hydrodynamic systems are designed to remove floated debris, sediments and other associated pollutants from surface water. They work by using fluid dynamics to separate the solids from liquids, channelling the flow around the unit, typically a large chamber, to produce a spiralling effect. The vortex produced causes the sediment to be deposited in the storage compartments at the base of the unit and the water is then discharged, free of suspended solids. A typical section is presented in Figure 2.9.

2.8.6 These units can be used to directly treat road surface runoff before discharging to accompanying SUDS systems.

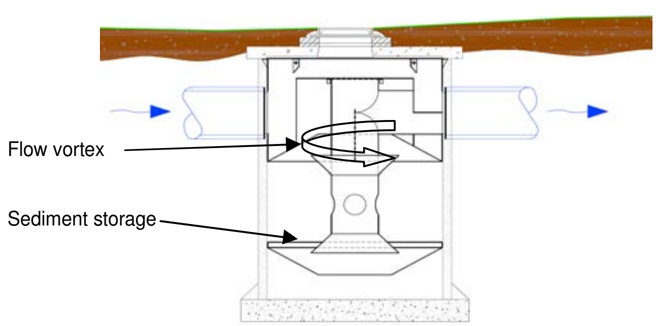


Figure 2.9 Hydrodynamic Systems

OIL SEPARATORS

2.8.7 Oil separators are often used in areas where there is a high risk of hydrocarbon contamination entering a drainage system. They generally comprise prefabricated chambers which rely on separation by flotation and storage of the contaminants. There are two types, detailed in Figure 2.10, full retention which are designed to treat all incoming flows, and by-pass separators which are designed to a limiting flow, with flows exceeding this by-passing the separator.

2.8.8 These separation units are typically positioned adjacent to roads to directly receive the surface runoff from trafficked areas where oil spillages may occur.

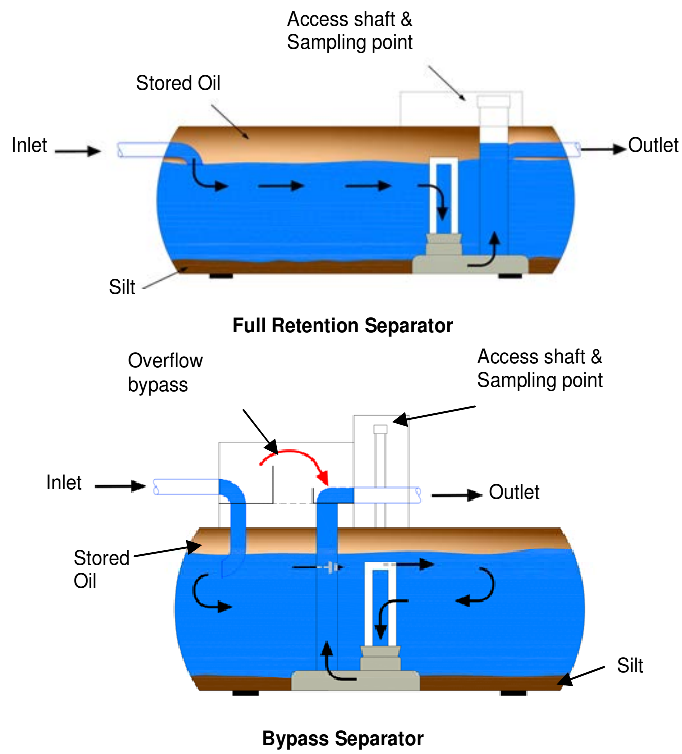


Figure 2.10 Typical Oil Separators

PREFABRICATED BIORETENTION

2.8.9 Prefabricated bioretention systems are used to remove dissolved and ultra-fine pollutants from surface water runoff, and can also provide small volumes of attenuation and flow reduction. Typically they consist of a concrete vault filled with a mixed bioretention media of sand and compost for greater permeability, whilst also allowing the growth of vegetation. The system has drainage running below the soil mix which conveys the water to either the receiving storm drainage, or for infiltration in the ground, as detailed in Figure 2.11.

2.8.10 These systems are often installed adjacent to roads, as runoff can flow directly into them through kerb inlets or gullies. This water flows, often through a filter layer, into the soil mix where the vegetation grows, and biological treatment occurs. Some systems have also been installed within the road carriageway to act as a traffic calming measure.

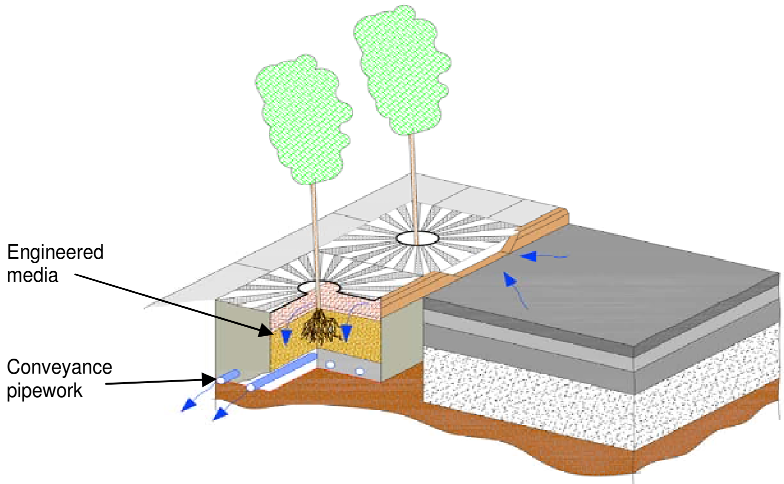


Figure 2.11 Prefabricated Bioretention

FILTRATION SYSTEMS

2.8.11 These are designed to remove sediments, oil & grease, metals, organics and nutrients. There are various filter media which are used, and it is typically found in cartridge form as detailed in Figure 2.12. Larger systems tend to work by having a series of these cartridges within a concrete unit, and a control device restricting the flow rate. As the water fills the filtration unit, it is forced through the media within the cartridges and into a collector pipe, to then be discharged. These systems are predominantly constructed adjacent to roads where surface runoff can pass directly into them for treatment. Smaller systems can be located within catch-pit chambers and gully pots situated in roads. These typically have a single cartridge for the filtration of the runoff water.

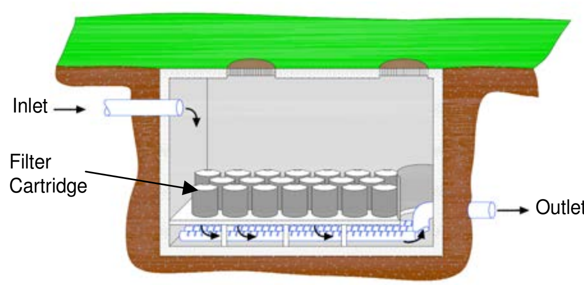


Figure 2.12 Typical Filtration System

WATER QUALITY INLETS

2.8.12 Water quality inlets, which are also known as oil/grit separators, operate with a series of chambers which promote sedimentation of coarse materials and separation of non-dissolved oils from surface water runoff. Most water quality inlets also contain screens to help retain larger or floating debris, and many also include a coalescing unit that helps to promote oil and water separation. These systems typically provide the first level of treatment of runoff from surfaces such as roads and car parks where oil and fuel spillages may occur. A typical detail is presented in Figure 2.13.

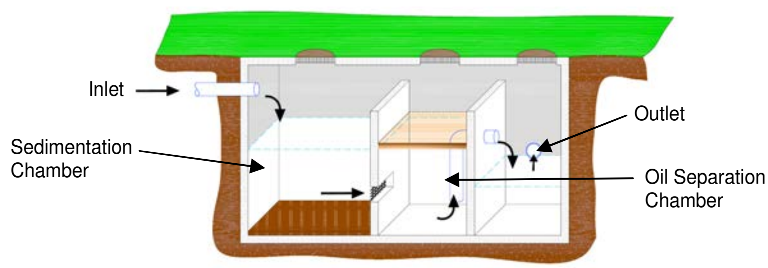


Figure 2.13 Typical Water Quality Inlet Structure

RETROFIT WETLAND DEVICES

2.8.13 Wetland devices are designed to treat runoff to remove bacteria, heavy metals, nutrients, petroleum hydrocarbons, and suspended solids. Contained within a single modular tank is a series of several chambers, through which the effluent flows and is treated by various methods. Initially the surface water runoff passes through sedimentation chambers to remove suspended solids, and then through a series of skimmers. This partially treated water then flows into the surrounded constructed wetland, comprising gravel substrates planted with wetland plants, and is treated by filtration, absorption and biochemical reactions. The water can then be discharged to a storm drainage network, or infiltrated into the surrounding soils.

2.8.14 These retrofit solutions, as detailed in Figure 2.14, can be installed adjacent to roads and car parks to receive surface water runoff from heavily trafficked areas, and can be used in conjunction with more conventional SUDS such as swales to fully treat water prior to discharge.

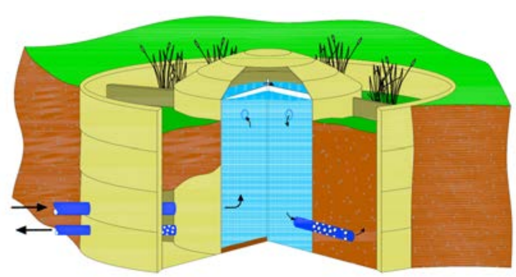


Figure 2.14 Retrofit Wetland Device

TANK STORAGE

2.8.15 Storm water tanks provide attenuation and temporary storage for surface water runoff during large storm events, preventing flooding. There are many different types of tanks available, ranging from large diameter pipes up to 4m, to arched chambers and cube structures. Most structures are designed to be installed below ground level and can be constructed beneath trafficked areas, utilising areas such as car parks. A typical example of tank storage is presented in Figure 2.15.

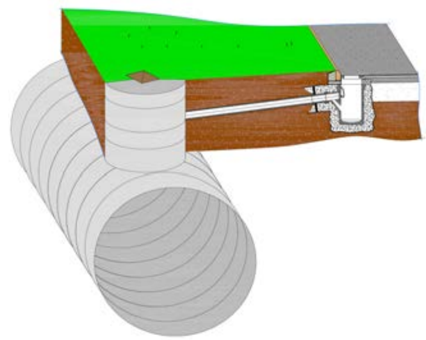


Figure 2.15 Tank Storage

VEGETATED SWALES

2.8.16 Vegetated swales are similar to traditional swales, described in § 2.4 above, however they have thick vegetation covering the side slopes and base. They are designed to treat runoff through sedimentation filtering by the vegetation in the channel, filtering through a subsoil matrix and/ or infiltration into the underlying soils. Check dams are often included to reduce the flow of surface water and to increase the attenuation and filtration opportunities. A typical detail is presented in Figure 2.16.

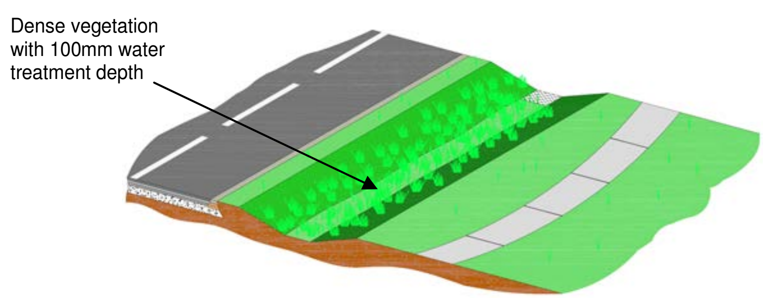


Figure 2.16 Typical Detail of Vegetated Swale

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3 Practical Guidance for Construction, Operation and Maintenance of Road SUDS

CHAPTER AIMS

- Practical guidance for particular SUDS features appropriate for use in roads taking into account detailing and construction activities.
- Preparation of operational and maintenance guidelines for SUDS in roads.
- To identify key features which require to be inspected and maintained.
- To promote the use of inspections to inform the maintenance strategy.
- Provide examples through links to case studies within the guidance.

3.1 DETAILING PRACTICE

3.1.1 Whilst the available design guidance provides specific detail on the SUDS feature, it takes no account of the effects of specific detailing relating to the location of a road SUDS feature where external factors may affect its performance.

3.1.2 For example, the location of permeable paving, or a filter drain at the bottom of an earthworks slope without a verge and protection prior to the establishment of vegetation, is likely to result in siltation from soil erosion contaminating the filter media leading to a loss of capacity and water quality, as detailed in Figure 3.1. A simple dished channel at the toe of the slope would serve to trap eroded soils, prevent clogging of the gaps between block paviours and contamination of the filter media.

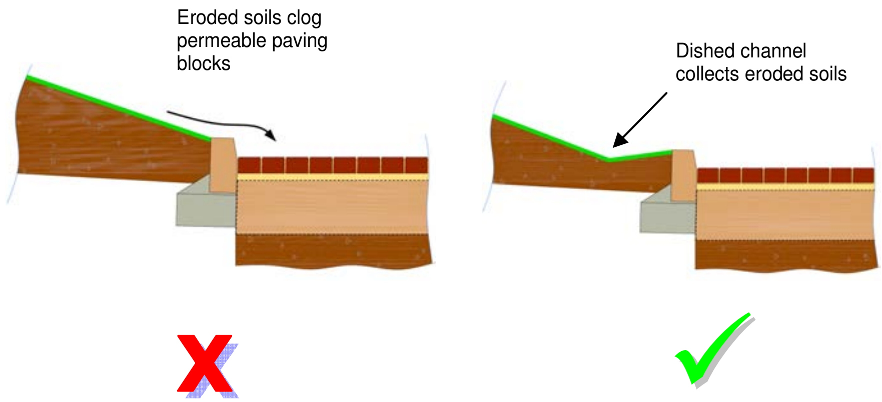


Figure 3.1 Earthworks Toe Detail

3.1.3 Other practical considerations such as the specification of grass seed mix for vegetated SUDS with slow and limited growth properties would assist in reducing the frequency of future maintenance. The use of plants requiring minimal maintenance should be explored, using the expert advice of a landscaping architect/ consultant.

3.1.4 Integration with site wide infrastructure including utilities also needs to be considered in the planning, design and detailing of SUDS within the road corridor.

3.1.5 Figures 3.2 and 3.3 show how the adoption of permeable paving can be integrated with the other functions of a road including utilities and conventional foul drainage to serve a development:

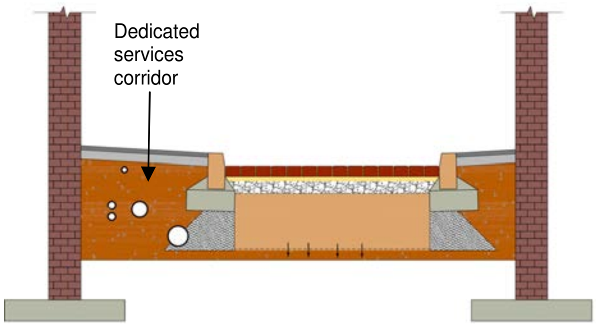
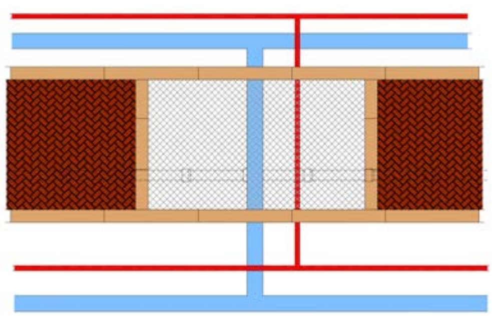
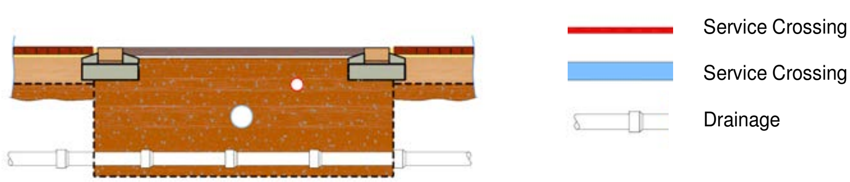


Figure 3.2 Services Corridor

3.1.6 Utilities within footways in dense urban settings allow the provision of SUDS within the road structure



Plan



Section

Figure 3.3 Delineated Utility Road Crossing

3.1.7 Where services crossings are required, these may be provided and bounded using flush kerbs and, for example changing the pattern adopted in the block paving or colour of the surfacing to define the extent of the service crossing for future maintenance access, as shown in Figure 3.3.

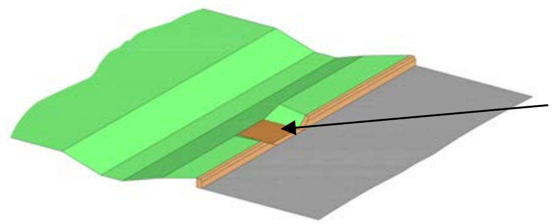


Figure 3.4 Drop Kerb Swale Inlet Detail

3.1.8 Where drop kerbs are applied to promote runoff from the road surface to swales, the introduction of a paving slab at road channel level, as shown in Figure 3.4, reduces erosion and accumulation of silt at this location.

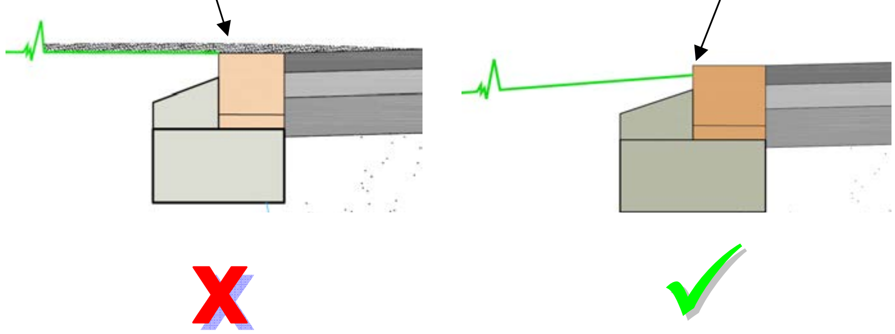


Figure 3.5 Filter Strip Roadside Edge Detail

3.1.9 Grass filter strips should be constructed 50mm below the road channel level to prevent build-up of silt at the road edge, impeding runoff of surface water from the road surface[6], as detailed in Figure 3.5.

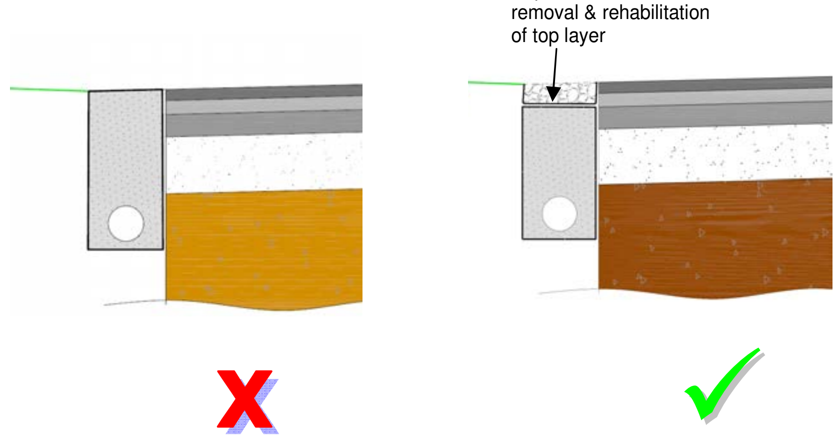


Figure 3.6 Filter Trench Detail

3.1.10 The introduction of a top layer of gravel filter media wrapped with permeable geotextile, as detailed in Figure 3.6, provides separation from the main body of gravel media and allows straightforward removal, cleaning and replacement of the contaminated top layer.

3.1.11 Where below ground SUDS features are being used, the introduction of monitoring and sampling chambers, detailed in Figure 3.7, allows the performance to be monitored and checks to be made on the presence and extent of contamination.

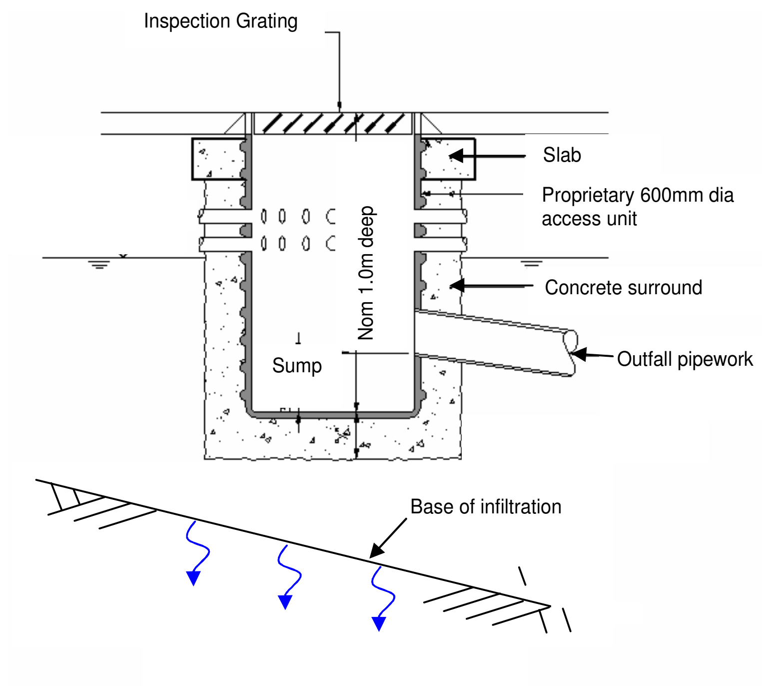


Figure 3.7 Typical Monitoring and Sampling Chamber Detail

3.2 INSTALLATION/ CONSTRUCTION GUIDELINES

SCOPE OF GUIDELINES

3.2.1 There is a statutory requirement to control the quality of surface water discharges from sites within "The Water Environment (Controlled Activities) (Scotland) Regulations 2005 (CAR) (NB incl. amendments and corrections – 2007)", with the control of water quantity governed by Local Authorities when discharging to a watercourse, and Scottish Water when discharging to a public sewer all of which is linked to the subsequent risk of flooding or capacity constraints.

3.2.2 The Water Environment (Controlled Activities) (Scotland) Regulations 2005 (CAR) (NB incl. amendments and corrections – 2007) regulates activities associated with the water environment.

3.2.3 CAR has three separate tiers of authorisation with increasing levels of monitoring and control. The 3 tiers of control are *general binding rules*, *registration* and *licences*. This tiered approach allows the level of regulation to which an activity is subject to be in proportion to the environmental risk posed by the activity and minimises the regulatory burden for both SEPA and operators. Every activity regulated by CAR falls under one of following regimes:

- Pollution control
- Abstraction
- Impoundment
- Engineering

3.2.4 The type of authorisation will depend on the level of impact the activity may cause, such as the following:

- A low risk activity will be granted a general binding rule (GBR)
- Low risk activities that cumulatively pose a risk to the water environment will need to be registered
- Activities that require site-specific controls will need a licence

PRE AND POST CONSTRUCTION EROSION AND SEDIMENT CONTROL

3.2.5 Erosion and subsequent sediment release into the water environment is one of the most common forms of waterborne pollution resulting from construction sites.

3.2.6 The risk of pollution and control of sediment release through construction works therefore needs to be considered at the outset prior to the commencement of the works with a site management plan prepared identifying the location and type of any temporary construction SUDS including their integration/association with permanent SUDS. The management plan should also include/address the need for the inspection and maintenance of the temporary SUDS including water quality monitoring/testing as appropriate and agreed with the relevant statutory authority.

3.2.7 Relevant guidance includes:

- CIRIA C698 - Site Handbook for the Construction of SUDS
- CIRIA C532 - Control of Water from Construction Sites – Guidance for Consultants and Contractors
- CIRIA C648 - Control of Water pollution from Linear Construction Projects: Site Guide
- PPG5 - Works and Maintenance in or near Water

3.3 CONSTRUCTION AND SITE HANDOVER INSPECTION

3.3.1 A consistent approach to inspection of constructed roads incorporating SUDS by using a construction and handover checklist is recommended. An example checklist is presented in Table 3.1:-

Phase and inspection description	Inspection date	Acceptability (✓ / X or N/A)	Date completed	Remarks
ROADS				
Formation				
Correct levels and grades				
Compaction in accordance with specification				
CBR in accordance with specification				
Infiltration Coefficient meets design criteria				
Sub – base / Capping				
Correct levels and grades				
Materials in accordance with the specification and testing				
Compaction in accordance with specification				
CBR in accordance with specification				
Density in accordance with specification				
Pavement				
Correct levels and grades				
Pavement thicknesses in accordance with design				
Compaction in accordance with specification				
Materials used in accordance with specification and testing				
Drainage				
Gullies clean, set at correct level				
Silt traps clear, set at correct level				
CCTV survey of pipework				

Table 3.1 Example Construction and Handover Checklist. **Continued overleaf**

SUDS				
Excavation				
Runoff from bare soil and contaminated areas diverted to temporary SUDS				
Soil not overly compacted to reduce permeability				
Excavation to required size and depth and correct location				
Side slopes are correct				
Debris and roots removed from base of feature				
No groundwater seepage in base of feature				
Construction				
Earthworks in accordance with specification				
Filter materials in accordance with specification and testing				
Compaction in accordance with specification				
Inlets, outlets and control structures in accordance with specification and drawings				
Construction to line and level as drawings				
Planting				
Planting in accordance with specification				
Planting condition and established				
Handover inspection				
No silting from construction				
No erosion or bare areas of planting				
All litter removed				
All inlets, outlets and control structures operating correctly				

Table 3.1 Example Construction and Handover Checklist

CONSTRUCTION PERIOD INSPECTIONS

3.3.2 During the construction period of the site, permanent & temporary SUDS used for treatment of construction runoff should be regularly inspected to ensure that runoff is being successfully managed across the site and that water quality within the downstream receiving watercourse or receiving sewer is not detrimentally affected.

3.3.3 It is recommended that SUDS used during the construction period, and general site conditions, are inspected on a regular basis (Dependant on complexity/size of scheme and techniques used) by a suitably experienced inspector. Control devices e.g. headwalls, orifices, hydro-brakes, etc should be observed on a regular basis during the construction period, and after periods of heavy rainfall, as these represent the highest risk of flooding due to blockages by construction debris.

> The suitable experienced inspector indicated above must have completed a recognised training module on SUDS inspection or be able to demonstrate through their experience an acceptable understanding of the required standards.

SITE HANDOVER INSPECTIONS

3.3.4 Following construction of the scheme and associated SUDS, a joint inspection should be undertaken to identify any defects and subsequent remedial works required to reinstate the SUDS feature to its intended design layout. This inspection should be attended by a representative of the contractor, the design team and a representative of the adopting/maintaining authority. Remedial measures should be agreed and recorded on a checklist, as outlined in Table 3.1, which will form the basis of a formal inspection report. The inspection report should be retained and include details of identified remedial measures including their satisfactory completion. This report will form the basis of future routine inspections undertaken by the adopting/maintaining authority providing a complete maintenance/performance history from inception.

3.3.5 It is anticipated that inspections will usually be visual only. Any necessary remedial or maintenance works should be identified and recorded on the inspection report at the time of the inspection with remedial works arranged by the appropriate person.

3.4 MAINTENANCE GUIDELINES

OVERVIEW

3.4.1 In this section, guidance is given in the development of a sustainable strategy for the maintenance of a completed SUDS feature or series of features associated with new roads.

3.4.2 The need for maintenance of the road is driven by three core principles:

- Safety – to comply with statutory obligations
- Serviceability – to ensure that the requirements for the road integrity and quality are met
- Sustainability – maximising value of the road network to the community and minimising costs over time

3.4.3 The guidance in this document does not provide prescriptive maintenance procedures, but directs that a series of inspections should inform the maintenance strategy. The guidance indicates when inspections should be carried out and identifies events which would be a reason for a further inspection.

3.4.4 Some design considerations are highlighted which can assist in lessening the long-term maintenance requirements, as well as some of the maintenance issues peculiar to specific SUDS features. Items which should be included in inspections are listed.

3.4.5 In most cases the maintenance tasks necessary for SUDS are already being undertaken by local authorities in the inspection and maintenance of streets, parks and watercourses within their boundary. Typically, the following traditional road features require regular inspections and repairs as appropriate:

- Carriageway defects
- Footways and cycle tracks
- Manhole and gulley covers, gratings and frames
- Gullies, catchpits and interceptors
- Kerbs
- Culverts
- Verges
- Landscaped areas
- Ponds with outflow controls
- Ancillary drainage items – headwalls, screens, aprons, valves, tidal flaps

3.4.6 Further details on routine maintenance management may be found within The Trunk Road Maintenance Manual: Volume 2 – Routine and Winter Maintenance Code [7].

3.4.7 Roads Asset Management Plan (RAMP), prepared by roads authorities comprise of a detailed statement / inventory of the assets owned by a roads authority, which enables the authority to gain a better understanding of, and make informed plans for, the future maintenance requirements and disposal of these assets, as well as the acquisition of new assets. A RAMP is a life cycle planning tool to enable informed decisions to be made about these assets, relating to expected life, maintenance requirements and regimes, renewal or replacement frequencies etc. based on the details it contains, and therefore it enables authorities to move from short term annual budgeting to long term financial planning.

THE NEED TO MAINTAIN

3.4.8 Un-maintained SUDS features may eventually fail operationally[1]. For example, experience shows that the useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely[2].

3.4.9 Where roads are constructed by a local authority, a robust maintenance regime serves to protect the investment made in roads assets[3]. In cases where assets are constructed by a third party and later vested with a local authority, a well-developed maintenance strategy prevents premature failure of the assets, and the resultant expenditure to the local authority.

3.4.10 Where SUDS features are not maintained they can become unsightly, and any amenity benefits which were intended during design may be lost. Similarly, while wildlife will investigate and annex new habitats, certain animal species may abandon or fail to survive in unmaintained areas.

3.4.11 Within the suite of SUDS features available there are systems which not only improve water quality, but aid mimicking the pre-development hydrograph. Any flood risk mitigation characteristics a system may possess will be lost in time where the system is not suitably maintained.

MAINTENANCE – WHEN?

3.4.12 Following practical completion of road construction, a one year defects liability period is entered into, during which maintenance and defect repairs are undertaken by the owner, prior to adoption by the roads authority.

3.4.13 During the defects liability period and following adoption, inspections of the roads SUDS should be carried out on a monthly basis, or after a severe rainfall event as part of a tailored monitoring framework. These will enable the owner to:

- Become familiar with the operation and performance of the system
- Address any construction or emerging defects, and
- Identify any initial maintenance that is required

3.4.14 A tailored monitoring framework should be sufficiently flexible to allow inspections to take place during inclement weather when the real-time performance of a system may be evaluated.

3.4.15 After an initial period, the long term schedule for visits for maintenance should be established based on the outcomes of previous inspections and maintenance. Consider two illustrative scenarios:

- A particular system may be prone to accumulating litter. If remedial measures cannot address this issue, inspection and maintenance will require to be more frequent to ensure the system performs satisfactorily.
- Another system is found to be performing well, with little sediment discharging into the feature and well established species of grass and planting with a slow rate of growth. In this case the interval between visits may be extended progressively.

3.4.16 Where tried and tested SUDS solutions are constructed, the monitoring framework developed for previous schemes may be used as a basis for monitoring new installations.

3.4.17 The Figure 3.9 flowchart indicates in outline how a tailored maintenance schedule may be developed.

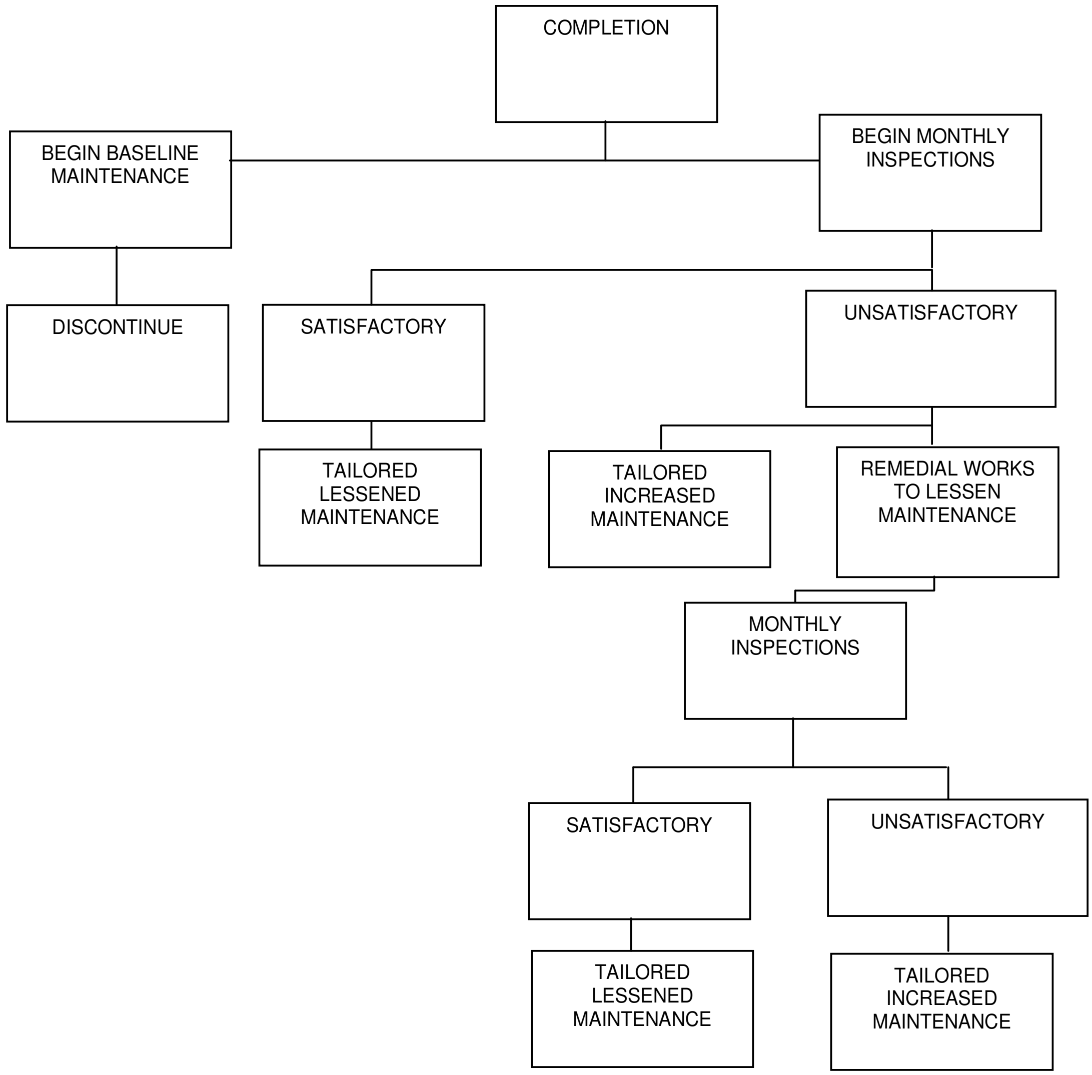


Figure 3.9 Tailored Maintenance Flowchart

3.4.18 At any time during the lifespan of a drainage system events may occur which would trigger an additional inspection. Any event with significant potential to adversely affect water quality or the integrity of the system will be a trigger for an additional inspection. Examples include:

- Immediately following a serious road traffic accident
- Immediately following the spillage of chemicals or fuels, or the use of fire fighting foams
- Immediately after collision or impact with the elements of the drainage system

3.4.19 The Figure 3.10 flowchart illustrates the sequence of events associated with an additional inspection.

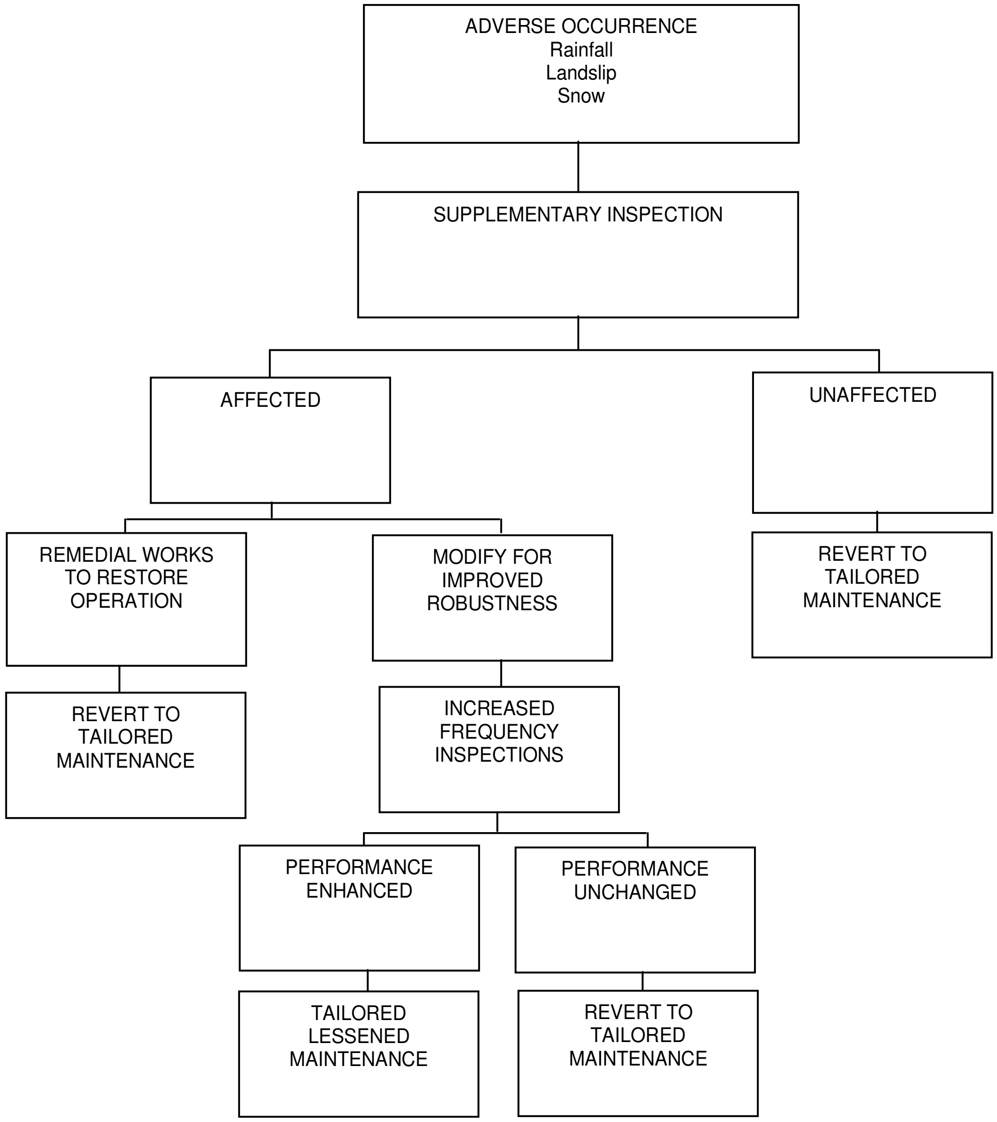


Figure 3.10 Sequence of Events Associated with an Additional Inspection

3.4.20 During the summer months, when water levels may be below designed levels ponds, wetlands and swales should be monitored to determine if irrigation or watering of plants is necessary.

3.4.21 Where construction is due to commence within the catchment of a SUDS feature, an inspection of the condition of the system should be undertaken. Similarly, where construction traffic is anticipated to exit a site onto a road draining to SUDS, the condition of the system should be recorded in advance.

3.4.22 Where the tailored inspection and maintenance regime indicates that long intervals may elapse between visits, the visits should be timed to take place shortly in advance of autumn.

3.4.23 Innovative solutions may require higher levels of monitoring and maintenance to comply with the manufacturer's specification. Even where a manufacturer makes specific recommendations, a tailored maintenance and monitoring framework should be developed. This will require continued dialogue with the manufacturer, and will be especially necessary where a system is warranted.

MAINTENANCE – WHO?

3.4.24 It will be the responsibility of the owner of the system to demonstrate that inspections, and maintenance, are being performed. This could be demonstrated by submission of a brief report after each inspection. The report should indicate the date of the inspection, its findings (including dated photographs), details of any maintenance performed, and the rationale for future variation of the monitoring framework.

3.4.25 Where there are doubts over ownership a lack of maintenance will often result. Ownership of the road SUDS features should be agreed during the evaluation stage of SUDS selection.

3.4.26 Adopting authorities should, wherever possible, share SUDS maintenance resources which will increase cost efficiencies and increase the knowledge base, and experience.

3.4.27 Further information on adoption responsibilities is provided in Chapter 4 Strategy for Adoption.

TYPICAL INSPECTION CHECKLIST

3.4.28 In this section a non-exhaustive list of inspection items are identified. This may be used and expanded by owners to develop bespoke checklists for specific installations, enabling the efficiency and general health of a SUDS feature to be assessed.

3.4.29 Inspect for:

- Blockages to outlets, filters and screens; manually wash filters periodically
- Invasive species of weed; arrange for removal and replacement with intended flora
- Balding spots within grass cover; renew grass and protect until established, consider the cause of the balding
- Erosion of side slopes and base; renew profile and revegetate immediately, consider stabilisation with erosion control mulch or biodegradable matting
- Signs of soil slumping; renew profile and ensure proper compaction of suitable sub soils, re-vegetate immediately
- Signs of burrows; record, consider whether damage to liners, etc may be occurring
- Signs of leaks; consider effect and remediate if necessary
- Disrupted or missing rock lining or rip-rap; replace, consider cause of disruption
- Sedimentation indicative of ponding on permeable block pavers; monitor, clean and restore permeability
- Deterioration of emergent and perimeter shoreline vegetation; treat and revegetate, consider choice of species
- Debris and accumulated litter; remove at each inspection and prior to mowing.
- Woody and overtaking vegetation; trim and prune all vegetation, including grass
- Excess sediment; remove accumulations, in particular near to culverts and channels
- Structural integrity of headwalls, chambers, grilles, etc; maintain urgently and immediately where a risk to Health & Safety exists

A well designed SUDS feature, which receives tailored maintenance and monitoring may be expected to be as durable as a traditional system of roads and drainage.

MAINTENANCE TO SPECIFIC SUDS FEATURES

3.4.30 Surface courses formed using permeable block paving require periodic maintenance to restore the permeability of the surface. The intervals for carrying this out will be determined through regular inspections but can be expected to be in excess of 10 years. In some places systems have been seen to operate for more than 20 years[4].

3.4.31 Research has shown that the performance of permeable block paving is influenced by its age through clogging of the joints and openings. Figure 3.11 presents the service life of permeable block paving over a 10 year period. The graph indicates that over a ten year period the infiltration rate reduces to approximately 25%, from an initial rate of 5000 l/s/ha to approximately 1300 l/s/ha.

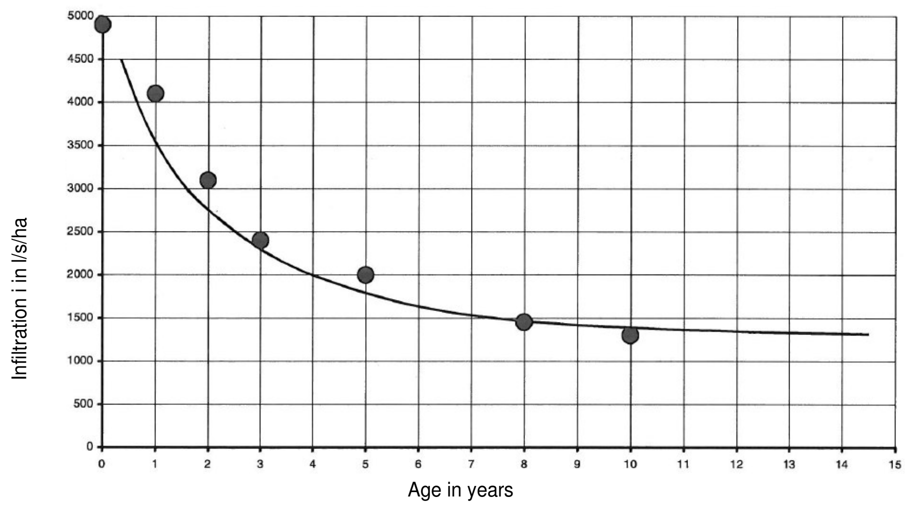


Figure 3.11 Infiltration Performance of Permeable Block Paving[8]

3.4.32 American and German experience recommends that the design infiltration rate through the surface of permeable block paving should be 10% of the initial design rate, typically 4000 mm/hour, to take account of the clogging effect over a 20 year design life[9], to reduce maintenance requirements.

3.4.33 There are no known examples where porous asphalt has been adopted by roads authorities in Scotland. Overseas experience shows that unclogging of porous road surfaces requires a combination of both high-pressure water cleaning and vacuum sweeping to restore drainage capacity, with a recommended frequency of a minimum of four times annually.[10]

3.4.34 Filter drains require frequent maintenance and offer only limited attenuation[5]. Where the inlet to a filter drain is an exposed surface at ground level, the surface material must be kept loose and clear of debris and sediment. It will not be sufficient simply to rake and loosen material inundated with sediment as this will allow sediment to penetrate further into the filter media, and lessen water quality.

3.4.35 Bioretention areas require frequent maintenance initially. However, over time their need for maintenance reduces to a level similar to the routine periodic maintenance required of any landscaped area. This will maintain the appearance of the treatment area and its ability to infiltrate surface water, and will include (1) pruning of trees and shrubs, (2) weeding, and (3) mulch replacement.

3.4.36 The harvesting of plants from wetlands should occur before the plants begin to transfer phosphorus from their foliage to below ground roots, or begin to lose metals that desorb during plant die-off. Vegetation should be cropped near to the end of each growth season to capture the nutrients and pollutants removed by the wetland vegetation[10].

3.4.37 The maintenance objectives for vegetated swales include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover. Grass height and mowing frequency may not have a large impact on pollutant removal[11]. Consequently, maintenance for hydraulic purposes may only be necessary once or twice a year however maintenance for safety or aesthetics or to suppress weeds and woody vegetation may be more frequent.

3.5 REINSTATEMENT GUIDELINES/ REMEDIAL MAINTENANCE

3.5.1 Over time there is likely to be a requirement to undertake remedial maintenance to the road and its drainage. The remedial maintenance measures associated with conventional roads and drainage typically include:

- Replacement of surface course
- Repairs to potholes
- Replacement of damaged kerbs
- Re-set displaced kerbs
- Replace damaged drainage covers
- Clean blocked drainage features
- Landscape replacement
- Repairs to road markings and street furniture

3.5.2 Equally, there will also be a requirement to undertake remedial maintenance to SUDS components associated with road drainage. These will typically be required between 10 and 25 years depending on specific site factors such as sediment load. With the exception of removal of sediments and hydrocarbons, the majority of the remedial maintenance measures are linked to landscape management/ replacement.

3.5.3 From time to time some partial reinstatement of the SUDS may also be required. For example, it may be necessary to lift and replace or relay permeable block paving on rare occasions when, even following regular maintenance, the bedding media may become excessively congested with sediment.

3.5.4 When replacement of filter drain media is required, the replaced media should be recycled. In addition, the permeability of the surrounding soils may be recovered by increasing the size of the trench by 50mm in each available direction.

3.5.5 The remedial maintenance associated with the SUDS components described in Chapter 2 is outlined in Table 3.2.

SUDS components	Remedial maintenance
Filter Strips	■ Repair Eroded areas ■ Re-level/ reinstate design levels ■ Remove build up of sediment ■ Remove hydrocarbon residues
Pervious Pavements – Permeable block	■ Rehabilitate surface and filter media ■ Repairs to depressions and rutted areas ■ Remediate landscaping to prevent eroded soils clogging pavement
Swales	■ Repair Eroded areas ■ Re-level/ reinstate design levels ■ Remove build up of sediment ■ Remove hydrocarbon residues
Filter drain/ infiltration trench	■ Clear pipework blockages ■ Replace geotextile ■ Rehabilitate filter media ■ Repairs to inlets and outlets
Bioretention	■ Replacement of vegetation damaged or covered with silt ■ Repair eroded areas ■ Replace damaged or diseased landscaping ■ Remove silt accumulations
Ponds	■ Repair eroded areas ■ Repair inlets, outlets and overflows ■ Replacement landscaping
Basins	■ Repair eroded areas ■ Repair inlets, outlets and overflows ■ Re-level/ reinstate design levels
Infiltration basins	■ Repair eroded areas ■ Repair inlets, outlets and overflows ■ Re-level/ reinstate design levels ■ Rehabilitate infiltration by scarifying/ spiking
Wetlands	■ Repair eroded areas ■ Repair inlets, outlets and overflows ■ Supplement plants
Sand filter	■ Repair of eroded areas ■ Replace clogged filter bed ■ Repairs to inlets and outlets

Table 3.2 SUDS Components Remedial Maintenance

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4 Procedure for Adoption

CHAPTER AIMS

- The aim of this chapter is to explain the adoptive status of SUDS features, the effect this has on their selection and how to get them adopted.
- Information on the current status of legislation governing adoption in England, Wales and Northern Ireland are included for reference.

4.1 LEGISLATION AND STATUTORY OBLIGATIONS

REVIEW OF EXISTING AND POTENTIAL FUTURE LEGISLATION

Roads

Roads (Scotland) Act 1984

4.1.1 Road construction is controlled by a process of construction consent as described in Section 21 of the Roads (Scotland) Act 1984. Procedures for application for Road Construction Consent (RCC) are generally described in guidance prepared by each local authority. The RCC application is made by persons other than the roads authority who wish to construct a road that will become adopted by the roads authority

4.1.2 The purpose of RCC is to ensure the road is constructed in accordance with the roads authority development guidelines and to protect the future maintenance liabilities of roads authorities. For residential development, a roads authority is protected against non-completion by the requirement for the developer to post a Road Bond, either in a cash sum or a security by an acceptable institution, for an amount sufficient to meet the construction cost of the road(s) outlined in the consent. The value of the Bond is determined by the roads authority, and must be deposited with the roads authority prior to commencement of house building.

4.1.3 All roads that are constructed to an RCC are private roads with public right of passage. Adoption can only take place when the developer offers the road for adoption and when the roads authority agree that all necessary remedial works have been carried out to the roads authority satisfaction.

4.1.4 Road Construction Consent is separate from Planning Permission and most developments, where a road is to be constructed, will require both.

4.1.5 The local authority may require confirmation for ongoing maintenance of SUDS features associated with new roads. It may be possible to combine roads SUDS with general SUDS for the development (roof water, hard standings, etc) where these are provided*. All SUDS that drain potentially publicly adopted roads should be maintained by the Roads Authority or Scottish Water, once adopted or vested by that body.

* If a Sewerage (Scotland) Act 1968 Section 7 Agreement is in place. See §4.4 for further details.

Planning

4.1.6 The application of SUDS techniques is a condition of planning.

Town & Country Planning (Scotland) Act 1997

4.1.7 The Town and Country Planning Act 1997 sets the planning context for new development and redevelopment of existing properties/ facilities.

4.1.8 *'This Act is the basis for the planning system and sets out the roles of the Scottish Ministers and local authorities with regard to development plans, development control and enforcement. The Planning etc. (Scotland) Act 2006 was an amending act and the 1997 act, although substantially amended, remains the principal piece of planning legislation.'*[1]

<u>Planning etc (Scotland) Act 2006</u>

4.1.9 The Planning etc (Scotland) Act 2006 seeks to modernise the planning process in Scotland. This Act replaces and amends sections of the 1997 Act.

4.1.10 The 2006 Act emphasises the responsibility of ministers and local authorities to contribute to sustainable development.

4.1.11 A 'Brief Guide' to the 2006 Act is available from the Scottish Government website (www.scotland.gov.uk/Publications/2007/03/07131521/0)

<u>PAN 61: Planning and Sustainable Urban Drainage Systems</u>

4.1.12 PAN 61: Planning and Sustainable Urban Drainage Systems was published in July 2001.

4.1.13 *'Sustainable development implies taking a multidisciplinary approach to address the many diverse and complex issues in the development process. One of these issues is surface water drainage. To provide Sustainable Urban Drainage Systems (SUDS) requires a number of disciplines and agencies (developers, planners, drainage engineers, architects, landscape architects, ecologists and hydrologists) to work in partnership. Planners have a central co-ordinating role in getting SUDS accepted as an integral part of the development process. Planning policy should set the framework in structure and local plans and in masterplanning exercises. In implementing SUDS on the ground, planners have a key role through the development control process, from pre-application discussions through to decisions, in bringing together the parties and guiding them to solutions which can make a significant contribution to sustainable development.'* (Para 1 from Introduction)

<u>PAN 79: Water and Drainage</u>

4.1.14 PAN 79: Water and Drainage was published in September 2006.

4.1.15 '*The purpose of this Planning Advice Note (PAN) is to provide advice on good practice in relation to the provision of water and drainage in a planning context. It encourages joint working in order to ensure a common understanding of any capacity constraints and agreement on the means of their removal. The PAN explains the framework within which Scottish Water provides and contributes to new water infrastructure and contains advice on the appropriateness of private schemes. It clarifies the role of the planning authority in setting the direction of development to inform the planning and delivery of new infrastructure in a coordinated way. It also highlights the respective roles of Scottish Water and the Scottish Environment Protection Agency (SEPA), indicating when and how they should interact with the planning system.'* (Para 3 from Introduction)

4.1.16 Paragraphs 47-49 deal specifically with SUDS.

<u>Building (Scotland) Regulations 2004</u>

4.1.17 Where SUDS features lie within private land and serve only one property (or a number of buildings under single ownership) then they will generally remain in private ownership. In this case responsibility for maintenance, etc. lies with the owner. In these circumstances they will generally have to comply with the requirements of the Building (Scotland) Regulations 2004.

4.1.18 The 'Environment' sections of both the 2007 Domestic and Non-domestic Handbooks (section 3) give requirements for building drainage. Section 3.6 deals with surface water drainage and paragraph 3.6.4 deals specifically with SUDS.

4.1.19 Note: Paragraph 3.6.5a states: *'… trial holes and finished soakaways should be a minimum of 5m from the dwelling and the boundary.'* Some slight relaxation of this figure may be possible on small sites with appropriate ground conditions.

Flood Risk Management (Scotland) Bill

4.1.20 The Flood Risk Management (Scotland) Bill makes provision in relation to the following areas: coordination and cooperation within the domain of flood risk management; assessment of flood risk and preparation of flood risk maps and flood risk management plans; amendments to local authority and SEPA functions for flood risk management; a revised statutory process for flood protection schemes, and amendments to the enforcement regime for the safe operation of reservoirs.

Water

Sewerage Scotland Act 1968

4.1.21 This Act established the duties on local authorities for the provision, construction, adoption and maintenance of sewers and sewerage systems. It defined the rights of owners to connect and the methods of control of discharges to the sewer system. In 1975 the new Regional and Islands Council's took over this responsibility from the local authorities. Following the disbandment of the Regional Councils in 1995, three larger Water Authorities (East, West and North) were established. At each of these changes, the new authority undertook the duties defined in the 1968 Act.

Water Environment and Water Services (Scotland) (WEWS) Act 2003

4.1.22 The WEWS Act transposes the Water framework Directive (Directive 2000/60/EC) into Scots Law.

4.1.23 This Act requires the control of:

- Point source discharges and diffuse sources liable to cause pollution
- The abstraction of water from the water environment
- The impoundment of surface water
- Alterations to the structure and condition of surface water habitats
- Artificial recharge or augmentation of groundwater

4.1.24 Sections 29, 30 and 33 of the WEWS Act amend the Sewerage Scotland Act 1968 and the Water Industry (Scotland) Act 2002 to include for the connection and adoption of SUDS by Scottish Water.

Sewers for Scotland 2nd Edition)

4.1.25 Sewers for Scotland 2nd Edition specifies Scottish Water's requirements for adoptable sewerage systems. Section 2B of this document describes SW's requirements for SUDS systems.

Environment

Environment Act 1995

4.1.26 Schedule 6 of the Environment Act 1995 establishes the status and constitution of SEPA. Further sections of the Act establish SEPA's role and responsibilities.

4.1.27 Since its creation SEPA has also been granted powers under other legislation, e.g. WEWS Act 2003.

4.1.28 Best Practice Management for Surface Water was first introduced in Scotland in the mid 1990's by the then Forth River Purification Board. Since this time the emphasis of SUDS in Scotland has been on improving water quality, unlike England & Wales where the emphasis has been on attenuation.

4.1.29 Since its inception in 1995 SEPA has worked to promote these measures, further developing SUDS ethos and practice.

Water Environment (Controlled Activities)(Scotland) Regulations 2005

4.1.30 The CAR Regulations (made under powers granted by Section 20 of the WEWS Act) supersede SEPA's policy 15 which previously stated the requirement for SUDS and those circumstances where discharge consent was required.

4.1.31 The CAR regulations identify those situations where SUDS are necessary and where specific licensing is required to permit work close to or within controlled waters. Guidance on the application of the CAR Regulations can be found in SEPA's document 'A Practical Guide' (at version 5 dated June 2008 at time of writing).

ENGLAND AND WALES

Roads

4.1.32 In England and Wales adoptable road construction is controlled by agreement in accordance with Section 278 of the Highways Act 1980.

4.1.33 Private roads are much more common in England and Wales than in Scotland. Usually these are the responsibility of the adjacent land owner. Often they are managed by a co-operative of owners/ residents.

4.1.34 The design, adoption and maintenance of SUDS for trunk roads fall under the responsibility of the appropriate trunk road authority.

Highways Agency

4.1.35 The Highways Agency is the Trunk Road Authority for England.

Wales

4.1.36 There are three Trunk Road Authorities covering North, Mid and South Wales respectively.

Planning

Town and Country Planning Act 1990

PPS25: Development and Flooding

Water

<u>Water Bill 1973</u>

4.1.37 Created 10 Regional Water Authorities

<u>Water Act 1989</u>

4.1.38 Allowed English and Welsh local authorities to sell off their water companies.

<u>Water Industry Act 1991</u>

4.1.39 Deals with the appointment and regulation of water undertakers, the duties of water companies with regard to water supply and sewerage services, financial provisions, powers and provision of information.

<u>Water Companies</u>

4.1.40 There are currently 10 water and sewerage companies operating in England and Wales. There are a further 14 companies who deliver water services only.

4.1.41 Information on these companies can be obtained from www.water.org.uk.

Environment

4.1.42 Environment Agency is an Executive Non Departmental Public Body responsible to the Secretary of State for Environment, Food and Rural Affairs and an Assembly Sponsored Public Body responsible to the National Assembly for Wales.

4.1.43 EA policy is to *'promote SUDS as a technique to manage surface and groundwater regimes sustainably.'*

4.1.44 Discharges to rivers, watercourses, other surfacewaters, groundwater, tidal waters or the sea may require discharge consent in accordance with Water Resources Act 1991 and Groundwater Regulations1998.

NORTHERN IRELAND

Roads

4.1.45 Roads Service is responsible for almost all roads in Northern Ireland.

4.1.46 Roads Service is an executive agency within the Department for Regional Development (DRD). Its responsibilities include: taking measures to implement the Regional Transportation Strategy for Northern Ireland 2002-2012; and managing, maintaining and developing the public road network (including its drainage systems).

4.1.47 Roads Service has experience of the design and operation of SUDS on a number of major new schemes that have had a measure of success in dealing with drainage issues.

4.1.48 The proposed strategy confirms that Roads Service will continue to implement SUDS to control runoff from new and significant highways.

4.1.49 Roads (Northern Ireland) Order 1993 (NI 15)

Planning

4.1.50 Planning Service is an agency of the Department of Environment (DOE). It is responsible for regulation of development and land-use. It also sets and monitors planning policy.

PPS 15 Planning and Flood Risk

4.1.51 Appendix C of PPS 15 Planning and Flood Risk describes SUDS measures, recognises their potential benefits, discusses constraints and refers to the SUDS Working Party (see below), but makes few definitive recommendations.

Water

4.1.52 Northern Ireland Water was formed on 1 April 2007 to manage the water resource and provide sewerage for Northern Ireland.

Water and Sewerage Services (Northern Ireland) Order 2006 (N.I.21)

4.1.53 This Order establishes the structure and responsibility for the provision of water and sewerage services within Northern Ireland.

Environment

4.1.54 Northern Ireland Environment Agency (NIEA) is an agency of the Department of Environment. It advises on and implements environmental policy and strategy. It also regulates discharges to watercourses

4.1.55 Rivers Agency is an agency of the Department of Agriculture and Rural Development. It is the statutory drainage and flood defence authority for Northern Ireland. It too regulates discharges to watercourses. It designs, constructs and maintains flood defences. It provides drainage infrastructure

Northern Ireland Sustainable Drainage Systems Working Party

4.1.56 The Northern Ireland Sustainable Drainage Systems Working Party has been developing a strategy for promoting the wider use of SUDS techniques in Northern Ireland.

4.1.57 This working party is chaired by Northern Ireland Environment Agency and including representatives of Northern Ireland Water Ltd (NIW), DRD Roads Service, DOE Planning Service, Department of Agriculture and Rural Development (DARD) Rivers Agency, Northern Ireland Housing Executive (NIHE), DOE Planning and Environmental Policy Group (PEPG), Department of Finance and Personnel DFP Central Procurement Directorate, the Agri-Food & Biosciences Institute (AFBI) and Belfast City Council.

4.2 PROCEDURE GUIDANCE

4.2.1 The procedural stages which are required are outlined in Figure 4.1.

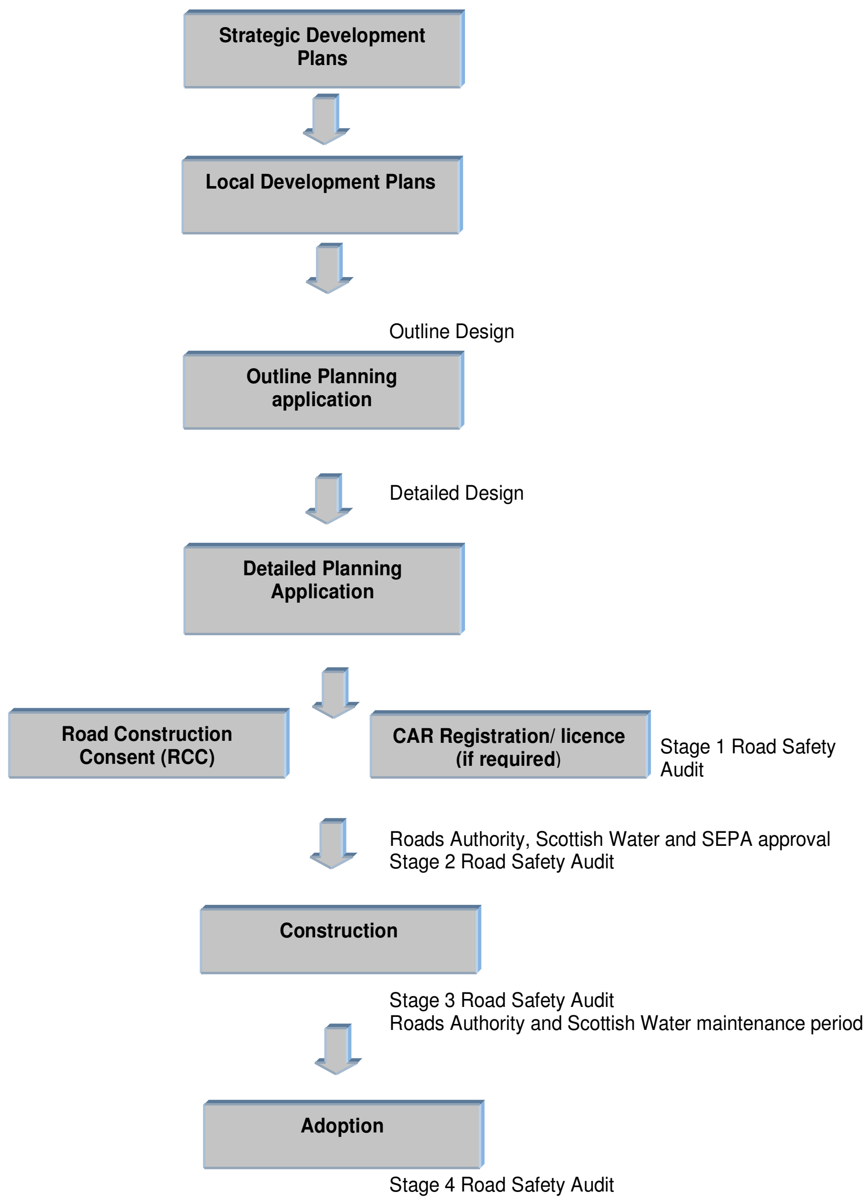

Figure 4.1 Flow Chart for Procedural Practice

STRATEGIC DEVELOPMENT PLANS

4.2.2 Strategic development plans will be prepared by Strategic Development Planning Authorities, and set out a clear vision and spatial strategy for their area. They will focus on key land use and development matters that cross planning authority boundaries. They will continue to form part of the statutory development plan, but need not contain long lists of policies. Local development plans sit below strategic development plans and provide specific detail on issues specific to the local area.

LOCAL DEVELOPMENT PLANS

4.2.3 The term local development plan is used in the Planning etc (Scotland) Act 2006 to describe a plan which covers an area entirely within the boundary of a local authority for which it sets the detailed planning policy and specific development objectives[2].

4.2.4 The Act requires that the local development plan sets out[2]:

- A spatial strategy, i.e. a detailed statement of the planning authority's policies and proposals for the development of land in the area covered by the plan
- Any other matters that may be prescribed by Scottish Ministers
- Any other matters the planning authority consider appropriate

4.2.5 The six key elements of the local development plan are:

- Development plan scheme
- Main issues report
- Proposed plan
- Amended proposed plan
- Adopted plan
- Action programme

PLANNING APPLICATIONS

4.2.6 Prior to submitting a planning application the applicant should consult with the local authority planning officer to determine the issues and views that the council will take into consideration when reviewing the application and reaching their decision. This is referred to as 'pre-application consultation'.

4.2.7 The pre-application consultation will reveal if further supporting documentation is required with the planning application. Similarly the outcome of this pre-application consultation may indicate that further discussions are required with other key stakeholders, for example where there is a risk of flooding, or the site has environmental designations such as Special Areas of Conservation. The RCC engineer should be involved at this stage of the process.

4.2.8 Forms required for the submission of a planning application can be downloaded from the local authority website, together with guidance on the completion of the forms and scale of fees appropriate to the type and scale of development.

4.2.9 Once the application has been lodged the local authority review the application and issue a Decision Notice normally within two months of the application validation date. In some instances the application for RCC may not be reviewed by the roads authority until planning permission has been granted.

ROAD CONSTRUCTION CONSENT (RCC)

4.2.10 Section 21 of The Roads (Scotland) Act 1984 provides a regime which enables parties to apply to the roads authority to construct a road. The various stages associated with the RCC process are outlined below, the principles of which should have been established at the planning stage:

- Design – preparation of designs and layout drawings which meet the design criteria requirements of the roads authority development guidelines. At this stage of the process, the levels of treatment and selection of SUDS components would be agreed
- Application – the Road (Scotland) Act 1984 requires the application be in such a form that it may be determined by the roads authority. At this time notification to all owners of adjacent land and other such persons as the authority may specify requires to be made by the applicant, which allows representation to be made within 28 days by those duly notified
- Determination – the Roads (Scotland) Act 1984 does not set out criteria against which an application is assessed. The determination process is assisted by the standards adopted by roads authorities within their development guidelines
- Security for private roads – Section 17 of the Roads (Scotland) Act 1984 makes provision for the requirement of a road bond, to be deposited, to meet the road construction costs, in relation to construction and adoption of roads associated with residential development. The Road Bond is to be reduced when certain stages of road construction have been reached as specified in the Security for Private Road Works (Scotland) Regulations 1985 and the Security for Private Road Works (Scotland) Amendment Regulations 1998
- Construction – the roads authority has a very clear interest in ensuring that the constructed road under a RCC is suitable for adoption. The roads authority will periodically inspect the road during construction, and also when they have been advised that construction is complete, when they will issue a defects list of remedial works required prior to the commencement of the maintenance period
- Private maintenance – this is undertaken by the developer for a defects liability period of 1 year, after which an inspection is carried out by the roads authority to ensure any defects have been made good
- Adoption – following completion of any remedial works on reported defects to the satisfaction of the roads authority the road is added to the register of public roads under clause 16.2 of the Roads (Scotland) Act 1984
- Public Maintenance – following adoption the maintenance and public liability burden associated with the road rests with the roads authority

CONTROLLED ACTIVITIES REGULATIONS (CAR)

4.2.11 In most circumstances it is likely that the provision of SUDS as roads drainage will be covered by General Binding Rules (GBRs), representing the lowest form of control. However, discharges of surface water from the following activities require a higher level of authorisation, a simple licence:

- Motorways/ trunk roads where any one outfall drains a length >1km
- More than 1000 car parking spaces
- More than 1000 houses
- Industrial estates including marshalling yards, lorry parks and distribution depots, but not low risk developments comprising one or several small units

4.2.12 Applications for a simple licence level authorisation to carry on controlled activities require to be made in writing to SEPA with the appropriate fee and information SEPA may require to process the application. The time period for determination of a simple licence application is four months.

4.2.13 Application forms, details of the charging scheme and practical advice on the Water Environment (Controlled Activities) (Scotland) Regulations 2005 can be found on SEPA's website www.sepa.org.uk

4.3 MAINTENANCE RESPONSIBILITIES AND LIABILITIES

OVERVIEW OF CURRENT POSITION

4.3.1 Until the recent changes implemented through the WEWS Act as described in paragraph 4.1.24 the position regarding adoption of SUDS was very unclear. In most cases neither Scottish Water, nor local authorities consider the adoption of SUDS to be their responsibility. This led to developers employing private maintenance companies to maintain these areas on their behalf.

4.3.2 The previous lack of clear guidance on responsibilities for SUDS in roads has led to inconsistencies and regional variations in adoption policy.

4.4 SECTION 7 AGREEMENTS (SCOTLAND)

4.4.1 The legal framework for the management of surface water in Scotland means that the most effective way to properly implement surface water management for developments is through agreements between the Local Authorities and Scottish Water.

4.4.2 Section 7 of the Sewerage Scotland Act 1968 makes provision for Scottish Water to enter into agreement with the Roads Authority to allow the use of their sewers for the conveyance of water from the surface of a road or to allow the use of road drains for the conveyance of surface water from premises.

4.4.3 This agreement, called a Section 7 Agreement, is intended to provide confidence to both parties that the activities carried out by the one do not have a negative impact on the assets belonging to the other by including the requirement to provide the necessary attenuation and treatment for each of their drainage activities and thereby ensure that development is not constrained by an inability to effectively drain an area.

4.4.4 Scottish Water, in collaboration with the Society of Chief Officers of Transportation in Scotland (SCOTS), has formulated a mutually acceptable document. A sample of the Minute of Agreement can be found in Appendix D.

4.4.5 However, it is recognised by both parties that each Local Authority may seek to amend the terms contained within the model document in keeping with each authority's legal interpretation.

4.4.6 It is intended that any Section 7 agreement will contain the general terms for a single authority wide agreement between Scottish Water and each Road Authority.

4.4.7 Individual developments will have an associated schedule which will refer to the terms of the agreement and contain site specific details, determined at officer level, of the ownership and maintenance arrangement for the entire development drainage system.

4.4.8 This guidance promotes the model Section 7 Agreement as developed by representatives of central and local government bodies for use in negotiations between respective authorities to facilitate the adoption and management of public infrastructure.

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1. Scottish Parliament. (2007). *Scottish Parliament Information Centre (SPICe) briefing 07/19, 27 April 2007: SB 07-19 Town and Country Planning Subject Profile,* Scottish Parliament. Edinburgh.

2. Scottish Parliament. (2006). *Scottish Parliament Information Centre (SPICe) briefing 06/08, 16 January 2006: SB 06-08 Planning Etc. (Scotland) Bill: Local Development Plans*, Scottish Parliament. Edinburgh.

5 Un-adopted SUDS and Retrofitting

CHAPTER AIMS

- Outline the criteria for selection and implementation of improvements to legacy SUDS and retrofitting SUDS to existing conventional roads drainage
- Describe the options available and benefits

5.1 BACKGROUND

5.1.1 The Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) research project 'Retrofitting Sustainable Urban Water Solutions' (2006)[1] defines 'retrofit SUDS' as follows:-

> ***'...to mean an existing drainage system which has been modified to include any number of sustainable drainage features that result in modifications to the hydraulic regime and/or improvements to water quality.'***

5.1.2 SUDS features are a requirement for all new developments, to deal with surface water runoff, improving water quality and reducing the risk of flooding.

5.1.3 The historical, pre-SUDS, development of drainage networks in Scotland and the UK has resulted in drainage capacity issues and diffuse pollution affecting watercourses and water quality. This pollution may be caused by the following:-

- Contaminated runoff from urban hard surfaces, routed by drainage systems, polluting watercourses
- Overloaded combined sewerage spilling foul sewage into watercourses, via combined sewer overflows (CSOs), during extreme storm events. This is termed an 'unsatisfactory intermittent discharge' (UID)

5.1.4 The European Union Water Framework Directive (European Commission, 2000)[2] sought to provide a framework for protection of the water environment and reduction in diffuse pollution.

5.1.5 The Water Environment and Water Services (Scotland) Act 2003[3] was written as a direct consequence, seeking to address the issues concerned, provide a Scottish context and transpose The Water Framework Directive into Scots law.

5.1.6 It is this legislation that provides the key driver for addressing the problem of diffuse pollution, requiring consideration of all possible alternatives to achieve this aim.

5.2 SCENARIOS

UN-ADOPTED SUDS

5.2.1 The recent introduction of Sewers for Scotland 2nd Edition[4] covers the legislation described above and includes sections detailing SUDS features and providing guidance for their design. This design guidance was intended to provide the basic requirements to allow adoption and vesting of SUDS by Scottish Water.

5.2.2 Although Scottish Water, and their predecessors, have in the past adopted and taken responsibility for maintenance of SUDS, this has been on an individual basis, dependent on particular site characteristics. These inconsistencies were attributable to lack of clear understanding of adoption responsibilities.

5.2.3 Previous design guidance has not covered adoption, beyond conventional sewerage/pipework. This, coupled with a reluctance to take on the maintenance burden for SUDS features where there was limited knowledge and experience of long term liabilities, had generally resulted in SUDS features not being adopted.

5.2.4 Similarly local roads authority development guidelines have not covered road drainage generally beyond gullies and spacing requirements.

5.2.5 Consequently there are a great number of SUDS features that have been installed historically where responsibility remains with the owner rather than a public body. In certain cases, a landscape/ maintenance company or other factoring agency are employed to maintain the SUDS features on behalf of the owner.

5.2.6 Although a developer or other party may be responsible for a SUDS feature, this does not mean that there is a structured programme of maintenance in place. The net result of this is that maintenance may only be carried out following the emergence of a problem in the system, rather than proactively.

INTRODUCTION OF SUDS INTO EXISTING ROADS

5.2.7 The historical development of road drainage networks has followed the principle of conveying water as quickly as possible away from the road to mitigate the perceived risk of deterioration in strength of the subgrade.

5.2.8 Although the implementation of SUDS as part of new developments can assist in reducing the risk of flooding and improve water quality in receiving watercourses and sewers, existing road drainage systems also need to be considered in this context. This is the principle objective of retrofitting SUDS to existing roads.

5.2.9 Opportunities for SUDS retrofit are noted in the Environment Agency research project 'Cost-benefit of SUDS retrofit in urban areas' (2007)[5]. The most likely occasions where retrofitting into an existing road drainage system could be considered to be practical are:

- During road reconstruction/resurfacing schemes
- During large scale drainage improvement schemes
- Increased residential expansion in urban and rural schemes

5.3 APPLICABILITY

GENERAL

5.3.1 There are various matters that need to be considered in assessing the applicability of modification of un-adopted SUDS and retrofitting SUDS to existing road drainage.

5.3.2 Generally for historical developments, which incorporate SUDS features, the contributing area into the SUDS will be from roofs, parking/driveways, roads, footways, and hardstanding areas. This includes both publicly adopted areas and private property.

5.3.3 It is this combination of public and private contributing catchment areas that requires careful consideration when proposing modification to un-adopted SUDS and retrofitting SUDS into existing roads.

UN-ADOPTED SUDS

5.3.4 It may not be appropriate to connect additional road drainage into unadopted SUDS, unless consideration has been given to the impact of additional flows on the existing size of the feature and its downstream outflow control.

5.3.5 The area for improvement, and essentially the application of un-adopted SUDS for roads, is the arrangement for formal adoption of SUDS by a public body. This will allow for a structured programme of maintenance to be put in place.

RETROFITTING

5.3.6 Sewers for Scotland 2nd Edition makes no reference to the retrofitting of SUDS. The applicability of retrofitting of SUDS to existing roads has, however, been assessed in recent research undertaken in general on SUDS retrofit.

5.3.7 The following SUDS features, depending on site conditions/constraints, are considered suitable for retrofit application:-

- Basins
- Ponds
- Infiltration trenches
- Filter drains
- Filter strips
- Swales
- Permeable surfaces

5.3.8 The above choices are also identified in a research project completed by Swan and Stovin (2002)[6] aimed at guiding the practitioner on possible retrofit options and advising where relevant guidance may be found.

5.3.9 It is recognised that the retrofitting of SUDS is a complex subject with various factors and issues involved.

5.3.10 The SNIFFER research project ‘Retrofitting Sustainable Urban Water Solutions’ (2006)[7] looked at the prospects of retrofitting SUDS on Houston Industrial Estate, West Lothian and outlined experience gained and lessons learned in SUDS retrofitting.

> During this project it was determined that, even before a decision is made to retrofit SUDS, a decision making methodology is required to provide guidance and to ensure that any decision to install a SUDS retrofit is fully justified.

5.3.11 Previous research has not specifically covered the application of SUDS retrofit to roads. The following list of issues should be considered for any scheme. This list is not exhaustive as particular site factors may require consideration of other issues:-

Issues to be considered in retrofitting

SUDS to roads

- Classification/standard of road/footway
- Rural/urban setting
- Traffic usage
- Verge/land ownership
- Available outfall
- Accessibility
- Stakeholders involved
- Existing road flooding
- Utilities
- Road vertical alignment/ crossfall
- Adjacent topography
- Soil type/permeability
- Traffic management
- Scheme costs (construction and operation/maintenance)
- Scheme performance
- Ownership and adoption
- Public amenity and biodiversity
- Safety

5.3.12 The particular weighting of each item, when considering a road for retrofitting, can only be evaluated on a site by site basis, based on a risk/ benefit analysis.

5.3.13 Examples of a practical and cost effective solution to retrofitting SUDS to an existing road are illustrated in Figures 5.1, 5.2, 5.3, 5.4 and 5.5.

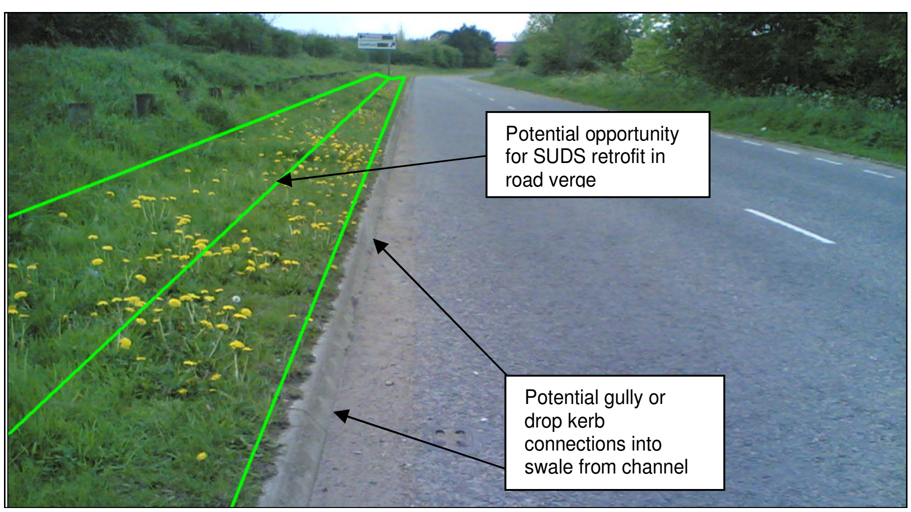

Figure 5.1 SUDS Retrofit in Road Verge

Figure 5.2 SUDS Retrofit in Road Build-out, Glasgow

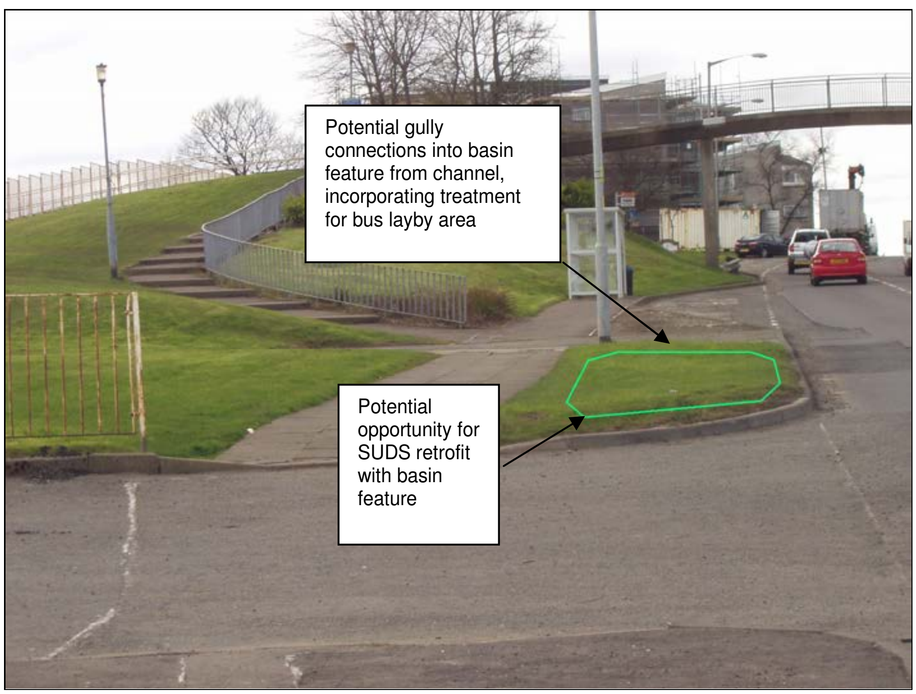

Figure 5.3 SUDS Retrofit in Road Build-out/Bus Layby, South Lanarkshire

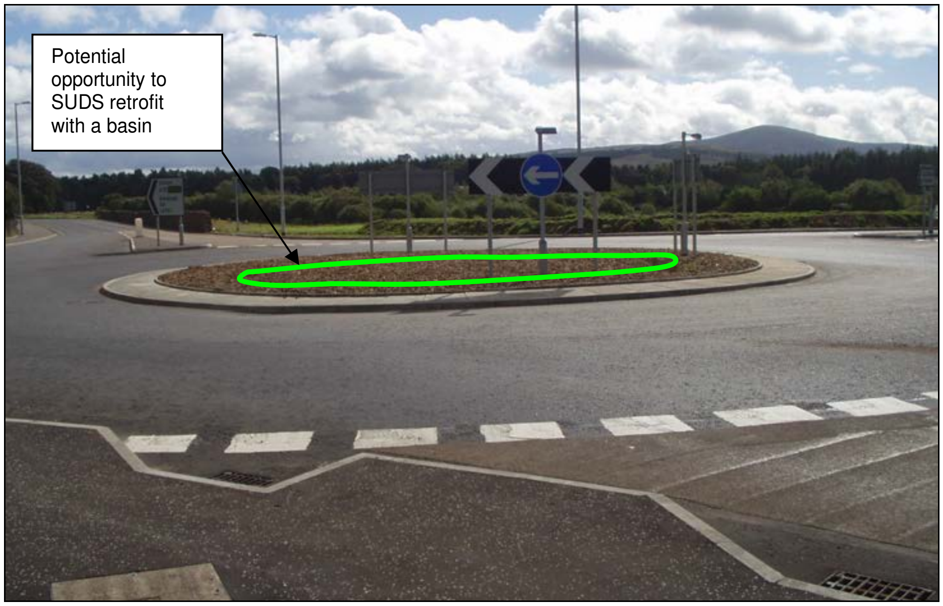

Figure 5.4 SUDS Retrofit in Roundabout Island, Lanark

Figure 5.5 SUDS Retrofit at Junction, South Lanarkshire

5.4 TECHNICAL FEASIBILITY

5.4.1 The technical issues to be addressed to allow progression of adoption of an un-adopted SUDS feature and retrofitted SUDS would generally concern available land, setting, existence of utility infrastructure and SUDS design criteria.

5.4.2 Historical SUDS features which have been installed will generally have been designed to the available guidance/standards that were current at the time. Alternatively they may have designed to no recognisable standard. In any event, any design guidance is likely to be different to current adoptable standards.

5.4.3 To satisfy themselves that the un-adopted SUDS feature is adequate for the contributing catchment and that the details are acceptable, the adopting body may ultimately require re-construction works to be carried out to meet their design criteria.

5.4.4 In any event, negotiation with various parties will be required to gain a legal agreement to facilitate construction, adoption, allocation of cost and maintenance responsibilities.

5.5 BENEFITS OF UN-ADOPTED SUDS ADOPTION AND SUDS RETROFITTING

5.5.1 Potential benefits of un-adopted SUDS adoption/SUDS retrofitting over conventional engineering techniques have been tabulated below:

Infrastructure Benefits

- Improvements to road drainage infrastructure
- Reduction in road and sewer network flooding
- Reduction in sewer and waste water treatment works maintenance burdens
- Reduced future maintenance costs

Environmental Benefits

- Improvement to water quality of receiving watercourses
- Enhancement/provision of habitat
- Ecological improvements/biodiversity enhancement

Amenity Benefits

- Provision of public amenity area
- Provision of educational/scientific site

5.5.2 It is important to note that not all SUDS retrofit schemes will accrue all the above benefits. Benefits will clearly relate to the nature of the SUDS features being implemented as part of the scheme.

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6 Factors Affecting Cost

CHAPTER AIMS

- Provide comparisons between costs for conventional road drainage and SUDS in roads
- Advise on the costs associated with implementing SUDS and the approach to whole life cost analysis

6.1 CAPITAL COST TRANSFER FROM CONVENTIONAL ROAD DRAINAGE TO SUDS IN ROADS

6.1.1 When considering the comparison between conventional road drainage and SUDS in roads it is important to take into account potential hidden savings offered by SUDS, for example, reduction in excavation and disposal of material if pervious surfaces are used as opposed to deep drains.

6.1.2 Costs associated with offsite enabling works such as increasing the capacity of downstream sewers are often not considered when making a comparison between conventional road drainage and SUDS in roads. Conversely, the cost of land take that may be required for SUDS requires to be taken into account, if the SUDS cannot be incorporated into the road corridor or public open space landscape provision.

6.1.3 The cost associated with upgrading or connection to existing sewers may be significant, but can be minimised or removed by using SUDS.

SUDS costs should also be weighed in terms of benefits to society, and not just be seen as a cost benefit to the developer or maintaining body. The application of SUDS is mandatory through existing legislation.

6.1.4 To illustrate the variations in construction cost for conventional road drainage and roads adopting SUDS features, a basic model has been created for a series of road construction scenarios, based on the following:

- 6m wide carriageway with 2m wide footways, road kerbs and heel kerbs at footways
- Subgrade CBR 5%
- Equivalent storage provided within conventional piped road drainage compared with SUDS features
- Common items including earthworks, street lighting, traffic signs and road markings are excluded from cost model
- Excavation arisings disposal are assumed to be undertaken within the development boundary
- Asphalt surfaced roads comprise:
  - 40mm HRA surface course
  - 50mm DBM binder
  - 80mm DBM base
  - 300mm Type 1 sub-base

- Footways comprise:
  - 30mm HRA surface course
  - 50mm DBM binder
  - 150mm Type 1 sub-base
- Permeable block paving comprise:
  - 80mm permeable concrete block pavers
  - 50mm sharp sand
  - Geotextile
  - 320mm gravel media
  - Geotextile or impermeable liner dependent on infiltration potential
- Costings on which percentages are evaluated are abstracted from SPON's Civil Engineering and Highway Works Price Book [1].

6.1.5 A summary of the findings is presented in Table 6.1.

Roads and SUDS description		% Overall construction cost compared to conventional construction road type (1)	% Saving in construction cost compared with road type (1)	% Drainage cost associated with each road description
(1)	Asphalt surfaced road, 2m wide asphalt surfaced footways each side, conventional road gullies and piped drainage system.	100	-	25
(2)	Permeable block paving, 2m wide asphalt surfaced footways each side, NO INFILTRATION	70	30	30
(3)	Permeable block paving, 2m wide asphalt surfaced footways each side, WITH INFILTRATION	56	44	11
(4)	Asphalt surfaced road, 2m wide asphalt surfaced footway one side, 2m grass filter strip and filter drain other side	87	13	22
(5)	Asphalt surfaced road, 2m wide asphalt surfaced footway one side, 2m grass filter strip and swale with drop kerb entry other side	76	24	11
(6)	Asphalt surfaced road, 2m wide asphalt surfaced footway one side, 2m grass filter strip and swale with road gullies	85	15	13
(7)	Asphalt surfaced road, 2m wide asphalt surfaced footways each side, conventional road gullies and filter drain one side	97	3	22

Table 6.1 Capital Cost Comparison

6.1.6 Research has also shown that for residential roads adopting permeable block paving the initial construction costs, for a CBR of 3.5% and above, are lower than those associated with asphalt surfacing, concrete block paving, pavement quality concrete and reinforced concrete[2].

6.2 CONSTRUCTION AND LAND TAKE COSTS

6.2.1 The construction costs associated with the provision of SUDS comprises the following components:

- Temporary SUDS management costs associated with erosion and sediment control during road and SUDS construction
- Permanent works including labour, plant and materials
- Landscaping and planting costs

6.2.2 Further considerations which can affect the cost of the road SUDS scheme may include:

- Site investigation and design costs
- Access, space and land take – depending on road classification
- Soil classification – higher costs associated with increasing difficulty in excavation in certain soil types, e.g. rock
- Component type and size – related to road classification and local rainfall characteristics
- Requirement for impermeable liners – where groundwaters are vulnerable or within contaminated soils
- Location may also impact on the cost as material, plant and labour costs may vary regionally. Equally local rainfall characteristics will affect the size of the SUDS components

The impact on costs associated with land take is likely to vary in significance based on the location of the proposed road and location of the associated SUDS features. In certain circumstances the effective cost of the land can be zero, where the area of land occupied by the SUDS feature has a dual purpose such as within the footprint of the road or within public parking, recreational areas or public open space.

6.2.3 In dense urban areas the cost of land take is likely to be significant, and this taken into account with the road type and road geometry is expected to influence the selection process for the SUDS feature appropriate for that particular setting.

6.3 OPERATIONAL AND MAINTENANCE COSTS

6.3.1 Maintenance costs associated with road and conventional drainage systems will include, but not be limited to the following activities:

- Cleaning and emptying of gully pots, silt traps and manholes
- Jetting and cleaning sewers
- Road sweeping
- Litter removal
- Road verge landscape management

> Many SUDS components may be easily maintained as part of the maintenance regime adopted for the road. The cost associated with this type of maintenance is usually comparable or lower than that associated with maintenance of conventional road drainage [3].

6.3.2 Cost research carried out on the Dunfermline Eastern Expansion (DEX) with data collected relating to maintenance activities carried out over a five year period concluded that on average, the annual cost of maintaining SUDS is approximately 20 – 25% lower than for the equivalent traditional drainage system[4].

6.3.3 Operation and maintenance activities may be categorised into the following:

- Inspection and monitoring
- Post inspection maintenance including litter and removal of debris
- Regular maintenance based on a frequency determined by monitoring including grass cutting and silt removal from pre-treatment features
- Unplanned maintenance due to operational problems or pollution incidents
- Remedial maintenance when lifespan of SUDS elements exceeded, for example geotextile replacement, or when sediment removal is required

6.3.4 Costs associated with operation and maintenance include:

- Labour, plant and material costs
- Replacement landscaping costs
- Disposal costs of contaminated sediments and vegetation

6.3.5 Costs may also be incurred if recycling of materials for re-use either within the SUDS feature or elsewhere is being considered.

6.3.6 Costs associated with remedial maintenance are required when the SUDS component is nearing the end of its design life and requires this type of maintenance to prevent failure. This type of maintenance includes:

- Sediment removal from ponds and basins
- Replacement of clogged geomembranes
- Removal, washing and replacement of filter drain media
- Take up of pervious surfaces including washing and replacement of filter media and replacing geomembranes

6.4 RESIDUAL LAND VALUE

6.4.1 The residual value is associated with the value of the land taken up by SUDS components that would otherwise be made available for development.

6.4.2 In terms of economic analysis the land occupied by a SUDS component over its whole life would have a residual value, which could be allowed for in a whole life costing analysis.

6.5 DISPOSAL AND DECOMMISSIONING

6.5.1 At the end of the design life of a particular road SUDS feature, it is likely that either rehabilitation of the feature would be undertaken, if the road is to remain in use, or decommissioning and disposal if the road is to be removed.

6.5.2 Where above ground features are used, such as swales, the costs are likely to be small due to the landscaped nature of these types of features. Conversely, where roadside filter drains or pervious pavements have been used the volume of material requiring disposal together with trapped pollutants may lead to increased costs influenced by landfill charges.

6.5.3 Equally, where ponds have been used and require decommissioning, disposal costs associated with removal of sediments to landfill may be high, dependant on the nature and pollutant content of the sediment.

6.5.4 In summary, the materials that may require to be disposed of as a result of maintenance and rehabilitation may include:

- Vegetation
- Road planings
- Granular fill/ filter media
- Permeable block paving
- Geomembranes
- Sediment

> Opportunities to recycle the road pavement materials and SUDS filter media may prove cost effective and should be explored, where practicable.

6.5.5 In order to assess the costs associated with the disposal of contaminated sediments, it will be necessary to have an understanding of the nature and concentration of pollutants captured within sediments. Research carried out in the UK and United States in 19 sample sites for a range of determinands indicated that all but one of the sediment sample concentrations indicated that the sediment need not be classed as a special waste. In the UK this would mean all but one of the dredged sediments could be spread to the bank sides of the SUDS feature[5].

6.6 RETROFITTING COST BENEFITS

6.6.1 SUDS retrofitting implements sustainable techniques within traditional road construction, and where conventional drainage is already in place. Inevitably there will be additional costs associated with retrofitting SUDS compared to a new build. Nevertheless, there are indirect cost benefits to be derived from retrofitting SUDS including[6]:

- Use of SUDS compared to conventional road drainage will reduce the burden at Combined Sewer Overflows (CSOs) and Waste Water Treatment Works (WWTWs) which may be at capacity, thus deferring investment in expanding their capacities
- Reduction in the runoff volume and peak flow will reduce risk of pluvial and fluvial flooding and associated costs
- SUDS recharge of aquifers may in certain areas help make savings in new water resource investment
- Reduction or limiting of flow to the WWTW will reduce energy costs, by more efficient treatment due to less dilution of wastewater with surface water runoff
- Reduction in road repair costs through poorly maintained/ rehabilitated conventional drainage system giving rise to weakness in pavement structure through leakage

6.7 ENVIRONMENTAL COSTS AND BENEFITS

ENVIRONMENTAL COSTS

6.7.1 The environmental costs are linked with environmental risks that may cause damage or failure of the road SUDS component. The environmental risks are normally mitigated against through the design process, monitoring and providing the appropriate maintenance to ensure the design performance criteria are met.

6.7.2 Environmental risks include:

- Severe pollution event of the receiving watercourse through accidental spillage or leakage into the SUDS system
- Flood damage due to exceedance not incorporated into the design and/ or poor performance attributed to poor design or inadequate maintenance

ENVIRONMENTAL BENEFITS

6.7.3 There are a range of environmental benefits that may arise from the implementation of SUDS road drainage, including:

- Reduction in diffuse pollution
- Savings in energy consumption
- Reduction in peak flows and storm runoff volumes
- Aquifer and river base flow augmentation
- Deferred investment in increasing WWTW capacities
- Amenity and potential recreational benefit some SUDS components can offer
- Potential for enhancements in habitat and biodiversity

6.7.4 The estimation of values of environmental benefits may be calculated using the Contingent Valuation Method (CVM)[7].

6.8 WHOLE LIFE COST ANALYSIS

6.8.1 The Building Services Research and Information Association define the whole life cost (WLC) analysis as a method whereby the project economic evaluation in which all costs arising, and benefits accrued from installing, owning, operating, maintaining, and ultimately disposing of a project are considered.

6.8.2 Whilst the capital costs of implementing SUDS may be lower than conventional drainage techniques, the significance of maintenance requirements requires to be examined, and the WLC tool provides a vehicle to gain an understanding of long term costs by the adopting authority.

6.8.3 To determine the present value over the design life of a SUDS feature, the following formula is commonly used:

$$PV = \sum_{t=0}^{t=N} C_t/(1+r/100)^t$$

where:

N = horizon time in years

r = discount rate

C_t = Total monetary costs in year t

6.8.4 The range of data required for input into the analysis includes the following:

- Proposed design life of the SUDS feature
- Capital costs including design and project management, site investigation, land take, construction including labour, plant and materials and post construction landscaping costs
- Operation and maintenance costs
- Disposal costs which may be incurred as a result of maintenance activities
- Residual costs linked to the value of the land used for the SUDS feature
- Discount rates set by the Treasury are used to convert all future costs to present values for comparison

6.8.5 Further details on the analysis of WLC can be found in CIRIA C697 The SUDS Manual. [7]

Research into WLC comparisons between concrete block permeable paving and traditional asphalt surfaced roads with conventional drainage indicates that for residential and industrial estate roads with subgrade CBRs of between 3 and 6%, that a saving of approximately 5% in unit WLC is made compared with asphalt construction, and between 15 and 30% compared with pavement quality concrete [2].

6.8.6 A WLC analysis at DEX comparing four detention ponds and their equivalent storage using traditional drainage chambers indicated that the WLC of traditional drainage are approximately double the costs for SUDS[3].

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Glossary

Adsorption – The adherence of gas, vapour or dissolved matter to the surface of solids.

Antecedent conditions – The wetness of a catchment prior to a particular rainfall event.

Attenuation – Reduction of peak flow and increase of duration of runoff during and following a storm event.

Base – The lowest bound layer of an asphalt pavement, formerly known as roadbase.

Basins – A ground depression acting as a flow control or water treatment structure that is usually dry and has a proper outfall, but is designed to detain stormwater temporarily.

Binder – The second layer of an asphalt pavement, formerly known as basecourse.

Biodegradation – The decomposition of organic matter by micro-organisms and other living things.

Bioretention areas – A landscaped ground depression that collects runoff so that it percolates through the soil below into an underdrain system, thus promoting pollutant removal.

California Bearing Ratio – An empirical measure of the stiffness and strengths of soils, used in road pavement design.

Capping layer – A layer of unbound aggregate of lower quality than sub-base that is used to improve the performance of the foundation soils before laying the sub-base and protect the sub-grade from damage by construction traffic.

Carriageway – The portion of the road which is used to carry vehicular traffic.

Catchment – The area which contributes surface water flow to a point in a drainage system. Can be split into sub-catchments.

Climate change – Climate change refers to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer).

Combined sewer – A sewer which is designed to carry both foul sewerage and surface water in the same pipe.

Combined Sewer Overflows – Overflow systems built into combined sewer networks which allow a certain amount of flow to discharge directly into a watercourse untreated, to ensure the sewer network does not become surcharged in storm conditions.

Control structures – A structure to control the flow rate or volume of water passing through or over it.

Controlled waters – Water defined and protected under the Water Resources Act 1991. Any relevant territorial waters that extend seaward for three miles from the baselines, any coastal waters which extend inland from those baselines to the limit of the highest tide or the freshwater limit of any river or watercourse, any enclosed dock which adjoins coastal waters, inland freshwaters, including rivers, watercourses, and ponds and lakes with discharges and ground waters (waters contained in underground strata). For the full definition refer to the Water Resources Act 1991.

Conveyance – The movement of water from one location to another.

Diffuse pollution – Pollution arising from land-use activities (urban and rural) that are dispersed across a catchment or sub-catchment, and do not arise as a process industrial effluent, municipal sewage effluent, deep mine or farm effluent discharge at a single point.

Dry swale – Shallow vegetated channel with filter in the base to convey surface runoff to the sewer network or infiltrate into the surrounding soils.

Embodied energy – The energy required to produce a service or product, e.g. during the manufacturing or processing stages. Can be related to CO_2 emissions.

Evapotranspiration – Process where moisture is lost from soil by evaporation of water and from transpiration by plants.

Exceedance – An event which has a result which exceeds a set target level, or in the case of drainage networks, a flow which exceeds the capacity of the sewers, causing surcharging and/or flooding.

Filter drains – A liner drain consisting of a trench filled with a permeable material, typically with a perforated pipe at the base to assist drainage. Can be used to convey water into a receiving drainage system or for infiltration.

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

Filtration – The removal of sediment or other particles from a liquid by passing it through a filter.

First flush – The initial runoff from an impermeable area or catchment subsequent to a rainfall event. As the runoff passes over the impermeable surface, it collects or dissolves pollutants and sediment, and this first portion of the runoff tends to be the most contaminated.

Footway – Area at the side of carriageways for pedestrian movement.

Full bore – A pipe flowing at full capacity.

Geocellular – A plastic box structure situated below ground, used to attenuate runoff.

Geogrid – A plastic grid structure used to increase the strength and stability of soils and aggregates.

Geotextile – A permeable plastic fabric. It can be used to filter water and protect, reinforce, separate or drain soils.

Greenfield runoff – The rate of runoff which would occur from a site prior to any development, in its undisturbed state.

Groundwater recharge – The process of surface water passing downwards through the soils into the groundwater in the saturated zone.

Gulley – An opening in the road pavement to allow surface water to enter the drainage system, typically constructed from a prefabricated gully with metal grate cover.

Habitat – An environment where an organism or group of organisms live.

Hydrocarbons - Any chemical compound made up of hydrogen and carbon. A major pollutant formed by the engine as a by-product of combustion.

Hydrodynamic systems – Proprietary systems designed to remove floated debris, sediments and other associated pollutants from surface water, using fluid dynamics to separate the solids from liquids.

Impermeable membrane – An artificial plastic fabric which is impermeable to prevent infiltration.

Infiltration – The passage of surface water into the ground, or groundwater into a sewer.

Infiltration basins – A dry basin which is designed to promote infiltration of surface water into the ground.

Infiltration coefficient – This is a measure of the soil's permeability and determines the rate at which infiltration occurs.

Infiltration testing – Carried out during site investigation works to determine the permeability and the infiltration coefficient of the soil.

Infiltration blanket/ trenches – A trench, typically filled with a permeable material, which is designed to promote infiltration of the surface water into the ground.

Local roads – Roads under the control of local roads authorities, such as general access roads, distributor roads and rural roads.

Metals – Pollutants which can be found on the road surface, such as lead, chromium, copper, nickel and zinc.

Microbial – Action of a bacterium causing disease or fermentation.

Moisture content – The amount of water present in the soil, usually given as a percentage.

Nutrients – Substances providing nourishment for living organisms, e.g. nitrogen & phosphorus.

Oil separators – Prefabricated proprietary system used to remove any spilled oils or hydrocarbons from surface runoff.

Peak flow – The maximum volume of water flowing in a watercourse or sewer over a certain period of time following a rainfall event.

Permeable concrete block paving – A surface which drains through voids between concrete blocks.

Pervious pavement – A surface that allows inflow of rainwater into the underlying construction or soil.

Ponds – A permanently wet depression designed to retain stormwater above the permanent pool and permit settlement of suspended solids and biological removal of pollutants.

Porous asphalt – An asphalt material used to make pavement layers pervious, with open voids to allow water to pass through.

Precipitation – The falling to earth of any form of water (rain, snow, hail, sleet or mist)

Rainfall intensity – The amount of rainfall occurring during a set unit of time, typically mm per hour.

Regional control – Surface water management for individual or multiple sites, normally in a balancing pond or wetland.

Residual risk – The risk still present after mitigation procedures have been implemented.

Retention time – The length of time that runoff is stored or detained to allow for settlement, or possibly biological action, to occur.

Return period – The frequency of an event occuring, e.g. a 100 year storm refers to the storm which occurs on average once every hundred years, or in other words its annual probability of exceedance is 1%.

Road Construction Consent – The process of gaining consent to construct roads, over which there is a public right of passage, to an agreed standard set by the local roads authority.

Runoff – Water flow over the ground surface into the drainage system. This occurs when the ground is impermeable, saturated or the rainfall is particularly intense.

Sand filters – Above or below ground structures comprising single or multiple chambers with a sand bed as a filter medium providing treatment of runoff.

Scottish Water – Statutory corporation in Scotland that provides water and sewerage services.

Sedimentation – The process by which particles in suspension in a liquid settle to form a sediment.

Sediments – Particulate material that can be transported by water flow.

Sewer – A conduit taking surface water and foul sewage from roads, footways, buildings and hardstandings from two or more curtilages' and having a proper outfall, adopted by a water authority.

Silt traps - Often referred to as catchpits, they are chambers constructed within a piped system located at regular intervals not exceeding 100m, at changes in direction and gradient and often prior to discharge of a piped system to a SUDS component. Provision is made for collection of silt by a sump which provides a permanent wet well.

Site control – Surface water management in a local area or site, e.g. picking up building roofs, car parks and other impermeable areas.

Source control – The control of surface water runoff at or close to the source.

Sub-base – A layer of unbound material laid onto the subgrade that provides a stable foundation for a pavement surface.

Sub catchments – A division of a catchment, to allow runoff to be managed as near to source as possible.

Subgrade – The material onto which the road pavement is constructed, usually natural in-situ, but may include capping layer.

Surcharge – Flow conditions where the hydraulic gradient is above the pipe soffit.

Surface course – The top layer of the road pavement which is in contact with the vehicular traffic.

Sustainable Urban Drainage Systems – A sequence of management practices and control techniques designed to drain surface water in a more sustainable way than some previous practices.

Swale – A shallow vegetated channel designed to convey and retain surface water runoff, and which can also allow for infiltration. The vegetation filters suspended solids.

Treatment volume – The proportion of the total runoff from impermeable areas which is required to be retained and treated to remove pollutants.

Trunk roads – A major road, usually connecting cities or large settlements, which is the recommended route for long-distance and freight traffic. Quite often dual carriageways or motorways.

Verge – Grassed margin bordering the carriageway and footways, but still located within the adoptable road extent.

Void space – The open spaces between gravel media which can are used as storage in permeable pavements and other treatment facilities.

Vortex separators – A proprietary SUDS system used for removal of suspended solids using hydrodynamic forces. (See Hydrodynamic systems)

Waste Water Treatment Works – A facility to treat and make less contaminated domestic and/or industrial effluent.

Watercourse – Any natural or manmade channel which water flows through.

Wetlands – A flooded area in which the water is shallow enough for the growth of bottom rooted plants.

Acronyms

AFBI	– Agri-Food & Biosciences Institute
BRE	– Building Research Establishment
CAR	– Controlled Activities Regulations
CBR	– California Bearing Ratio
CDM	– Construction Design & Management
CIRIA	– Construction Industry Research Information Association
CSO	– Combined Sewer Overflow
CVM	– Contingent Valuation Method
DEX	– Dunfermline Eastern Expansion
DFP	– department of Finance and Personnel.
DMRB	– Design Manual for Roads and Bridges
DOE	– Department of the Environment.
DRD	– Department for Regional development.
NIEA	– Northern Ireland Environment Agency
NIHE	– Northern Ireland Housing Executive.
NIW	– Northern Ireland Water Ltd
PAN76	– Planning Advice Note 76
PEPG	– Planning and Environmental Policy Group.
RAMP	– Roads Asset Management Plan
RCC	– Road Construction Consent
RoSPA	– The Royal Society for the Prevention of Accidents
SEPA	– Scottish Environmental Protection Agency
SFRA	– Strategic Flood Risk Assessment
SNIFFER	– Scotland & Northern Ireland Forum For Environmental Research
SPP7	– Scottish Planning Policy
SUDS	– Sustainable Urban Drainage Systems
SWMP	– Surface Water Management Plan
TRRL	– Transport and Road Research Laboratory
UID	– Unsatisfactory Intermittent Discharge
WEWS Act	– Water Environment and Water Services (Scotland) Act 2003
WLC	– Whole Life Costing
WWTW	– Waste Water Treatment Works

Appendices, Figures & Tables

Appendix A List 1 And 2 Group Substances

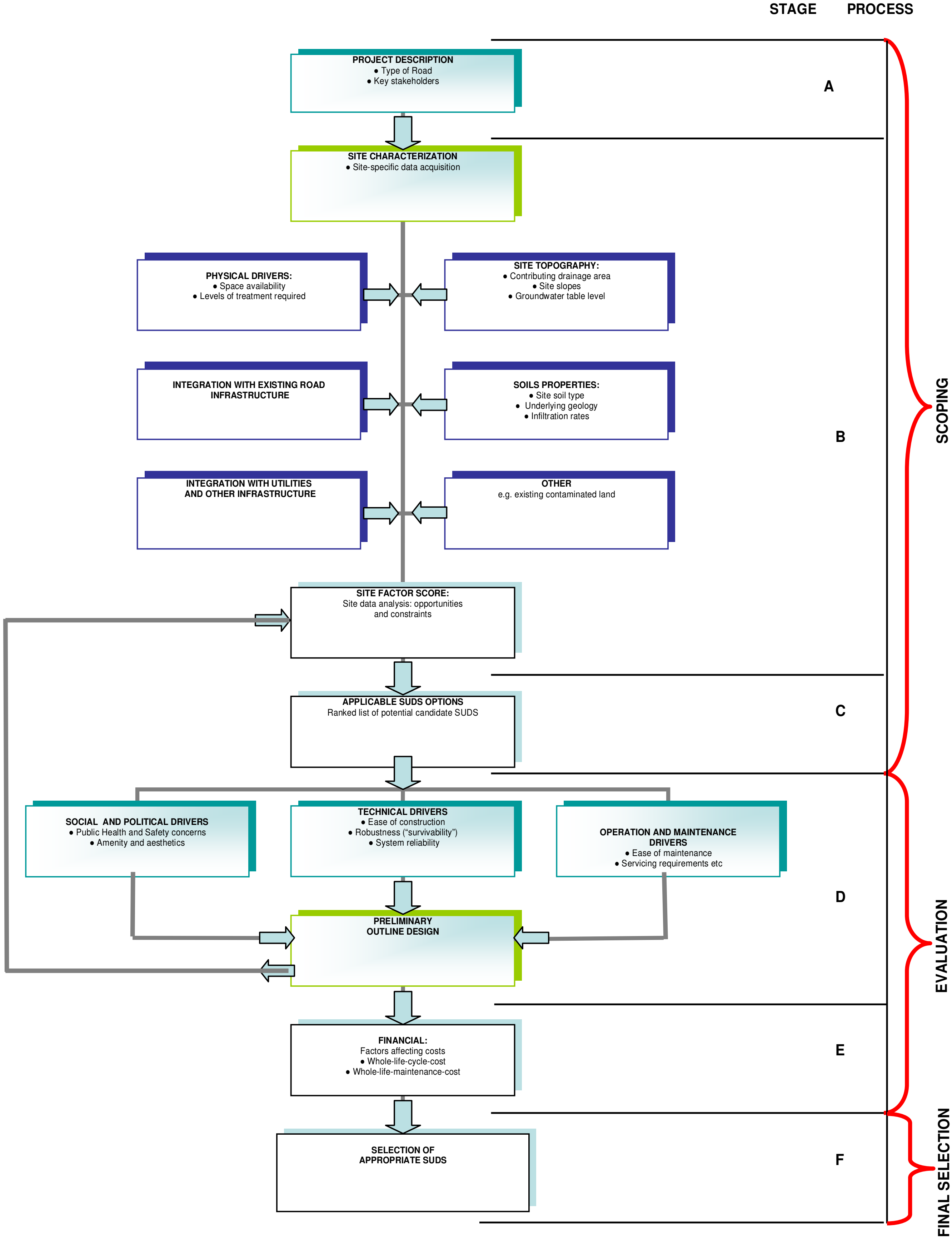
LIST 1

- Organohalogen compounds (and substances which may form such compounds in the aquatic environment)
- Organophosphorus compounds
- Organotin compounds
- Mercury and its compounds
- Cadmium and its compounds
- Cyanides
- Substances which are carcinogenic, mutagenic or teratogenic in or via the aquatic environment
- Mineral oils and hydrocarbons

LIST 2

- The following metalloids and metals and their compounds: zinc, copper, nickel, chrome, lead, selenium, arsenic, antimony, molybdenum, titanium, tin, barium, beryllium, boron, uranium, vanadium, cobalt, thallium, tellurium and silver
- Biocides and their derivatives not appearing in List 1
- Substances which have a deleterious effect on the taste and/ or odour of groundwater, and compounds liable to cause the formation of such substances in such water and to render it unfit for human consumption
- Toxic or persistent organic compounds of silicon, and substances which may cause the formation of such compounds in water, excluding those which are biologically harmless or are rapidly converted in water into harmless substances
- Inorganic compounds of phosphorus and elemental phosphorus
- Fluorides
- Ammonia and nitrites

Appendix B Road SUDS Selection Tools



STAGE
PROCESS
PROJECT DESCRIPTION
• Type of Road
• Key stakeholders
A
SITE CHARACTERIZATION
• Site-specific data acquisition
PHYSICAL DRIVERS:
• Space availability
• Levels of treatment required
SITE TOPOGRAPHY:
• Contributing drainage area
• Site slopes
• Groundwater table level
INTEGRATION WITH EXISTING ROAD INFRASTRUCTURE
SOILS PROPERTIES:
• Site soil type
• Underlying geology
• Infiltration rates
B
SCOPING
INTEGRATION WITH UTILITIES AND OTHER INFRASTRUCTURE
OTHER
e.g. existing contaminated land
SITE FACTOR SCORE:
Site data analysis: opportunities and constraints
APPLICABLE SUDS OPTIONS
Ranked list of potential candidate SUDS
C
SOCIAL AND POLITICAL DRIVERS
• Public Health and Safety concerns
• Amenity and aesthetics
TECHNICAL DRIVERS
• Ease of construction
• Robustness ("survivability")
• System reliability
OPERATION AND MAINTENANCE DRIVERS
• Ease of maintenance
• Servicing requirements etc
D
PRELIMINARY OUTLINE DESIGN
EVALUATION
FINANCIAL:
Factors affecting costs
• Whole-life-cycle-cost
• Whole-life-maintenance-cost
E
SELECTION OF APPROPRIATE SUDS
F
FINAL SELECTION

SUDS Options Matrix																								
			SUDS Component												Pre-treatment			Proprietary systems					Storage/ Attenuation	
		Speed (High, medium, low)	Permable Block pavements	Porous Asphalt	Filter strips	Filter drain	Bioretention areas	Sand filters	Swales	Infiltration trenches	Infiltration basin	Wetland	Detention basin	Ponds	Gullies	Silt traps	Oil separators	Hydrodynamic systems	Prefabricated bioretention	Filtration systems	Retrofit wetland devices	Vegetated swales	Modular system storage	Tank Storage
Road Hierarchy	Trunk Road	H	X	X	√	√	X	X	√	√	√	√	√	√	√	√	√	X	X	√	√	√	X	√
	Rural Road	H	X	X	√	√	X	X	√	√	√	√	√	√	√	√	√	X	X	√	√	√	X	√
	Distributor Road	M	X	X	√	√	√	√	√	√	√	X	√	X	√	√	√	√	√	√	√	√	√	√
	General Access Road	M	X	√	√	√	X	√	√	√	√	X	√	X	√	√	X	X	X	X	X	X	√	X
	Industrial Access Road	M	X	X	√	√	X	√	√	√	√	√	√	√	√	√	X	√	√	√	√	√	√	√
	Short Culs-de-Sac	L	√	√	X	X	√	√	√	√	√	X	X	X	√	√	√	X	X	X	X	X	√	X
	Homezone/ Shared Surface	L	√	√	X	X	√	√	X	X	X	X	X	X	X	X	X	X	X	X	X	X	√	X
	Minor Access Link	M	√	√	√	√	√	√	√	√	√	X	X	X	√	√	X	X	X	X	X	X	√	X
	In-Street Car parks	L	√	√	X	X	√	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	√	X

SUDS Performance Matrix											
		Performance					Pollutant Removal				
Technique	Description	Peak flow reduction	Volume reduction	Water quality treatment	Amenity potential	Ecology potential	Total suspended solids	Nutrients	Heavy metals	Bacteria	Fine sediment and dissolved pollutants
Pervious pavements	Allows inflow of surface water to underlying layers	H	H	H	L	L	H	H	H	H	H
Filter strips	Vegetated strips of gently sloping ground draining water evenly from impermeable areas and filter out particulates	L	L	M	M	M	M	L	M	M	H
Filter drain	Linear drains/ trenches filled with a permeable material, often with a perofrated pipe in the base of the trench	M	L	H	L	L	H	L/M	H	M	H
Swales	Shallow vegetated channels that convey or retain flow. The vegetation filters particulates	M	M	H	M	M	H	L	M	M	H
Infiltration trenches	As filter drains, but allowing infiltration through trench base and sides	M	H	H	L	L	H	L/M	H	M	H
Ponds	Depressions used for storing and treating water, with a permanent pool and bankside emergent and aquatic vegetation	H	L	H	H	H	H	M	H	M	H
Detention basin	Dry depressions designed to store water for a specific retention time	H	L	M	H	M	M	L	M	L	L
Infiltration Basin	Depressions that store and dispose of water via ir	M	H	H	H	H	H	M	H	M	H
Wetland	As ponds, but the runoff flows slowly but continuosly through aquatic vegetation. Shallower than ponds	H	L	H	H	H	H	M	H	M	H
Bioretention areas	Vegetated areas for collecting and treating runoff before discharge downstream, or to the ground via infiltration	M	M	H	H	M	H	L	H	M	H
Sand filters	Treatment devices using sand beds as filter medi	L	L	H	L	L	H	L	H	M	H
Pre-treatment											
Gullies		L	L	M	L	L	M*	L	L	L	L
Silt traps		L	L	M	L	L	M*	L	L	L	L
Oil separators		L	L	M	L	L	M	L	L	L	L
H High		M Medium				L Low					
* risk of re-suspension during extreme events											
References											
C697 The SUDS Manual	www.mastep.net/database/data.cfm										

SUDS Maintenance Matrix

Required action	SUDS Component: Pervious pavements	Filter strips	Filter drain	Swales	Infiltration trenches	Ponds	Detention basin	Infiltration basin	Wetland	Bioretention areas	Sand filters	Pre-treatment systems: Gullies	Silt traps	Oil separators
Regular maintenance														
Litter and debris removal		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Brushing and vacuuming	✓													
Grass cutting		✓		✓		✓	✓	✓	✓		✓			
Vegetation management/ weeding		✓	✓	✓	✓	✓	✓	✓	✓		✓			
Shoreline aquatic vegetation management						✓	✓	✓	✓					
rehabilitation of surface filter media			✓		✓						✓			
Sediment removal														
Occasional maintenance														
Re-seed areas of poor vegetation		✓		✓		✓	✓	✓	✓	✓				
Weeding	✓	✓	✓		✓					✓				
Sediment removal from water body						✓	✓	✓	✓					
Landscape management inc tree pruning				✓		✓	✓	✓		✓				
Reinstate design levels							✓	✓						
General sediment removal			✓		✓	✓	✓		✓			✓	✓	✓
Change filter media			✓		✓						✓			
Remedial maintenance														
Reinstate design surface levels	✓	✓		✓			✓							
Repair eroded areas		✓		✓		✓	✓	✓	✓	✓				
Remove sediment		✓		✓		✓	✓	✓	✓	✓				
Rehabilitation of filter media	✓		✓		✓						✓			
Replace geotextiles	✓		✓		✓									
Repair inlets, outlets, overflows, structures		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Supplement planting									✓					

Appendix C Case Studies

WORKED EXAMPLE 1 – WAUCHOPE SQUARE, CRAIGMILLAR, EDINBURGH

PROJECT DESCRIPTION

Wauchope Square redevelopment is part of the City of Edinburgh's Craigmillar Regeneration Project. The Craigmillar Regeneration Project is part of an ambitious plan to transform 150-acres of open space in South East Edinburgh into a network of new public parks, woodlands and community activity areas: this new vision for a new 'Green Quarter' for the Capital will have Craigmillar at its heart.

This redevelopment was completed in 2009. The SUDS drainage is for the road only, the roofs of the adjacent houses and schools have separate SUDS. The roads SUDS will be adopted by Edinburgh City Council.

This worked example follows the stages and processes identified in the SUDS for Roads Selection Flowchart.

SCOPING STAGE

1. Type of Road
   Homezone/ shared surface: The proposed development would consist of 2/3 storey townhouses and 4 story residential apartment blocks.
   Applicable SUDS options
   - Permeable Block pavings, Porous asphalt, Bioretention areas, sand filters and modular storage system

Photo 1. Home Zone Sign

2. Key Stakeholder
   The principal stakeholders were Parc/EDI, the City of Edinburgh Council and the residents of Craigmillar.

PHYSICAL DRIVERS:

3. Space availability
   Space was at an absolute premium at the site.

4. Levels of treatment required
   Located close to the site is the Niddrie Burn that has been classified by SEPA as been at risk and is considered to have pressures from both diffuse source pollution including land transport and from point source pollution from sewage disposal activities.

Roads typically require two levels of treatment and therefore the environmental risks described above require two levels of treatment to be provided.

SITE TOPOGRAPHY:

5. Contributing drainage area
   Total contributing drainage area is approximately 7.05 hectares.
6. Site slopes
   The proposed site is gently sloping and is < 5%.

7. Groundwater table level:
   Groundwater strikes and seepages were recorded at depths between 2.00 meters and 2.70 meters below existing ground level (mbgl).

SOIL PROPERTIES:

8. Site soil type:
   Table 2 gives an overview of the strata encountered during the site investigation works.

Table 2. Soil and Rock Data

Stratum	Depth to Underside of Strata (mbgl)
Topsoil	0.10 – 0.80
Made Ground	0.50 – 1.90
Glacial Sand and Gravel	0.90 – 3.80
Glacial Till	1.10 – 7.80 (where proven)
Weathered Bedrock	1.90 – 9.20
Bedrock	Encountered at between 4.90m and 9.20m bgl

9. Underlying geology

The rocks underlying the site have been classified as highly productive aquifers in which the flow is dominated by fractures and fissure. Groundwater flow is towards the north in the direction of the Firth of Forth (the sea) at a relatively shallow gradient of 0.015. Although a perched groundwater within the permeable strata was anticipated, an inspection of borehole logs held by The British Geological Survey (BGS) did not record the presence of groundwater or bodies of perched water within the glacial till deposits.

Bedrock: The bedrock was made of interbedded sequence of sandstone, mudstone and siltstone and was encountered at between 4.90 mbgl and 9.20mbgl.

10. Hydraulic conductivity: Infiltration rates were not recorded for the site.

INTEGRATION WITH EXISTING ROAD INFRASTRUCTURE

The project is a part of the larger Craigmillar Regeneration Project. Any proposed SUDS option should be able to tie in with the proposed and existing roads within the project.

INTEGRATION WITH UTILITIES AND OTHER INFRASTRUCTURE

Any proposed SUDS option should be able to tie in with the proposed and existing utilities and other infrastructures such as buildings etc within the project. The SUDS must be capable of being excavated for access to services without damaging the flow paths. Parts of the development are designed to ‘Homezones’ standards and the SUDS must comply with these.

OTHERS

Soil Contamination

An elevated cadmium concentration was recorded within the Made Ground at one trial pit (0.45m bgl) and no other samples had elevated contaminant concentrations. It was decided that the contamination identified that that particular location was representative of a contamination hotspot and further investigations were undertaken prior to construction to confirm extent of contamination in the vicinity of the trial pit.

Surface Water abstractions

There are no surface water abstractions within a 1km radius of the site.

SITE FACTOR SCORE:

Site data analysis: opportunities and constraints

Site characteristic summary:

- Space was at absolute premium.
- Two levels of treatment required.
- The total contributing drainage area is 7.02 ha.
- The proposed area has gently sloping terrain.
- The high groundwater table level is well above 1m.
- The bedrock was encountered approximately 4.90m bgl.

Communal parking areas available for application of pervious pavements

Table 3. Site Factor Scoring Table

	Permeable Block pavements	Porous Asphalt	Bioretention areas	Sand filters	Modular Storage Systems
Land / Space requirement	1	1	1	0	1
Level of treatment required	2	2	1	1	0
Contributing Drainage area	1	1	1	1	1
Site Gradient	1	1	1	1	1
Water Table level	1	1	1	0	0
Underlying geology	1	1	1	0	1
Soil Type	1	1	1	1	1
Integration with existing road Infrastructure	1	1	1	1	1
Integration With Utilities and other Infrastructure	1	1	1	0	0
Contaminated land	1	1	1	0	1
Surface Water abstractions	1	1	1	1	1
Flow attenuation	1	1	0	0	1
SITE FACTOR SCORE	13	13	11	6	9

APPLICABLE SUDS OPTIONS

The following ranked list of potential candidate SUDS was drawn up;

- Permeable block paving;
- Porous Asphalt
- Bioretention areas
- Modular Storage Systems
- Sand filters

EVALUATION STAGE

Here the SUDS alternatives for the site are further evaluated. In this stage, the list is narrowed down based on the site factor scores.

Craigmillar is the only project in Edinburgh to be selected to further the objectives of the Scottish Sustainable Communities Initiative (SSCI). The SSCI encourages inspirational developments which will serve as exemplars of the highest quality. Criagmillar is also at the heart of the new vision for a new 'Green Quarter' for the City of Edinburgh,

There are also plans for a new community woodland and arboretum, a restored river park following the course of the Niddrie Burn, and an enhanced Craigmillar Countryside Park. The community woodland and arboretum would also have open spaces for picnic spots and play areas as well as a network of paths and cycle tracks and open views to Craigmillar Castle and the Forth Estuary.

Given the pressures on the restoration of the Niddrie Burn; sand filters and modular storage systems are screened off from the list as road runoff treatment is a huge priority. The Homezone concept is also an important consideration for any SUDS option considered and selected.

The options that are further evaluated and screened using other site specific as well as non-site specific factors such as; social and ecological benefit, operation and maintenance requirements and other technical issues such reliability and robustness of the selected options are:

- Permeable block paving
- Porous Asphalt
- Bioretention areas

SOCIAL AND POLITICAL ISSUES:
A new school at the location will be at the centre of the new community. Consequently, any SUDS devices selected should not create the perception of public health hazards. As regards the site, the use of either type of pervious pavement or bioretention would not present any public health or safety concerns.

Although there is limited space for a SUDS solution with high amenity value within the Square, the site is seen as one requiring a high material specification and therefore any SUDS option selection must be visually appealing. Both options of permeable block paving and the bioretention areas could fulfil that requirement.

TECHNICAL DRIVERS
Installation techniques vary for the type of permeable material chosen, but in general are similar to requirements for the impervious materials they replace. Permeable block paving are perceived to the relatively easy to construct and would therefore work well on the site. Although bioretention areas are relatively new in Scotland, they are gaining in popularity as well and are relatively easy to construct as well.

OPERATION AND MAINTENANCE DRIVE
Any installed pervious paving would be maintained as per manufacturer instruction. The use of pervious pavings would not be encouraged in areas without a dedicated service strip since any remedial work by utilities might not be satisfactory and may compromise the efficiency and function of the pavement. Therefore, existing and proposed utilities must be identified and considered and dedicated service strips would be included with the design.

PRELIMINARY OUTLINE DESIGN
Hydrological Design – details required for a sample section of pervious paving.

FINANCIAL:
The financial driver on this project is based on the overall budget of £200 million for the entire Craigmillar regeneration project as a whole and therefore need not be investigated in detail in this worked example.

FINAL SELECTION
The stakeholders agreed to go with a final selection of permeable block paving. A guarantee was secured by Formpave (the permeable block paving manufacturers) for 15 years.

The permeable block paving would combine surface stability and permeability. They are comparatively low cost since they are to be used where normal hard-standing such as car-parking would have to be implemented anyway.

Photo 2. Permeable block paving on the site

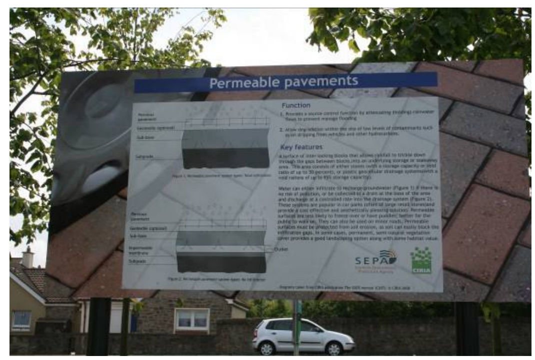


Photo 3. Sign post educating the public on the use of permeable paving on the site

Photo 4. Road Construction Type M1 in Progress

Photo 5. Road Construction Type M2 Completed

Photo 6. . Different Types of Paving Used on Site.

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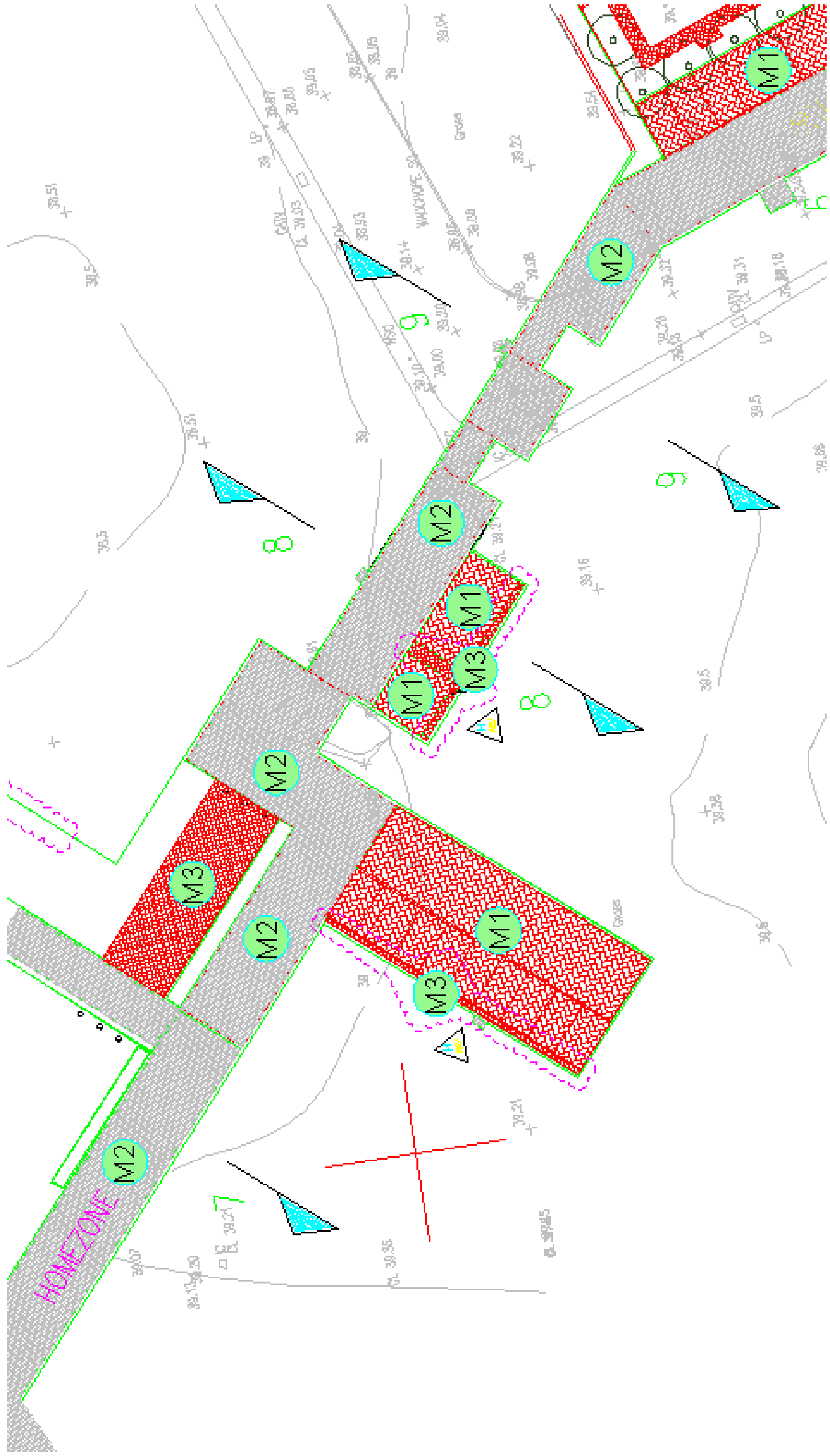

Figure 1. General Plan of Wauchope Square Showing Road Construction Type

ROAD CONSTRUCTION DETAILS

The following details are given to assist the designer of the road in achieving a robust SUDS design using permeable paving. Details will vary from site to site and from manufacturer to manufacturer.

The general layout of the road is shown in **Figure 1** which shows the relative positions of the different construction types.

In general, surface water is directed to the permeable parts of the construction. The surface water is attenuated and treated there. Approximately 25% of the water will evaporate and some will infiltrate into the ground. The excess discharges into the Scottish Water sewer at the site.

Road construction type M1

Figure 2 shows the basic pervious paving detail where there are no services beneath. The surface area allows diffused entry of the runoff (first level of treatment) to a bedding layer and sub-base of graded clean stone providing both storage and a filtering action which provides the required second level of treatment normally required by SEPA. This sub-base also contributes to the attenuation of flow required by the local authority.

Road construction type M1A

Type M1A (**Figure 3**) was required because access was needed across the site of the pervious paving to developments which had been sub-let for housing construction at the same time as Wauchope Square was being built. The main infrastructure including servicing had to be installed prior to the surfacing and as an expediency, the road structure was taken up to just below the permeable finishing and temporary blacktop was laid. The detail has a pervious membrane at its base and the backfill around the services is selected granular material. The ground is very variable and this detailing permits infiltration where it is possible.

If reinstatement following post-construction insertion of services is required, this detail also permits easier replacement of the membrane since the required overlaps are smaller.

Once these sub-let houses were completed 40mm holes at 1m centres were drilled through the asphalt and filled with gravel before the surfacing was laid. This detail gave the required performance both during and after construction, while at the same time permitting infiltration into the soil wherever possible.

Road construction types M2 and

These details are shown in **Figure 4** (heavier traffic) and **Figure 5** (lighter traffic and parking). This impermeable construction detail was used for services strips and drainage was across the surfaces to the pervious paved areas.

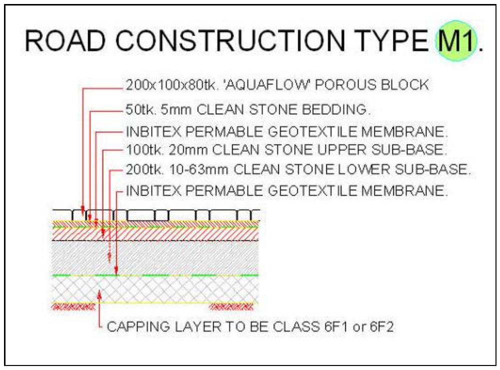

Figure 2. Pervious Paving Detail

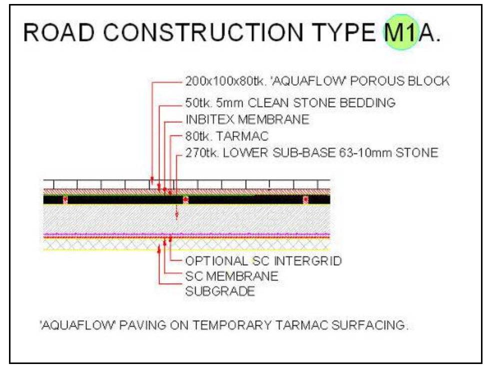

Figure 3. Pervious Paving over temporary construction (Aquaflow)

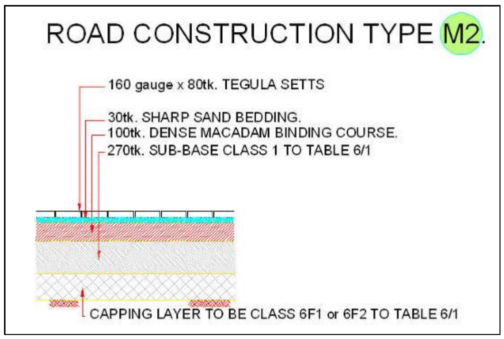

Figure 4. Services Strip (Tegula Setts)

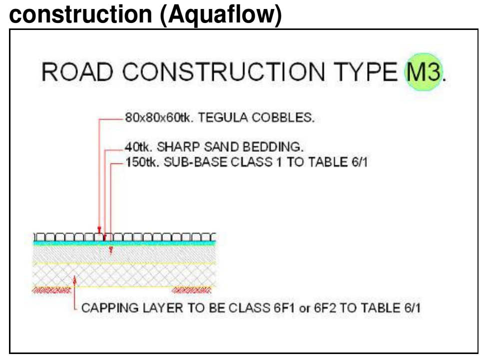

Figure 5. Services Strip (Tegula cobbles)

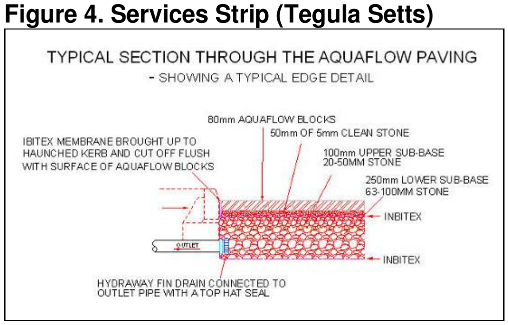

Figure 6. Pervious paving edge detail

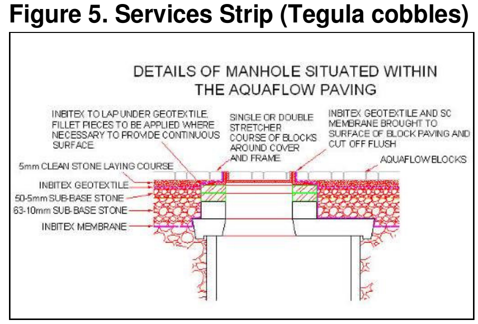

Figure 7. Pervious paving manhole detail

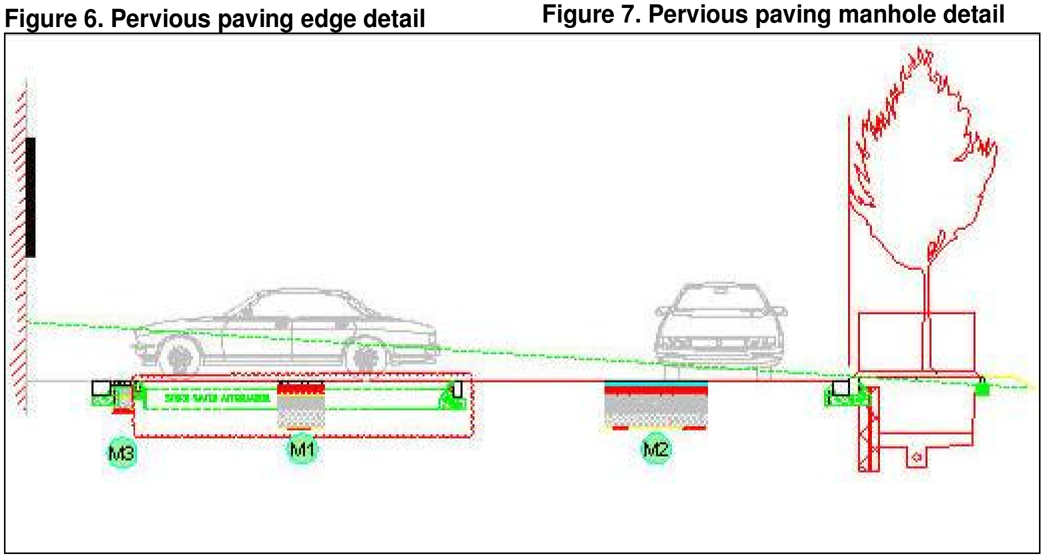

Figure 8. Cross Section through the HomeZone

WORKED EXAMPLE 2 – CALDERGLEN HIGH SCHOOL

This example is located at Calderglen high school which is on the western outskirts of East Kilbride, South Lanarkshire. The school was built under a public-private partnership contract. While the site drainage had to address runoff from the full development including buildings and recreational areas, the SUDS in the example relate specifically to the vehicular accesses at the school.

Although the accesses at his location were not adopted, they are to adoptable standard. The SUDS covered in the example are permeable paving within car parks and a detention basin. The development was completed in 2009.

This worked example follows the stages and processes identified in the SUDS for Roads Selection Flowchart.

Photo 7. **Permeable paving at disabled parking spaces**

Photo 8. Detention basin with school to right and public road to left

SCOPING STAGE

PROJECT DESCRIPTION:

The site drainage includes both the vehicular accesses and roof runoff.

1. Types of Road
   The school has vehicular accesses which are effectively 'General Access Roads', shared surfaces and 'In-Street Car Parks': The school has a number of linked buildings for which access and parking are provided.

   Applicable SUDS options
   - The SUDS options considered were - permeable block pavings, porous asphalt, bioretention areas, filter drain, sand filters and modular storage system, although only permeable paving and detention basin are included in this example.
2. Key Stakeholders
   South Lanarkshire Council, school governors, private developer.

PHYSICAL DRIVERS:

3. Space availability
   Space was at an absolute premium on the site. The site was divided into zones and drained to give attenuation and treatment of the runoff from the entire site. Areas such as the pitch are drained separately but tied in into the overall site drainage.

4. Levels of treatment required

The site accesses require two levels of treatment.

SITE TOPOGRAPHY:

5. Contributing drainage area

The overall site area of the school site is approximately 8 ha, of that 2.76 ha is impermeable surfaces including roofs, access and play areas. There is a single discharge point where the limiting discharge of 5 l/s/ha was agreed with South Lanarkshire Council. The total storage volume for the site was calculated to be 765 m^3. This volume was distributed around the site in a variety of SUDS components which total the 765 m^3..

6. Site slopes

   The proposed site is gently sloping and is < 5%.

7. Groundwater table level:

The groundwater level was more than 5m below ground level.

SOIL PROPERTIES:

8. Site soil type:

9. Underlying geology:

The British Geological Society Map (BGS) Sheet 23W, shows that that the site is underlain predominately by glacial till comprising rock fragments in a stiff to hard clay, silt and sandy matrix. The BGS Hydrogeological Map of Scotland (1:625,000 scale) indicates that the site is underlain by Carboniferous strata with aquifers in which flow is dominantly in fissures and other discontinuities. The BGS Groundwater Vulnerability Map of Scotland (1:625,000) indicates that the site is underlain by moderately permeable strata.

10. Infiltration rates

The SUDS design was based on a preliminary site investigation and it was assumed that no or an exceedingly limited infiltration of rain water was possible. Therefore the attenuation and drainage system proposed must cope with the maximum flows calculated. The SI confirmed this approach and that infiltration would not generally be viable.

Since infiltration was not a general option and some areas of paving were close to buildings, an impermeable liner was specified where permeable paving was used. A liner was not considered necessary for the detention basin since there were no concerns with the buildings.

INTEGRATION WITH EXISTING ROAD INFRASTRUCTURE

The school development was on the site of an existing school. There was no impact on the road infrastructure.

INTEGRATION WITH UTILITIES AND OTHER INFRASTRUCTURE

There was no connection of surface water to Scottish Water's sewers and all surface water discharged through a single point to the local watercourse, the Rotten Calder.

OTHERS

Soil Contamination

There was none

Surface Water abstractions

There were none within a significant distance.

Flooding potential

The school site is at 175m above sea level and more than 10m higher than the local watercourse thus the site is not subject to marine or pluvial flooding. The local topography is such that rainwater from other areas locally does NOT enter the site.

SITE FACTOR SCORE:
Site data analysis: opportunities and constraints
Site characteristic summary: This site has a fully integrated SUDS solution with a range of different SUDS and so scoring was not appropriate.

APPLICABLE SUDS OPTIONS
Only those SUDS of direct application for roads are included in the example.

EVALUATION STAGE

SOCIAL AND POLITICAL DRIVERS

- Public Health and Safety concerns. Potential steep slopes at detention basin. The intermittent storage of water in the detention basin was not seen as being a significant hazard and the basin is not fenced.
- Amenity and aesthetics. The varied surfacing was used to enhance the general appearance of the school and, for example, to create durable markings for parking spaces.

TECHNICAL DRIVERS

- Ease of construction. Not of prime importance since skilled labour on site.
- Robustness ("survivability"). Important with school children.
- System reliability. Important but regular inspection by grounds maintenance staff.

OPERATION AND MAINTENANCE DRIVERS

- Ease of maintenance. Of less importance because of availability of grounds maintenance staff.
- Servicing requirements etc. Sweeping of permeable paving.

FINANCIAL:
Factors affecting costs

- Drainage costs were a relatively small component of total school cost.

FINAL SELECTION

SELECTION OF APPROPRIATE SUDS
The total site area is 7.96 Ha and the total impermeable area is 2.76 Ha.

Analysis showed that a total volume of 765m^3 based on a discharge of 40 l/s for the 1:30 year storm was required. This is equivalent to the existing 1:2 year storm green field run-off. This volume was provided on the site in a number of different SUDS components. These were sized as the design progressed and a check was made at the end of the detailing to ensure that the different components had a total volume of at least 765m^3. The storage balance was included in underground structural plastic units.

DETAILS FROM COMPLETED PROJECT

Figure 9 indicates the locations of the roads SUDS used in this example within the overall school project. It will be noted that the examples are located where space is very limited – a typical situation for roads SUDS.

Figure 9. Overall General Plan of Calderglen High School showing the outline of the new buildings

PERMEABLE BLOCK PAVING

Permeable block paving was installed in all car parking areas within the school property and, where possible due to falls, runoff from the access surfaces also drains through the block paving. The permeable paving has an impermeable membrane to prevent downward movement of water - the porous paving specified for Calderglen is the Aquaflow system. Since infiltration was never an option and some areas of paving were close to buildings, the impermeable liner was specified. Figure 10 shows a typical cross section detail incorporating an impermeable liner below the pavement structure. The liner should otherwise not normally be required under Parking areas.

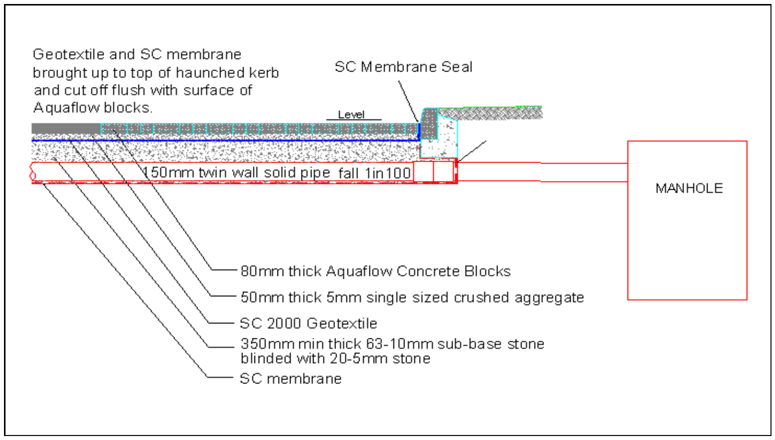

Figure 10. Permeable block paving cross section details

Figure 11 shows a typical detail incorporating special road surface features (disabled parking bays). The bays are formed using permeable paving which receives runoff from the adjacent access surface.

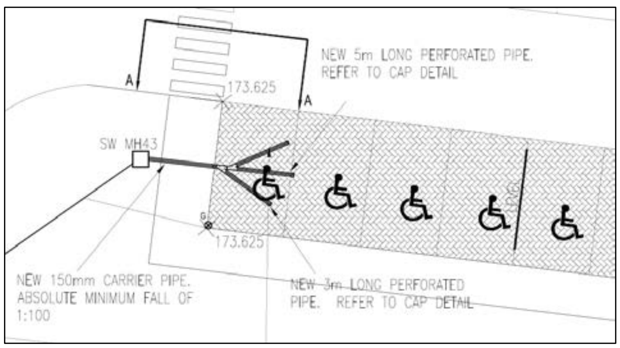

Figure 11. Permeable paving for disabled parking spaces

Figure 12 shows a standard cross section through road construction where the road drains on to permeable paving. Note that the complete structure is also underlain by an impermeable membrane.

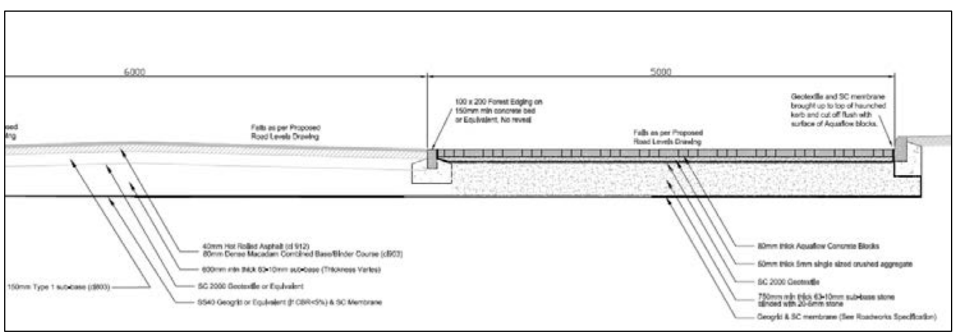

Figure 12. Cross section through road construction where the road drains on to permeable paving

DETENTION BASIN (SHOWN AS POND ON WSP PLANS)

The basin is remote from the road structure which means that the storage of the water cannot affect its structural integrity. The basin drains a section of road and parts of the building roofs. Details are shown in Figure 13 (where the basin is called a pond) and in Figure 14. Slopes are slack (1:2) close to the road due to safety considerations.

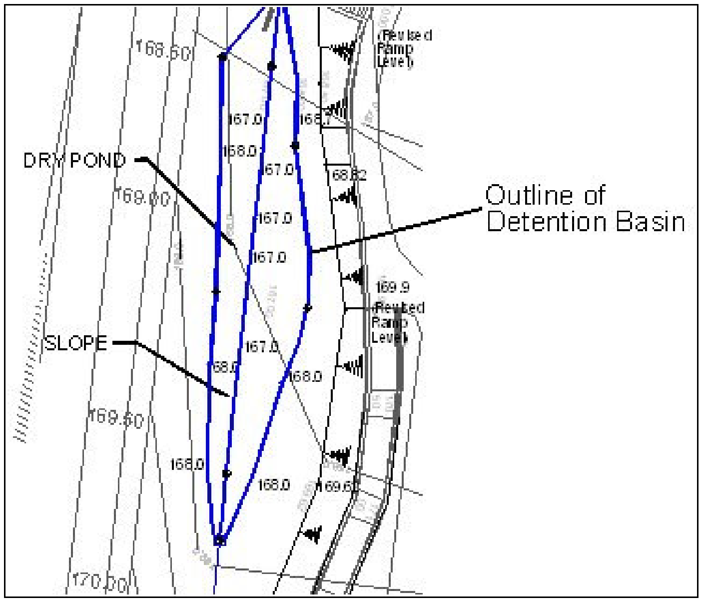

Figure 13. Layout of detention basin

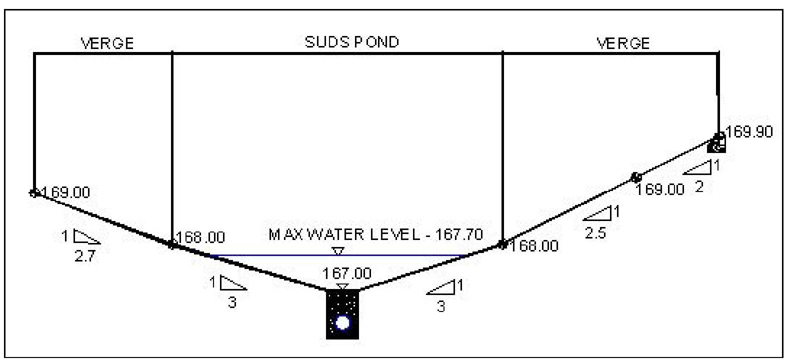

Figure 14. Cross section through detention basin

Water drains from the base through the filter media. This gives first (settlement) and second (filtration) levels of treatment. Control of the outflow is essential and this is located in a separate manhole away from the basin. The basin is unlined, permitting infiltration and reducing the direct flow of runoff to the West Calder Water.

Maintenance of the basin will be restricted to grass cutting (along with much of the school grounds) and periodic removal of sediment from the top of the filter. The amount and frequency of sediment removal will depend effectively on the amount of 'gardening' activities within the school grounds.

All figures which follow are reproduced with the permission of: South Lanarkshire Council and WSP Ltd.

WORKED EXAMPLE 3 – J4M8 DISTRIBUTION PARK, WEST LOTHIAN

PROJECT DESCRIPTION

This worked example is a roadside filter strip and swale on an adopted link road to a distribution centre. The roads SUDS in this location require three levels of treatment, two of which are provided in the filter strip and swale while the third is provided by a pond which also incorporates the storage required for flow attenuation.

SCOPING STAGE

1. Type of Road
   Access road, classified as 'Industrial Access Road' off an A class road, close to a motorway junction.

Photo 9. Filter Strip and Swale

Photo 10. Swale with gulley inlets (note kerb and footpath)

2. Key Stakeholders
   The developer, Strawsons Property, wished to develop the former Inchmore Farm area of the J4M8 Distribution Park. The design would be required to meet the requirements of West Lothian Council and Transport Scotland.

PHYSICAL DRIVERS:

3. Space availability
   Space was not a particular issue at this site and the SUDS ponds were integrated into the overall landscape design. The source control SUDS addressed in this example have been built into open space which is required for sight lines along the busy link road.

4. Levels of treatment required
   Three levels of treatment are required for this industrial access road which is also in a sensitive receiving water catchment. The sensitivity is due to the amount of developments on the catchment and the low dilution of pollutants in summer.

SITE TOPOGRAPHY:

5. Contributing drainage area
   The overall site area of some 82 hectares is located some 2km southwest of Bathgate, bounded by the A7066 to the north, M8 motorway to the south, A801 to the west and Riddochhill Bing and Whitehill Industrial Estate to the east.

6. Site slopes:
   The site slopes in an easterly direction from an elevation of 163.0m Above Ordnance Datum (AOD) to 150.0m AOD at the eastern boundary. There is a small depression at an elevation of 148.0m AOD within the northeast margins of the site.

7. Groundwater table level:
   Historical site investigation data has indicated the presence of groundwater at two locations; within the southern margins of the site at depths between 2.5 and 4.5m and at the north west corner of the site at a depth of 2.7m.

SOIL PROPERTIES:

8. Site soil type:
   The superficial drift deposits are composed mainly of boulder clay (glacial till). In addition there are smaller zones of undifferentiated clay/ silt and peat, and made ground in small areas within the eastern margins of the site.

9. Underlying geology
   The bedrock is limestone coal bearing strata of the Carboniferous Age, dipping generally to the west. Coal and fireclay workings have been exploited in the district, the most recent phase being discontinued about 1982. Three old shafts and two former adits, whose condition is unknown, are believed to be present within the site.

   Further investigation work was recommended in the site investigation to establish the extent of past mining activity in the eastern margins of the site and assess and mitigate any potential impacts on the proposed SUDS.

10. Hydraulic conductivity:
    Infiltration is not possible due to a combination of soil of low hydraulic conductivity (Boulder Clay) and high water table.

INTEGRATION WITH EXISTING ROAD INFRASTRUCTURE

CCTV surveyors Underground Inspection Services ltd (UIS) completed a CCTV survey of the site surface water outfall culverts from their origins to watercourse outfall locations.

INTEGRATION WITH UTILITIES AND OTHER INFRASTRUCTURE

There is no significant infrastructure which impact on the roads SUDS.

SITE FACTOR SCORE:

The surface water drainage system comprises an open channel system following, where possible, the route of proposed roads infrastructure in this area of the distribution park to the retention ponds. The SUDS features discharge to the culvert which outfalls to the Bog Burn in the north and culvert discharging to the River Almond in the south.

Based on the site topography, land availability and site constraints, it is considered that the most appropriate form of water treatment and attenuation would be a combination of pipework, open channel watercourses and swales providing conveyance and the second level of site control treatment, with retention ponds located at the north east and south east margins of the site, beneath the 132KV overhead power lines, providing the third level of site control treatment and attenuation. Scottish Power have intimated that they are not averse to the principles of a SUDS retention pond beneath the 132 KV overhead power lines provided that the appropriate health and safety measures are implemented and excavations for the proposed retention pond are not less than 30m from the nearest pylon leg.

The main SUDS features comprise retention ponds to provide treatment and attenuation. The north pond is designed to attenuate runoff from the 200 year return period storm, and has a 4Vt treatment volume of 13,190m^3, and attenuation volume of 16,500m^3 with a maximum outflow restricted to 77l/s to meet culvert capacity constraints. The south pond is also designed to attenuate runoff from the 200 year return period storm, and has a 4Vt treatment volume of 23,000m^3, and attenuation volume of 17,700m^3 with outflow restricted to 280l/s.

Site data analysis: opportunities and constraints
Site characteristic summary:

- Space was not a critical factor.
- Two levels of treatment required upstream from the pond.
- The total contributing drainage area is approximately 82ha.
- Source control should be used wherever possible.
- The proposed area has gently sloping terrain.

The groundwater table level is below 2.5m, where it has been found.

Table 4. Site Factor Scoring Table (assumes all options have a retention pond to provide three levels of treatment)

	Filter strip and swale	Detention basin	Filter trench and detention basin	Directly to the pond
Land / Space requirement	1	1	1	1
Level of treatment provided	2	1	2	1
Contributing Drainage area	1	1	1	1
Site Gradient	1	1	1	1
Water Table level	1	1	1	1
Underlying geology	1	1	0	1
Soil Type	1	1	1	1
Integration with existing road Infrastructure	1	1	1	1
Integration With Utilities and other Infrastructure	1	1	1	1
Contaminated land	1	1	0	1
Surface Water abstractions	1	1	1	1
Flow attenuation	1	1	1	1
SITE FACTOR SCORE	13	12	11	12

APPLICABLE SUDS OPTIONS

The following ranked list of potential candidate SUDS was drawn up;

- Filter strip and swale
- Detention basin
- Filter trench and detention basin

Directly to pond

EVALUATION STAGE

The options selected are:

- Filter strip and swale
- Pond

SOCIAL AND POLITICAL ISSUES:

There were none

TECHNICAL DRIVERS

The design of SUDS within the distribution park requires three levels of treatment in accordance with the treatment train criteria. Attenuation is a West Lothian Council requirement in accordance with their requirement to control flooding. As this site discharges to watercourses via culverts, the council require that the surface water discharge from the post-development site is attenuated to, at most, the 2 year return period storm, with a provision to accommodate the 200 year return period storm within the development site area without detriment to properties within or out-with the proposed site area.

OPERATION AND MAINTENANCE DRIVER

At the present time, it is not expected that the SUDS conveyance system or retention pond feature will be adopted by either West Lothian Council or Scottish Water. Responsibility for maintenance of these features will, therefore, revert to Strawsons Property.

PRELIMINARY OUTLINE DESIGN

Hydrological Design –

The distribution park is located immediately northeast of junction 4 of the M8 motorway, with its access from the A801.The Inchmore Farm area occupying an overall area of some 82 hectares forms the northern margins of the distribution park extending from the A801/A7066 roundabout at the west of the site to Whitehill Industrial Estate to the east. All of the required treatment volume was provided in the retention ponds. Additional treatment volume in swales was considered to be a 'bonus'. The equation used for the determination of treatment volume was;

Vt (m3/ha) = 9.D[SOIL/2 + (1-SOIL/2).I]. The resulting treatment volumes are given in Table 5

Table 5. Pond treatment volumes

Pond	$4V_t$ Required (m^3)	$4V_t$ Provided (m^3)
1	19,665	23,056
2	13,054	13,189

In addition to the volume required for treatment, a separate volume is required to attenuate the 200 Year Return Period Storm. The attenuation volumes for each pond were as given in Table 6.

Table 6. Pond attenuation volumes

Pond	Max outflow (l/s)	Max water level (m)	Attenuation Vol. (m^3)
1	177.4	155.46	17,681
2	72.8	149.13	16,441

Treatment Train

The typical treatment train for the site to provide three levels of treatment were; Roadside Filter Strip – Swale – Retention Pond.

FINANCIAL:

The SUDS at this site gave rise to no extra costs.

FINAL SELECTION

The preferred option for the roads SUDS at the development are roadside swales as shown in Photo 9 and 10 and Figure 15.

Figure 16 shows the road cross section while the swale, road kerb details are shown in **Figure 17** and Figure 18.

In all SUDS for this development the third level of treatment is provided by one of the retention ponds.

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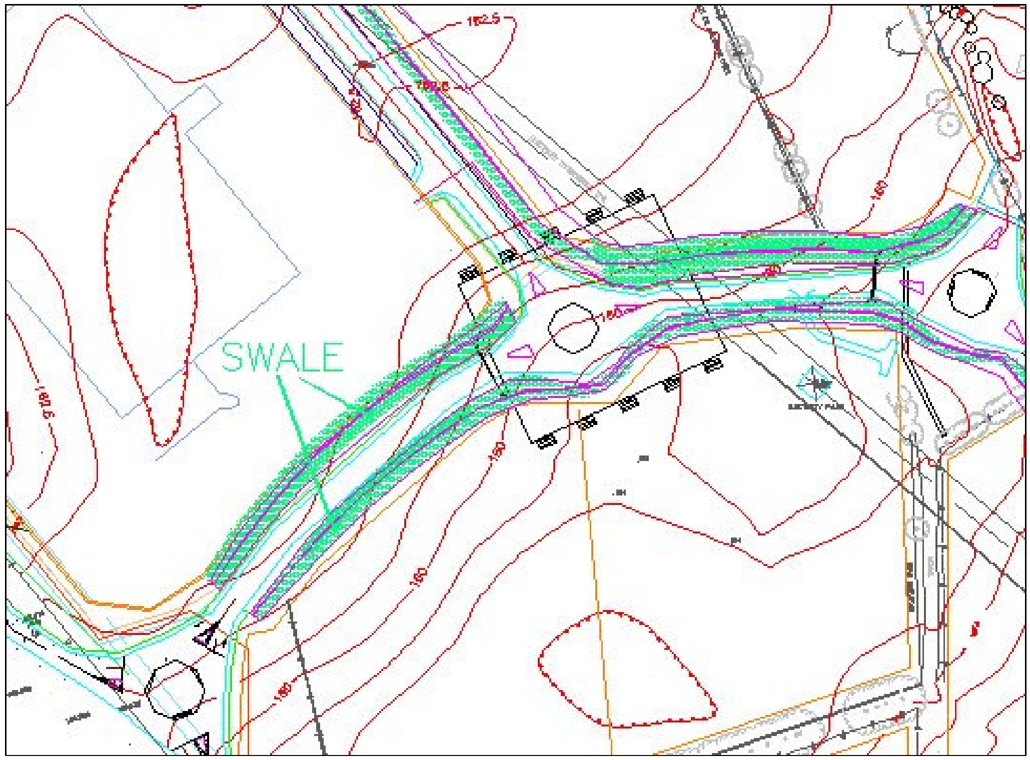

Figure 15. Layout of roads SUDS at J4M8

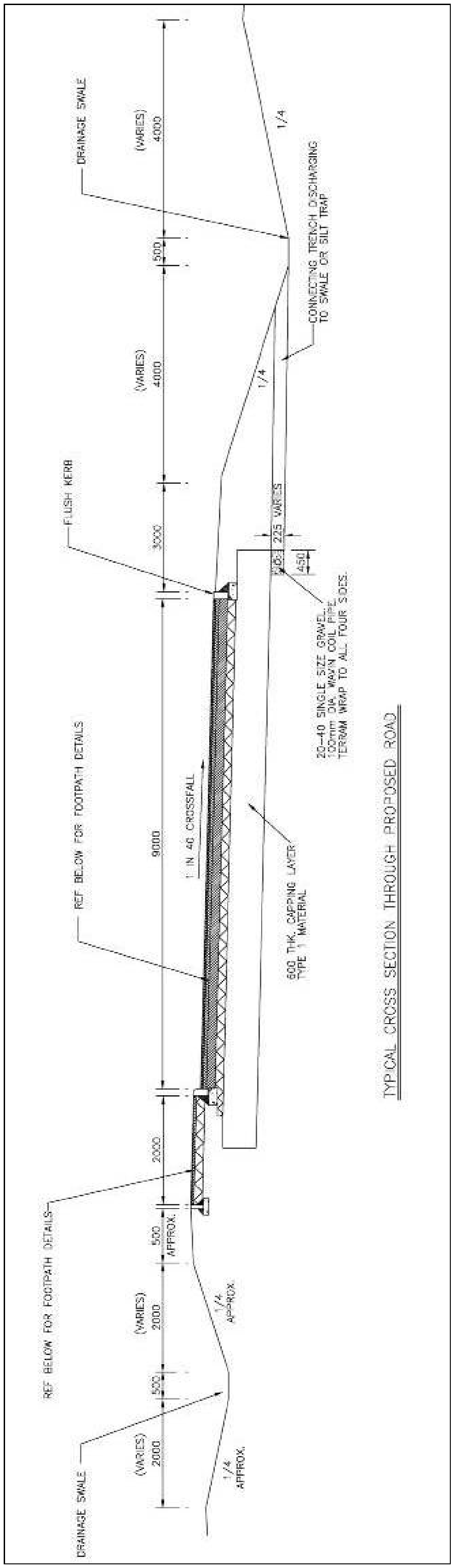

Figure 16. Road cross section

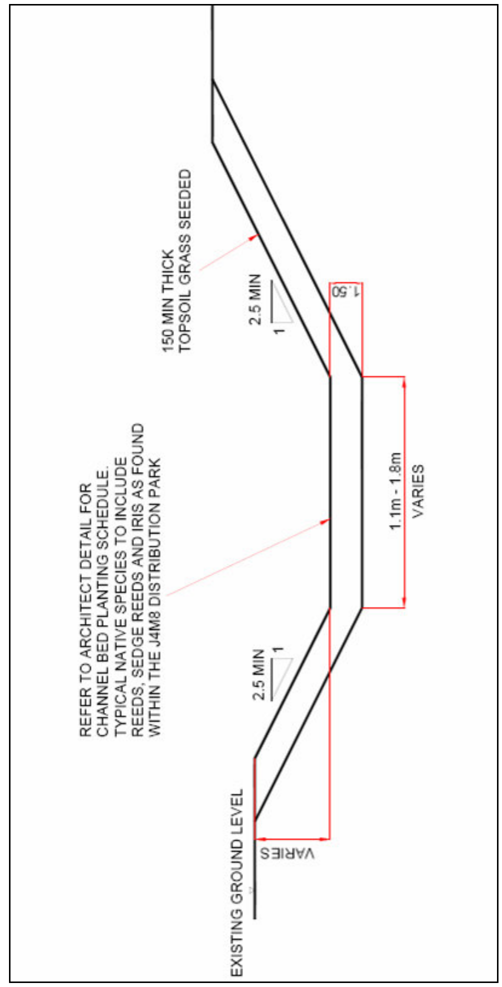

Figure 17. Conveyance swale and filter strip adjacent to industrial access road

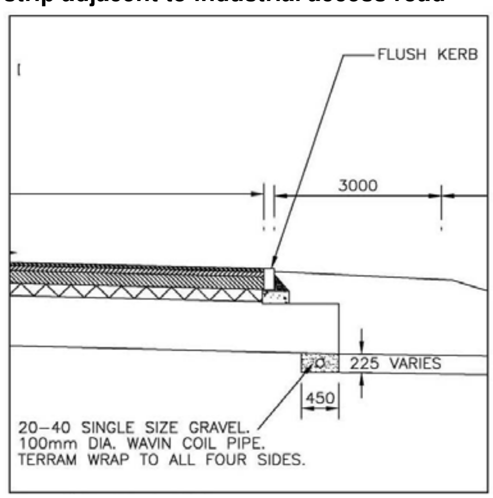

Figure 18. Flush kerb detail

WORKED EXAMPLE 4 – WHITENESS NURSERY DUNDEE

PROJECT DESCRIPTION

It is proposed to redevelop the site of a former nursery in Dundee into high quality housing. The SUDS have to drain housing and associated parking/ driveways (1,850m^2) and an improved access road (505m^2). The total area of the site is slightly more than10,000 m^2, thus, some 24% of the site is to be developed.

Infiltration capacity of the soil and rock is highly satisfactory and infiltration SUDS have been designed.

SCOPING STAGE

1. Type of Road

Minor access road and Homezone/ shared surface: The development has some 20 houses and associated paved surfaces.

Applicable SUDS option;

- Permeable Block paving, infiltration basin and detention basin.

2. Key Stakeholders

Developer, Local Authority, Scottish Water.

PHYSICAL DRIVERS:

3. Space availability

Space is not a critical issue on the site, although the relative locations of open space had an effect on the option selected.

There is a watercourse to the west of site but it is very small and this creates severe problems for any discharge there.

Existing houses down slope to the south might possibly suffer from a change of infiltrating water.

4. Levels of treatment required

One level of treatment (See section 2.4).

SITE TOPOGRAPHY:

5. Contributing drainage area

10,000m^2.

6. Site slopes

The site itself is relatively flat but the north-south slope of the general area is a principal design issue for this site. To the north of the site is a major road artery and access from this main road is steep, causing the access road water to flow on to the site. To the south of the site, and down slope is a housing development built in the 1970s. Infiltration of surface runoff is the best option but protection of these homes to the south is important.

7. Groundwater table level:

Twelve trial pits dug on the site were logged as being dry. Half of the pits were to a depth of 2.5 metres or deeper.

SOIL PROPERTIES:

Three boreholes, twelve trial pits and six infiltration tests were undertaken at the site.

8. Site soil type:

The site is underlain by sandy gravel with some silt and some cobbles. Infiltration tests were carried out at six locations which were considered to be representative of likely ground conditions. The values of infiltration obtained ranged from 2.17x10-4 m/s to 5.26x10-3 m/s. These values are relatively high and, for comparison, are equivalent to from twice to nearly 50 times the rainfall intensity recommended in Sewers for Scotland for single houses (40 mm per hour).

9. Underlying geology

The underlying rock is a highly fissured Old Red Sandstone at a depth of approximately 10m.

10. Hydraulic conductivity:

The site investigation concluded that the water table is at a sufficient depth that the potential for infiltration will never be affected by high water table, and that infiltrated flow from the site will continue to flow (partly) vertically and cannot affect buildings to the south.

INTEGRATION WITH EXISTING ROAD INFRASTRUCTURE

This is not a problem at this newly developed site.

INTEGRATION WITH UTILITIES AND OTHER INFRASTRUCTURE

No.

OTHERS

There is no soil contamination

No issues.

Surface Water abstractions

There are no surface water abstractions within a 1km radius of the site.

SITE FACTOR SCORE:

A scoring exercise was not undertaken for this site

APPLICABLE SUDS OPTIONS

The following ranked list of potential candidate SUDS was drawn up;

- Permeable block paving;
- Porous Asphalt
- Bioretention areas
- Modular Storage Systems
- Sand filters

EVALUATION STAGE

SOCIAL AND POLITICAL ISSUES:

None.

TECHNICAL DRIVERS

Drainage from the steep section of the access road (Figure 22) had to be routed to a SUDS before discharge or infiltration. The solution to this problem was to have all inflow via trapped gullies and a silt trap prior to discharge into the permeable paving at the turning circle.

The majority of the road on site is relatively horizontal and permeable construction was adopted (Figure 19).

The houses are drained by separate soakaways on each plot.

This system has no parts which are to be adopted by Scottish Water.

OPERATION AND MAINTENANCE DRIVE
Here.

PRELIMINARY OUTLINE DESIGN
Hydrological Design – details required for a sample section of pervious paving.

FINANCIAL:
Road drainage was only a small part of the cost of the development. However, the site could not actually be developed without an acceptable SUDS solution.

FINAL SELECTION
The information obtained from the infiltration tests indicated that even in the most extreme rainfall there is unlikely to be runoff from the site since all of the rainfall will infiltrate into the ground. Furthermore, the land has been terraced in the past for the nursery. This causes slow movement of water and encourages infiltration.

Part	Description
A-E	Adoptable access road. Drainage is through gullies at appropriate locations and a 300mm diameter conveyance pipe to the infiltration area
F	Adoptable access road using permeable paving.
G	Adoptable turning area using permeable paving.
H	Adoptable turning area using permeable paving.

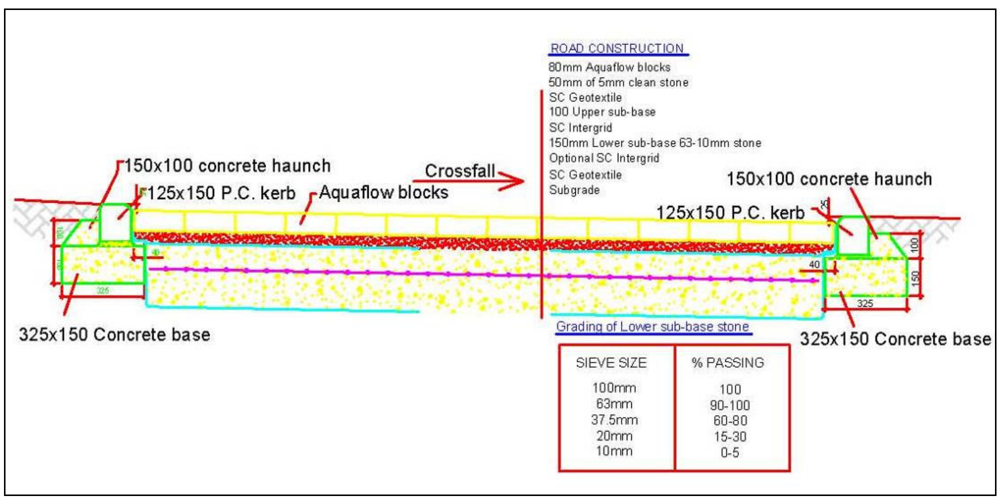

Figure 19. Section through porous road construction

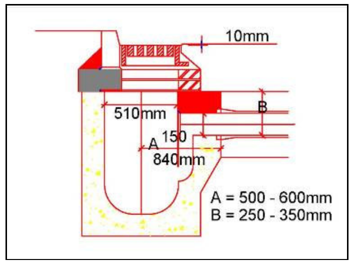

Figure 20. Detail of trapped plastic road gully

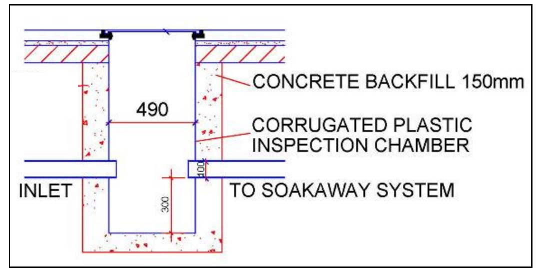

Figure 21. Silt trap manhole detail

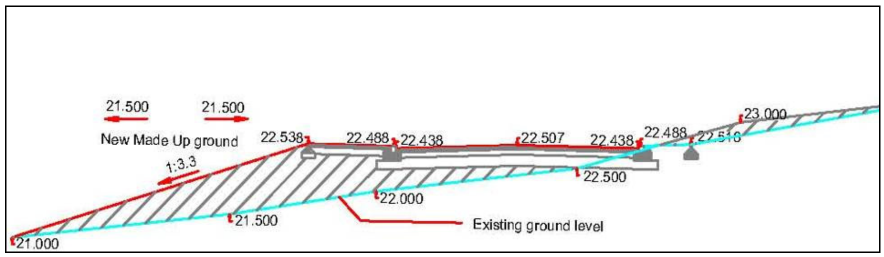

Figure 22. Typical section through impermeable road construction

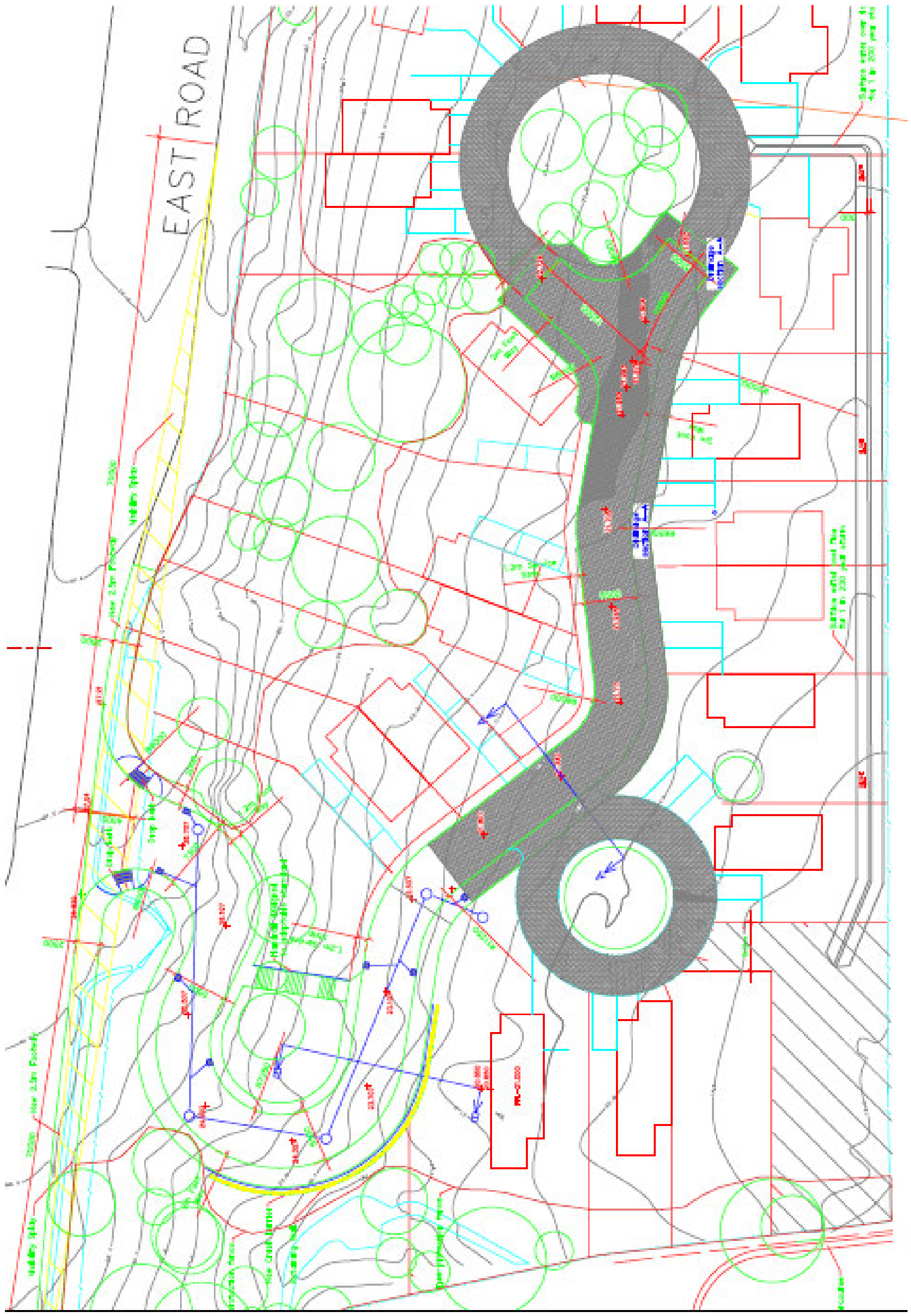

Figure 23. Site plan

The help of L.N. Henderson & Associates in developing this worked axample is acknowledged

Appendix D Specimen Section 7 Agreement and Minute of Agreement

MINUTE OF AGREEMENT

BETWEEN

Scottish Water established in terms of the Water Industry (Scotland) Act 2002 and having its principal office at Castle House, 6 Castle Drive, Dunfermline KY11 8GG ("Scottish Water")

And

[ ] Council incorporated by Local Government etc Act 1994 [designated] as Roads Authority in terms of the Roads (Scotland) Act 1984 ("the Roads Authority ")

WHEREAS:-

(A) Scottish Water is responsible for the provision of such public sewers and SUD systems as may be necessary for effectually draining its area of domestic sewage, surface water and trade effluent, and to make such provision, by means of sewage treatment works or otherwise, as may be necessary for effectually dealing with the contents of their sewers, conform to section 1 of the Sewerage (Scotland) Act 1968;

(B) The Council as a Roads Authority as interpreted in Section 151 of the Roads (Scotland) Act 1984, ("the 1984 Act"), is responsible for managing and maintaining public roads in its area conform, to Section 1 of the 1984 Act, and may drain a public road conform to section 31 of the 1984 Act;

(C) Section 7 of the Sewerage Scotland Act 1968 ("the 1968 Act")provides that

- a Roads Authority and Scottish Water may agree, on such terms and conditions as may be specified in the agreement, as to the provision, management, maintenance or use of their sewers or road drains for the conveyance of water from the surface of a road or surface water from premises and that;

- a Roads Authority or Scottish Water shall not unreasonably refuse to enter into an agreement for the purposes of this section or insist unreasonably upon terms or conditions unacceptable to the other party, and any dispute arising under this section to which the Scottish Ministers are not a party as to whether or not a Roads Authority or Scottish Water are acting unreasonably, shall be referred to the Scottish Ministers, who, after consultation with the Roads Authority concerned and Scottish Water, shall determine the dispute, and their decision shall be final.

IT IS AGREED by the Parties as follows:-

1 Definitions and Interpretation

In this Agreement:-

"Parties"	means Scottish Water and the Roads Authority.
"Roads Authority"	has the same meaning as in the Roads (Scotland) Act 1984.
"Road"	means a public road maintainable at the public expense, or subject of an agreement with the Roads Authority for its adoption as such.
"Roads Drainage System"	means the system of SUDS, gullies, pipes and channels together with any associated structures used to convey surface water from a Road extending to and including the relevant connection as defined in Section 30 & 31 of the Roads (Scotland) Act 1984.
"Relevant Connection"	means a connection to a Public Sewer which is used solely for any purpose in connection with the drainage of a road maintainable by the Roads Authority. or means a connection to a Road Drainage System which is used solely for any purpose in connection with the drainage of a Public Sewer maintainable by Scottish Water.
"Relevant Public Sewer"	means a Public Sewer that is connected to a Roads Drainage System.
"Relevant Roads Drainage System"	means a Roads Drainage System connected to a Public Sewer.

“Conveyance of water"	means the routing of water and/or surface water, and any associated sediments, above ground and/or underground, subject to and inclusive of attenuated storage volumes, and/or treatment volumes, and/or flow limit control structures and/or sediment control structures, natural, built, intended or otherwise, under various short, medium and long duration rainfall event(s).
“Public Sewer”	means any sewer or SUD system which is vested in Scottish Water.
“Sewer”	has the same meaning as in Section 59 of the Sewerage (Scotland) Act 1968.
“Sustainable urban drainage system” (SUDS)	has the same meaning as in Section 59 of the Sewerage (Scotland) Act 1968.

2 Acknowledgement and Consent to use of Public Sewers

2.1 Scottish Water acknowledges the rights of continued use by the Roads Authority of any existing Relevant Connection made prior to the date of this Section 7 Agreement.

2.2 The Roads Authority agrees that in making use of Public Sewers it shall comply with the provisions of this Agreement.

2.3 Scottish Water agrees that the Agreement represents good practice and shall apply to any connections to be made by the Roads Authority to a Public Sewer in respect of its Road Drainage Systems and to the continued use by the Roads Authority of any such Public Sewer.

3 Acknowledgement and Consent to use of Roads Drainage Systems

3.1 The Roads Authority acknowledges the rights of continued use by Scottish Water of any existing Relevant Connection made prior to the date of this Section 7 Agreement.

3.2 Scottish Water agrees that in making use of the Roads Drainage Systems it will comply with the provisions of this Agreement.

3.3 The Roads Authority agrees that the Agreement represents good practice and shall apply to any connections to be made by Scottish Water to a Road Drainage System in respect of its Public Sewers and to the continued use by Scottish Water of any such Roads Drainage System.

4 Making new connections

4.1 The Roads Authority when proposing a connection to or works which may affect a Public Sewer, and Scottish Water when proposing a connection to or works which may affect the Roads Drainage System, shall give reasonable notice to, and submit such plans, specifications and drawings (together with supporting calculations) as may be required for approval by, the other party prior to commencement of any works.

4.2 Upon receipt of a notice under Clause 4.1 the party receiving the notice may require that the proposals incorporate any or all of the following, all to an agreed timetable depending on complexity:

a) The provision of trapped gullies, oil separators, grit separators and catch-pits so that oil, silt, and grit are not passed into the Public Sewer or Roads Drainage System (as the case may be);

b) Measures to limit the peak rate of design flow through the connection to the public sewer to a flow equal to the pre-development flow value unless otherwise agreed by both parties;

c) Measures to minimise the impact on adjacent premises of any surface flooding resulting from rainfall exceeding the design rainfall intensity;

d) Measures to ensure that any new surface water drainage is treated via SUDS, where practicable, upstream or downstream of the connection to the Relevant Public Sewer;

e) So far as reasonably practicable and in accordance with the parties respective rights and responsibilities under statute and at common law, measures to ensure that surface water or groundwater from adjacent land or property, including from ditches and watercourses, does not enter the Roads Drainage System or Public Sewer (as the case may be);

f) Ensuring that all pipes, gullies, manholes, inspection chambers and other parts of the sealed underground drainage system are sufficiently watertight so not to admit sub-soil water;

g) Ensuring the proposals comply with any Relevant Technical Standards.

4.3 The party making the connection shall implement its proposals only in accordance with the plans and specifications previously submitted to and approved in writing by the other party. Necessary changes in the course of the works shall be submitted in writing to the other party for approval.

4.4 Each party shall,

a) prior to carrying out works pursuant to Clause 4.2, give reasonable notice to the other party in order that the other party can monitor the works and;

b) afford the other party all reasonable facilities for monitoring the works;

c) have regard to all reasonable requests from the other party in connection with the works.

5 Subsequent alterations to a Public Roads Drainage System

5.1 The Roads Authority shall not alter a Relevant Roads Drainage System without the prior written consent of Scottish Water where any alterations would result in any material impact on the Relevant Public Sewer, such consent not to be unreasonably withheld or delayed.

5.2 The Roads Authority shall not, without the prior written consent of Scottish Water, carry out any works to a road which significantly increases the area of roads that is drained to a Public Sewer.

6 Subsequent alterations to Public Surface Water Drainage

6.1 Scottish Water shall not alter any Relevant Public Sewer without the prior written consent of the Roads Authority where any alteration would result in any material impact on the Relevant Roads Drainage system, such consent not to be unreasonably withheld or delayed.

6.2 Where, in accordance with Section 12 of the 1968 Act, Scottish Water receives notice from either an owner or occupier of premises or the owner of a private sewer, desiring to connect surface water to a Relevant Public Sewer, and which is likely to affect a Relevant Roads Drainage System, Scottish Water shall submit for approval to the Roads Authority.

7 Records – Pertaining to Section 7 Agreements

7.1 The Roads Authority shall maintain records of known connections of roads drainage to any Public Sewer as far as is reasonably practicable.

7.2 Scottish Water shall maintain records of all Relevant Public Sewers and any properties that are, in accordance with this agreement, connected to a Roads Drainage System as far as is reasonably practicable.

7.3 Records required under Clauses 7.1 and 7.2 shall be in a form agreed between the parties, and shall include (insofar as the information is known to the parties) plans showing:

a) The location of all connections to the Public Sewer and Roads Drainage System;

b) The location and design criteria of properties or groups of properties that are connected to the Roads Drainage System via Scottish Water apparatus;

c) The location and design criteria of the Relevant Roads Drainage System connected to the Public Sewer;

d) The location of the inlets and the layout of the Roads.

7.4 Each party shall supply copies of any records held by them in accordance with Clauses 7.1 and 7.2 to the other party on request.

7.5 The parties agree to co-operate with the exchange of information held by them regarding connections between their respective systems.

8 Maintenance of Relevant Roads Drainage Systems

8.1 The Roads Authority shall take all reasonable steps to maintain any Relevant Roads Drainage System (including SUDS) in full and proper repair so as to ensure that it continues to function effectually.

9 Maintenance of Public Sewers

9.1 Scottish Water shall take all reasonable steps to maintain any Relevant Public Sewer (including public SUDS) in full and proper repair so as to ensure that it continues to function effectually.

10 Inspection and testing

10.1 Nothing in this Agreement shall limit or restrict Scottish Waters rights to investigate a defective drain or sewer under Sections 15 and 48 of the Sewerage (Scotland) Act 1968 and the parties confirm that for the purposes of this Agreement such a drain or sewer shall include any road drainage system adopted by the Roads Authority.

10.2 Nothing in this Agreement shall limit or restrict the Roads Authority's rights to investigate a defective drain or sewer under Section 140 of the Roads (Scotland) Act 1984 and the parties confirm that for the purposes of this Agreement such a drain or sewer shall include any drain or sewer vested in Scottish Water.

11 Control of Discharges

11.1 The Roads Authority and Scottish Water agree to work together to ensure, as far as reasonably practicable that where possible only each party's statutory surface water generated from roads and areas agreed in writing (which may include an area within the curtilage of a building) discharges to a Relevant Roads Drainage System or Relevant Public Sewer. Neither party accepts liability for the unauthorised acts of third parties

12 Indemnity

12.1 Each party shall exercise its rights under this agreement at its own risk and shall hold harmless and indemnify the other party against any liabilities or costs incurred which would not have arisen if this Agreement had not been made.

12.2 Each party shall hold harmless and indemnify the other party against all losses, liabilities and costs arising from any claim by any person or competent authority arising from any breach by them of this Agreement.

13 Termination of Relevant Connection

13.1 Except where otherwise agreed with Scottish Water in writing, where a road ceases to be publicly maintainable, the Roads Authority shall arrange to disconnect any connections and make good the Public Sewer, unless it makes an agreement to continue to operate and maintain the Roads Drainage System and copies this to Scottish Water.

13.2 Except where otherwise agreed with the Roads Authority in writing, where a Public Sewer discharging to a Roads Drainage System is removed or replaced Scottish Water shall disconnect any connections and make good the Roads Drainage System unless it makes an agreement to continue to operate and maintain the sewer and copies this to the Roads Authority.

13.3 Prior to the Roads Authority's termination of a relevant connection from a Relevant Roads Drainage System to a Relevant Public Sewer, or Scottish Water's termination of a relevant connection from a Relevant Public Sewer to a Relevant Roads Drainage System, the party proposing the disconnection shall:

a) give reasonable notice to the other party in order that the other party can monitor the work;

b) afford the other party all reasonable facilities for monitoring the work; and

c) have regard to all reasonable requests from the other party in connection with the work.

13.4 Where a party terminates a relevant connection, they shall remove all drains or sewers by which the connection had been made, and shall seal and make good the Public Sewer or Roads Drainage System (as the case may be) to the reasonable satisfaction of the other party.

14 Notices

14.1 Any notice, request, consent or approval shall be sent to the registered office or principal business address of either party via an agreed method and to an agreed timescale.

15 Data Protection and Access to Information

15.1 The parties shall comply with their respective obligations under the Data Protection Act 1998 ("the 1998 Act") and the Computer Misuse Act 1990, and any amending or new legislation insofar as performance of the Agreement gives rise to obligations under those Acts and shall ensure that it does nothing knowingly or negligently which places the other party in breach of any obligations under the 1998 Act.

15.2 The parties shall co-operate so as to assist in enabling each of them to comply with their respective obligations under all legislation and guidance.

16 Severance

16.1 Each provision of this Agreement is severable and distinct from the others. The parties intend that every such provision shall be and remain valid and enforceable to the fullest extent permitted by law.

16.2 If any such provision is or at any time becomes to any extent invalid, illegal or unenforceable under any enactment or rule of law, it shall to that extent be deemed not to form part of the Agreement but (except to the extent in the case of that provision) it and all other provisions of the Agreement shall continue in full force and effect and their validity, legality and enforceability shall not hereby be affected or impaired, provided that the operation of the Agreement would not negate the commercial intent and purpose of the parties under the Agreement. Should however this bring about a material change, the Agreement may be reviewed by both parties.

17 Accrued Rights and Remedies

17.1 The termination of the Agreement shall not prejudice or affect any claim, right, action or remedy that shall have accrued or shall thereafter accrue to either party.

18 Rights and Duties Reserved

18.1 All statutory or common law rights, duties and powers which the parties are under are expressly reserved.

19 Third Party Rights

19.1 Unless the right of enforcement is expressly provided, no third party shall have the right to pursue any right under this Agreement.

20 Waivers

20.1 Failure of either party to this Agreement to enforce at any time or for any period of time any of the provisions of this Agreement shall not be construed to be a waiver of any such provision and shall in no matter affect the right of that party thereafter to enforce such provision.

20.2 No waiver in any one or more instances of a breach of any provision hereof shall be deemed to be a further or continuing waiver of such provision in other instances.

21 Disputes

In the event of any dispute arising between the parties to this Agreement,

21.1 Either party to this Agreement may refer the matter to a Panel comprising a nominated director or equivalent of Scottish Water and the Roads Authority, for their consideration. The Panel shall, in good faith, and in accordance with the required technical standards of both parties endeavour to agree a solution. The parties shall require to take such steps as the Panel agree to implement the solution, and within such timescale as may be agreed by the Panel.

21.2 In the event that agreement cannot be reached by the Panel on any matter, either party to this Agreement may refer the matter to the Scottish Ministers in terms of the 1968 Act.

21.3. In the event that either party is in breach of any of their obligations incumbent upon them in this Agreement, the other party may give to the party in breach notice in writing specifying such breach. The party in default shall within a reasonable time specified therein, remedy such breach; and in the event that the party in breach fails to remedy the breach within the time specified, and where such breach affects the statutory obligations of the other party, or the obligations of the other party in terms of this Agreement, the said other party may take such steps as are reasonable to remedy the breach. The party in breach shall thereafter require to pay on demand to the other party all reasonable costs, fees and outlays incurred in remedying the breach.

This clause is without prejudice to any rights either party may have to damages in statutory or at common law.

22 Review

The parties will review this Agreement no later than the fifth anniversary of the last date of signing and every tenth year thereafter. The Agreement will continue until such time as such review may take place

23 Assignation

Neither party will assign the Agreement without the written consent of the other which consent may be withheld without reason given.

24. Termination

This Agreement shall continue in force until terminated by either party giving at least six months written notice to the other party or if in breach.

25 Costs

25.1 Each of the Parties will bear their own costs and expenses in connection with this Agreement in the normal administration of this Agreement, if however one party is in breach the other party may seek costs for additional expense

25.2 Scottish Water will pay the costs of registering this Agreement in the Books of Council and Session and obtaining [Two] Extracts ([one] for Scottish Water and [one] for the Council).

26 Consent to Registration

The Parties consent to registration of this Agreement in the Books of Council and Session for preservation and execution:

NB: SCOTS have recognised that legal advice from each individual Authority may vary and as such the wording of final agreements with each Authority may differ.

This is particularly relevant to section 12 and to sections 15 to 31 where legal advice will clearly play apart in any final agreement.