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Natural Water Retention Measures

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Individual NWRM

Filter strips

ACTeon environment research & consultancy

Office International de l'Eau

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Environment

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I. NWRM Description

Filter strips are uniformly graded, gently sloping, vegetated strips of land that provide opportunities for slow conveyance and (commonly) infiltration. They are designed to accept runoff as overland sheet flow from upstream development and often lie between a hard-surfaced area and a receiving stream, surface water collection, treatment or disposal system.

Filter strips are generally planted with grass or other dense vegetation to treat the runoff through vegetative filtering, sedimentation, and (where appropriate) infiltration. They are often used as a pre-treatment technique before other sustainable drainage techniques (e.g. swales, infiltration and filter trenches). Filter strips are best suited to treating runoff from relatively small drainage areas such as roads and highways, roof downspouts, small car parks, and pervious surfaces.

Filter strips can serve as a buffer between incompatible land uses, and can provide locations for groundwater recharge in areas with pervious soils. Filter strips are often integrated into the surrounding land use, for example public open space or road verges. Local wild grass and flower species can be introduced for visual interest and to provide a wildlife habitat.

II. Illustration

Large filter strip in urban area (USA)

Source: https://austintexas.gov/content/1361/FAQ/2483

III. Geographic Applicability

Land Use	Applicability	Evidence
Artificial Surfaces	Yes	Filter strips are potentially applicable to all artificial surfaces, or as a boundary between an artificial surface and other land use.
Agricultural Areas	Yes	Filter strips are effective when receiving overland sheet flow from an adjacent area. This could apply, for example, to a field, or to artificial surfaces in agricultural areas such as farm yards. In agricultural or forest areas this measure may be almost interchangeable with buffer strips (A2 and F1), although Environment Agency (2012) differentiates the two through the active management of filter strips.
Forests and Semi-Natural Areas	Possibly	
Wetlands	No	

Region	Applicability	Evidence
Western Europe	Yes	
Mediterranean	Yes	
Baltic Sea	Yes	
Eastern Europe and Danube	Yes	

IV. Scale

	0-0.1km²	0.1-1.0km²	1-10km²	10-100km²	100-1000km²	>1000km²
Upstream Drainage Area/Catchment Area	✓					
Evidence	Filter strips should generally be used as the first stage of a SuDS 'train', accepting overland runoff from adjacent impermeable/ low permeability areas. As a result, the contributing catchment area tends to be relatively small, for example a car park, road surface or small field. CIRIA (2007) recommends a maximum upstream drainage length of 50m.					

V. Biophysical Impacts

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	None	
	Slow Runoff	Low	Due to their rough surface (as a result of dense vegetation cover), filter strips will provide some slowing of runoff (mainly for smaller rainfall events), but this may be relatively minor since there is no storage capacity as such.
	Store River Water	None	
	Slow River Water	None	
Reducing Runoff	Increase Evapotranspiration	Low	The rate of evapotranspiration will depend on dimensions, residence time and type of vegetation. With dense vegetation and relatively low velocities, evapotranspiration is substantially increased, particularly if trees are planted. Evapotranspiration in filter strips can be far more efficient than predicted by agricultural engineering. Hess (2014) carried out experiments that showed vegetation can evapotranspire more than needed if there is an excess of water, by up to 30mm per day.
	Increase Infiltration and/or groundwater recharge	Low	Filter strips are designed to be permeable, although due to the low residence time there is likely to be relatively little infiltration.
	Increase soil water retention	Low	Introduction of vegetation may over time increase the organic matter content and associated ability of the soil to retain water.
Reducing Pollution	Reduce pollutant sources	None	Where infiltration can occur, the potential for pollution to groundwater needs to be considered. However CIRIA (2009) concluded that "the potential for contamination of groundwater from SuDS schemes appears to be low, except from industrial areas. The potential for serious pollution is associated with accidents rather than the continuous background pollution from these areas". This conclusion drew on recent work by SNIFFER (2008) that found "the vast majority of heavy metals, PAHs and petroleum hydrocarbons are retained in the top 10 cm of soil" based on bare-soil lysimeter tests, and noted that the addition of a vegetative layer would allow further uptake of pollutants. However it is clearly important to

			consider the risks of pollution to groundwater on a site-specific basis in light of the wider water management, activities occurring within the drainage area of the measure and groundwater sensitivity (depth, soil permeability). Creating green areas reduces hard surfaces and leads to reduced surface leaching of pollutant sources.
	Intercept pollution pathways	High	Under low to moderate velocities, filter strips effectively reduce particulate pollutant levels by removing sediments, organic materials and trace metals. Appropriate design (including slope, width and vegetation type) is therefore important to achieving high effectiveness. Literature reviews of the effectiveness of filter strips at pollutant removal have been carried out by Environment Agency (2012) and DTI (2006). Wide ranges of effectiveness were found: - Suspended solids reduction: EA (2012) 28-96%; DTI (2006) 54-84% - Total phosphorus reduction: EA (2012) 25-88%; DTI 25-40% - Total nitrogen reduction: EA(2012) 27-100%; DTI 20% - Metals: DTI (2006) 16-55% It is likely that achieving high effectiveness at pollutant removal will be improved by good design, adequate maintenance and limited fertiliser use. This is particularly evident from the occasional negative values reported in the literature, suggesting that a reduction in water quality could potentially occur over time, for example due to a lack of maintenance and build-up of sediments, or by application of fertiliser.
Soil Conservation	Reduce erosion and/or sediment delivery	High	Sediment deposition is the primary aim of filter strips, achieved by capture of sediment in vegetation at low flow velocities. Reductions in suspended sediments are achieved downstream of the filter strip, as discussed above. Cranfield University (2006) carried out a literature review specifically looking at soil loss, predominantly from rural areas, and found on average a 76.8% reduction in soil loss was achieved by grass buffers (with filter strips being included in the category).
	Improve soils	None	

Creating Habitat	Create aquatic habitat	None	
	Create riparian habitat	None	
	Create terrestrial habitat	Medium	Filter strips introduce permanent vegetation to what may otherwise have been an artificial surface or arable land. The diversity of the vegetation is limited by the function it must perform, and is normally predominantly grasses, but native and wild flowers can be added for increased diversity. Nevertheless a large variety of trees, shrubs and plants are suited for filter strips (MDDEFP et MAMROT, 2014). Filter strips should be planted with native vegetation to be most effective in enhancing biodiversity. They can be incorporated as an element in a network of green areas, and to create green corridors, which are important for the provision of terrestrial habitat.
Climate Alteration	Enhance precipitation	None	
	Reduce peak temperature	Low	Filter strips provide green areas. Depending on vegetation density and how widespread they are, they can contribute to creating cool islands in urban landscapes (as a result of evapotranspiration, water supply, shading).
	Absorb and/or retain CO_2	Low	If a filter strip is added where no vegetation would otherwise be present, this will result in a localised increase in uptake of CO_2, particularly if woody vegetation is included.

VI. Ecosystem Services Benefits

Ecosystem Services		Rating	Evidence
Provisioning	Water Storage	None	Filter strips do not provide significant storage.
	Fish stocks and recruiting	None	
	Natural biomass production	Low	By creating green areas, filter strips may contribute to natural biomass production, particularly if the vegetation is dense.

Regulatory and Maintenance	Biodiversity preservation	Low to medium	By creating green areas within the urban landscape where there would otherwise be hard surfaces (or, for example, permanent native vegetation in an arable area) filter strips provide a contribution to biodiversity preservation. Although the diversity of the vegetation is generally relatively low, this nevertheless provides an improvement over traditional drainage and urban land cover. Development of biodiversity depends on soil moisture and choice of vegetation. The extent to which this benefit is provided depends on the soil moisture and choice of vegetation. Even when their individual contributions are minor, their potential for contributing to networks of vegetated areas and green corridors can make them an important element in biodiversity preservation in urban landscapes.
	Climate change adaptation and mitigation	Low	Filter strips can contribute to climate change adaptation. Predominantly this is by improving adaptation to the more intense rainfall events that are expected as a result of climate change. In addition, if new vegetation is introduced, particularly woody vegetation, they may also make a contribution to increasing carbon sequestration and helping to regulate urban temperatures.
	Groundwater / aquifer recharge	Low	Filter strips may promote infiltration to groundwater, although since the retention time is low, the contribution is likely to be limited.
	Flood risk reduction	Low	In isolation, filter strips provide little benefit in terms of flood risk reduction because they do not store runoff and provide only limited control on peak flow rates. However they are generally used as the first stage in a SuDS 'train' and in that respect form a component of urban runoff management and hence flood risk reduction.
	Erosion / sediment control	Medium	COWI (2014) identify urban runoff as being a relatively minor consideration for erosion and sediment control at the catchment scale. Nevertheless, sediment deposition is the primary function of filter strips, and so does provide some contribution to this benefit.
	Filtration of pollutants	High	Filter strips are effective in capturing sediments and reducing concentrations of associated pollutants.
Cultural	Recreational opportunities	None	While filter strips provide green areas, ideally they should not be used for traffic or heavy footfall as it may reduce the effectiveness at filtration. Generally they will be incorporated in to areas that are not expected to be crossed regularly, and as such would not be expected to provide any significant recreational opportunities.
	Aesthetic / cultural value	Low to medium	Measures such as filter strips, in urban areas, introduce green space to areas that are otherwise likely to be artificial surfaces. This contribution of green spaces,

			although in limited extents, may provide some aesthetic value. Creation of green areas contributes to improving urban landscapes. Using SuDS such as filter strips is a communication tool for promoting sustainable water management. Keeping water on show (rather than hiding it in traditional drainage systems) helps to raise people's awareness and knowledge. This is particularly the case where the detail and value of SuDS is communicated to the public, for example by installing information panels.
Abiotic	Navigation	None	
	Geological resources	None	
	Energy production	None	

VII. Policy Objectives

Policy Objective		Rating	Evidence
Water Framework Directive			
Achieve Good Surface Water Status	Improving status of biology quality elements	None	
	Improving status of physico-chemical quality elements	Low	Through contributing to reduction in diffuse pollution through filtration of pollutants and interception of surface runoff, filter strips can make a small contribution to improving water quality in receiving waters.
	Improving status of hydromorphology quality elements	None	
	Improving chemical status and priority substances	Low	Through contributing to reduction in diffuse pollution through filtration of pollutants and interception of surface runoff, filter strips can make a small contribution to improving water quality in receiving waters.
Achieve Good GW Status	Improved quantitative status	None	Although filter strips may allow some infiltration, the contribution is likely to be negligible on the scale of a groundwater body.
	Improved chemical status	None	

Prevent Deterioration	Prevent surface water status deterioration	Low to medium	By intercepting a potential diffuse pollution vector from the contributing catchment, filter strips can help to protect the receiving water body from deterioration as a result of new diffuse pollution sources.
	Prevent groundwater status deterioration	None	Although filter strips can allow infiltration, the spatial extent will be limited and the potential to influence groundwater status is likely to be negligible.
Floods Directive			
Take adequate and co-ordinated measures to reduce flood risks		Low	In isolation, filter strips provide little benefit in terms of flood risk management because they do not store runoff and provide only limited control of peak flow rates. However they are generally used as the first stage in a SuDS 'train' ' and in that respect form a component of coordinated flood risk management.
Habitats and Birds Directives			
Protection of Important Habitats		None	
2020 Biodiversity Strategy			
Better protection for ecosystems and more use of Green Infrastructure		Medium	As a green infrastructure component, increased application of filter strips may contribute to meeting the objectives of the 2020 Biodiversity Strategy, particularly in urban areas.
More sustainable agriculture and forestry		Low	Where used to intercept runoff from low permeability surfaces in agricultural areas (i.e. as rural SuDS components) filter strips can contribute to more sustainable agricultural practices.
Better management of fish stocks		None	
Prevention of biodiversity loss		Low to medium	By providing green space in urban areas, filter strips can make a contribution to the prevention of biodiversity loss. The extent of contribution will be more or less effective depending on the type of vegetation used and how widespread they are.

VIII. Design Guidance

Design Parameters	Evidence
Dimensions	The impervious area draining to filter strips should be controlled to reduce the risk of sheet flows changing to concentrated flows, since filter strips are designed to treat sheet runoff. Where concentrated flows are likely, alternative measures (e.g. swales) should be used. The maximum drainage length to a filter strip should not exceed 50m. Filter strips should be a minimum of 6m wide. To gain maximum water quality treatment (e.g. to remove particulates as a pre-treatment for other sustainable drainage features), incoming runoff should be even distributed across the filter strip with a water depth (during runoff events) of less than 50mm. Wider filter strips are required for steeper slopes, since velocities are likely to be higher.
Space required	CIRIA (2007) recommend 'at least 1m width of filter strip for every 6 m "length" of drainage area', and state that widths of between 6 and 15m are generally effective.
Location	Filter strips need to be located immediately adjacent to their drainage area, in order to be able to accept overland (sheet) flow rather than flow that has already been channelled or piped. As such, they are generally located immediately located to, for example, car parks or farmyards. While they should be incorporated in to wider landscaping, they should not be located in areas where significant footfall is expected, because compaction will reduce their effectiveness.
Site and slope stability	Filter strips should be gently sloping, in general between 2% and 5% (CIRIA, 2007). Steeper slopes bring a risk of erosion and channelling of flows, while ponding may occur on shallower slopes.
Soils and groundwater	Although filter strips provide only relatively modest infiltration to groundwater, they should not be used on brownfield sites or other areas where there is a risk of leaching contaminants into underlying groundwater. They should also not be used to treat runoff from pollution hotspots, again to avoid pollution risk to underlying groundwater. To ensure that infiltration potential is maintained, the seasonally high groundwater table should as far as possible be more than 1m below ground level.
Pre-treatment requirements	Filter strips generally provide the first stage of runoff management, capturing overland flow directly from impermeable or low permeability areas. As such, no pre-treatment is required, and indeed filter strips can be used as pre-treatment before other measures such as swales and ponds.
Maintenance requirements	Regular inspection and maintenance is important for the effective operation of filter strips. Maintenance access should be available. Regular maintenance will include litter and debris removal; grass cutting, managing other vegetation and removing nuisance plants. Other less frequent maintenance activities will include: re-seeding areas or altering plant types in event of poor vegetation growth; repair of eroded or damaged areas; removal of sediment and other pollutants.

Synergies with Other Measures	Filter strips are most effective if applied at the start of a SuDS 'train', for example, feeding in to a swale or pond.

IX. Cost

Cost Category	Cost Range	Evidence
Land Acquisition		Filter strips are moderately high land-take measures used within the urban environment, since their width is important for ensuring effectiveness. There may therefore be some costs associated with their use, most likely opportunity costs of not using that land for development. The costs will depend on the land values at the site under considerations and cannot be generically quantified. Due to the higher costs of land, it is usually more expensive to retrofit filter strips to already developed areas as compared to constructing them in an undeveloped region.
Investigations & Studies		
Capital Costs	€3-€30 / m^2 filter strip area	The UK SuDS Cost Calculator (www.uksuds.org) indicates that capital costs for filter strips can range between €15 and €30 per m^2 filter strip area. CIRIA (2007) indicates a much lower cost range (€3-€6 per m^2 filter strip area). Cost ranges will vary considerably depending on the design of filter strip, density and variety of vegetation, and the use of substrate materials such as gravel to increase the effectiveness of the filter strip.
Maintenance Costs	€0.50-€6.50 / m^2 filter strip area	As with capital costs, maintenance costs for filter strips vary considerably depending on the design of the filter strip. Maintenance cost ranges identified in the literature: • CIRIA (2007) - €0.50 / m^2 filter surface area • Wilson et al (2009) - €1-€2 / m^2 filter surface area • UK SuDS Cost Calculator (www.uksuds.org) - €3.00 - €6.50 / m^2 filter surface area Maintenance costs are likely to be the same order of magnitude as normal green spaces.
Additional Costs		

X. Governance and Implementation

Requirement	Evidence
Stakeholder involvement	The effective planning, design, construction and operation of urban NWRM requires the involvement of a wide range of stakeholders. This may include local planning authorities, environmental regulators, sewerage undertakers, highways authorities, private landowners and land managers, and other bodies with responsibilities for drainage and water management (e.g. irrigation bodies, drainage boards, etc). Effective planning is essential to delivering urban NWRM, since they must be delivered within the constraints of the urban environment. This requires alignment between stakeholders from planning authorities through to developers and land owners.
Ensuring clear responsibility for maintenance	The adoption of SuDS has historically been a major issue in ensuring their long-term effectiveness. This is important for linear features such as filter strips, which may cross different land ownerships and will reduce in effectiveness if only partially maintained.
Ensuring that appropriate design standards and effective designs are implemented appropriately at each location	The preparation of planning guidance and/or SuDS guidance documents that set out planning and design criteria, as well as local technical information (e.g. on soil types and underlying geology) can assist in this.

XI. Incentives supporting the financing of the NWRM

Type	Evidence
National and local legislative and regulatory requirements	Some countries and territories encourage and/or require the use of Sustainable Drainage systems in new development. For example, in England the use of SuDS is required through planning policy for new developments over a certain size. National and local instruments are the most widely effective for SuDS due to their wide-scale application at the household or very local level. The possibility of local incentives should always be explored (since they cannot be covered here comprehensively).
CAP funding for rural SuDS	Where applied in agricultural areas, filter strips may constitute (all or part of) an ecological focus area, as defined under CAP Pillar I, or may be eligible for the European Agricultural Fund for Rural Development (EAFRD) in relation to improving water management and preventing soil erosion.
LIFE+	In some cases integrated SuDS schemes (i.e. which may include filter strips along with other measures) may be eligible for LIFE+ funding.

XII. References

Reference	Comments
CIRIA (2009) Overview of SuDS performance: Information provided to Defra and the EA.	
Cranfield University (2006) Strategic placement and design of buffering features for sediment and P in the landscape. Defra project PE0205.	
COWI (2014) Support Policy Development for Integration of Ecosystem Service Assessment into WFD and FD Implementation – Resource Document, January 2014. Draft report.	
DTI (2006) Sustainable drainage systems: a mission to the USA.	
Environment Agency (2012) Rural Sustainable Drainage Systems (RSuDS)	
SNIFFER (2008) Source Control of Pollution in Sustainable Drainage (UEUW01)	
Woods-Ballard, B, Kellagher, R, Martin, P, Jefferies, C, Bray, R and Shaffer, P (CIRIA) (2007) The SuDS Manual, CIRIA C697.	
MDDEFP et MAMROT (2014), Guide de gestion des eaux pluviales, Chapitre 11 – Les pratiques de gestion optimales des eaux pluviales	Manual about SuDS components in Quebec, Canada.