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Natural Water Retention Measures

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Individual NWRM

Infiltration trenches

Environment

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I. NWRM Description

Infiltration trenches are shallow excavations filled with rubble or stone. They allow water to infiltrate into the surrounding soils from the bottom and sides of the trench, enhancing the natural ability of the soil to drain water. Ideally they should receive lateral inflow from an adjacent impermeable surface, but point source inflows may be acceptable with some design adaptation (effectively they are a form of soakaway). Infiltration trenches reduce runoff rates and volumes and can help replenish groundwater and preserve base flow in rivers. They treat runoff by filtration through the substrate in the trench and subsequently through soil. They are effective at removing pollutants and sediment through physical filtration, adsorption onto the material in the trench, or biochemical reactions in the fill or soil. However they are not intended to function as sediment traps and must always be designed with an effective pre-treatment system where sediment loading is high (e.g. filter strip). Unless very effective pre-treatment is included in the design, they are best located adjacent to impermeable surfaces such as car parks or roads/highways where there levels of particulates in the runoff are low. They work best as part of a larger sustainable drainage treatment train.

Infiltration trenches are easy to integrate into a site and can be used for draining residential and non-residential runoff. Due to their narrow shape, they can be adapted to different sites, and can be easily retrofitted into the margin, perimeter or other unused areas of developed sites. Infiltration trenches are also ideal for use around playing fields, recreational areas or public open space. They can be effectively incorporated into the landscape and designed to require minimal land take.

II. Illustration

Example of infiltration trenches with stones in urban area

III. Geographic Applicability

Land Use	Applicability	Evidence
Artificial Surfaces	Yes	Infiltration trenches are potentially applicable to all artificial surfaces, subject to consideration of the suitability of underlying soils and geology to infiltrate water and consideration of the potential to mobilise contamination or act as a vector for poor quality water to enter groundwater.
Agricultural Areas	Possibly	Infiltration trenches are most effective when receiving runoff from impermeable surfaces and providing retention to allow water to infiltrate. They are less likely to be applicable to other low-permeability surfaces such as field runoff, since high sediment loading will reduce the effectiveness of the trench. However infiltration trenches can be used with pre-treatment to reduce sediment loading, and may be applicable for artificial surfaces in agricultural areas, such as farmyards and roads. Environment Agency (2012) recognises infiltration trenches as a measure relevant to 'rural SuDS'.
Forests and Semi-Natural Areas	No	
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	Infiltration trenches are generally designed to collect and infiltrate runoff from a small area such as a car-park. Environment Agency (2012) suggest a maximum contributing area of 0.2 km^2, while Dublin Drainage (year unknown) recommend only 0.05 km^2.

V. Biophysical Impacts

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	Medium	Blanc et al (2012) conclude that infiltration trenches are effective for runoff reduction for up to 1 in 30 year events. This corresponds to CIRIA (2007) recommendation of designing trenches to accept a 1 in 10 or 1 in 30 year event. The trench design must take in to account the infiltration rate of the underlying soil, to ensure effective operation. Blanc et al (2012) found in their review of literature that antecedent conditions can have a significant influence on performance. In addition, effectiveness can reduce significantly over time if high levels of sediment are allowed to enter the trench: effective pre-treatment must be included if significant sediment loaded is expected in runoff.
	Slow Runoff	Low	
	Store River Water	None	
	Slow River Water	None	
Reducing Runoff	Increase Evapotranspiration	None	
	Increase Infiltration and/or groundwater recharge	High	Infiltration trenches function by collecting runoff and infiltrating it to the underlying soils. They are generally designed to infiltrate all water from the contributing drainage area up to a 1 in 30 year event (CIRIA, 2007).
	Increase soil water retention	Low	Infiltration trenches consist of a sub-surface structure with enhanced infiltration capacity, As such they could be considered to effectively increase soil water retention, although as this is achieved through introduction of a new medium, it does not, strictly speaking, change the soil itself.
Reducing Pollution	Reduce pollutant sources	None	EA (2012) carried out a literature review of evidence of pollution removal and found reductions of: - Between 50-99% suspended solids reduction - 15-75% reduction in total phosphorus - 50-80% reduction in nitrogen
	Intercept pollution pathways	Medium	

			(based on only two infiltration trench studies). These are consistent with the values achieved in case study Sweden_02, which involved infiltration trenches in Kungsbacka. This study achieved 80% removal of suspended solids, 50% of total inorganic nitrogen and 50% overall for heavy metals. It is likely that achieving high effectiveness at pollutant removal will be improved by good design and adequate maintenance. The potential for pollution to groundwater needs to be considered. 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". However it might be considered that infiltration trenches could pose a higher risk than some other infiltration measures, since they bypass the vegetation and soil layers. Pre-treatment prior to the infiltration trench will help to manage this risk, but site-specific assessments must always be undertaken, and infiltration trenches avoided for areas with a higher risk of pollution in runoff.
Soil Conservation	Reduce erosion and/or sediment delivery	Medium	Infiltration trenches are effective in the removal of sediments where they are entrained in runoff in low concentrations, e.g. from roads. However high levels of sediment loading are likely to significantly reduce the performance of a trench over time, and require pre-treatment.
	Improve soils	None	
Creating Habitat	Create aquatic habitat	None	
	Create riparian habitat	None	
	Create terrestrial habitat	None	
Climate Alteration	Enhance precipitation	None	
	Reduce peak temperature	None	
	Absorb and/or retain CO2	None	

VI. Ecosystem Services Benefits

Ecosystem Services		Rating	Evidence
Provisioning	Water Storage	Low	Infiltration trenches store runoff and infiltrate it to groundwater. Through this impact, they enhance the potential of the landscape to store water during floods and make this water available for other purposes (e.g. recharge to groundwater, offering soil moisture to support terrestrial ecology).
	Fish stocks and recruiting	None	
	Natural biomass production	None	
Regulatory and Matinenance	Biodiversity preservation	None	
	Climate change adaptation and mitigation	Low	By helping to limit urban runoff and flooding, and recharging groundwater, infiltration trenches provide a contribution to adaptation to the higher intensity storm events expected due to climate change.
	Groundwater / aquifer recharge	High	Infiltration trenches can provide full infiltration from areas of hardstanding that would otherwise runoff to sewers or surface water. As a result they provide a significant, although localised, contribution to groundwater recharge.
	Flood risk reduction	High	Infiltration trenches contribute to reducing the rate of surface runoff from artificial surfaces. They can reduce the risk of surface runoff flooding and contribute to a reduction in peak river flows in small catchments.
	Erosion / sediment control	Low	Infiltration trenches are effective in the sediment control only where it is entrained in runoff in low concentrations, e.g. from roads. Higher levels of sediment loading require pre-treatment. A combination of pre-treatment and an infiltration trench can therefore contribute to this benefit. COWI (2014) identify urban runoff as being a relatively minor consideration for erosion and sediment control at the catchment scale, and therefore even when providing effective removal at a local scale, the overall benefit is likely to be low.
	Filtration of pollutants	Medium	Infiltration trenches provide a contribution to reducing urban diffuse pollution, through reducing total runoff, as well as (often in combination with pre-treatment) preventing/reducing infiltration of pollutants to groundwater. There is some risk of the introduction of pollutants to groundwater, but in general, CIRIA (2009) concludes

			that this risk is low, providing these measures are not used to drain pollution hot-spots.
Cultural	Recreational opportunities	None	
	Aesthetic / cultural value	Low	Using SuDS such as infiltration trenches can be used as a communication tool for promoting sustainable water management. Being able to visualise the drainage system on the surface (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 interception of surface runoff, infiltration trenches 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 interception of surface runoff, infiltration trenches can make a small contribution to improving water quality in receiving waters.
Achieve	Improved quantitative status	Medium	Infiltration trenches are designed to store and infiltrate runoff. As such, they enhance recharge to groundwater and thereby contribute to improving quantitative status of

			underlying groundwater bodies. The volume contribution from each individual trench is, however, small.
	Improved chemical status	None	
Prevent Deterioration	Prevent surface water status deterioration	Low	By intercepting a potential diffuse pollution vector from the contributing catchment, infiltration trenches can help to protect the receiving water body from deterioration as a result of new diffuse pollution sources.
	Prevent groundwater status deterioration	Low	Infiltration trenches may contribute to preventing deterioration in groundwater status where they maintain the overall level of recharge to groundwater in areas where the extent of hardstanding is increasing.
Floods Directive			
Take adequate and co-ordinated measures to reduce flood risks		High	Infiltration trenches can make a significant contribution to reducing surface runoff flood risks, particularly where used as part of a wider sustainable drainage system in urban areas.
Habitats and Birds Directives			
Protection of Important Habitats		None	
2020 Biodiversity Strategy			
Better protection for ecosystems and more use of Green Infrastructure		Low	As an effective component in sustainable urban water management, infiltration trenches provide a contribution towards improved green infrastructure and protection of ecosystems. However in isolation the contribution is limited, particularly because an infiltration trench itself does not contribute any new habitat.
More sustainable agriculture and forestry		Low	Where used to intercept and infiltrate runoff from low permeability surfaces in agricultural areas (i.e. as rural SuDS components) infiltration trenches can contribute to more sustainable agricultural practices.
Better management of fish stocks		None	
Prevention of biodiversity loss		None	

VIII. Design Guidance

Design Parameters	Evidence
Dimensions	Infiltration trenches should generally be 1-2m deep, and filled with stone aggregate. The void ratio of the aggregate fill material should be sufficiently high to allow adequate percolation and to reduce the risk of blockage. CIRIA (2007) recommends fill material 40 to 60mm in diameter, while ADOPTA (2006) indicates a broader range: from 20 to 80 mm. They should normally have a high-level outfall with a flow control device, to accommodate excess runoff from large rainfall events.
Space required	Infiltration trenches can be effectively incorporated into landscaping, and with careful design they require minimal land area.
Location	Infiltration trenches should be integrated into overall landscape design and should take account of the location and use of other site features. Trenches can be located within open spaces, potentially enabling dual use of land, although in such situations must be constructed with sufficient strength to cater for surface loads acting on them, to avoid the fill being damaged or scattered. Due to their narrow shape, infiltration trenches can be adapted to fit within many site configurations and are easier to retrofit to existing situations where they can be incorporated into margins or perimeter areas. Infiltration trenches should not be installed immediately adjacent to buildings, nor to shrubs or trees.
Site and slope stability	Infiltration trenches are generally restricted to relatively flat sites, although can be placed parallel to contours on slopes. The longitudinal slope should not exceed 2%, to keep velocities limited to allow for pollutant removal and promotion of infiltration. (CIRIA, 2007)
Soils and groundwater	Infiltration trenches should not be used on brownfield sites unless the risk of contaminant leaching is very low. They should not be used for primary treatment of runoff from pollution hot-spots if the risk of groundwater pollution is high. Seasonally high groundwater levels should be at least 1m below the base of the trench where designed for infiltration. Infiltration tests should be undertaken to confirm suitability, and consideration must be given to the need to protect underlying groundwater from contamination.
Pre-treatment requirements	Infiltration trenches should be used to capture runoff from areas with low sediment loading (e.g. car parks). Where this is not the case, effective upstream pre-treatment is required to remove sediment and fine silt. With regards to sediment loading, particular consideration should be given to the timing of installation as part of a wider construction programme. Runoff from construction is likely to contain much higher levels of sediment and can cause clogging, reducing the effectiveness from the outset. (SNIFFER, 2004)

Maintenance requirements	Regular inspection and maintenance is extremely important for the effective operation of an infiltration trench. Regular maintenance will include removal litter and debris; removal and washing of exposed stones; weed removal; inspection for clogging or blockages; and trimming any roots that may be causing blockages. Other less frequent maintenance activities will include: removal of sediment from pre-treatment devices; and remedial actions and repairs as required. Performance of an infiltration trench may deteriorate significantly without adequate maintenance.
Synergies with Other Measures	Infiltration trenches can be used as part of a wider sustainable drainage 'train' to comprehensively manage surface water, for example from a new development.

IX. Cost

Cost Category	Cost Range	Evidence
Land Acquisition		Infiltration trenches are typically relatively low land-take measures and can often be incorporated in to developments without significant opportunity costs for land use.
Investigations & Studies	€ 2-€10k	Geotechnical investigations are required to confirm the land stability and underlying soil/geology conditions prior to construction. These may need to be intrusive and require analysis of land contamination to determine the suitability of infiltration techniques.
Capital Costs	€70-€90 / m^3 stored volume	Construction costs for infiltration trenches will vary depending on the depth, geometry and underlying soil/geology conditions. Capital cost ranges are between €70 and €90 per cubic metre of runoff storage, although the units in which costs are presented in the literature varies so it is challenging to make direct cost comparisons: • CIRIA (2007) - €70-€90 / m^3 stored volume • UK SuDS Cost Calculator (www.uksuds.org) - €90-€110 / m length of infiltration trench • Environment Agency (2007) - €80 / m^2 trench area • Environment Agency (2012) - €70-€90 / m^3 stored volume The range is consistent with case study Sweden_02 at Kungsbacka, which had a total cost of 19,000 € for 243 m^3, which gives a cost of 78 €/m^2.
Maintenance Costs	€0.25-€4.00 / m^2 surface area	Maintenance costs are indicated at €0.25-€4.00 / m^2 surface area, with CIRIA (2007) indicating lower costs (€0.25-€1.40), Environment Agency (2007) indicating a slightly higher range (€1.00-€3.00) and the UK SuDS Cost Calculator (www.uksuds.org) indicating the highest maintenance costs (€3.00-€4.00).

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.
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, it is possible that infiltration trenches (most likely as part of a wider sustainable drainage scheme) may be eligible for the European Agricultural Fund for Rural Development (EAFRD) in relation to improving water management.

XII. References

Reference	Comments
ADOPTA (2006) Fiche technique “Puits d’infiltration”	Adopta is a French independent association promoting sustainable water management. This is a technical document designing soakaways
Blanc, J, Arthur, S and Wright, G (2012) Natural flood management (NFM) knowledge system: Part 1- Sustainable urban drainage systems (SUDS) and flood management in urban areas.	
CIRIA (2009) Overview of SuDS performance: Information provided to Defra and the EA.	
COWI (2014) Support Policy Development for Integration of Ecosystem Service Assessment into WFD and FD Implementation – Resource Document, January 2014. Draft report.	
Dublin Drainage (year unknown). Infiltration trenches and soakaways. http://www.uksuds.com/information/Infiltration_Trenches_Soakaways.pdf	
Environment Agency (2007) Cost benefit of SUDS retrofit in urban areas.	
Environment Agency (2012) Rural Sustainable Drainage Systems (RSuDS)	
SNIFFER (2004) SUDS in Scotland- The Monitoring Programme of the Scottish Universities SUDS Monitoring Group. SR(02)51. Final Report.	
www.uksuds.org – SuDS Construction and Maintenance Costs Calculator	This site has been developed by HR Wallingford to provide tools for site drainage design and evaluation, aimed at developers and SuDS Approval Bodies in the UK and Ireland. The site is updated with current thinking on SuDS and the requirements of UK and Ireland SuDS standards. The site includes a cost calculator to provide indicative costs of SuDS scheme components for construction and maintenance – the generic unit cost factors have been used when this website is referenced.
Woods-Ballard, B, Kellagher, R, Martin, P, Jefferies, C, Bray, R and Shaffer, P (CIRIA) (2007) The SuDS Manual, CIRIA C697.	