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Natural Water Retention Measures

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Individual NWRM

Detention basins

Office International de l'Eau

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Environment

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I. NWRM Description

Detention basins are vegetated depressions designed to hold runoff from impermeable surfaces and allow the settling of sediments and associated pollutants. Stored water may be slowly drained to a nearby watercourse, using an outlet control structure to control the flow rate. Detention basins do not generally allow infiltration: see U12 for infiltration basins.

Detention basins can provide water quality benefits through physical filtration to remove solids/trap sediment, adsorption to the surrounding soil or biochemical degradation of pollutants.

Detention basins are landscaped areas that are dry except in periods of heavy rainfall, and may serve other functions (e.g. recreation), hence have the potential to provide ancillary amenity benefits. They are ideal for use as playing fields, recreational areas or public open space. They can be planted with trees, shrubs and other plants, improving their visual appearance and providing habitats for wildlife.

II. Illustration

Example of a detention basin in Leicester, UK (photo courtesy of Susdrain)

Source: http://www.susdrain.org/delivering-suds/using-suds/suds-components/retention_and_detention/Detention_basins.html

III. Geographic Applicability

Land Use	Applicability	Evidence
Artificial Surfaces	Yes	Detention basins are potentially applicable to all artificial surfaces.
Agricultural Areas	Yes	Detention basins are most effective when receiving runoff from impermeable or low permeability surfaces. This could apply both to artificial surfaces in agricultural or forestry areas (e.g. roads or farmyards), as well as to runoff from, for example, fields with compacted soils. Environment Agency (2012) identifies them as being relevant to rural Sustainable Drainage systems.
Forests and Semi-Natural Areas	Yes	
Wetlands	No	

Region	Applicability	Evidence
Western Europe	Yes	
Mediterranean	Yes	There are no regional constraints to use of detention basins. They can be useful for locations prone to mosquitoes because they should be designed to drain relatively quickly after an event, with the base drying out completely, therefore limiting the potential for mosquitoes to become established.
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	A detention basin should be designed to be appropriate for the contributing catchment area (as well as rainfall characteristics). In theory they can be designed to accommodate any volume of runoff, from any catchment area, desired, and CIRIA (2007) states that there is no maximum catchment area. However in general, sustainable drainage principles promote managing runoff close to source, i.e. with a relatively small catchment area, and therefore it is not envisaged that a contributing area greater than 1 km^2 would be likely.					

V. Biophysical Impacts

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	High	Detention basins temporarily store runoff, then releasing it at a slower rate downstream, e.g. in to a receiving watercourse. The capacity to store runoff is dependent on the design of the basin, which can be sized to accommodate any size of rainfall event (CIRIA, 2007 identify up to a 1 in 100 year event as being not uncommon).
	Slow Runoff	High	
	Store River Water	None	
	Slow River Water	None	
Reducing Runoff	Increase Evapotranspiration	Medium	Some increased evaporation is likely to occur during storage. The rate of evapotranspiration will depend on dimensions, residence time and type of vegetation. With more vegetation and relatively low velocities, evapotranspiration is substantially increased, particularly if trees are planted. Evapotranspiration in detention basins may 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	None to low	Detention basins are not designed to allow infiltration to underlying soils and groundwater (instead see measure U12, Infiltration basins). Although infiltration is not encouraged, some natural infiltration may occur unless the design specifically prevents it (e.g. by lining).
	Increase soil water retention	None to 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	
	Intercept pollution pathways	Medium	Detention basins can be effective at pollutant removal, particularly as a result of settling of particulate pollutants (although they are often used downstream of other source-control measures such as swales, where sediment deposition may already have occurred). Literature reviews of the effectiveness of detention basins 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) 30-90%; DTI (2006) 61%

			- Total phosphorus reduction: EA (2012) 14-70%; DTI (2006) 19% - Total nitrogen reduction: EA(2012) 15-45%; DTI (2006) 31% - Metals: DTI (2006) 26-54% It is likely that achieving high effectiveness at pollutant removal will be improved by good design and adequate maintenance.
Soil Conservation	Reduce erosion and/or sediment delivery	Medium	Detention basins can effectively capture sediment in urban or rural runoff (sometimes, where concentrations are high, in conjunction with a pre-treatment system), thereby reducing sediment concentrations in downstream watercourses. As shown above, a high removal rate of suspended solids is possible in a well-designed system.
	Improve soils	None	
Creating Habitat	Create aquatic habitat	None	
	Create riparian habitat	None	
	Create terrestrial habitat	Medium to high	Detention basins may provide biodiversity benefits through the creation of new green spaces. Their effectiveness in creating terrestrial habitat depends on the design and particularly on the type of vegetation.
Climate Alteration	Enhance precipitation	None	
	Reduce peak temperature	Low-Medium	Detention basins could provide some contribution to lowering peak temperatures in urban areas, similarly to other green spaces. 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 to medium	If a detention basin 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	Medium	Detention basins are effective at temporarily storing, allowing it to be released at a more controlled rate. 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	Low	By creating green areas, detention basins will provide some contribution to natural biomass production, particularly where the vegetation is dense.
Regulatory and Maintenance	Biodiversity preservation	Medium	By creating green areas within the urban landscape, detention basins may contribute to biodiversity preservation. The extent to which this benefit is provided depends on the soil moisture and choice of vegetation. Even when their individual contributions are relatively 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	Medium	By helping to limit urban runoff and flooding, detention basins provide a contribution to adaptation to the higher intensity storm events expected due to climate change. In addition, if new vegetation is introduced, particularly woody vegetation, they may also increase carbon sequestration and help to regulate urban temperatures.
	Groundwater / aquifer recharge	None to Low	Although infiltration is not encouraged, natural infiltration may occur unless it is specifically prevented by the design.
	Flood risk reduction	High	Detention basins contribute to reducing the volume and rate of surface runoff, particularly from artificial surfaces (urban areas). Used in conjunction with other SuDS features, they can reduce the risk of surface runoff flooding and contribute to the reduction in peak river flows in small catchments.
	Erosion / sediment control	Medium	Detention basins (sometimes with pre-treatment) can be effective in allowing the settlement of sediment entrained in runoff, preventing it from entering downstream watercourses. COWI (2014) note that sediment in urban runoff has relatively little influence on the catchment scale, but nevertheless there will be some local benefit,

			and when applied in rural (agricultural) areas the benefit may be more significant.
	Filtration of pollutants	Medium	Detention basins can be effective in reducing diffuse pollution, both from urban and agricultural runoff. This occurs primarily through sediment deposition, which may be enhanced by pre-treatment.
Cultural	Recreational opportunities	Medium	By contributing to urban green spaces, detention basins may provide some recreational opportunity benefits. They may be used, depending on the way they are designed (dimensions and type of vegetation) for recreational activities such as a playing field.
	Aesthetic / cultural value	Medium	By contributing to urban green spaces, detention basins may contribute some aesthetic benefit to the urban landscape. Using detention basins is a good 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 interception of surface runoff and associated sedimentation, detention basins 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 and associated sedimentation, detention basins can make a small contribution to improving water quality in receiving waters.
Achieve Good GW Status	Improved quantitative status	None	Although detention basins may in some cases allow some natural infiltration, they are not designed to do so, and 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	Medium	By intercepting a potential diffuse pollution vector from the contributing catchment, detention basins can help to protect the receiving water body from deterioration as a result of new diffuse pollution sources.
	Prevent groundwater status deterioration	None	Although detention basins may allow some natural infiltration, depending on soil permeability and residence time, they are not designed to do so, and the contribution is likely to be negligible on the scale of a groundwater body.
Floods Directive			
Take adequate and co-ordinated measures to reduce flood risks		High	Detention basins make a significant contribution to reducing surface runoff flood risks, particularly 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		Medium to high	As a green infrastructure component, increased application of detention basins will contribute to meeting the objectives of the 2020 Biodiversity Strategy, particularly in urban areas. The extent of contribution will be more or less effective depending on the type of vegetation used, the dimensions and how widespread they are.
More sustainable agriculture and forestry		Low	Where used to intercept and store runoff from low permeability surfaces in agricultural areas (i.e. as rural SuDS components) detention basins can contribute to more sustainable agricultural practices.
Better management of fish stocks		None	
Prevention of biodiversity loss		Medium	By providing green space in urban areas, detention basins 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 the measures are.

VIII. Design Guidance

Design Parameters	Evidence
Dimensions	The size of a detention basin is dependent on several factors such as topography, the effective contributing area, and the relationship between the amounts of incoming and discharged water. They can be designed to be any size, depending on the storage requirements. CIRIA (2007) makes recommendations as to the design, including: - A maximum depth of not more than 3m - A flat bottom to the basin - Recommended length:width ratio of between 2:1 and 5:1 - Side slopes should not normally be greater than 1 in 4 (for reasons of safety, ease of maintenance and amenity) SNIFFER (2004) recommend that specific account should be taken of construction runoff (e.g. where a detention basin for a new development is installed early in the construction phase), when there is likely to be a higher concentration of sediment entrained in runoff. This may involve over-sizing the basin, with the expectation of some loss of storage due to sediment deposition.
Space required	Detention basins are relatively high land-take measures. However they are well suited to dual purpose use (e.g. sports fields), which can be achieved by being taken in to account at an early stage in development planning and design.
Location	Basins require a large accessible area that is relatively flat and with an appropriately-sized drainage catchment. Account should be taken of natural features that could be used to form the basin and/or provide additional storage areas in order to minimise the need for artificial landscaping.
Site and slope stability	The basin floor should be made as level as possible to maximise storage potential and minimise the risk of erosion. This will also reduce flow velocities within the basin and maximise pollution removal potential for detention basins (CIRIA, 2007). However it is also possible to include 'micropools' or wetland areas within the basin, if desired, for increased biodiversity. It is important to avoid siting detention basins in areas where water storage may cause slope stability or foundation problems, e.g. in areas of landslides or at the top of slopes, unless a full engineering risk assessment has been carried out.

Soils and groundwater	Groundwater levels should be taken in to account to ensure that the basin will not fill with groundwater, reducing the storage capacity for surface runoff. CIRIA (2007) notes that this applies even where the basin is lined, as the liner may 'float' if groundwater rises beneath it. Unlined detention basins should not be used on sites with a risk of contamination to groundwater (presence of a pollutant source, and a pathway through permeable soils).
Pre-treatment requirements	Pre-treatment can be included where high concentrations of sediment in runoff are expected, and this may help to reduce maintenance requirements.
Maintenance requirements	Regular inspection and maintenance is essential to ensure effective ongoing operation. Maintenance should include: - Litter and debris removal - Grass cutting for spillways and access routes - Removal of sediment from inlets and outlet - Backfilling/rehabilitation of any channelling created during flush floods
Synergies with Other Measures	Detention basins can be incorporated with other measures, particularly upstream source control (e.g. green roofs, swales etc) to form a comprehensive sustainable drainage system for managing both urban and rural runoff.

IX. Cost

Cost Category	Cost Range	Evidence
Land Acquisition		Detention basis are high land-take measures used within the urban environment. The primary cost is therefore the cost of land acquisition or the opportunity cost of not using that land for development. This 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 these basins to already developed areas as compared to constructing one in an undeveloped region.
Investigations & Studies	€1k-€10k	Geotechnical investigations are required to confirm the land stability and underlying soil/geology conditions prior to construction. These may need to be intrusive.
Capital Costs	€10 to €110 per m^3 detention volume	Construction costs scale with the storage volume of the detention basin. Costs given in the UK typically range between €20 and €40 per cubic metre of storage volume provided: • CIRIA (2007) - €20-€30 / m^3 detention volume • Atkins (2010) - €25-€35 / m^3 detention volume

		• UK SuDS Cost Calculator (www.uksuds.org) - €20-€40 / m^3 detention volume But others suggest the potential for much higher costs: • Chocat et al (2008) 9 to 90€/m^3 detention volume • Certu (2006), 12 to 110 €/m^3 detention volume More generally, Environment Agency (2012) indicates that the cost of a "small detention basin will typically be less than €5000". Costs will be higher where additional retaining bunds are required and lower where greater use is made of natural or existing topographic features.
Maintenance Costs	€0.5-€5 / m^2 basin area	Ongoing maintenance is essential to maintain the effectiveness of detention basins. Since these basins are long-lived, once in operation only minimal maintenance costs arise. Quarterly inspections of inlets and outlets as well as sediment and trash dredging might be required. Mowing around the basin margins would be possible but it may increase costs. Annual maintenance costs range between €0.5 and €5 per m2 of basin area. CIRIA (2007) and Wilson et al (2009) indicate a lower maintenance range of €0.5-€2.5 per m^2 basin area, whilst the UK SuDS Cost Calculator (www.uksuds.org) indicates a higher maintenance cost range between €4 and €5 per m^2 basin area.
Additional Costs		N/A

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 and restoration	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	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, detention basins 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 managing soil erosion.
LIFE+	In some cases integrated SuDS schemes (i.e. which may include detention basins along with other measures) may be eligible for LIFE+ funding.

XII. References

Reference	Comments
Atkins (2010) Bath and North East Somerset Flood Risk Management Strategy Report (www.bathnes.gov.uk)	
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.	
CERTU (Ministère de l'Ecologie, du développement et de l'aménagement durables) (2008), L'assainissement pluvial intégré dans l'aménagement	
Chocat, Abirached, Delage, Faby (2008), Etat de l'art sur la gestion urbaine des eaux pluviales et leur valorisation, Tendances d'évolution et technologies en développement, ONEMA, OIEau	
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.	
Drain Dublin (year unknown). Detention Basins. http://www.uksuds.com/information/Detention_Basins.pdf	
DTI (2006) Sustainable drainage systems: a mission to the USA.	
Environment Agency (2012) Rural Sustainable Drainage Systems (RSuDS)	Guidance document by the Environment Agency of England, with information on measures relevant for rural (agricultural) sustainable drainage.
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.
Wilson, S, Bray, B, Neesam, S, Bunn, S and Flanagan, E (2009) Sustainable Drainage: Cambridge Design and Adoption Guide	
Woods-Ballard, B, Kellagher, R, Martin, P, Jefferies, C, Bray, R and Shaffer, P (CIRIA) (2007) The SuDS Manual, CIRIA C697.	