Surface water management and green infrastructure

In this briefing Richard Ashley, Pennine Water Group and Roger Nowell, Sheffield City Council, provide an overview of the exciting developments in linking the management of surface water to green infrastructure for multi-value benefits

The need to manage surface water differently to the past

In a time of economic constraint it is incumbent on policy-makers and professionals to seek multi-value benefits from any new or adapted infrastructure wherever possible. The need to consider multi-functionality of any flood risk management measures was deemed to be axiomatic when discussed at the workshop on the future of flood risk management research organised by Learning to live With Environmental Change (LWEC, 2010).

Delivering multi-functionality is not straightforward as it invariably crosses practicability, utility and institutional boundaries. For example, Figure 1 shows a multi-functional area near the centre of Rotterdam in The Netherlands, which is primarily a stormwater storage area that fills up during rainfall. The grassed areas and the coloured art on the far bank make it visually attractive, provide recreational value, and the area can provide cooling to the surrounding buildings in hot weather.

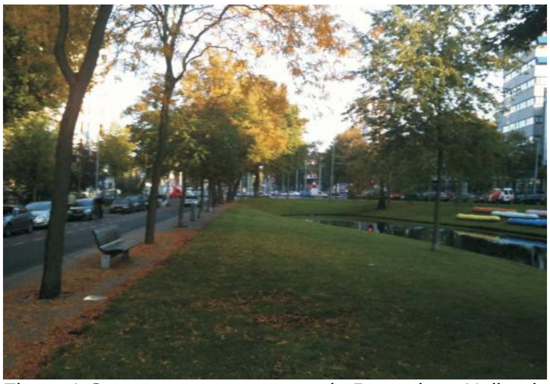

Figure 1 *Stormwater storage area in Rotterdam, Holland*

The City of Rotterdam is responsible for the area as both sewerage managers and city park

In contrast, Figure 2 shows an area in The Hague, in Holland, where a former combined sewerage system has been converted to a separate system and the stormwater directed to several shallow subterranean infiltration tanks, which is the responsibility of the local authority. In this case, any added value from the new stormwater infrastructure is not apparent as the green areas were already there before the tanks were installed. No added value from exposed surface water has been provided, although groundwater replenishment has been delivered. Due mainly to cost concerns, the local authority has failed to take advantage of the multi-value opportunities.

Figure 2 *Workers standing on top of a shallow sub-terranean infiltration tank at a housing area in The Hague, Holland*

In England and Wales, Ofwat has questioned the economics of continuing to provide new sewer capacity to cope with future flood and pollution risk as being unaffordable. Also, because of the Flood and Water Management Act 2010, it is likely that new stormwater infrastructure will preferentially use non-sewered options such as SuDS. The proposed consultation on the National SuDS Standards for this is expected before the end of 2010, and the standards are expected to promote the SuDS triangle of quantity-quality-amenity (Woods-Ballard et al, 2007). The first of these, the effectiveness of SuDS in managing water quantity is reasonably well understood, but the quality performance is less so especially in UK conditions as few monitoring programmes have been carried out. Nevertheless in order to provide some guidance indicative numbers of treatment stages are suggested in differing circumstances using the different SuDS components. The third part of the triangle assessing the amenity performance of SuDS is considered to be a more subjective process particularly due to the variability of scenarios and differing demands etc associated with urban design. Notwithstanding the misgivings about the predictability of SuDS performance and the costs of maintenance, their use will become more common in the UK and there is a need to ensure that the maximum value can be obtained from this.

The potential synergistic benefits from co-management of surface water on the surface rather than below ground, and other needs such as greening urban areas are supported by several disciplines. For example, the Manual for Streets (Department for Transport, 2007), which is currently being updated, includes sustainable drainage as a means of "bringing environmental benefits, such as flood control, creating wildlife habitats and efficient wastewater recycling" as an important part of the function of streets. The Commission for Architecture and the Built Environment (CABE) has published several documents related to green infrastructure (GI) and its importance in creating healthy and high quality environments (e.g. CABE, 2009). Urban water is an important element in sustaining green areas, and can include such areas as part of the surface water management train. Multi-functions such as enhancing biodiversity and living spaces, and attenuating the urban heat island, are all improved through managing water on the surface.

The link between surface water management and quality of place is a vital concept and is successfully delivered in many countries such as the USA, where low impact development (LID) and GI approaches are used interchangeably (USEPA, 2008) and Australia as part of water sensitive urban design (WSUD) (Ashley, 2009).

Figure 3 shows a development at Elvetham Heath where, despite the housing being of relatively high density, the water remains on the surface in swales, ponds and wetlands. The water acts with the GI areas, typical in their extent for a housing development, to create a pleasant environment. This scene would not be as visually attractive if the drainage was in buried pipes.

In The Netherlands there are many developments taking advantage of the multi-functional value of surface water. Some examples use stored water on a garage roof as a solar energy collector, and De Draai in Heerhugowaard has combined use of groundwater and surface water to provide 83 per cent of the on-site water needs and it is used as a heat storage and heat collection system that can be used for heating in winter and cooling in summer (De Graaf *et a*l, 2008). Compared with conventional systems this development will also emit 60 per cent less CO2.

From this it is clear that Managing surface water so that it can help to deliver multiple functions is a major opportunity for improving urban environments and also adding value that cannot be obtained from burying stormwater infrastructure.

Figure 3 *Swales at Elvetham Heath*

Determining multi-value and synergies

Demonstrating the added value of managing surface water for multiple benefits is difficult in monetary terms, but there are tools available for this from a GI perspective. Woods Ballard *et al* (2007) advocate the use of a whole-life cost (WLC) approach for newly installed systems, which in practice is often complex to apply due to the various responsibilities for surface water management. Appropriate attribution of costs and benefits to the various and disparate stakeholders may be problematic. These various stakeholder groups have approaches to benefit and cost assessments appropriate to their own spheres of activity in relation to surface water management (SWM), SuDS and other urban developments, and these may not provide a consensual estimate that can be accepted by all stakeholders. For example, the sewerage undertakers' research body in the

Benefits from GI (Center for Neighborhood Technology)	
Urban trees	Stormwater detention Reduced energy for heating or cooling Reduce adverse health impacts from extreme heat events Air quality improvements CO_2 reductions (avoided and sequestered)
Permeable pavements	Increased stormwater retention Reduced energy use, air pollution and greenhouse gas emissions Reduced ground conductivity (urban heat island and use of salting in winter) Reducing air pollution Reduced noise pollution
Water harvesting	Reduced potable water use Increasing available water supply Improved biodiversity Public education
Green roofs	Stormwater retention Reduced building energy use Carbon sequestration Greenhouse gas emission reduction Urban heat island mitigation Improved air quality Noise reduction Biodiversity and habitat Longer roof life
Infiltration practices including rain gardens, bioswales, constructed wetlands	Stormwater retention and pollutant removal
Other	Increased property values Recreation value Avoided conventional infrastructure costs Reduced wastewater treatment costs Reduced flood risk damage Increased groundwater recharge Societal benefits such as crime reduction

Table 1 *Valuing the multiple benefits of green infrastructure (adapted from Wise et al, 2010)*

UK (UKWIR, 2009) looked at the benefits and costs of the use of SuDS as a means of separating combined sewers, whereas the Environment Agency (EA, 2007) developed an approach to evaluation of the costs and benefits of using SuDS to retrofit surface water management systems. Neither of these methodologies include the full range of potential added benefits of using surface water systems within the urban context as previously outlined.

In the USA, evidence indicates that using LID or GI for surface water management is cheaper than using buried drainage systems even when comparing capital and operating costs (USEPA, 2007). The potential added economic value of using stormwater management infrastructure for multiple benefits has been the subject of recent initiatives in both the USA by the Center for Neighborhood Technology CNT (Wise *et al*, 2010) and in the UK by CABE (Genecon, 2010) as part of the use of GI. While it is possible to criticise the details of the way in which the benefits such as local crime reduction, has been monetised in these tools, the relative values of using different options for surface water management can be still be

compared. The benefits as related to surface water are listed in Table 1 for the USA tool.
The Genecon (2010) valuation toolbox for economic development related to GI uses 12 benefit groups:

1 Climate change mitigation and adaptation.
2 Water and flood management.
3 Quality of place.
4 Health and well-being.
5 Land and property values.
6 Investment.
7 Labour productivity.
8 Tourism.
9 Recreation and leisure.
10 Biodiversity.
11 Land management and products from the land.
12 Other, e.g. transport and education.

The benefits provided by each of these are defined by further reduction into specific and in many cases, measurable indicators. Some of these will be included in an assessment of the monetised benefits, whereas others may only be considered in a qualitative sense as any comparative evaluation.

The CNT toolbox has been used in Philadelphia to evaluate the joint application of GI with reductions in the overflows from the existing combined sewerage system as part of a city-wide greenworks plan (City of Philadelphia, 2009). The use of GI in this context is shown to provide a large added economic benefit to the City (see Figure 4), for a 50 per cent uptake of retrofit non-piped surface water management systems. The application of GI in this way is ensuring private investors adopt the delivery of the GI plan and stormwater management plan (SBN, 2010).

Looking to the future

In the USA a group known as the "cool mayors" has pledged to combat the effects of climate change by using every opportunity, including the use of GI for stormwater management. There are now 26 mayors across the USA that have signed up to this approach. Unlike the USA and many other countries, the UK has chosen to separate its water management from local authority control and this approach of delivering multi-value benefits from managing stormwater on the surface can be much more difficult to achieve.

The inclusion of GI in UK urban areas is still predominantly on traditional aesthetic, recreational and biodiversity grounds. Often the management liability determines if they are to be promoted and what quality they should have. While this may create a difficulty in removing opportunities for the water function of GI to be realised, if the aims for improved water management are made more apparent then the arguments for GI with all its incidental benefits becomes stronger. The strong GI initiatives promoted by many in the UK such as CABE, Natural England and regional agencies (e.g. Community Forests North West, 2010) emphasise how we can effectively use existing and new GI networks and help to deliver the myriad multi-value benefits including future surface water management.

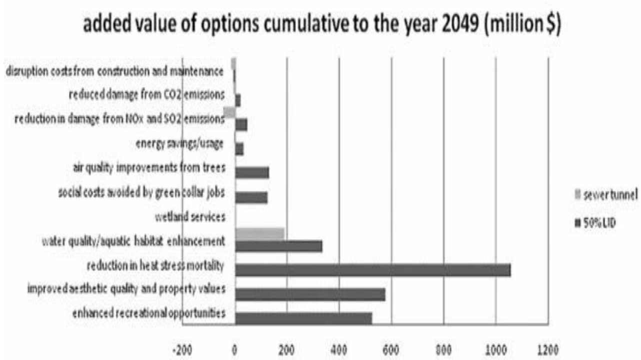

Figure 4 *Added value of using GI synergistically with surface water management in the Philadelphia greenworks plan (Wise et al, 2010)*

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