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Urban river corridors and sustainable living agendas

Beyond drainage: the role of SUDS in climate change mitigation and adaptation

Introduction

Sustainable Drainage Systems (SUDS) is a generic term used in the UK to refer to various measures aimed at controlling surface water runoff (and associated flooding and pollution problems) from urban catchments. Examples of SUDS include green roofs, soakaways, swales, infiltration trenches ponds and wetlands.

SUDS provide areas within the built environment where the natural processes of rainwater interception, storage and infiltration can take place, offering a more sustainable approach to the management of urban storm water runoff than impermeable surfaces, conventional underground pipe and storage-based solutions.

However, SUDS also have wider environmental benefits, including an impact on microclimates in urban areas, which are often overlooked.

The urban microclimate is of significant importance to the health and wellbeing of urban dwellers. The removal of vegetation and increase in hard impervious surfaces rapidly removes water from the immediate environment, preventing cooling by evaporation. Dark materials absorb solar radiation and urban street canyons prevent the heat escaping.

SUDS can replace some of the evaporative cooling lost through urbanisation, and can therefore provide climate change adaptation and mitigation against Urban Heat Island (UHI) effects.

Research carried out by the URSULA project quantified the relative benefits of different designs for water management and UHI mitigation at a study site in Sheffield.

The findings demonstrate the potential benefits of including SUDS for climate change adaptation and mitigation, as an integral element of urban design

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The scenarios

The designs are based in the same location, with identical climates; however in order to demonstrate the benefits of the systems, different weather conditions are considered for the analysis of the hydrology and Urban Heat Island (UHI) effects.

The baselines scenario is the "As-is" situation. The site is drained to conventional (combined) sewers,, and there are no SUDS. The site is an 11.3 ha urban area adjacent to the River Don in Sheffield, UK, on the northern edge of the city centre. The site is bounded to the west, south and east by the River Don. The site is predominantly mixed use; there are many vacant or underused plots .

Away from the river channel and banks, there are few areas of green-space, and much of the site is impermeable. The area is at risk of flooding and was subject to serious inundation during the floods of Summer 2007.

The other two scenarios (Street and Flood Channel) are hypothetical research scenarios designed by the URSULA project team. These latter scenarios were designed to be highly contrasting, drawing out different possible elements of riverside redevelopment.

For the two scenarios, basic SUDS concepts were employed, therefore natural drainage pathways are utilised; source control structures were sought wherever possible in preference to regional or offsite controls. Treatment trains were also employed where appropriate.

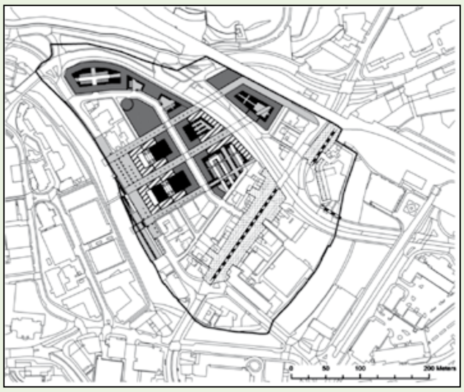
Consideration of the local microclimate was also incorporated into the design by influencing the height / width ratios of the streets. Stepped building heights next to open areas were included to reduce the risk of high wind speeds and vegetation, particularly trees, was incorporated when it was in keeping with the design ethos.

Key features of the hypothetical design scenarios are shown below.

Physical characterisation

The physical characteristics of each scenario were determined from 2-D CAD representations in the Geographical Information System (GIS) software ArcView v9.3.

Design scenarios – Key elements



New buildings are kept within existing grid structure and are stepped in height; from 2 storeys, close to the river, to 5 storeys.

Water is treated as a resource, but is not visible on the site.

Rainwater is directed to courtyard rain gardens and tree pits.

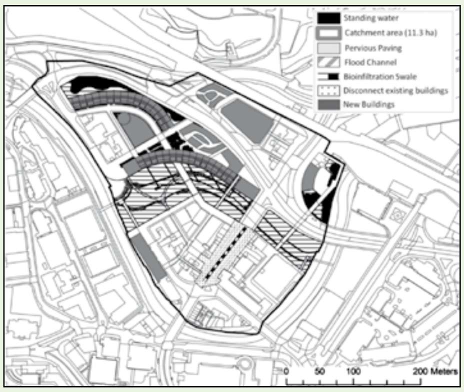
All new buildings have green roofs. Runoff from roofs is directed to courtyard rain gardens, with excess flow directed to the existing Combined Sewer System.

Some existing buildings are disconnected from the Combined Sewer System via bioretention swales.

Flood protection up to the 1 in 200 year flood event is provided by a low linear wall along the waterfront, complemented by deployable barriers.

There is extensive tree planting throughout the site.

Scenario 1 Streets



A flood channel bisecting the site provides flood protection up to the 1 in 100 year flood event and additional greenspace.

New 2-storey buildings mirror the contour of the flood channel, with two 15 and 25 storey high rise eco-towers providing additional floor space to free up land for the flood channel.

New impermeable surfaces are drained via riffles and swales to ponds through to a wetland area within the flood channel.

The surface water from existing buildings is disconnected from the Combined Sewer System into the wetland.

Excess flows are directed to the existing Combined Sewer System.

Scenario 2 Flood channel

Hydrological evaluation

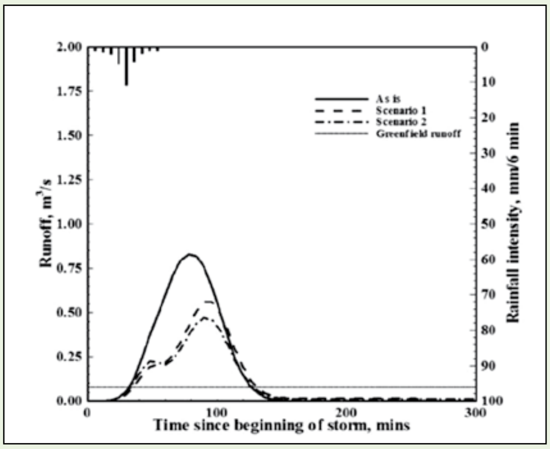
Surface water runoff for each SUDS scenario was modelled using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). Four storms were modelled:

- A 30 yr 60 min design storm; and
- A 100 yr 60 min design storm for Sheffield. These storms are routinely used within drainage design to test compliance with runoff legislation, and for exceedance flows.
- The 04/10/08 storm for Sheffield (a 1.38 yr return period).
- The 13/06/2007 storm for Sheffield (a 15.97 yr return period and the precursor to the Sheffield Floods in June 2007).

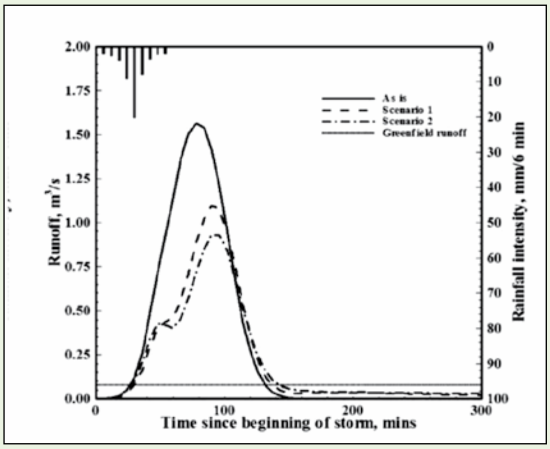
Findings

The rainfall-runoff profiles show that the provision of SUDS goes some way to reducing both the total volume and flow rate from the case study site.

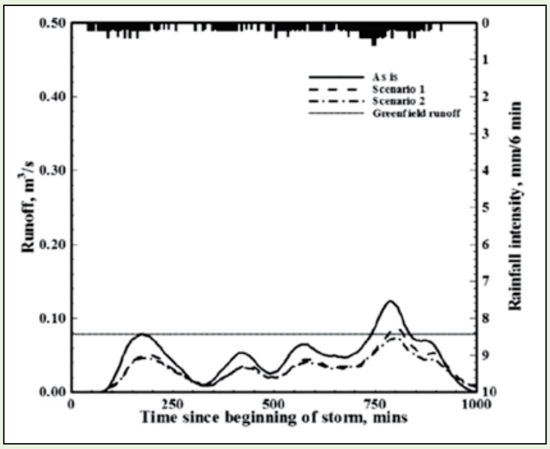
The flood channel scenario provided a greater level of flow reduction than the other scenarios for almost all storms modelled; and achieves both a greater reduction of total volume and attenuation of peak runoff.



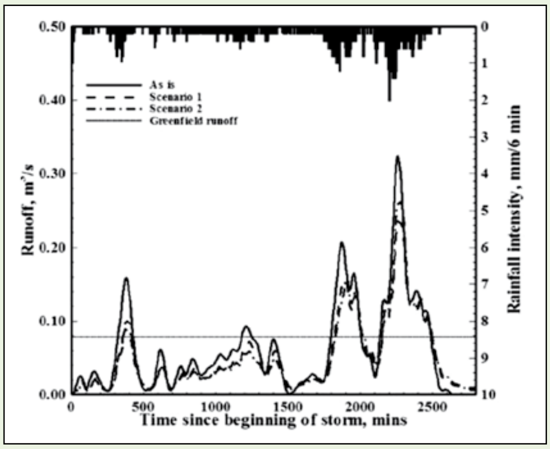
a) 30yr 60min design storm



b) 100yr 60min design storm



c) 04/10/2008 monitored rainfall

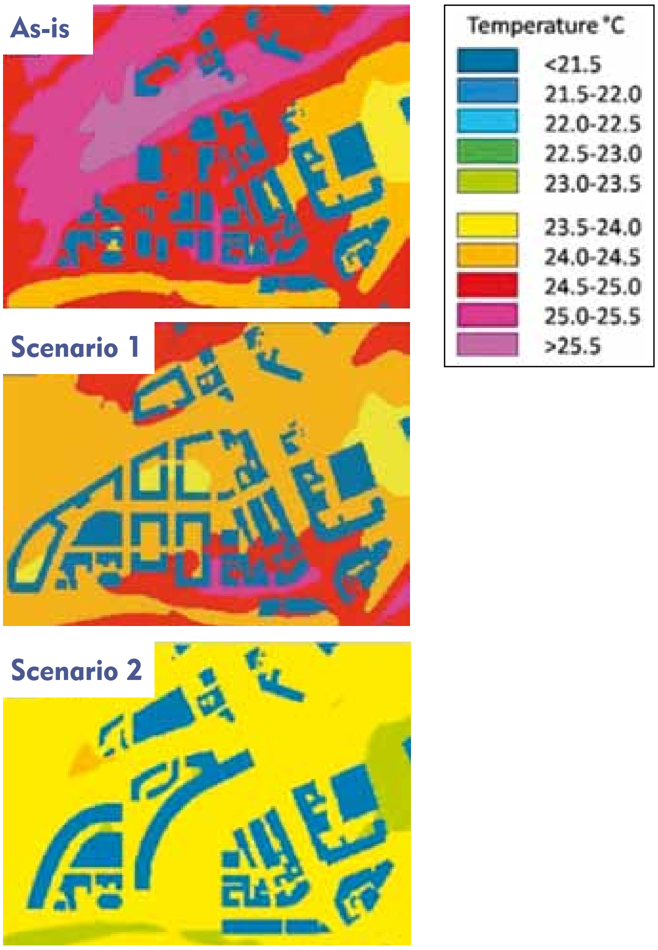


d) 13/06/2007 monitored rainfall

Microclimate impacts

The local microclimate within each scenario was modelled using ENVI-met BETA4, a numerical model that combines simulations of wind flow, radiant, sensible and latent heat flux, alongside transpiration and evaporation from vegetation and soils. The influence of vegetation on shading and the drag effects on air flow was also included. Simulation was for 12 hours (8am to 8pm) on a Summer day.

The contour plots show the temperature variation across the whole site for the three scenarios.



Both the "As Is" and Scenario 1 have hot spots reaching temperatures greater than 25°C. However, the area covered by this extreme is much larger in the "As Is" scenario. Scenario 2 has a more even and cooler temperature profile. This may be due to the increased wind velocities through the park of between 1.5 and 2.4 m/s.

Both Scenario 1 and Scenario 2 showed reduced air temperatures compared to the "As Is" Scenario, including late in the day when the UHI is at its greatest. In these two scenarios, SUDS reduce local average air temperatures by up to 1°C and are comparable in terms of comfort.

In the evening , the relative humidity (RH) at all sites was lower than 70% which can be deemed comfortable. Scenario 2 provided the greatest reduction in both average and peak local air temperatures. This demonstrates a clear link between SUDS and alleviation of UHI effects.

Feasibility

The Flood Channel scenario provided a greater level of flow reduction than the Streets scenario for almost all storms modelled; and provided the greatest reduction in both average and peak local air temperatures. This demonstrates clear benefits of SUDS in alleviating UHI effects.

However, this scenario required a greater land area than the other scenarios. Due to the nature of the design, it is not possible to implement incrementally, so the feasibility of such a scheme is questionable. This highlights the need to consider the inclusion of SUDS early in the design stages

Key messages

This work demonstrates that urban greening through the use of SUDS can impact the surrounding microclimate by reducing temperatures and improving comfort, contributing to climate change mitigation.

Unlike conventional drainage systems, SUDS systems also contribute to green infrastructure, providing additional benefits for recreation and biodiversity, improving resilience to climate change.

The two different designs illustrate the flexibility to adopt the form of SUDS that fits best with a desired urban form.

Implementing SUDS in retrofit/regeneration contexts may be more challenging than green field , but is essential.

Urban planning and site design must go beyond the drainage impact of SUDS and consider these wider benefits of climate change adaptation. However, it is essential to include this consideration from the beginning of the design process to maximise the climate change adaptation and mitigation benefits.

Acknowledgements

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