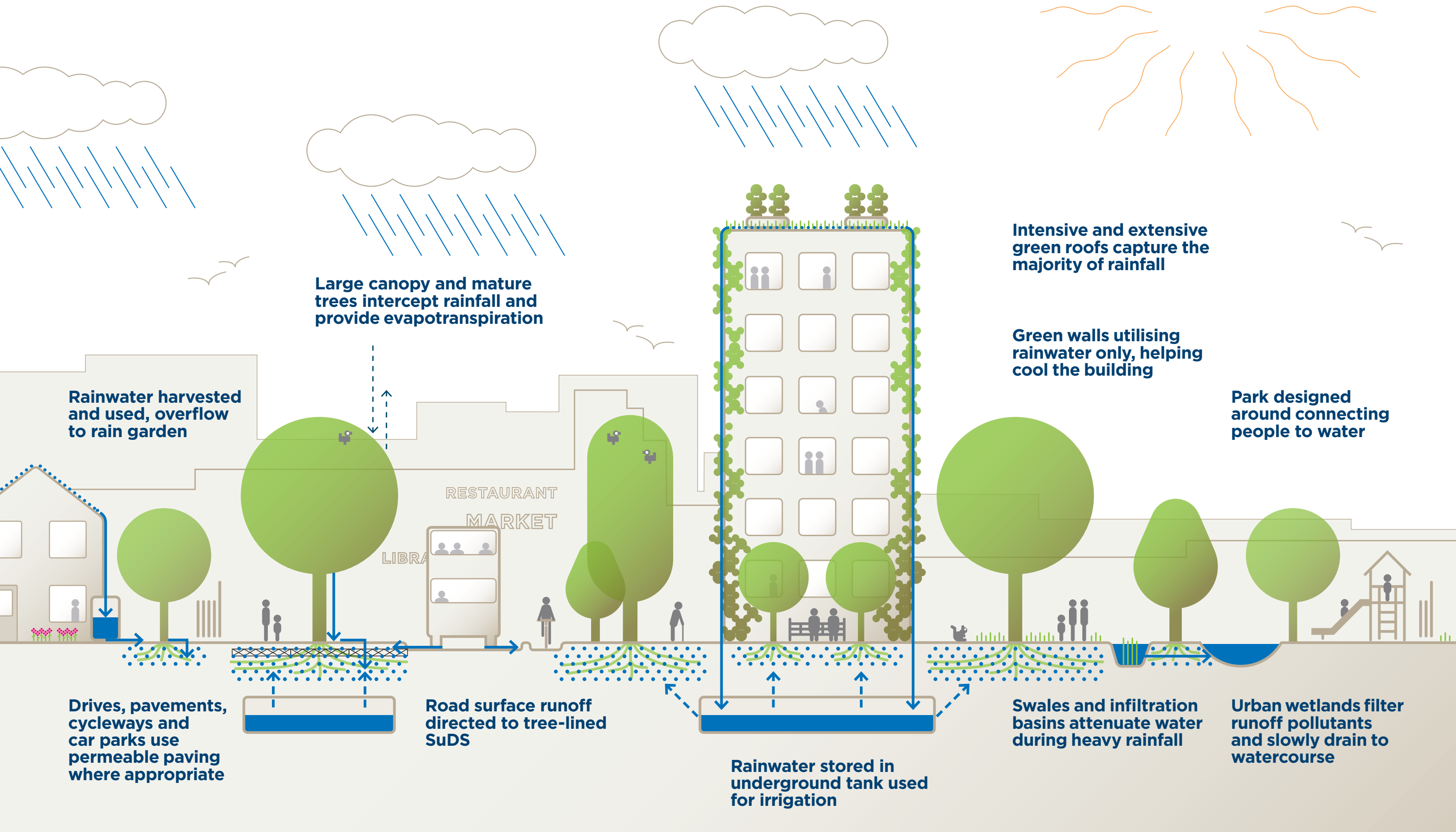
First Steps in Urban Water

Managing Water as a Resource



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2 Hanlon, H.M. et al. 2021. Climatic Change 166, 50. Link

3 Terms highlighted in blue italics are defined in the Glossary overleaf.

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Climate change is creating more extreme weather[1], and the frequency and severity of both flooding events and droughts is increasing[2]. Sustainable water resource management is essential to mitigate both effects while improving water quality.

Managing water as a problem

Historical land and water practices have modified our river catchments. Rural land uses (eg intensive farming) can increase the volume of rainfall runoff and flow of sediment into rivers; channel straightening moves the water more quickly downstream; and impermeable urban surfaces create runoff and flood easily (Fig. 1). Moreover, traditional *combined sewers*[3] treat surface runoff as wastewater and were not designed for the current or future extreme rainfall events, or urban population densities. When heavy rainfall events inundate combined sewers, storm overflow pipes permit untreated sewage and wastewater to enter rivers and seas. Between 2019 and 2022, 10 million hours of storm overflows[4] polluted rivers and bathing waters.

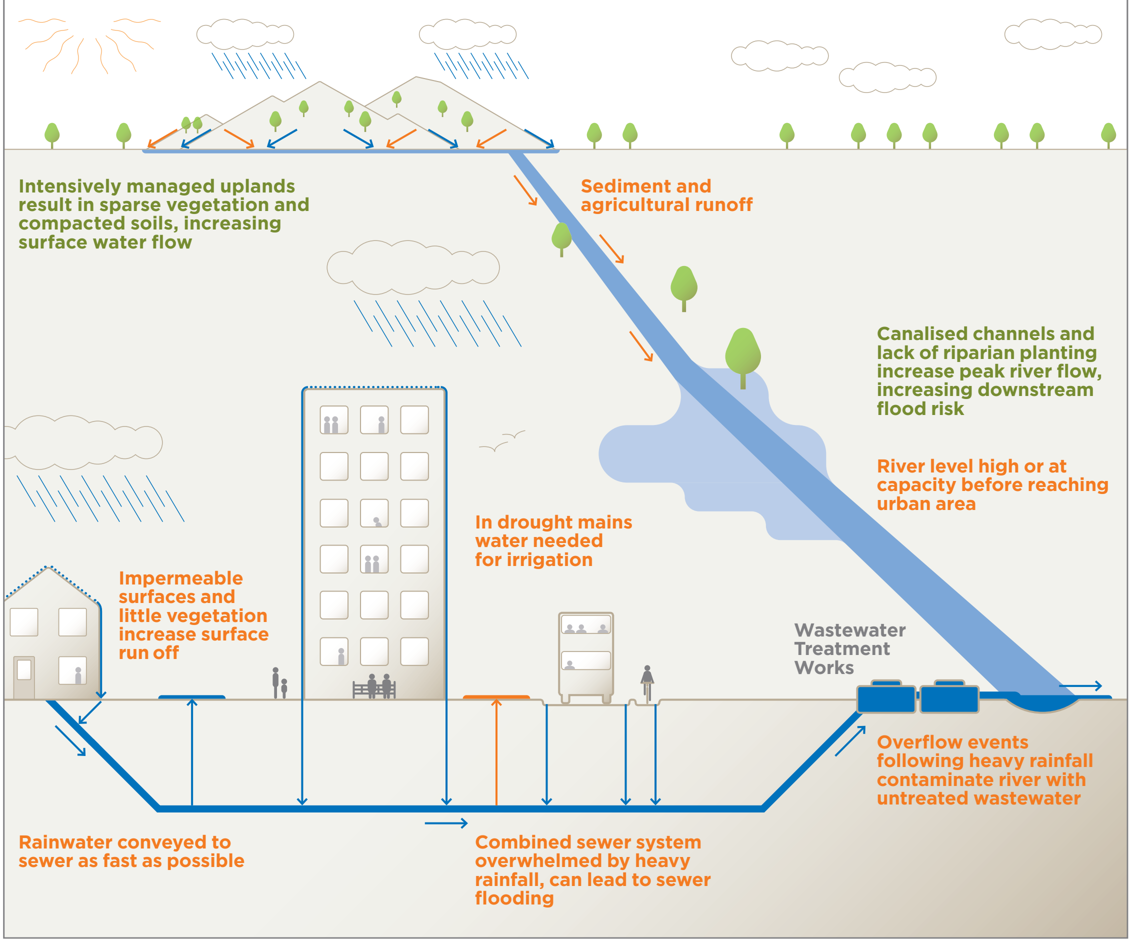
Our water resources face challenges from both climate change[1] and population growth[5]. In the UK, we currently use ~14 billion litres of water per day and will need 4 billion more by 2050[6], with future water shortages likely[7].

Managing water as a resource

We must slow the flow and improve water quality upstream by altering land management[8]; reduce urban runoff by intercepting rainfall and increasing infiltration; harvest rainwater and recycle greywater[9] (Fig. 2). This will reduce flood and storm overflow risk, provide irrigation for hot summers[10], and preserve water resources for drinking. *Green infrastructure (GI)* is fundamental for managing water. It reduces costs compared to traditional drainage[11] and provides a multitude of other benefits[12].

Globally, strategies for managing urban water include site-specific designs – *low impact development (LID)* and *sustainable drainage systems (SuDS)*; broader frameworks for city or regional management – *integrated urban water management* and *water sensitive urban design (WSUD)*; nature-centric approaches – *nature-based solutions (NbS)*; expansive city-wide concepts – *sponge cities*[13]. In the UK, the 2010 Flood and Water Management Act (FWMA), National Planning Policy Framework (NPPF) and local policies encourage or mandate SuDS. Schedule 3 of the FWMA, proposed for implementation in 2024, makes SuDS mandatory in all new development, with drainage systems needing approval from the SuDS approval body (SAB) before construction work can begin[14].

Fig. 1 **Water as a problem: urban water management without positive interventions**



Green Infrastructure (GI) for water resource management

By storing or slowing surface water, the use of SuDS and other GI reduces flood risk[15] and improves water quality (Table 1). To design for more extreme rainfall events, it is important to manage *exceedance* flows (Box 1). SuDS should be designed in accordance with DEFRA's technical standards[16]. Table 2 overleaf outlines the key considerations for the planning, delivery, and management of such interventions.

Table 1 **Effectiveness of GI interventions**[17]

Green walls	Retain up to 75% of rainfall. Remove 33-99% of total suspended solids and 30-83% of nitrates.
Street trees	An average tree can intercept 3.2m³ of rainfall per year*, with SuDS-enabled trees reducing peak flow by 81%.
Greenspace	30% of annual rainfall is infiltrated or retained, with 42-100% reduction in suspended sediments.
Green roofs	Can reduce peak flow by up to 88% and delay it by up to five hours.
Filter strips and swales	Reduce runoff by an average of 70% and total suspended soils by 79%.

*There are significant variations between broadleaf and evergreen trees, species, age and maturity.[18,19]

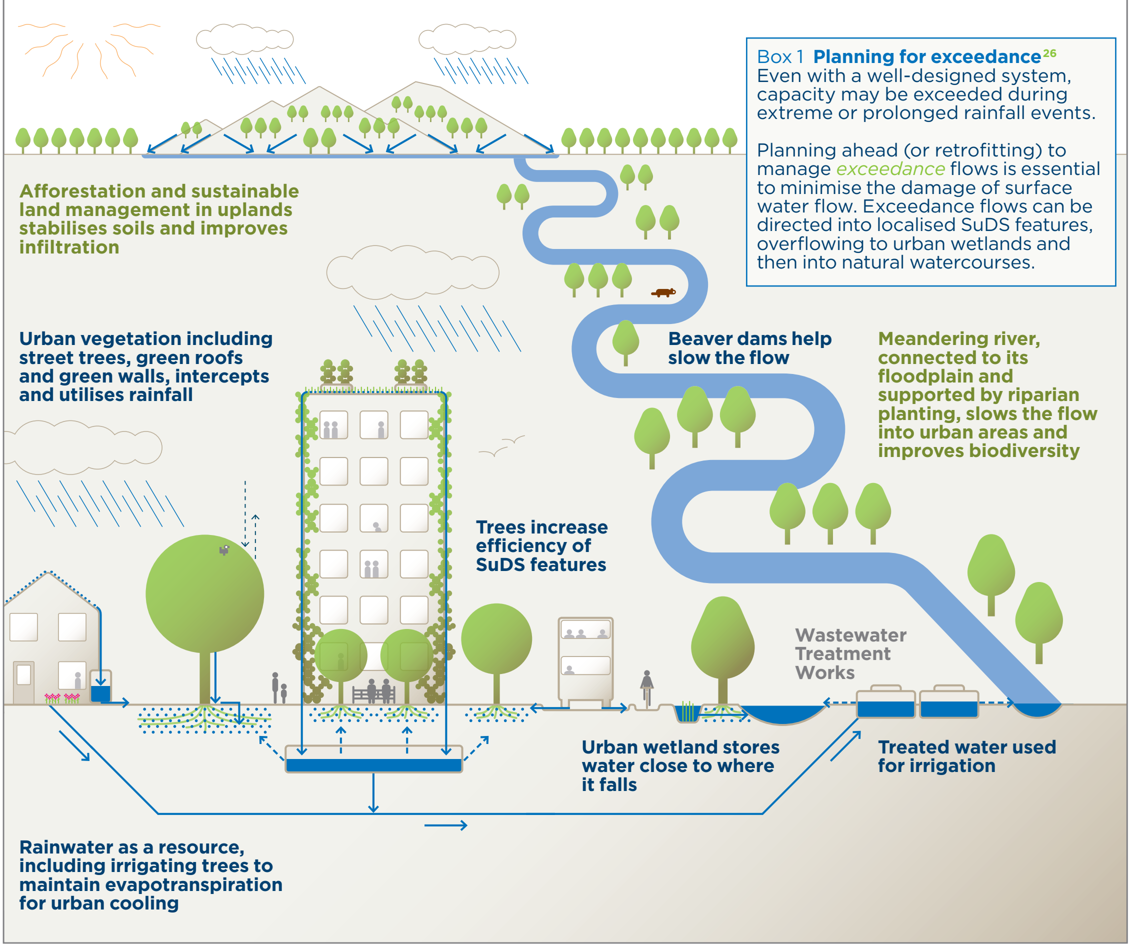
Integrated planning

It is important to make SuDS and other GI interventions integral to the overall development design. This enables different design elements to complement each other and can make the individual interventions more cost-effective. For instance, new cycleways and car parks can be integrated into SuDS by using permeable paving and bioswale tree pits. SuDS can be retrofitted into existing places[20], providing an opportunity to increase biodiversity and improve the urban fabric.

Financing improved water management

As part of their Plan for Water[6] the UK government will create a Water Restoration Fund, using money from water company fines and penalties to support habitat improvements and catchment projects. Natural England's Nutrient Mitigation Scheme[21] is being trialled in the Tees catchment whereby developers fund schemes that remove pollution to offset the impact of their development. The Green Finance Strategy[22] sets out how private finance will be mobilised to support public sector investment, which can help meet the scale of investment needed to manage water sustainably. On a household scale, capturing rain and surface water on property may reduce sewerage bills[23] and some water companies offer free water butts[24,25].

Fig. 2 **Water as a resource: urban water management with positive interventions**



Box 1 **Planning for exceedance**[26]

Even with a well-designed system, capacity may be exceeded during extreme or prolonged rainfall events.

Planning ahead (or retrofitting) to manage *exceedance* flows is essential to minimise the damage of surface water flow. Exceedance flows can be directed into localised SuDS features, overflowing to urban wetlands and then into natural watercourses.

References

23 Ofwat. Link

24 Anglian Water. Link

25 Southern Water 2023. Link

26 For more information on managing exceedance see Ciria 2006 *(C635F)*. Link and Ciria 2014 *(C738)*. Link

27 For more information on valuation see Jaluzot, A. and Ferranti, E.J.S. 2019. Link

28 Armson, D. et al. 2013. Urban Forestry & Urban Greening 12, pp. 282–286. Link

29 ARUP 2015. Link

30 See Appendix C, Sewage Sector Guidance. Link

31 Forest Research. Link

32 Susdrain. Link

33 TDAG 2014. Link

34 TDAG 2018. Link

35 Interpave. Link

36 BGS SuDS Infiltration Map. Link

37 Interlay. Link

38 Environment Agency 2023. Link

39 Living roofs. Link

Other resources

Ciria 2015. *The SuDS Manual (C753F)*. Link

Ciria 2017. *Guidance on the construction of SuDS (C768F)*. Link

ICE 2023. *ICE Manual of Blue-Green Infrastructure*. Link

Glossary

Combined sewers.
A sewer system that takes foul water as well as surface water.

Evapotranspiration.
Combines evaporation and transpiration. Evaporation is the process by which water from soil and plant surfaces changes from a liquid to a vapour. Transpiration is the process by which trees absorb water through their roots and transfer it up to the leaves where it evaporates into the environment through leaf pores.

Exceedance.
When waterflows exceed the system capacity.

Green Infrastructure.
A strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services.

Integrated urban water management (IUWM).
Integrated management of all parts of the water cycle within a catchment, including water supply, groundwater, wastewater and stormwater.

Low impact development (LID).
A "design with nature approach" to hydrology. Term used widely in USA.

Nature-based solutions.
Actions to protect, conserve, restore, sustainably use and manage natural or modified ecosystems.

Sponge city.
A holistic strategy to tackle urban pluvial flooding while improving ecosystems and the environment. Term used widely in China.

Sustainable drainage systems (SuDS).
SuDS are designed to maximise the opportunities and benefits we can secure from surface water management.

Water sensitive urban design (WSUD).
Integrating water cycle management with the built environment through planning and urban design.

Key elements

1. Treat water as a resource
Value water: minimise use of potable water by appropriate use of rainwater and filtered and treated greywater.

2. Small changes have a large effect
The cumulative effects of multiple small-scale interventions can be substantial.

3. Integrated water management
Link water management with urban heat reduction, flood risk management and greenspace provision, using valuation tools[27] to maximise societal benefit. Include all key players early – design teams, utilities, planners, highway engineers, local communities, and other stakeholders.

4. Use trees wherever possible
Trees improve the performance of GI[28] and deliver a wealth of social, environmental and economics benefits[12].

5. Use of mapping and modelling
Make use of geographic information systems and hydraulic modelling software to help assess the most suitable interventions.

6. Design with maintenance in mind
Have a maintenance plan in place before supervised construction starts. Include regular inspections, components and how they work, identified disposal sites, action plan for accidental spills, and advice on how to undertake excavations (eg utilities). Co-design with relevant maintenance regimes where appropriate (eg soft landscape management).

7. Plan for SuDS adoption[29]
Water companies have the capacity to adopt SuDS that are predominantly used for drainage from buildings or their paved areas, provided they are designed according to their guidance[30].

Table 2 **Ensuring water management interventions are appropriate and effective**

Intervention	Planning considerations	Delivery	Management	Case studies
All SuDS options[31, 32]	– Suitability of area: Topography, geology, groundwater flows. – Discharge locations, bypass system for use while cleaning, disposal areas of organic arisings. – How they fit into wider design – amenity and biodiversity. – Maintenance plan.	– Use skilled and experienced contractors, following government guidelines[16].	– Clearing of inlets and outlets. – Vegetation management. – Littler picking. – Checks and maintenance of components.	Link
Tree planting pits[33, 34]	– Type of system, eg structural soils, rafted, crated. – Underground services. – Tree species: right tree right place. Order well ahead of time. – Irrigation system design. – Use of mulch to reduce evaporation.	– Adequate quantity and quality of growing media. – Timing of planting – autumn/winter best for rainfall. – Ensure contractors have adequate environmental awareness (ISO 9001 certification).	– Irrigation of trees. – Pruning regime. – Tree safety inspections.	Link
Permeable paving[35, 36]	– System type: Total, partial or no infiltration. – Steepness of land. – Underground services. – Contaminated sites, designed not to drain water into water table. – Porosity of underlying soil.	– Use of type 3 sub-base. – Use of skilled and experience contractors[37].	– Suction sweeping. – Manual weed removal/weed burner (avoid weed killers as they may enter groundwater). – Permeable asphalt requires pressure wash or flushing every quarter.	Link Link
Swales, infiltration basins and rain gardens[32, 36]	– Soil permeability. – Connection to and from other features. – Catchment area – size needed. – Steepness of slopes.	– Integrate into surrounding landscape. – Use of appropriate planting – consider biodiversity, and visibility constraints if near highway.	– Grass cutting (less often if managed as meadow). – Litter picking. – Inspection of components. – Remove silts[38] – wildlife piles or compost.	Link Link
Rainwater harvesting	– Sizing of tank using rainwater figures against usage. – Connect overflow to other systems.	– Mesh/filters to stop insects and debris.	– Empty before heavy rainfall. – Clean mesh/filters.	Link
Green roofs and walls[39]	– Intensive vs extensive. – Overflow routes. – Irrigation system design.	– Appropriate planting for substrate and biodiversity. – Skilled and experienced contractors.	– Irrigation of plants and general plant maintenance. – Checks and maintenance of components.	Link Link Link
Designing for exceedance[23]	– Identify the flood pathways, incorporate them into emergency management plans. – Public awareness of pathways.	– Can alter pathways with groundworks. – Ensure subsequent works do not block designed pathways.	– Monitoring waterflow during storm events against assumed water pathways. – Keep pathways clear.	Link

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