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UK Sustainable Drainage Systems: past, present and future

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Abstract

Urban drainage has developed from an engineering discipline concerned principally with public health and safety outcomes, into a multi-faceted vision linking drainage with environmental and wider social and economic imperatives to deliver multi-functional outcomes. UK attention is too often focused on surface water as 'a problem' despite international progress and initiatives showing that an 'opportunity-centred' approach needs to be taken. Sustainable Drainage Systems (SuDS/SUDS) as part of an integrated approach to water management, cost-effectively provide many benefits beyond management of water quality and quantity. New tools are available that can provide the means to design SuDS for maximum value to society and this requires greater collaboration across disciplines to seize all of the opportunities available. Tools and a roadmap for this are introduced, including guidance, design objectives and criteria for maximising benefits. These new supporting tools and guidance can help provide the business case for using SuDS.

Key words

Sewers & drains, Municipal & public service, Urban regeneration.

Introduction

Demonstrating practice in the USA, Roesner's prize-winning paper: 'Joint management of urban runoff quality and combined sewer overflows', when presented to the UK's Wapug (wastewater planning users group) conference in Blackpool in November 1994, was hailed as inspirational. Twenty years on, the plethora of international research in the area has shown the need for an integrated approach and the many added benefits from using alternatives to traditional piped drainage. Despite this, uptake in the UK is slow (Ashley et al, 2014).

Sustainable Drainage Systems (English acronym - SuDS**;** Scottish - Sustainable Urban Drainage Systems - SUDS) were described in 2007 as: "surface water drainage systems developed in line with the ideals of sustainable development" and in 2015 as: "…designed to maximise the opportunities and benefits we can secure from surface water management" (Woods-Ballard et al, 2007 & 2015 respectively). 'Sustainable' is used only in the UK acronym: 'SuDS/SUDS', however sustainability depends on context (Ainger & Fenner, 2014). UK guidance related to SuDS is the Construction Industry Research and Information Association (Ciria) Manual (first edition: Woods-Ballard et al, 2007; second edition: 2015). SuDS is the term used throughout this paper to describe urban drainage systems that deal with surface water as alternatives to traditional piped drainage, examples of which are shown in Figure 1. “SuDS can take many forms, both above and below ground… SuDS that are designed to manage and use rainwater close to where it falls, on the surface and incorporating vegetation tend to provide the greatest benefits. Most SuDS schemes use a combination of SuDS components to achieve the overall design objectives for the site” (Woods-Ballard et al, 2015).

Figure 1 Examples of SuDS schemes – clockwise from top left: Highway draining Biofilters in Ashford (Sue Ilman); Storage basin Hamilton (Brian D’Arcy); University of York campus swale (by permission of Arup); Linear wetland, Stamford (Steve Wilson)

SuDS should be an intrinsic part of the built environment (Landscape Institute, 2013). In addition to providing water quantity and quality controls, SuDS can support natural ecological systems and are more adaptable than piped drainage systems (Eckart, 2012); an important attribute in the face of climate change and urbanisation (e.g. Rogers et al, 2012).

Innovation is needed to align societal systems and services with sustainable development (e.g. D’Arcy, 2013). In England, the National Planning Policy Framework (Nppf, Dclg, 2012) states that the “purpose of planning is to achieve sustainable development” and “Planning must be a creative exercise in finding ways to enhance and improve the places in which we live our lives”. This rationale has led to the use of SuDS being enshrined in the planning process rather than in a Local Authority SuDS Approval Body as intended in the Flood and Water Management Act 2010 (Fwma) (Pickles, 2014; Planning Practice Guidance, 2015). However, this fails to address the most important issue that Approval Bodies were designed to address, that of ownership and long term maintenance, nor does it remove the automatic right to connect surface water drainage systems into the public sewer system as intended in the Fwma. Hence the maintenance aspirations set out in (Dclg, 2015) are still unresolved. In Scotland the SUDS working party (2015) state that “There are no recognised situations where, with adequate planning, a development may be constructed and that SUDS cannot be installed”, this contrasts strongly the lukewarm approach to SuDS use in Defra (2015), which ignores the water quality and other benefits, and the ‘not too costly’ qualification in Planning Practice Guidance (2015) for England.

Internationally, much of the drive for change in the way stormwater is managed has been due to environmental concerns (e.g. Brown et al, 2009) but growing interest in economic aspects has led to greater scrutiny of the added value of SuDS (Nylen & Kiparsky, 2015). The need for a value-based perspective linked to ‘Ecosystem Services’ (HM Government, 2011), emphasises the need to exploit the added benefits that SuDS provide.

In this paper we consider the trajectory of practice in the UK to date, and suggest how the uptake of sustainable drainage might be better supported. Tools and a roadmap are presented that can help support a business case for making SuDS business as usual.

Looking back

It was not until the 19th Century that it became normal to enclose waterways, mainly due to the link between poor drainage and human health. At this time, much of the layout of London was reshaped synergistically with sewerage and drainage construction. The ‘sanitary revolution’ in London championed by Chadwick in the 1880s was not straightforward to bring about. Disinclination of engineers to change practice then (Hamlin, 1992) can be compared with today’s reluctance to adopt SuDS as business as usual (e.g. Wielebski, 2012). Nor were the 19th Century institutions responsible for water and wastewater necessarily fit for the new purposes planned, as could be argued today (Ellis & Revitt, 2010).

Successful maintenance of public health and welfare by water supplies and sewerage has been within the province of the engineer for more than a century with below ground piped systems being largely independent of other services. This has set the standard for the way in which drainage has traditionally been managed as ‘business-as-usual’. But increasing uncertainty about quantities of surface water generated in the future now gives rise to an imperative to link drainage better into urban planning and design.

During the 1980s ‘standardised’ models became available that allowed the simulation of the hydraulic performance of urban drainage systems, such as the UK ‘Wallingford Procedure’ (DoE/HR, 1981), which provided a rational and risk-based approach to prioritise investment in managing storm flows that is now used in many parts of the world. Subsequently, successive severe floods led to the Pitt Review in 2008 with many calls for more routine use of SuDS to alleviate water quantity problems.

The present: From problems to opportunities

Climate and economic uncertainty have prompted a need to deliver society's systems and services in a more flexible and cost-effective way, planned outside the envelope of 'certainty'. SuDS can provide treatment as part of storage and conveyance for the 'diffuse pollution' arising from the washoff of pollutants including solids, nutrients and metals (D'Arcy, 2013). Understanding of the water quality enhancement processes in SuDS has advanced, but its complexity leads to considerable uncertainty in modelling, although no more so than the equivalent for piped drainage systems (Schellart et al, 2010). SuDS have to be capable of capturing a wide range of pollutants with varied properties and it is essential that a treatment train designed to address the likely pollutants from a development be used.

The relationship between surface water, water quality and urban design and planning has become better understood (e.g. Ellis & Revitt, 2010) and reinforced in the recent restatement of the need to consider 'exceedance drainage' (Digman et al, 2014). Figure 2 illustrates where SuDS can provide an important role in managing the four types of rainfall and for which spatial planning is an essential component.

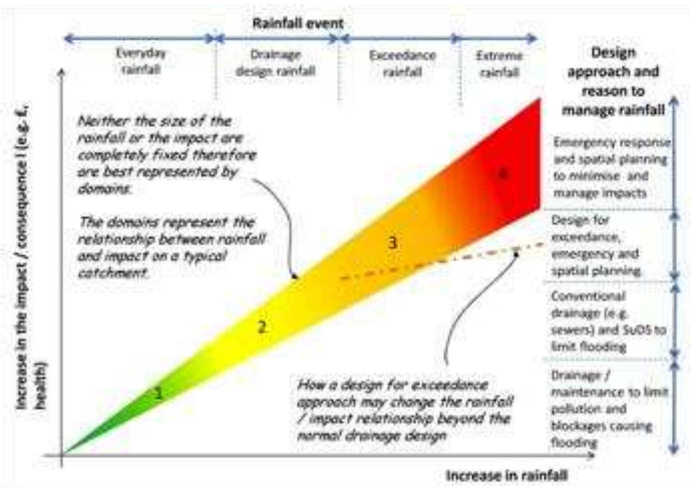

Figure 2 the concept of exceedance (Digman et al, 2014; copyright Ciria).

SuDS are important in providing opportunities to manage water on urban surfaces by subtle and multi-purpose features that store water temporarily or direct the flow safely to places of least impact. This is illustrated in Figure 3. Despite this, exceedance design has not been extensively implemented (Digman et al, 2014).

Figure 3 An illustration of the use of a swale in managing exceedance flows – a network of swales conveys flows in excess of the 1 in 30 year design event safely through the Upton housing development (Ciria)

Across the UK, there has been varied uptake of SuDS and it has become business-as-usual only in Scotland. Research has demonstrated the effectiveness of SuDS, but there are still problems in delivery (D'Arcy, 2013) especially regarding a lack of effective regulatory control in Scotland and the rest of the UK needs to note the lesson that there needs to be effective regulatory control of SuDS design, construction and operation.

In Wales, Dŵr Cymru Welsh Water (DCWW) has developed a 'Surface Water Management Strategy' (SWMS) as part of a broader 'sustainability vision', now the 'Rainscape Initiative' (Smale, 2015). The devolved administration in Wales has identified the benefits of SuDS and has worked with DCWW to encourage their use, creating a business case that emphasises the wider benefits that SuDS can bring to communities as a whole.

In England, placing SuDS within the planning process is designed to 'avoid excessive burdens on business' (Pickles, 2014). Without adequate regulation and a clear mechanism for adoption and maintenance, housebuilders will not routinely implement SuDS in England, whereas Wales and Scotland's regulatory regime should help ensure SuDS are the 'business-as-usual' option.

Recent studies have demonstrated the value of SuDS to society (e.g. Hair et al, 2014). SuDS can also support and enhance biodiversity (Defra, 2011) and add to the stock of natural capital. New analyses link Ecosystem Services valuation with SuDS and surface water management (e.g. Ashley et al, 2011). Initiatives in Australia have shown how surface water contributes to 'liveability' (de Haan et al, 2014).

Nonetheless, the full opportunities available from better use of surface water as part of urban planning and place making are being overlooked in the UK, especially by planners (Shaffer et al, 2014).

Without regulation, a business case is essential in order to take the wider value of SuDS into account. Various studies have considered the relative cost of using SuDS (e.g. WSP, 2013) and there is growing evidence for the economic benefits of SuDS as multi-functional infrastructure. An example is the traffic roundabout in Figure 4 that collects runoff to alleviate flooding and infiltrates, stores, treats, and provides reuse water for cooling, abates vehicle noise, and is a recreational facility.

Figure 4 Uptown Normal, Illinois, USA – a community event held on what is usually a road traffic roundabout [by permission of The Town of Normal].

A number of tools are available for assessment of the added benefits of SuDS (Jayasoorlya & Ng, 2014). One of these, (Cnt, 2010) has demonstrated the added value of using retrofit SuDS to manage 50% of the stormwater in Philadelphia as some $2.8bn, compared with less than $200k in additional benefits from a traditional sewer storage tunnel.

The Ciria project "Demonstrating the multiple benefits of SuDS" has developed a spreadsheet valuation tool, 'BeST' (Benefit of SuDS Tool) to support decisions in regard to design and operation (Digman et al, 2015). The benefits included are shown in Table 1. The tool may be used to compare options (Shaffer et al, 2014).

Benefit category	What it covers	Monetised in the tool

Benefit category	What it covers	Monetised in the tool
Air quality	Damage to health from air pollution	✓
Amenity	Attractiveness & desirability of area	✓
Biodiversity and ecology	Sites of ecological value	✓
Building temperature	Cooling (summer) or insulation (winter)	✓
Carbon reduction and sequestration	Operational (reduced energy use), embodied (reduced water use), sequestration (planting)	✓
Crime	Crimes against property or people	×
Economic growth	Business, jobs, productivity	×
Education	Enhanced educational opportunities	×
Enabling development	Headroom for housing/other growth	✓ / ×
Flexible infrastructure/ climate change adaptation	Improved ability to make incremental changes to systems (no regrets)	×
Flooding	Damage to property/people	✓
Groundwater recharge	Improved water availability or quality	✓
Health	Physical, emotional, mental health benefits from recreation and aesthetics	✓
Pumping wastewater	Reduced flows to works	✓
Rainwater harvesting	Reduced flows, pollution or mains consumption	✓
Recreation	Involvement in specific recreational activities	✓
Tourism	Attractiveness of tourist sites	×
Traffic calming	Risk of road accidents or street-based recreation opportunities	×
Treating wastewater	Reduced volume to treat in combined systems	✓
Water quality	Surface water quality improvements to aesthetics, health, biodiversity, etc	✓

Table 1 Ciria SuDS multiple benefit (BeST) valuation tool categories

The future

SuDS are a vital component of our ability to adapt and to cope with future rainfall uncertainty (ASC, 2012), and are a resource for a range of benefits (Table 1). The overarching principle of SuDS design in Ciria's revised manual is that "Surface water runoff should be managed for maximum benefit" (Woods-Ballard et al, 2015). This principle is supported by four pillars of design as shown in Figure 5.

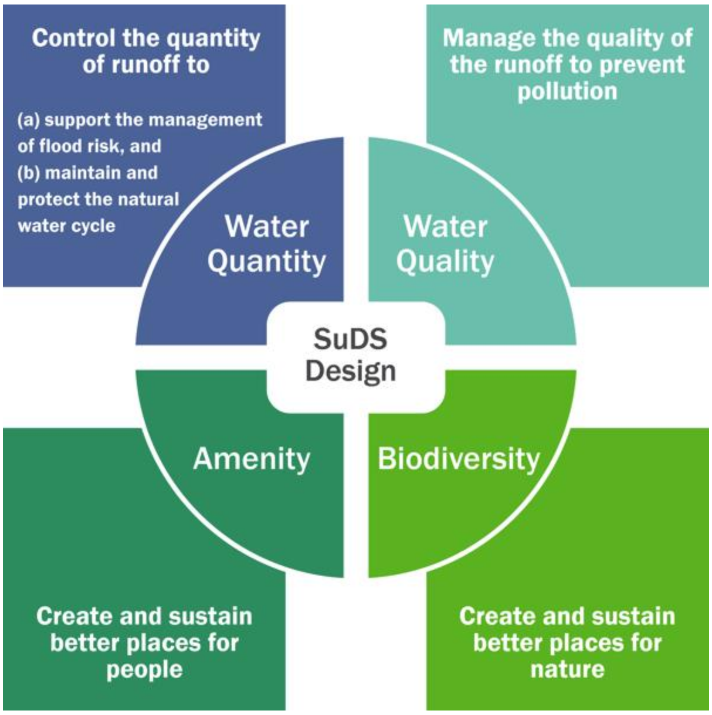

Figure 5 the pillars and design objectives of SuDS design (Woods-Ballard et al, 2015)

Realising the benefits from SuDS necessitates seeing all forms of water as potential opportunities (e.g. Crc, 2014; Abbott et al, 2013) and requires buy-in from a wide range of stakeholders, including some not traditionally interested in drainage matters, like Health Authorities, but also Transport Authorities and Water Companies. However, in each case it will be essential to establish a business case (e.g. iBuild, 2015). This will not be straightforward as illustrated by the discontinuity in the way main river flood management is funded in England and how SuDS are recommended for use only where they are not 'too costly'. Funding for main river and coastal flooding measures is considered in terms of the costs and benefits, unlike SuDS by Dclg (2015), where the emphasis is entirely on costs.

Figure 6 presents a vision of a stepwise approach to SuDS as routine business in the UK. Once there is even more confidence that the technology is effective and affordable, government can establish the legal framework that delivers two essentials:

a) Stability for business and public sectors, with a requirement for compatible technical guidance across all sectors;

b) Clarity on adoption/vesting, supported by adoption standards, which must deliver a legal remit for public bodies to have budget for retrofits with ongoing maintenance.

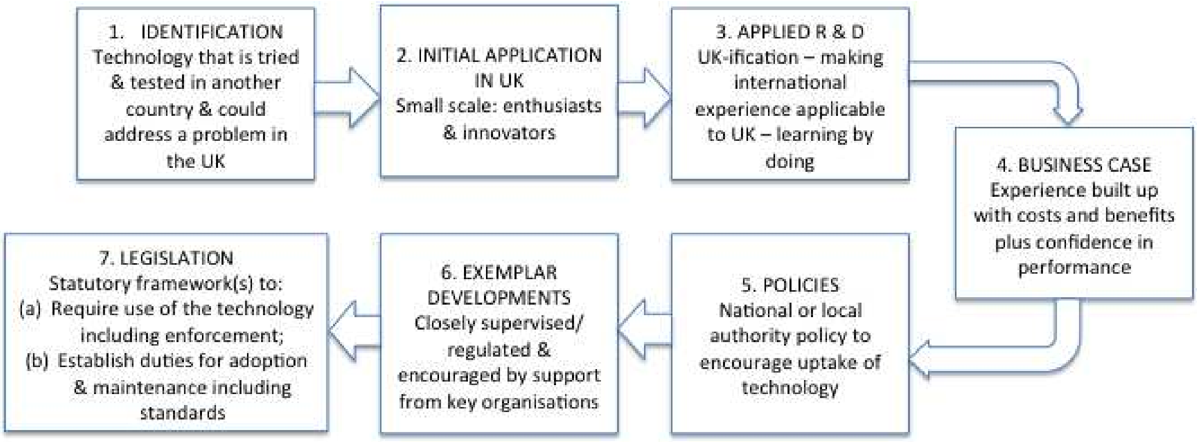

Figure 6: Seven steps to routine business for sustainable drainage technology for the built environment in the UK.

Taking SuDS into the future (Figure 6) so that they become business as usual will necessitate innovative collaboration and engagement with local communities (Green Alliance, 2015), building on initiatives like catchment partnerships. In England weak regulations and a planning framework that has downgraded the place of sustainability and removed support for green infrastructure, will allow developers *carte blanche* in the way in which they provide drainage. Now that the requirement for SuDS is merely guidance and part of the 'planning balance' rather than statutory, there is a concern that local authorities may prioritise other issues in preference to SuDS to encourage development when determining planning applications.

Conclusions

Surface water management should be about maximising opportunities to deliver high value schemes that work hard for local communities. Because our existing drainage assets will be in use for many years to come, the scope for benefits from retrofitting, particularly where sewer capacity constrains development is much greater than solely providing SuDS for new developments. However, disputes about ownership, maintenance and the role of regulation may continue to be amongst the greatest challenges in making SuDS business as usual.

The place of water in urban areas will have to become part of the Smart City of the future, one where there is more than simply a 'nexus' of services, systems and infrastructure, rather a new multiple functioning of our urban infrastructure and a wealth of value delivered by our surface water resources. Experience, however, indicates that this will be most likely to be delivered by effective regulation, appropriate monitoring and action by all concerned. In places where there is effective regulation, such as the USA, this drives best practice, the effective use of multi-beneficial SuDS and creates a clear business case (e.g. Nylen & Kiparsky, 2015). It is unfortunate that the regime for SuDS in England, in contrast with Scotland and Wales, fails to recognise the need for effective regulation that will make sure we deliver the greatest overall benefits for society.

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