A review of 20 years of SUDS in Scotland

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ABSTRACT

Introduction
Sustainable urban drainage systems or SUDS were introduced in Scotland over 20 years ago, following a Forth River Purification Board (FRPB) review of water pollution issues, which identified urban drainage as a significant source of diffuse pollution in the River Forth Catchment. A review of progress made over the 20 year period considers the lessons learnt and examines how legislation, key policies and guidance have played a lead role in influencing their uptake. Engagement with practitioners and responsible bodies such as developers, consultants, architects, manufacturers, local authorities, the water utility Scottish Water (SW) and the Scottish Environment Protection Agency (SEPA) has also positively advanced the SUDS agenda. The review looked at several surveys that targeted these bodies from when the SUDS concept was in its infancy to the present day.

Methodology
The surveys were conducted using various methodologies from face to face and telephone interviews to postal and online surveys. The number of participants of individual surveys varied, but a similar audience was targeted in each case, providing a useful indication of perceptions of SUDS over the years. Four key surveys document progress over the 20 year period, namely:

- A MSc project carried out by the University of Abertay in 1996 to determine knowledge, perceptions and understanding of SUDS in Scotland (McKissock et al, 1999);
- A survey carried out in 2003 by Hyder Consulting, on behalf of SEPA, to evaluate SUDS guidance in Scotland (McKissock et al, 2003);
- Abertay University survey, carried out on behalf of the Sustainable Urban Drainage Scottish Working Party (SUDSWP) in February 2013, to provide anecdotal information to support research which appraised how source control SUDS has been delivered, is currently being delivered, and how to further future implementation (Duffy et al, 2013a);
- Hydro International survey carried out in September 2013, which was designed to gauge how successful practitioners believe Scotland has been in delivering SUDS (Hydro International, 2013).

Scottish legislative context
The successful uptake of SUDS has been heavily influenced by emerging legislation (Figure 1). Initially this legislation was water quality driven (Tingle 2006, Cashman 2007), but more recently flood risk management has become increasingly prominent following serious flood events experienced in Glasgow during the winter of 2002 acting as a wake-up call to further consider SUDS initiatives to address flood risk management issues, (Duffy et al 2013b).

When SUDS were first introduced in Scotland, the Control of Pollution Act (1974) gave the regulatory authorities at the time, the power to protect the aquatic environment from pollution (Macrory and Zaba 1978, Macleod, 1997). A Forth River Purification Board (which was replaced by SEPA) study, carried out in 1996 in the River Forth catchment, revealed that approximately 41km of Class 3-4 rivers (1 is high water quality, 4 is the worst water quality) were adversely affected by urban runoff (FRPB, 1994). This was the equivalent of 25% of all Class 3-4 waters in the area. The findings of this study also highlighted that that urban drainage as a diffuse source of pollution was a primary polluter of water courses (Ellis 1985, Ellis et al 1987, Hamilton and Harrison 1991) and this was the catalyst for the FRBP and subsequently SEPA to promote the use of SUDS within their catchment (D'Arcy and Frost 2001, SEPA 1996). Since that time, the use of SUDS has become a planning requirement for most new developments through Scottish Planning Policy on a national level (Scottish Executive, 2001) and this requirement is also translated in to local plans. Since 2004, SUDS have also been included in the Building Regulations.

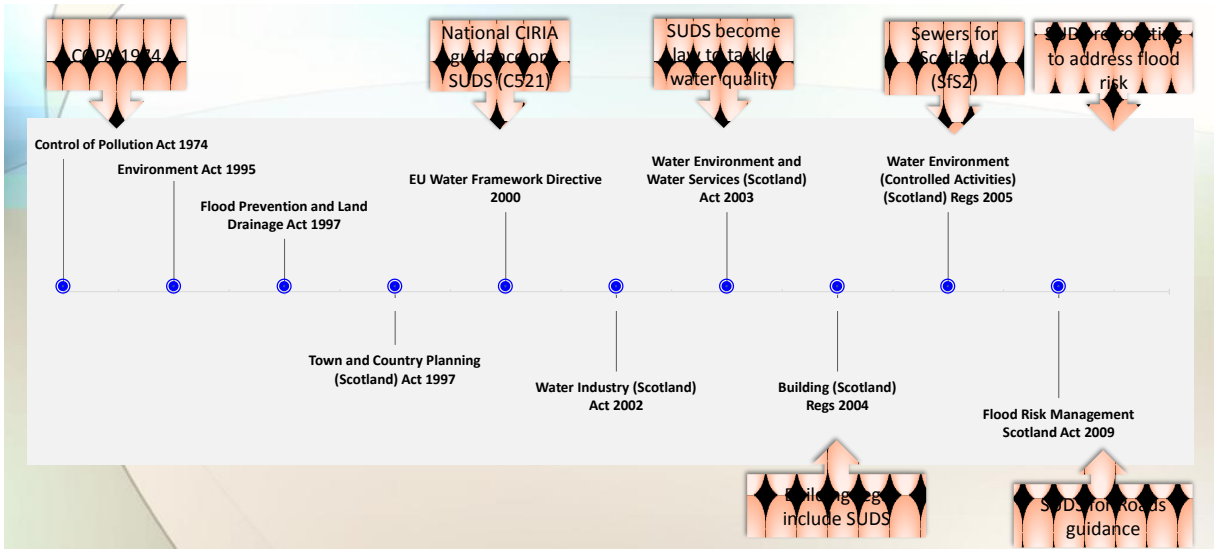

Figure 1 – SUDS timeline in Scotland

In 2003, the Water Environment and Water Services (WEWS) Act was enacted, which transposed the EU Water Framework Directive into Scottish law (EU, 2000), to tackle water quality issues. It also specifically established a system of river basin management to reduce levels of pollution and protect habitats. This not only made the use of SUDS law, but also encouraged a more co-ordinated approach in the way surface water was managed by the multiple agencies involved in dealing with this resource. This legislation made it a requirement to prepare River Basin Management Plans (RBMPs) (Scottish Executive, 2006) and stated:

'Local Authorities, Scottish Water and SEPA will work together to co-ordinate their efforts to tackle pollution from diffuse urban sources. This will include incorporating Sustainable Urban Drainage Systems into local plans and programmes'.

The WEWS Act also resulted in SUDS becoming legally recognised as part of the surface water sewer network requiring the drainage authority Scottish Water (SW), to vest and maintain public SUDS (Taylor *et al*. 2014, Duffy *et al.* 2013c). In 2008, SEPA enforced regulations which made it law to implement SUDS in all new developments (SEPA 2012a, 2012b).

There was little national guidance available until 2000. Prior to 2000 the only guidance available was based on guidelines imported from Best Management Practices (BMPs) constructed in the US (DArcy and Roesner 1997, Maxwell 1997). This is reflected in some of the earlier example of SUDS with lack of local technical guidance proving in time that many fail to operate as per design (Lucey *et al.* 2011). However, the publication of the first Scottish SUDS design manual, produced by CIRIA (Martin et al, 2000), undoubtedly had a positive effect on the quality of the designs which were being constructed. Guidance has now been available for quite some time on SUDS, however, adoptable standards were not introduced until 2007, with the publication of Sewers for Scotland 2 (WRC, 2007, Aukerman *et al.* 2011, Duffy *et al.* 2013c). This gave Scottish Water the power to vest in certain types of SUDS, if they are designed and constructed in accordance with these standards. Sewers for Scotland 2 was followed by SUDS for Roads in 2008 (Pitner and Allerton, 2008), providing guidance on the design of roads incorporating SUDS.

The uptake of SUDS retrofits to deal with existing surface water management issues has been relatively limited until recently. The use of more traditional options, such as oversized pipes, has been the preferred solution in many cases. However, the Flood Risk Management Act (2009) is slowly beginning to change this, with many of the local flood risk management plans and strategies (most of which are still in draft format) highlighting the importance of adopting better co-ordinated and more sustainable methods of managing surface water as discussed by Sarah Hendry from UNESCO Centre for Water Law, Policy and Science, University of Dundee (Howarth (Ed), 2008). The utilisation of SUDS retrofits is central to the Scottish Government's Surface Water Management Planning Guidance, published in 2013. An increasing number of surface water management plans are being produced, including the Glasgow City Centre Surface Water Management Plan (McKay et al, 2015), which adopted a philosophy of keeping runoff above ground wherever possible and introducing blue/green corridors to control and convey runoff generated by this highly urbanised catchment.

Findings of the University of Abertay 1996 survey

The University of Abertay questionnaire was devised in response to the lack of understanding of surface water management techniques which could be employed to control runoff, in particular to deal with water-quality degradation in Scotland. The target audience were those dealing directly with SUDS. A total of 119 questionnaires were distributed to engineers, environmental consultants, local councils, water authorities and planners, with 43 returned. The largest number of questionnaires (75) was sent to consultants, the remainder split equally between water undertakers and councils. Just over half of these who responded, had been involved in development which required runoff to be controlled, suggesting they had some experience of the subject.

At the time the survey was carried out SUDS were a relatively new concept in Scotland and practitioners were relatively inexperienced in their design and construction. The survey was also carried out prior to the publication of any UK based design manuals this was reflected in their design. When questioned on the availability of guidance, this highlighted as an issue. In particular, the lack of information on adoption and also on their effectiveness, as the survey was carried out prior to any SUDS monitoring being carried out in Scotland. Only 5% of those questioned believed that there was adequate guidance on adoption and 2% believed that guidance on the effectiveness of such systems was adequate.

The findings of the survey suggested that the perceived knowledge on the subject was high, with 72%, 74% and 79% claiming that they knew about swales, infiltration systems and stormwater wetlands respectively. However, when a sample of the 79 SUDS identified in the survey were inspected, many of the structures, such as the 'so-called' swales were actually steep sided ditches with very little vegetation or in some cases un-recognisable as wetlands. The respondents were also questioned on the perceived deterrents to SUDS. The results, which are described in Figure 2, suggest that maintenance was the primary deterrent, followed by cost and then adoption.

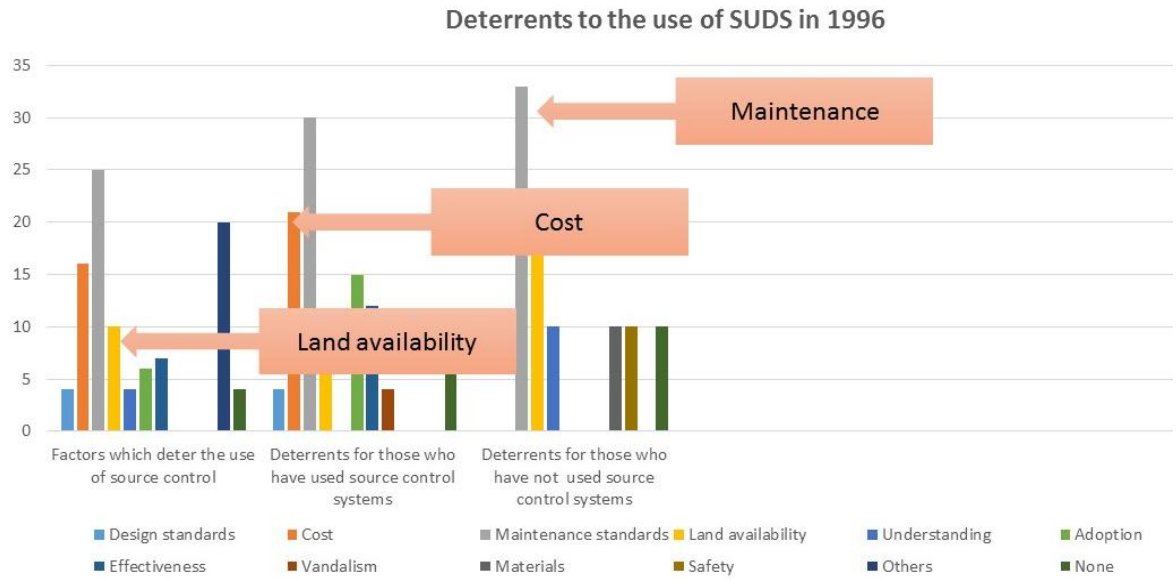

Figure 2 – Deterrents to the use of SUDS in 1996

Results of the 2003 Hyder Consulting survey

The 1993 survey, carried out by Hyder Consulting on behalf of SEPA, was developed to evaluate diffuse pollution guidance and reference material in Scotland. The aim was to establish attitudes, perceptions and experience of practitioners, and was carried out in 2 stages:

- **Phase 1:** Focus groups and interviews
- **Phase 2:** Postal questionnaire

Phase 1 consisted of questioning representatives from SEPA, Scottish Water, academics, CIRIA, consultants, SNH, developers and local authorities. A total of 7 interviews were carried out, attended by 45 individuals. In addition, a further 4 telephone interviews and 2 semi-structured interviews were conducted. Phase 2 involved the use of a postal questionnaire, with a target audience selected to cover individuals who were likely to be involved with the design and implementation of SUDS. A total of 830 were sent and 160 returned, giving a response rate of 20%. The target audience was confirmed as being appropriate, when 98% of the responders suggested that they were familiar with the term SUDS. When questioned further, 50% of the individuals who had responded

had been involved with the implementation/construction of 6 or more sites, suggesting that many were experienced in the subject.

The survey identified that SEPA references and CIRIA publications were the most popular source of SUDS guidance in Scotland. The pivotal role of the CIRIA manual in Scottish SUDS implementation is highlighted in SEPA policy at that time (SEPA Policy 15), which states that: 'SEPA shall refer to… the manual… as the primary source of authoritative information on sustainable urban drainage systems'. The manual was also referenced in government planning guidance (Scottish Executive, 2001); and since then it has been at the heart of relevant planning advice and national policies in Scotland.

In terms of deterrents to the use of SUDS, the findings were similar to those described in the 1996 University of Abertay survey. Many respondents felt that a lack of clarity about who was responsible for adoption and maintenance of SUDS had been the main deterrent to their use. One participant stated that: "*SUDS is an essential step forward for the benefit of the environment, however there is still a vale of cloud hanging over this design system regarding… adoption and future maintenance*" Respondents were also encouraged to name several different deterrents to SUDS implementation. The adoption and maintenance issue was identified as being the greatest deterrent (90 of 455 responses). Land take was also found to be a significant deterrent (64 responses).

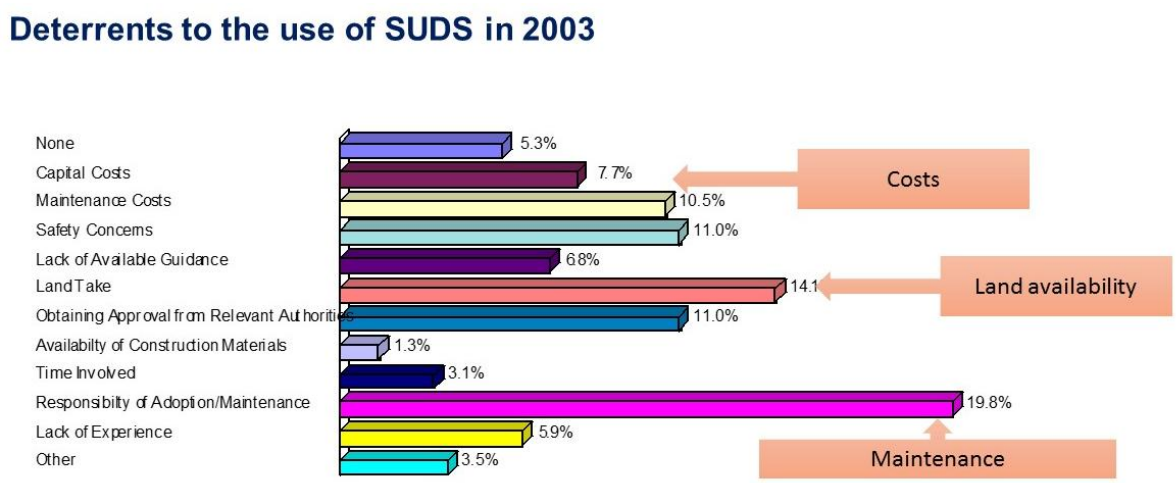

Figure 4 – Deterrents to the use of SUDS in 2003

University of Abertay Survey 2013

A three phased research project was commissioned by SUDSWP to appraise delivery of source control SUDS on a global scale and provide recommendations for furthering their implementation in Scotland. A workshop delivered to the SUDS Working Party and online / telephone surveys were developed during stage 3 of the project. The workshop was developed to gain an insight into the diverse opinions of SUDSWP members including targeted professionals on their understanding of source control techniques, investigate preferences, identify key barriers and determine the appetite within the stakeholder platform for furthering implementation.

It was apparent that there is an appetite for these solutions and technical knowledge is evident for implementing source control SUDS. The initial response to what the key barrier is was 'cost', but further discussion identified that there appears to be a fundamental lack of confidence regarding performance in the urban landscape, primarily with regards to more novel techniques such as green roofs, rainwater harvesting and rain gardens / bioretention units. In Scotland there are limited documented flagship or exemplar schemes (apart from the Dunfermline Eastern Expansion, DEX, a mixed 5.9km^2 development site served by end of pipe 'traditional' SUDS such as ponds, basins and roadside swales where construction began in 1996 with completion expected by 2020, see Duffy *et al.* 2012 for more information). There have been many feasibility or design studies such as those developed by the Glasgow and Clyde Valley Network (for example see Barber (Ed) 2010), however few have become a practical reality to date (Duffy et el 2013c).

To add value to the workshop and Phases 1 and 2 research findings, two different types of survey were also conducted to obtain anecdotal information from professionals and researchers in the field on the understanding of source control SUDS, extent and barriers to implementation:

- an online survey was distributed through the SUDSnet website (82 responses over a period of one month) where it was felt that the target audience would primarily be those professionals and academics

who were interested or involved with source control SUDS implementation such as consultants, local authorities, water authorities, planners and the research community (75% practitioner responses).

- semi-structured questionnaires delivered to a small number of professionals (15) covering similar professional backgrounds as the online survey (50% practitioners, 25% public bodies, 25% research).

The surveys focused on source control SUDS, as there is concern that uptake is not as widespread as expected at the beginning of the SUDS journey in Scotland, however many responses such as legislation, the most referred to guidance materials, adoption and long-term management issues are synonymous with perceptions surrounding SUDS in general.

An initial question in the **online survey** invited respondents to indicate if they had been involved with implementing the techniques with a very high number of respondents (80%) answering yes with 67% responding that they had been directly involved with implementing 10+ schemes. Of particular note on analysis of the online survey was the response to the question that asked if there was scope for more widespread use of the (source control) techniques – 99% agreeing that yes, there was more scope and implying that the stormwater treatment train approach was not being implemented.

Question number 6 asked respondents if they thought that legislation was adequate from the key responsible bodies involved with regulating drainage infrastructure: a) building regulations; b) planning applications; c) highways and drainage approvals; d) environmental regulation. All questions received less than 50% positive (yes) responses. Environmental regulation received the highest response (42%), highway drainage approvals (36%), planning approvals (33%) and building regulations (31%). The role which building regulations play in implementing and enforcing source control SUDS was also raised during the workshop and telephone interviews. The final question was an open ended question which asked respondents if they had any further comments. All responses, except one, offered insights into perceived barriers to the implementation of SUDS.

The **telephone survey** involved a more qualitative research methodology with questions being more open ended in order to elicit comprehensive answers from respondents (Bryman 2001). This meant that respondents could explain any important opinions regarding each question in detail if they wished as opposed to the online questionnaire structure which did not allow personal expressions until the end of the survey. Only 47% of respondents had been directly involved with implementing source control which was a surprisingly low figure considering the respondents were chosen for their activity in the field.

Question 9 'do you have access to maintenance activity / cost information?' responses were low with almost 60% negative responses. Of the positive responses, 12% had maintenance activity information and 29% had cost information which they could share.

Question 11 asked respondents 'what guidance documents would you refer to for advice on source control implementation?' CIRIA guidance (42%) was clearly ranked the highest by more than 50% over any other guidance available with research materials the second highest at 12%. CIRIA guidance quoted included all guidance related to SUDS and not just the SUDS manual (CIRIA, 2007). Local Authority planning guidance, SfS2 (WRc plc, (Pub). 2007) and SUDS for Roads (Pitner and Allerton, 2009) were also highly ranked.

The question was also asked 'which public organisations or professional body do you find is the most helpful for providing information / guidance?' CIRIA again was ranked the highest. Susdrain (http://www.susdrain.org/) was also cited as a helpful source of information. Susdrain could have been added to the CIRIA score however it was felt important to distinguish between the two as susdrain is a fairly recent resource developed by CIRIA which has gained popularity in a very short timescale indicating the need for resources such as this by professionals in the field. Local Authorities were also cited as useful sources of information (21%) with several respondents citing specific authorities who they considered to be particularly helpful. SEPA / EA were ranked the third most helpful resource for advice / guidance however both agencies also received negative responses.

At the specific request of the SUDSWP a final question was included towards the telephone survey: 'do you know if there are any checks / sign offs for source control SUDS implementation – pre or post construction?' Although this was only included in four surveys the answer was 100% negative. One respondent replied: *"No formal checking through planning application but should get picked up through RCC (roads construction consent), however although this happens for roads, this rarely happens formally for the SUDS".* Lack of effective enforcement regimes by responsible bodies including quality control is not an ideal situation and will account for systems which may not be constructed according to best practice and prone to failure and therefore having less than anticipated life expectancies.

Findings regarding barriers to implementation were consolidated for the workshop / surveys (Figure 5). Clarity (of concept and functionality), education (capacity building) and governance (regulation and enforcement) were the most cited responses (21% - 17%). Cost of implementation (14%) and responsibility (ownership and adoption) (13%) are still considered to be key barriers with issues surrounding maintenance and land take (3%)

not considered a major deterrent. However it must be remembered that this survey was specifically related to source control SUDS where additional land is often not purchased or set aside for many location types.

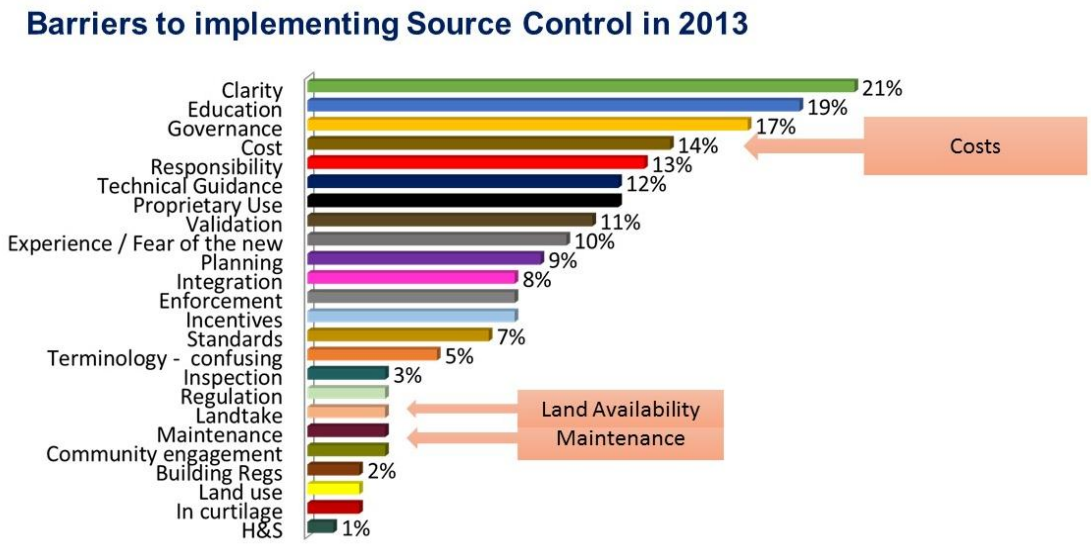

Figure 5 – Deterrents to the use of (source control) SUDS in 2013

Hydro International survey 2013

The purpose of this survey was to gauge how successful professionals believe Scotland has been in delivering SUDS and to identify possible barriers to future progress. There were a total of 151 responses, amongst those represented were engineers, developers, SEPA and Scottish Water. The survey was also followed up by an expert panel, who met to discuss the findings of this research, including representatives from the Scottish Government, industry leaders and drainage experts.

The main positive to come from the survey findings was that the overwhelming majority (97%) believed Scotland had successfully implemented SUDS since the 2003 Water Environment and Water Services Act was introduced and 85% of the responders agreed legislative drivers have helped Scotland to make more effective progress with SUDS than England and Wales. However, when questioned further, very few (2%) thought Scotland had been completely successful in SUDS implementation.

As with previous surveys, adoption was cited as a significant barrier to progress. Many also suggested that regulation and guidance was not sufficiently clear on both maintenance (60%) and adoption (67%). A concern which was also raised by 78% of those questioned was that inadequate funding was available for the adoption and maintenance of SUDS in Scotland.

Results and Discussion

The results from these studies suggest that attitudes to SUDS have changed over the years, with practitioners becoming more receptive to the concept, as it has progressed from 'an American idea which will never work in Scotland', to routine business (McKissock et al, 1999). However, community engagement is still very limited, with the prevailing attitude still being 'out of sight, out of mind'. Scotland has much to learn from global experience, including projects such as the Melbourne 10,000 and Puget Sound 12,000 raingardens initiatives (http://www.melbournewater.com.au/raingardens and http://www.12000raingardens.org/, where educational campaigns using terminology which the public can understand, has contributed to the success of WSUDS / LIDs in these countries.

What is striking when reviewing the findings of each survey is that there are underlying themes in the responses to all of the surveys. Some of the issues identified in the earlier surveys have been largely resolved, such as the absence of guidance. This has been largely addressed though the publication of numerous CIRIA guidance manuals, Sewers for Scotland 2 technical standards, SEPA publications and the SUDS for Roads manual; but the results of the survey carried out by Duffy et al (2013) suggested that more guidance may still be required. This appears to be more with uncertainty surrounding the application of the different measures and benefits provided by SUDS primarily in the treatment train philosophy (and the difference between this and the SUDS triangle concept) including capacity building via case studies for the more novel SUDS techniques. There has been

significant progress in terms of the numbers of SUDS implemented, with only 79 SUDS schemes being identified in 1996, which increased to over 3,900 in 2000 (Wild et al, 2002). Updated asset registers are in the process of being developed by local authorities and it is envisaged that many more thousands have been constructed since 2000. This is largely due to SUDS becoming law under the WEWS Act and such measures being required under Scottish Planning. However, there still seems to be a general lack of confidence in SUDS design and a lack of good demonstration sites across Scotland.

It is widely acknowledged that SUDS implementation has come a long way, but there are still fundamental issues which were identified in the surveys carried out 20 years ago which have still to be addressed. The adoption of SUDS, or rather who is willing to take the responsibility of adopting and maintaining SUDS, is still seen as a primary deterrent to their use. There is an urgent need to clarify these issues Apart from one study that investigated actual costs of regional ponds at DEX in 2005 (Duffy *et al.* 2005), costs associated with SUDS are still perceived as an issue, which may be due to the lack of published information on actual capital and operating costs for all types of SUDS measures considering the prevalence of the systems in Scotland. 60% of those who participated in the survey carried out by Duffy *et al*. (2013) said that they had no access to maintenance activity details or cost information.

The preferred types of SUDS over the 20 year period tend to be those which require the least land take, such as filter drains, permeable paving and soakaways. There has also been a tendency for practitioners to employ end of pipe systems rather than source control methods, with the amenity benefit of certain measures often being overlooked. The SUDSWP workshop highlighted the appetite for introducing novel source control techniques.

Conclusions

It is obvious that in Scotland environmental regulation has proven to be the simplest, most effective mechanism for implementing SUDS as a driver for environmental improvement. So what does the future hold for SUDS in Scotland? Current institutional arrangements in Scotland mean that responsibilities for managing drainage and surface water are split between different organisations and land owners. There is no one body with overall responsibility. This also means that there are fragmented funding responsibilities, which influences the ability of organisations such as local authorities and Scottish Water to adopt large numbers of SUDS. Surface water management is an area where different organisations need to work together pooling knowledge and resources, sharing costs and aligning actions. The Flood Risk Management (Scotland) Act 2009 goes some way to addressing this; encouraging authorities responsible for the management of surface water to adopt a more holistic and collaborative approach than previously was the case. The Duffy *et al.* (2013) survey also suggested that Scotland has weak enforcement of regulatory requirements and inspection policies. This is also an area which requires addressing, as there is little benefit in employing SUDS if they are designed incorrectly, they are not maintained and they are not inspected at regular intervals.

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