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Urban Drainage in Ireland – Embracing Sustainable Systems

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Abstract

The current approach to stormwater management in Ireland new developments are restricted to greenfield rates that would have occurred prio development. This typically involves the use of holding tanks constructe developments to attenuate runoff from stormwater which is released at a reduced rate v control structure into nearby drainage network. Improved urban drainage policies now require that sustainable drainage systems (SuDS) are used to meet this objective. This study presents an evaluation of practices that may improve the adoption of new policies. The findings are based on surveys and focus groups practitioners involved with the planning and design of systems. Although the study indicates that SuDS benefits are reasonably well understood, for many, their u reasons, has remained unpopular. Concerns with ongoing maintenance and long-term responsibility of SuDS is the main impediment to embracing the use of such systems in drainage strategies.

Keywords: SuDS, drainage, environment, urban development, defence/ management, storm, river basin management.

Introduction

The issue of sustainable drainage is on the global agenda but issues w implementation remain. While considerable advances in th guidance and performance of sustainable drainage systems (SuDS) have been made in recent years, their role within the Irish planning sphere has only rec established. Prior to this, traditional systems that focused conveyance of runoff, combined with some storage, were the nor SuDS utilise natural resources and replicate natural processes at any site, thereby minimising environmental impacts. Both hard and soft measures can be used to mimic natural processes. Hard SuDS measures are those below ground and resemble more closely traditional drainage practice but incorporate SuDS principles (examples include permeable pavements or SuDS features such as filtration systems). Soft SuDS measures such as swales, ponds and wetlands are above ground and typically offer greater benefits in terms of water qua than hard options.

Since the publication of the Greater Dublin Strategic Drainage Study (Dublin Drai Consultancy, 2005), the use of SuDS has become mandatory in all new devel Ireland. At this time, the Irish Office of Public Works initiat (FSU) programme. The FSU included as one of its components a flooding issues with a view to providing direction to the engineering community in the futu for improving methodologies for urban catchment f stormwater management in Ireland.

The first part of the study assessed the perception of practitioners and methods an associated guidance material used in Ireland for flood estimation in urbanisi catchments (O'Sullivan 2010). The objective of the second part of the study presented in this paper, identifies perceived issues with control of Ireland. The main aims were to:

- Assess the use of SuDS for stormwater control in Ireland;
- Determine the factors affecting the selection of SuDS;
- Identify the trends to the implementation of SuDS;
- Identify the perceived technical adequacy of current manuals focused on SuDS design and implementation

Background

In the context of stormwater management, urbanisation alters areas of impervious surfaces coupled with a resultant increase in compacted loss of permeability (De Kimpe and Morel 2000). This alters the natural hydrology of catchments and results in river regimes with greater high flows and lower low flows. Higher flows and flood risk result from a greater proportion of incident rainfa catchments appearing as direct runoff and the sewers, culverts and culverting of natural streams that accompany developmen conveyance of stormwater through drainage networks (Sheeder et al. 2002) increase in runoff volumes being conveyed in artificial drainage network through the soil column and a decrease in the capacity for recharge of aquifers to provide baseflows (Cardoso 1994). Stormwater management traditionally focused on collection and conveyance of runoff to an outfall as quickly as possible posing significant threats to receiving watercourses in terms of increased pollution and (Kirby 2005). This changed when the threats to the degradation of watercourses were realised and according to Niemczynowicz (1999) the 1970s witnessed a shift storage approaches with detention and retention. This approach, as implemented in newly developed areas around, typically involved detention measures to attenuate runoff to greenfield values that wo have occurred prior to development (Doyle 2003). These practices to focus primarily on attenuating runoff to greenfield values were criticised by passing the natural treatment processes that occur through the column and consequently runoff reaching the receiving watercourses contaminated by pollutants such as oils, detergents, trac herbicides. Such approaches were recognised as being unsust of stormwater management were progressively broadened in the 1980s to include natural water quality together with the protection of water cycles ecosystems of watercourses (Niemczynowicz 1999). These principles are now engrained in SuDS guidance documents that require consideration of requirements that include volume and frequency of runoff a (for example Woods Ballard et al. 2007). Integrated approaches to stormwater management are also being advocated for the sustainable management of urban water environment (Rauch et al. 2005). These approaches are based on the promotion of reuse of stormwater and while similar, are referred to differently in different countries. For example, Integrated Urban Stormwater Management (IUSM) has attracted attention in Australia, New Zealand and the US where separate storm water systems are more common (Brown 2005). Water Sensitive Urban Design (WSUD) is another stormwater management approach that has been implemented in Australia (Coombes et al. 1999). Approaches of this type that incorporate source control (on site) control in the context of a holistic approach to stormwater management can reduce flood risk and improve the ecological integrity of watercourses through removal of pollutant and sediments (Kirby et al. 1997; Larsen 1999; Niemczynowicz 1999; Butler and Parkinson 1997).

Although a review of sustainable drainage undertaken by Pratt (2001) identified their benefits when implemented correctly, a number of issues need to be addressed for widespread adoption in terms of integrated approaches to stormwater management. Issues with institutional frameworks and maintenance are identified as potential barriers (Brown 2005; Niemczynowicz 1999). Regulatory instruments in planning legislation also pose a problem (Kirby 2001). White and Howe (2005) identify impediments to SuDS implementation at various stages of the development control process. Although regular maintenance is key to the long-term performance of some SuDS installations (Schlüter and Jefferies 2005), questions on longevity together with uncertainty as to who takes responsibility for management and maintenance are also perceived (Kirby 2005; McKissock et al. 1999). Although considerable guidance on aspects of design, implementation and maintenance requirements of SuDS is readily available, a lack of awareness of this information and failing to fully understand all its components is also evident. According to Niemczynowicz (1999) changes in urban water management are significant and should be addressed in the long-term through integrated strategies. Not only new improved technologies applied is required but the need to implement these through better communications and capacity building between the key actors in organisations is also important. Effectiveness can also be strengthened through improving the legislative framework in which SuDS are implemented together with continuing to educate both practitioners and society of SuDS benefits

In the context of SuDS becoming mandatory, this paper presents results of some of the issues that are at the forefront of integrating them into sustainable development in Ireland.

Methodology

Quantitative and Qualitative research methods were used to gather information for this evaluation. The quantitative element comprised the circulation of a self-completion postal questionnaire that addressed all aspects of urban catchment analysis in Ireland. Questionnaires were circulated to all 26 counties in the Republic covering a range of organisations, agencies and consultancies with planning and design issues in urban drainage and urban flooding (Table 1).

A total of 291 questionnaires were circulated and from this 83 completed questionnaires were returned. Seventeen incomplete questionnaires were returned. Of the 83 respondents who completed the questionnaire, 75% had experience in drainage and design these, 61 claimed to have worked in designing and implementing SuDS.

The qualitative work in this study comprised four focus groups in Dublin (two groups and Galway and this geographic spread ensured that issues across Ireland represented. Focus group participants were recruited from questionnai The optimum number of participants for a focus group was identified from be practice as between 6 and 8. To encourage attendance, focus groups w during lunch in centrally located hotels and. However, there were we cancellations and the need to reschedule some of the participants for focus groups, resulted in the numbers summarised in Table 2. A focus group topic guide was developed through consultation with the Technical Steer ensure independent and unbiased moderation, an external consultant was appointed to moderate the groups.

Results

Approaches to Stormwater Management

Respondents to the questionnaire were asked to identify the most commonly used method for attenuating stormwater and restricting outflows to pre-development runoff values. This was an open question and the replies from the full sample of 75 valid responses are shown in Figure 1.

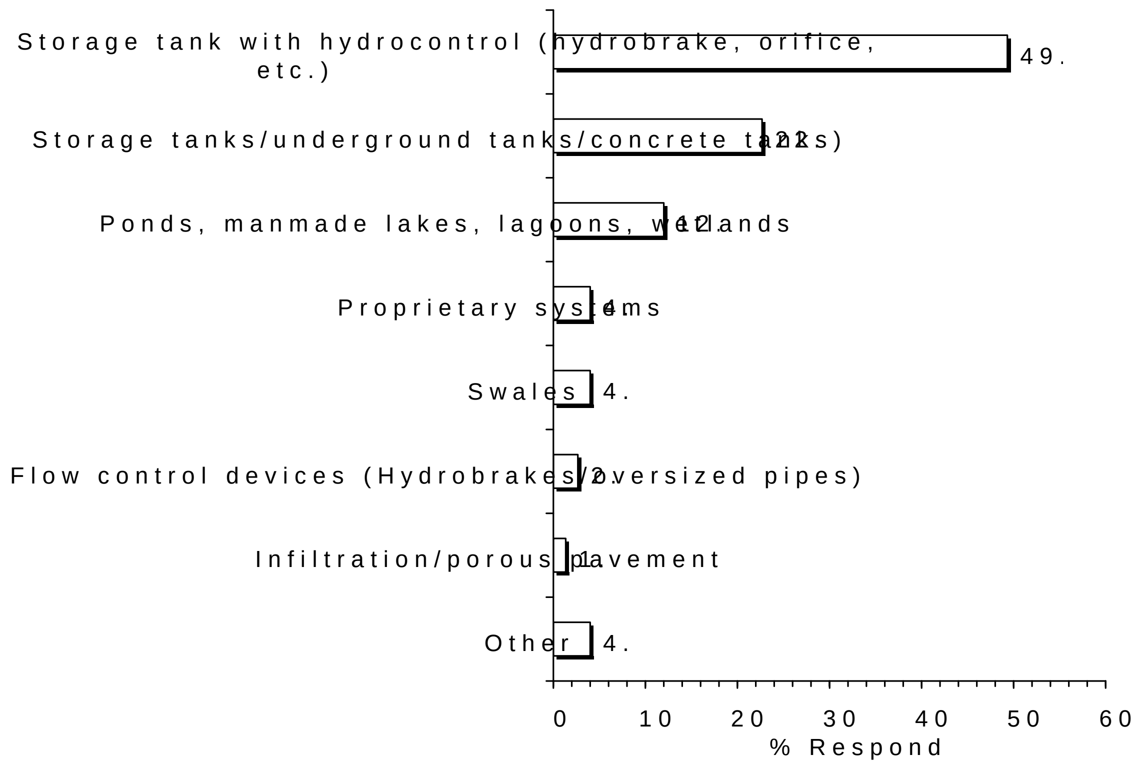

Figure 1

As indicated by 72% of respondents, structural attenuation/ storage **tanks** for managing runoff has been common. In most cases, tanks are used in com… flow restriction devices such as hydrobrakes or flow control orifice plates. Respondents also mentioned using proprietary systems. Measures such as attenu… swales, detention and retention ponds and wetlands that use natural treatment processes for a site were less commonly used. This result suggests that in absence of policies that demand sustainable drainage practices, stormwater management that focuses primarily on runoff volume would be likely to … Following the publication of the SUDS Guide in 2005, SUDS in new developments is mandatory, except in situations where their inclusion is impractical due to circumstances. It should be noted however, that where there are very few SuDS … impractical and at more limited sites, the design constraints … most appropriate. This recognition is encapsulated in regional policies issued by Local Authorities and is reflected in the following comment that was made at a focus group

&..even the wording (in policy documents) has changed. It has gone from you must consider SuDS as an option to SuDS must be your option, and if you don t, you must explain why not

This part of the questionnaire also required respondents to … directly involved with a development that required **SuDS** the im… Although not reflected in Figure 1 where results indicate that attenuation s… been extensively used, 61 respondents confirmed to have experience of SuDS installations and this subset represented the remaining sample for the remaining questions.

Sustainable stormwater management utilises techniques that replicate natural resource… natural rainfall-runoff processes at any site and minimises anthropo… impacts. Optimising techniques for stormwater control within the context of specific site characteristics are at the core of the concept. However, the individual measures identified in Figure 1 do not in themselves constitute … series of techniques incorporating source, site and regional controls in the management train. Source control methods (water butts or roof collector for example) retain or infiltrate runoff close to the point of origin … downstream facilities. Site control comprise of treatment systems for individual developments or groups of developments such as detention basins, swales and filter strips. A management train incorporating a number … will have the capacity to provide water quality improvements in add… control. Regional control measures are facilities that control runoff … catchment scale (not less than 2 hectares) and in some ins… provide biological treatment to reduce pollutants from contamina… The management train approach involves assessing the characteristic… divided into elements within a development such that an optimised drainage … can be developed for each of the individual sub-catchments. The approach offers the potential for treatment processes to be utilised at sub-catchment level so that th…

pollutant load of runoff can be successively reduced through the managem
train. Correctly designed systems will therefore include a number of methods
implemented in series that control the stormwater volume and improve water
quality. Understanding the overall techniques of source, site
therefore integral to the management approach of sustainable drainage and was
assessed in the survey. Results are shown in Figure 2.

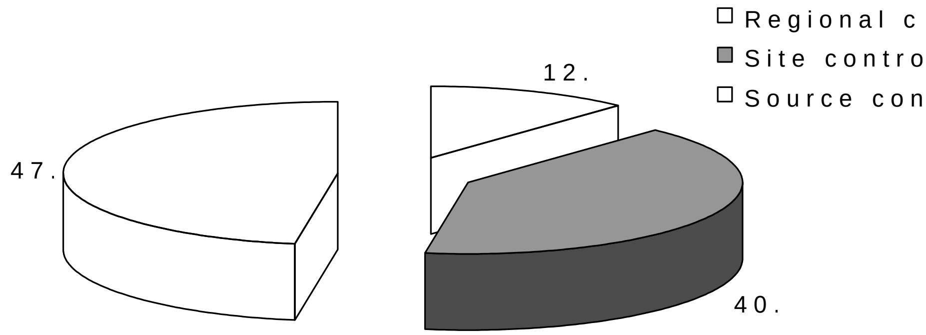

Figure 2

Figure 2 indicates that an understanding of the concepts of source,
control was most widespread among respondents with 47.5% and 40.4% of
respondents understanding source and site control respectively. Regional control was
less well understood with only 12.1% of respondents being aware of the co
The data suggests that respondents with experience in the design and installa
of individual SuDS measures for a single or group of adjace
consider drainage strategies in the context of the management train

The individual measures for implementing SuDS most commonly used by respondents
are summarised in Figure 3.

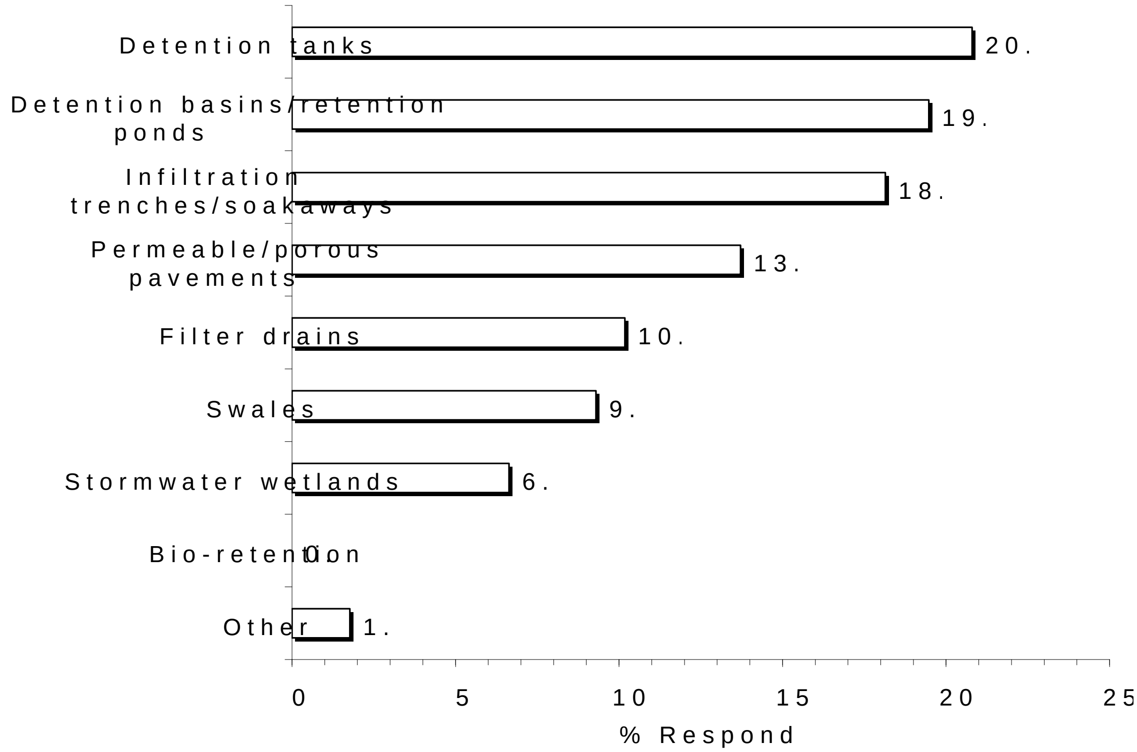

Figure 3

Detention (short-term storage) and retention (indefinite storage) of stormwater is well represented in Figure 3 with the use of detention tanks and detention tanks accounting for almost 21% and 20% respectively. Infiltration stormwater through trenches, drains and soakaways is also The lower usage of swales and wetlands is most likely due to the perception that thes measures are associated with land take excess. This is a common miscon however, and if integrated sympathetically and appropriately in land-takes do not need to be large (Dickie et al., 2010). Furthermore, intelligent des these components in the context of the overall development, where for exa storm events can be stored temporarily on the surface of op for swales and wetlands to be overly large.

Other methods mentioned by respondents include proprietary systems, undergro oversized pipes and roof gardens. Source control measures that utilise soils a remove pollutants from water runoff did not feature in any of suggesting that respondents are either not familiar with this method of stormwater t management or have reasons why these measures should not be imple may also indicate the perceived divide that exists regardin aspects of stormwater control.

Factors Affecting the Use of SUDS Measures

Respondents were asked to rank the importance of factors affect[ing the] selection and design of SuDS on a scale of 1 to 5 (where 1 is not at all important a[nd 5 is] very important). Results are summarised in Table 3.

Table 3 indicates that in excess of 50% of respondents considered all the factors listed in the questionnaire to be important with maintenance costs and s[...] accorded the highest priority. However, the use of SuDS in providing areas of recreational amenity and wildlife habitat was considered less important by respondents, suggesting that the ecological and environmental benefits of SuDS are not given high priority in the decision making processes that dev[...]

Deterrents to the implementation of SuDS

From a given list of possible deterrents, respondents identified the factors that th[ey] perceived limit the use of SuDS. These are summarised in Figure 4.

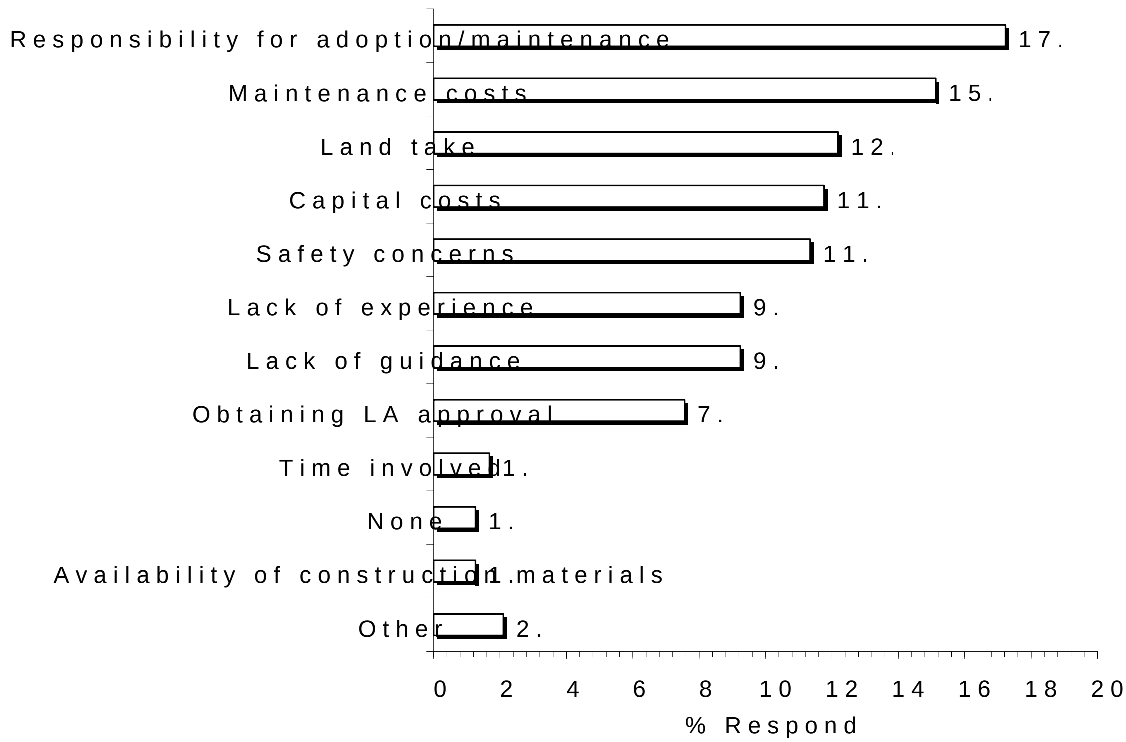

Figure 4

The findings in Figure 4 are broadly in line with sentiments reported elsewhere McKissock et al. 2003; Kirby 2004). Results indicate that the issues related to ongoing performance together with unclear allocation of responsibility for long-term maintenance and management of the system. Although such issues can be addressed by overcoming legislative and institutional [...] integrated regulatory framework for urban drainage that involves all the releva[nt ...]

stakeholders a long-term strategic approach (CIRIA, 2013). Concerns permeated the focus group discussions.

Realisation that the longevity and performance of SuDS depend on their correct design and construction and minimising ongoing maintenance is represented in the following comment:

> Local authorities don't want to be landed with more maintenance. SuDS schemes may have to be undone if unsatis[...] installed. The Local Authority has to be compensated if they tak[e] charge of SuDS (LA)

Comments of this type however, suggest that traditional drainage [...] require maintenance. This is obviously not the case and poor upkeep of systems is a contributory factor in many pluvial floods. Furthermor[e ...] constructed incorrectly will not function as designed and in[...] SuDS installation or not, the Local Authority will be saddled with any associated liabilities.

Perceived costs associated with SuDS were also considered to be deterrents. 24% of respondents identified land costs and capital costs as a significant [...] of th[...] This was reinforced at a focus group where it was noted that it is more economically advantageous (with storm water) to put in a concrete box under the development than use extra land for SuDS.

The frequent reference to maintenance costs as a deterrent to SuDS implementation from many survey respondents highlights a lack of awareness regarding this issue and their inclusion in Figure 4 is somewhat unwarranted. A cost analysis of SuDS in the Cambridge City Council Sustainable Drainage Design and Adoption Guide (Wilson et al., 2009) indicates that if incorporated into a general maintenan[ce ...] maintenance costs associated with SuDS are not excessive and do not differ significantly from those for a general landscape.

Perceived issues with excessive land take for SuDS also feature highly in Figure [...] Traditional drainage systems are typically buried undergro[und ...] minimal land take. While it is accepted that SuDS can necessitate a more significa[nt ...] take, this is not always the case and the actual land requir[...] method in the management train. Some surface SuDS measures have larger land takes but o[...] more attenuation benefits and water quality improvements. Conversely, hard SuDS options have smaller footprints but don't provide the same wa[...] biodiversity benefits as soft solutions. It should also be noted that [...] impose considerable constraints on retrofitting SuDS, land take is much less of an issue if SuDS are integrated into a development (Dickie et al., 2010).

A lack of experience or familiarity with the use of SuDS, particularly amongst developers, was recognised by over 9% of respondents as being a [...]

reflected in the following focus group comment:

> To most developers, this whole SuDS notion is a very recent phenomenon & many are not familiar with it. I have to spend a lot of time ove phone explaining the basic concepts of SuDS with them

Furthermore, many developers are unwilling to spend money on integrati development schemes. However, it was also noted that SuDS knowledge engineering consultancies and architectural practices can

> Lack of familiarity is an issue. Neither the architects nor engineers are familiar with it

While the quantitative and qualitative elements of this rese reasons why SuDS installations were not popular amongst develope some SuDS features in other countries were recognised when it was not

> They certainly sell (development space) in the US and Scandinavia w there's an area of water to look out on

A small number of respondents also identified the presence of boulder clay as an impediment to implementing SuDS in the Greater Dublin area. This reflects a poor understanding of the range of techniques amongst these respondents and suggests that SuDS are viewed in a narrow context limited only to infiltration. While it is accepted that the presence of boulder clay will restrict infiltration, SuD require infiltration, other measures such as swales and
Contractual obligations of fully functioning SuDS installations were also identified as a potential deterrent.

Guidance material for SuDS design

The absence of formal guidance was cited by over 49% of respondents as being an impediment to implementing SuDS. In a further question, respondents were asked t rate the quality and availability of guidance documentation for SuDS design and whether more guidance would assist them in SuDS for storm water management. Res shown in Figure 5.

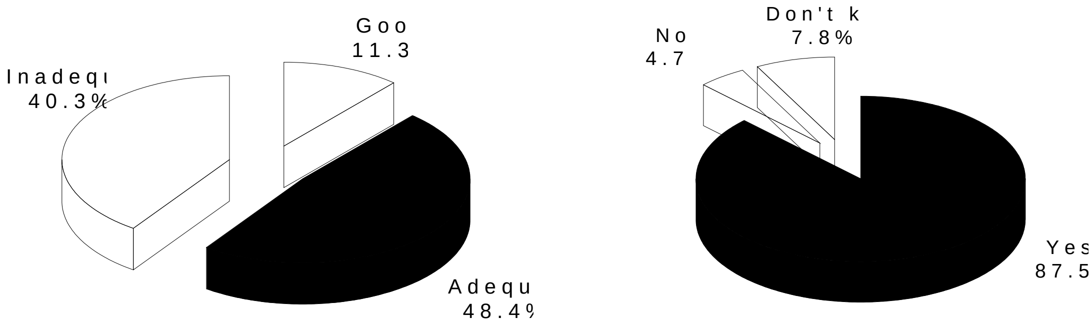

Figure 5

Of the 61 respondents approximately 60% were satisfied with SuDS guidance and reasons for dissatisfaction were generally associated with determining flow and volume calculations from developed catchments ra issues with SuDS installations. These issues are represented in the following group comments:

> Some guidance on the greenfield runoff is also necessary. What is likely to be if there is development?

> I d like more guidance on the urban fraction and the be particular catchment

> The problem is the size of the catchments as some of th small. There is no guidance relating to different size catchments

Respondents also identified sources of guidance that they have access SuDS installations. The question included a list of SuDS guidance establishe material and included a provision where respondents more specific de of guidance documents. The sources mentioned are summarised in Figure 6

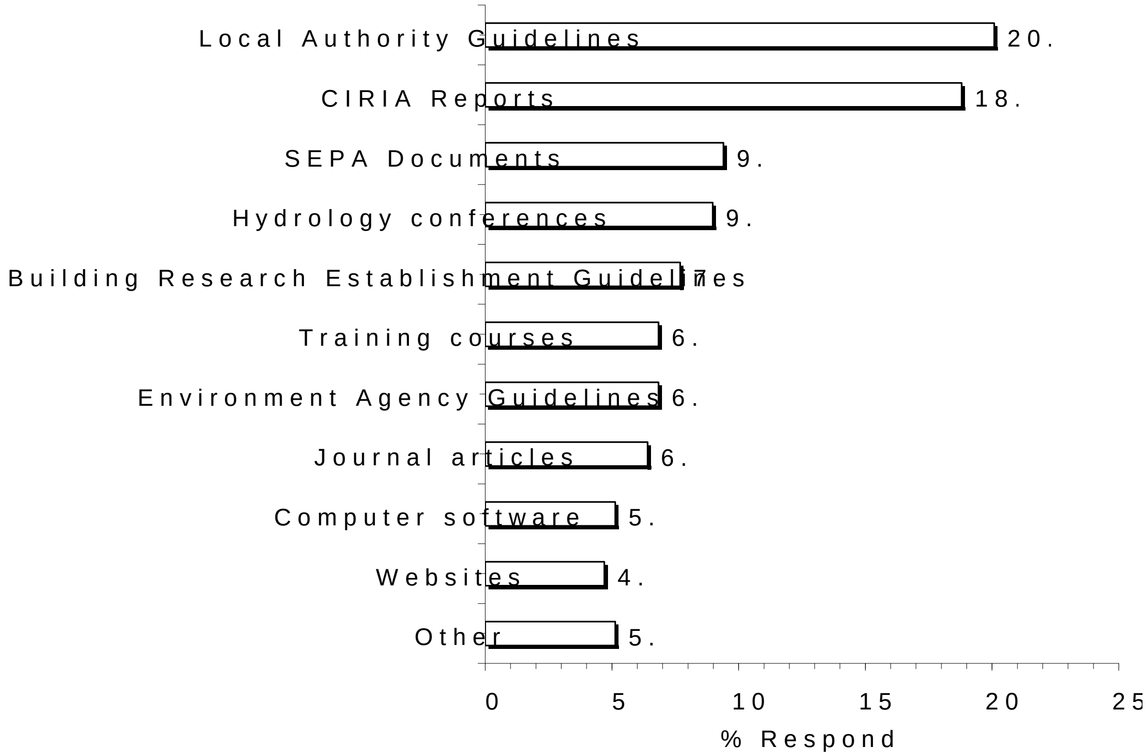

Figure 6

Figure 6 indicates that Local Authority guidelines and CIRIA (Construction Industry Research and Information Association) reports are the m documents for SuDS guidance in Ireland with approximately 20% respondents having accessed the Local Authority guidelines referred to Volumes 2 and 3 of the GDSDS and other Dublin City Council Stormwater Management Policy for Developers (2008). The CIRIA reports cited were R123, R142, C521, C523, R180, C582, R156, C609, and SuDS R142. Guidance in Scotland, published by the Scottish Environmenta (SEPA), was used by in excess of 9% of respondents. The Building Research Establishment (BRE) Digest 365 was recognised as a usefu by 8% of respondents. Training courses offered by Engineers Ireland, the Institu Engineers (ICE) and the Institute of Hydrology (IoH), literature from academic journals together with commercially available comp websites/ documentation from proprietary system providers also feature in Figure 6. Other citations made reference to reports produced by HR Wa Pollution Prevention Guidelines (PPGs) developed by the UK Environment Agency, SEPA and Environment and Heritage Service in Northern Ireland, Highways Agency (HA) Report 103/01 (now superseded by (103/06) that provides g vegetative treatment systems for highway runoff and United States EPA fact sh online.

Respondents were also requested to state the SuDS guidance they became available. Responses to this question are summarised in Figure 7.

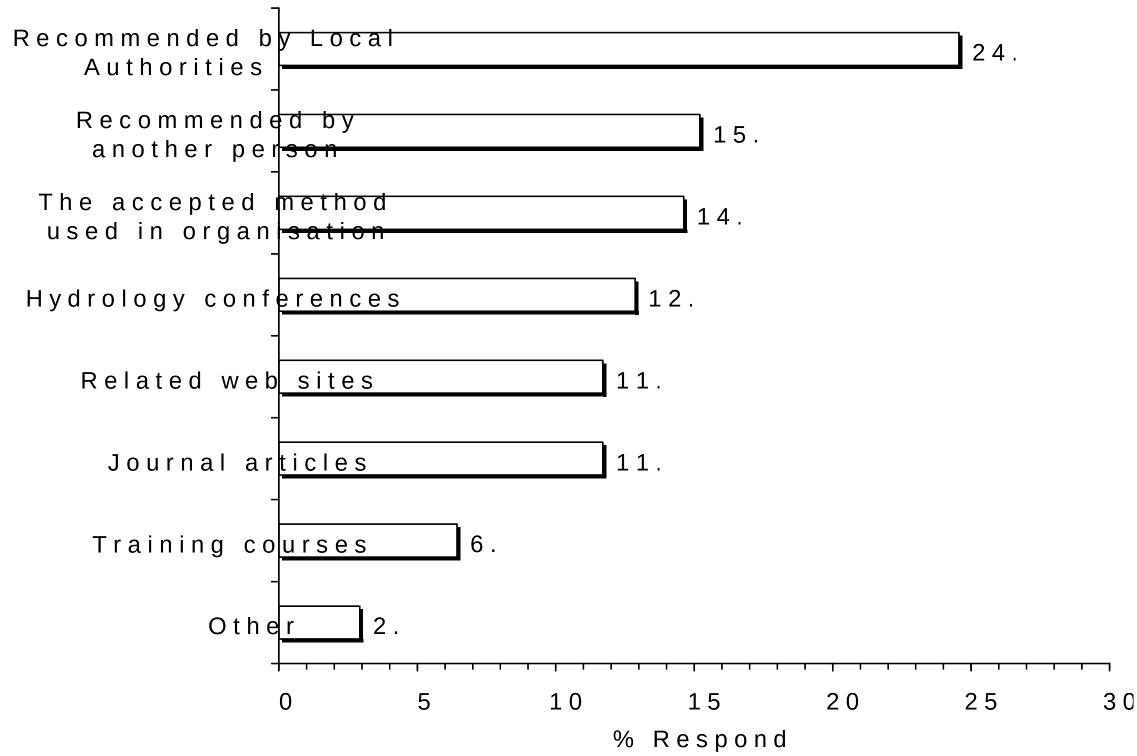

Figure 7

Discussion

Recent changes to stormwater management policies in urban and ur Ireland have made the use of SuDS mandatory for countering adverse effects o growth. This study however, identified impediments to a more widespread and effective adoption of SuDS. At a basic level, 61 responder returned questionnaires) to the survey claimed to have exp and Figure 3 shows the measures commonly used in the context of SuDS. However, these results appear inconsistent with Figure 2 where the c control measures were understood by less than half the sa measures were understood by significantly less. The data suggests that while respondents may have experience with individual components that contri understanding the concept of an integrated system that progresses from local source controls to larger downstream site and regional controls. Given that this management train is at the core of SuDS, the results highlight a know deficit amongst practitioners.

The research focussed heavily on identifying deterrents to th The most commonly stated impediments to maintenance, land take and lo responsibility of the systems, which is consistent with the findings in similar studies

(McKissock et al., 2003; Kirby 2004) result, largely from misconceptions a
understanding of SuDS. Figure 4 shows that a major concern amo
respondents was where the long-term responsibility for the system rests
surprising given that drainage law was written before the existence and use of
SuDS. While the ownership and maintenance of conventional draina
understood, the responsibility for provision, operation and mainte
well established. Taking in charge procedures in Ireland will require
to overcome the conservative attitudes of some Local Autho
combined with unfamiliarity with their installation and performanc (Dublin Drainage
Consultancy, 2005)

The inclusion of land take and maintenance costs is common in Figure
misconceptions regarding SuDS and this is contrary to scientific literature that in
land take and maintenance costs need not be significant
conventional drainage systems ([illegible] 2006; [illegible] et al., 2009; Wicks et al., 2010)
Furthermore, while maintenance costs were identified as dete
of SuDS, the role of source control in reducing maintenance costs of othe
later in the management train was not identified by any focus group or survey
participant.

This lack of understanding of SuDS is more surprising giv
amongst participants with the quality and availability of guid
and implementation of SuDS (Figure 5). This indicates that knowledge is bein
from a very diverse set of sources (Figure 6) and therefor
awareness and improving understanding of SuDS amongst the
making available a national guidance document for Irish conditions. The engi
community also has a professional responsibility to maintain
SuDS implementation and Continuing Professional Develop
vehicle through which the knowledge base can be expanded.

Given that Figure 3 indicates that drainage measures in the past focussed
runoff volume rather than quality, the changes in drainage policy that hav
mandatory in development plans are now supportive of sustainability
principles in drainage practice. In this context, a more holistic and integrated a
that involves, planners, engineers and water resource mana
Ireland, the responsibility for planning issues is geographically organised with
Local Authorities. Administrative borders are not observed by water
of the physical effects of different stormwater management be
assessed at river basin or catchment scales. The EU Floods Directive Implementatio
will assist in this regard.

This study indicates that incorporating sustainability principles in stormwater
management will require efforts at a number of levels. No
insurmountable, but will require implementation of supplement applied technologies and
and to increase education provision of integrated water ma
overall objectives are [illegible] in current principles

that will direct future actions involving sustainability criteria a key element is

Conclusions

The main findings arising from the questionnaire responses a the basis of this study were as follows:

(1) Until recently, stormwater management in Ireland was focused on volume control with less consideration being given to quality aspects discharge to nearby drainage networks. Changes in receiving wat stormwater management policies and the use of SuDS mandatory water quality is now at the forefront of management strategie

(2) A perceived barrier to the use of SuDS is the maintenance and ownership. SuDS systems require maintenance in order to operate going to own and maintain the system is the major challenge implementation of SuDS scheme. These issues were identifi important by participants in the context of procedures used Authorities for taking-in-charge SuDS.

It should be noted however, that maintenance costs featured promi a deterrent to the implementation of SuDs, these costs n more than costs associated with maintaining traditional d

(3) Guidance for design and implementation of SuDS is currently drawn from a range of diverse sources. A holistic and integrat management would therefore benefit from national g supported by software for SuDS design.

(4) Given that the engineering profession has a community responsibility maintain and develop its knowledge, the use of Continuing Professi Development (CPD) programs is a potential vehicle through whic knowledge base of SuDS design, implementation and ongoing perfo be expanded.

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Word Count: 5518 (inclusive of abstract and references)

Table 1 Breakdown of responses to questionnaires

Target S	Questionnaires circu	Questiones retur	Incompe retu	Total respos	Response rat (%)
Contract Builder Develop	31	7	4	11	35.5
Consult	104	36	5	41	39.4
Public (Councils Academ State..	135	36	5	41	30.4
Insuran	14	1	2	3	21.4
Architec /Planners n design	7	3	1	4	57.1
Total	291	83	17	100	34.4

Table 2 Participant numbers at focus groups

Focus gro	Locatio	No. of Parti
1	Dublin N	12
2	Dublin S	5
3	Galway	4
4	Cork	4

Table 3 Factors which influence respondents SUDS selection of

SUDS Selectio criteria	Importance of criteria (as noted by % of) respond				
	Not at impor t	Not ve impor t	Neithe importa nor unimpor	Quite impor t	Very impor t
Provision o amenity	0	21.3	24.6	49.2	4.9
Creation of v habitat	1.6	19.7	24.6	47.5	6.5
Cost of cons	0	3.3	14.8	44.3	37.7
Cost of main	0	0	3.3	36.1	60.7
Safety consic	0	0	4.9	27.9	67.2
Soil condit	0	3.3	16.4	39.3	41.0
Availability land	0	0	9.8	31.1	63.9
Limiting volu runoff	0	1.6	11.5	52.4	34.4
Water qual manageme	0	1.6	11.5	52.5	34.4