REPORT BY THE FOUNDATION FOR WATER RESEARCH

WASTEWATER RESEARCH & INDUSTRY SUPPORT FORUM

RETROFITTING GREEN INFRASTRUCTURE FOR RAINWATER - WHAT'S STOPPING US?

A WORKSHOP TO EXPLORE THE ISSUES

A Workshop Held

Monday 19th April 2010

at

GLA, City Hall, The Queens Walk, London SE1 2AA

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- Provide a forum for discussion between users
- Facilitate the exchange of information between relevant organisations
- Identify areas for improvement or modifications to and associated research and development of wastewater planning modules
- Identify education and training needs and encourage the necessary education and training.

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1 Executive summary

Retrofitting Green Infrastructure For Rainwater - What's Stopping Us?

The objective of using green infrastructure (GI) for rainwater is to reduce the rate at which rainwater falling on urban areas runs off and also the total amount of that runoff. It might be complemented by grey infrastructure where GI does not have sufficient capacity to treat all of the runoff but in that case the grey infrastructure can be much smaller, less expensive and less disruptive to build.

GI has multiple benefits. It takes pressure off underground drainage networks and thus reduces the risk of sewage flooding. It controls runoff at source. It reduces the climate change emissions of wastewater management because with less water entering the underground network, less has to be pumped and less has to be treated. Evapotranspiration by GI counteracts the heat island effect of cities, which improves quality of life, reduces stress and reduces need for air-conditioning – a saving of energy and climate change emissions. Where trees are used in GI, they reduce wind chill and heat loss in winter, which reduces energy consumption for space heating.

GI it is different from hard engineering (it could be argued that it is more subtle and more sophisticated) it requires a broader spread of disciplines and co-operation (and possibly co-funding) across different departments and organisations (budget holders), but it is less expensive and it is more resilient to climate change. In contrast big end-of-pipe solutions can stop discharges into rivers but they do not stop property or infrastructure flooding and their operation has substantial energy demand.

Cities in Australia, Germany, the Netherlands, Sweden and the USA (as examples), have adopted GI much more quickly than the UK. They consider that retrofitting GI into existing cityscapes and developments is an essential tool for adapting to the predicted effects of climate change. The main lack of space for retrofitting GI into existing cityscapes is in the heads of the people who should be doing it.

A difference between the exemplars of GI in other countries and the UK is partly institutional. Responsibility for drainage, highways, housing, biodiversity and open spaces in the UK has been split between different institutions, whereas in most other countries all these functions are very frequently the responsibility of the municipal authorities. This should not be an excuse for the UK's relative tardiness and it should not be forgotten that communication within large organisations is often far from perfect. The Flood and Water Management Act 2010 (Anon 2010) could improve things somewhat because local authorities have been tasked with coordinating response, however the workshop found that

- GI is not taught in the relevant degree courses (e.g. Civil Engineering) so engineers are less likely to think of it,
- Road schemes, especially traffic calming, could include GI but the budget holders have no responsibility for drainage,
- Even GI-aware professionals often do not appreciate Soil Science or Landscape Architecture so they approach GI from the wrong perspective
- Roofs are out of sight and out of mind but they have massive GI opportunity because of the area they occupy in towns and cities
- GI would not feature on any company's asset register; the sewerage companies currently have an interest in maximising their capital base
- Hard engineering has the appeal of being high profile, a capital asset and a single project, whereas GI comprises a multitude of small projects with lower capital cost (and residual value)
- In the UK, we do not give enough interpretive information about GI schemes so members of the public are not sufficiently aware of GI and what it can do

GI is necessarily a multiplicity of small components, each contributing to the whole. It therefore appears that it takes longer to implement than grey engineering, this could be a fallacy because of the time required for planning permissions of large grey infrastructure. For example the Thames Tideway Tunnel (TTT) was first proposed in the early 1990s to intercept combined sewer overflows and prevent them discharging into the River Thames, it will not be completed until 2020. The TTT (costing £4 bn) will not prevent a single property flooding, whereas 30 years of installing GI would have accumulated substantial control at source, prevented property flooding and prevented CSO discharge. In aggregate green should be more resilient to climate change than grey and have a smaller whole life cost.

A story that John F. Kennedy (35th US president 1961-1963) is reputed to have liked to cite is particularly apposite:

> “The great French Marshall Lyautey once asked his gardener to plant a tree [to shade his troops]. The gardener objected that the tree was slow growing and would not reach maturity for 100 years. The Marshall replied, 'In that case, there is no time to lose; plant it this afternoon!'”

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2 Introductory note

The term Green Infrastructure (GI) for rainwater management is used to mean "natural systems" to absorb rainwater either so that it does not run off or so that the portion that runs off does so more slowly over a longer period of time. It includes rain gardens and other planting schemes that are connected hydraulically with impervious surfaces, green roofs, porous paving, swales, infiltration basins, etc. It is related to SUDS or SuDS (sustainable urban drainage systems or sustainable drainage systems) but commonly these terms convey the idea of schemes having large footprints and therefore difficult to accommodate within existing cityscapes. Numerous examples show that GI can be accommodated within existing cityscapes if people have the will, knowledge and imagination. GI is a component of 'Low Impact Development' (LID).

The date of the workshop coincided with the period when European airspace was closed because of dust when the Icelandic volcano near Eyjafjallajoekull glacier erupted. This meant that two of the contributors, Tom Liptan and Richard Ashley were unable to participate but it meant that Kevin Reid was able to participate because his flight from UK had been cancelled.

The meeting was held at the iconic City Hall, designed by Norman Foster & Partners and opened in 2002. It uses only 25% of the energy of a conventional office because of, amongst other things, shading and natural ventilation. The area around City Hall uses SuDS, though this is not publicised nor are there any interpretive information boards to tell members of the public about it.

Its shape is derived from a geometrically modified sphere, so that it achieves optimum energy performance by minimising the surface area exposed to direct sunlight. Analysis of sunlight patterns throughout the year produced a thermal map of the building's surface, which is expressed in its cladding. A range of active and passive shading devices is also employed: to the south the building leans back so that its floor-plates step inwards to provide shading for the naturally ventilated offices; and the building's cooling systems utilise ground water pumped up via boreholes from the water table; this water is also used for lavatory flushing. These energy-saving techniques mean that chillers are not always required and that for most of the year the building can function with no additional heating. Overall, it has the capacity to use only a quarter of the energy consumed by a typical air-conditioned office building. In 2007 photovoltaic panels were installed on the roof for electricity generation.

3 Portland, Oregon pioneer of sustainable stormwater management

Tim Evans, FWR and TIM EVANS ENVIRONMENT (www.timevansenvironment.com)

In the absence of Tom Liptan, Tim described what he had seen of Portland's sustainable stormwater programme (http://www.portlandonline.com/bes/index.cfm?c=34598), which features retrofitting GI at strategic locations throughout the city, including the congested downtown area. In Portland, GI complements "grey" infrastructure. A primary motivation was to protect salmon in the Willamette and Columbia rivers, something to which the public can relate and which is identified in interpretive display boards, logos on kerbs (left) etc. As is so often the case, people and knowledge have been keys to Portland's success. The programme is supported at senior level in the City Council by a Commissioner (elected representative) who is enthusiastic about GI; it is implemented by a team that has a strong knowledge base in Landscape Architecture and Soil Science. Engineers calculate the amount of water that needs to be handled, landscape architects design the GI and then it is back to engineering to construct it – the process can be regarded as pretty similar to designing a house or other building.

Portland's historic average annual rainfall is 1.2 m with three relatively dry months in summer. In 2005 the city covered 135 miles^2, with 25 miles^2 of rooftops and 45 miles^2 of pavement. The infiltration capacity of the soils in some places where GI has been applied was near zero (i.e. very poor drainage) but that has improved with time because of the action of plant roots, microbial activity, etc. In other places drainage is good. On the face of it, these circumstances (high rainfall and low permeability soils) do not appear conducive to GI but the fact that Portland has been successful demonstrates that GI can be applied widely.

Early on, Portland developed the Combined Sewer Overflow (CSO) Facilities Plan under the CSO Abatement Program. They looked at Best Management Practices (BMPs) for flow control to address CSO events in the Columbia Slough and Willamette River. In the Plan, downspout disconnection was recognized as one of four Cornerstone Projects, which are relatively low-cost projects that reduce CSOs by keeping stormwater runoff out of the combined sewer system. Other Cornerstone Projects were sewer separation, sump installation, and stream diversion. As a direct result of the Plan, Portland created the Downspout Disconnection Program in 1993, in which the City provides outreach and incentives for residents of selected neighbourhoods to disconnect downspouts from the combined sewer system and to redirect roof water to gardens and lawns. More than 50,000 homeowners have disconnected downspouts, removing about 3.8 million m^3 of stormwater per year from the combined sewer system.

Figure 1 NE Siskiyou Green Street before retrofitting GI

Since 1977 Portland has charged a separate stormwater utility fee to help pay for stormwater management costs. In 2000 the City Council established a reward system for ratepayers who keep stormwater from leaving their property. They called it Clean River Rewards, it came into effect in October 2006 after the City launched a new utility billing system. Clean River Rewards offers residential ratepayers up to a 30 percent discount based on the extent to which they can manage runoff from roof areas. Commercial customers can claim a discount for managing runoff from both roof and paved areas. Credits are offered for having a small impervious footprint (less than 1,000 square feet), creating or maintaining tree coverage, disconnecting downspouts, installing rain gardens or drywells, and other low impact development BMPs. The City processes applications without site visits and conducts oversight via spot checks to ensure that BMPs are in effect and maintained properly. To assist ratepayers with stormwater retrofit options, BES hosts an online technical assistance page and offers workshops tailored to residential and commercial customers.

Figure 2 NE Siskiyou Green Street with GI - raingardens modulate runoff and traffic; an interpretive board (right) explains GI

NE Siskiyou Green Street is an often cited example. It won the American Society of Landscape Architects' Stormwater Curb Extensions Award in 2007[1]. It is regarded as one of Portland's best green street stormwater retrofit examples. Figure and Figure compare before and after retrofitting GI; the wooden fence with laurel hedge right are points of reference. Figure 1 shows that the street was not dissimilar to many suburban streets in the UK; surface water gullies, kerbs and grass strips but no hydraulic connection between the road surface and the planted area.

The [extended width] planting strips (rain gardens) absorbed 80% of the runoff from this street. The interpretive information board (right) explains and reinforces the valuable job that the landscaping is doing for storm water management, in addition to traffic calming and being aesthetically pleasing.

The residents maintain the planting, which enhances their environment and probably adds to property values.

NE Siskiyou Green Street was the first of its kind anywhere. The project replaces the no-parking zone of a typical residential street with landscaped stormwater curb extensions designed to capture street stormwater runoff. It was built in the autumn of 2003, and exemplifies the principles of sustainable stormwater management and showcases the value of simple, cost effective, and innovative design solutions.

Figure 3 Glen Coe School - raingarden bottom left and planted swale beside carpark

Initially residents were reluctant to accept GI but it is now recognised as enhancing neighbourhoods and residents are asking the City to install GI in their streets.

The topography around **Glen Coe** Elementary School falls towards the junction at the centre of Figure 3. Surface water converged at this point and then ran off towards the bottom left of Figure 3 flooding properties.

A new surface water drain (grey solution) would have cost $144 million, instead Portland constructed a swale planted with native plants beside the carpark; it has hydraulic connectivity with the car park and with the road and sidewalk (Figure 4). Excess surface water from the swale is piped under the road to a spiral raingarden (figure 5). The swale is also a resource for teaching about Oregon's native plants.

[1] http://www.asla.org/awards/2007/07winners/506_nna.html

Figure 4 GI for surface water from the carpark, sidewalk and road at Glencoe

Figure 5 Glencoe raingarden - water circulates clockwise

Water flows clockwise around the raingarden modulated by a succession of small weirs; finally there is buffer storage amongst cobbles. Whenever the combined capacity is exceeded and the garden floods, the excess volume is discharged to a surface water drain, which is smaller than the "grey" engineering solution would have required because of all the infiltration, evapotranspiration and attenuation.

The capital cost of the 'green element' was $11 million and the 'grey' was cut to $75 million – a saving of $58 million. Since there will be much less water to pump and to treat, the operating and carbon costs and the whole-life cost of the green/grey engineering solution will be considerably less than the all grey solution. In addition the GI element is aesthetically attractive and more resilient to climate change. GI is more than infiltration because the action of plant roots, leaf litter incorporation and soil biomass stimulates and maintains soil structure and actually increases soil infiltration capacity. During the growing season, transpiration by the plants replenishes the soil's water absorption capacity like emptying a storage tank but pumped by the sun rather than electricity.

Greenstreets and downspout disconnection in the vicinity of the University of Portland's halls of residence and teaching facilities in the downtown area of the city demonstrate that GI can be retrofitted into more congested areas.

Rainwater is diverted from roads into a chain of narrow planted areas let into the sidewalk (Figure 6). Experience showed that it was necessary to add a small ridge of tarmac otherwise water would flow past the entrance, which gave rise to rather unproductive discussion about health and safety! Rainwater flows from the road gutter into a rain-garden, some infiltrates, some is retained by the planting and the excess flows out of the down-slope end and into the next rain-garden in the chain. Initially there were fears that the soil would be blinded with sediment and debris but that has not proved to be the case, neither has toxic shock from chemicals on the roads. Rain-gardens receive 4 weeding and trimming maintenance visits per year. In 2009 there were 900 'green street facilities' throughout the city. There have been no plant failures.

Figure 6 Chain of rain-gardens in down-town Portland, note the tarmac water diverter bottom right and the covered channels connecting the gutters to the gardens

Figure 7 Hamilton Ecoroof

Look at any city from the sky and there are a lot of roofs, Portland is no exception. It has ambitious plans to convert these to greenroofs to modulate runoff. Developers who install greenroofs are permitted additional floorspace, there is also a payment of $\$5/m^2$ for retrofitting greenroofs. In January 2011 there were 271 greenroofs in the city totalling 5.2 ha and the target is more than 3 times this area. One of the key aspects has been measuring and documenting performance. The Ecoroof on the Hamilton high-rise (Figure 7) was installed in 1999; monitoring data for 2002 – 2010 show 55% rain retention. That is water that does not have to be piped, pumped or treated. The evaporation of the water cools the air and the urban heat island effect. The growing medium protects the roof membrane, which extends its life, and adds thermal insulation. In some cases greenroofs provide an additional amenity for users of the building.

4 Urban Greening in London: Mayoral strategies

Matt Thomas, Urban Greening, Transport & Environment directorate at the GLA

The Greater London Authority (The GLA) is a strategic authority with a London-wide role to design a better future for the capital. The Mayor, currently Boris Johnson, and the London Assembly are elected by Londoners. The staff of the GLA is a permanent body that provides continuity in the ongoing development and delivery of strategies for London. Its role is to make sure that the work that done on behalf of London is of the highest standard, regardless of the political background of the Mayor, his or her team or Assembly Members. The London Assembly's role is to scrutinise the work of the Mayor and represent Londoners' interests.

Many areas of delivery are the responsibility of the boroughs of which there are 33 including the City of London Corporation. Each borough is managed by a local council that is responsible for administering the borough, and for delivering public services such as housing, refuse collection and schools. As the strategic authority for London, the GLA works closely with the boroughs to deliver the Mayor's long-term strategy for London, ensuring that the big picture of the capital is taken into account at the local level. The Mayor sets the pan-London vision and strategy and uses his/her position and influence to ensure the boroughs help deliver on that vision. The GLA works closely with the boroughs on everything from funding improvements in public spaces to developing public transport infrastructure, to dealing with all London's waste and litter to London-wide crime fighting initiatives.

Figure 8 Green London?

Counting parks, gardens, street trees and water, only 35% of London is 'grey' (Figure 8) but it is still a lot less green and more sealed than the surrounding area outside London.

"Urban Greening" is part of a vision to make London a 'cleaner, greener and more civilised city'. The Mayor is particularly keen on beautifying London. Part of the urban greening team's role is to help deliver this vision by increasing green infrastructure in London. Political support and drive are provided by:

- London Plan: Spatial development strategy for Greater London http://www.london.gov.uk/shaping-london/
- Leading to a Greener London: an environment programme for the capital http://www.london.gov.uk/who-runs-london/mayor/publications/environment/leading-greener-london/
- The draft climate change adaptation strategy for London http://www.london.gov.uk/climatechange/strategy
- London Tree & Woodland Framework: http://www.london.gov.uk/priorities/environment/urban-space/trees
- Mayor's Street Trees: http://www.london.gov.uk/priorities/environment/urban-space/trees
- London's Great Outdoors – A Manifesto for Public Space: http://www.london.gov.uk/greatoutdoors/manifesto/
- Living Roof and Walls: - Technical report: supporting London Plan policy http://www.london.gov.uk/priorities/planning/research-reports/technical-research-reports
- East London Green Grid Framework – Supplementary Planning Guidance http://www.london.gov.uk/thelondonplan/guides/spg/spg_09.jsp

Urban Greening targets include:

- Increasing tree cover from 20% to 25% by 2025 (an additional 2 million trees by 2025), 30% by 2050. The Mayor's Street Tree Programme includes a £4m grant scheme based on priority areas for planting 10,000 trees by 2012
- Increasing green cover in the centre of London by 5% by 2030 and a further 5% by 2050. The Priority Parks project has £6m of grants to improve 11 parks selected by public vote. Capital Growth's target is to create 2012 new spaces for growing food by 2012.
- Creating 100,000 m^2 of green roofs by an as yet unspecified date
- Extending the East London Green Grid from the current 280 ha to 1000 ha of green space.

Thermal imaging and LiDAR can be used to quantify green cover by remote sensing.

In addition to the aesthetic benefits of greening, part of the motivation is to reduce surface-water runoff. Central London has a large combined impermeable surface area which means fast runoff, ponding in depressions, diversion to surface water drains, surcharging of combined sewers resulting in CSO spills or surface-water [or sewage] flooding. Reducing the rate of runoff will reduce flooding and damage from intense rainfall– such as recent thunderstorms in London where tube stations were flooded causing massive disruption to Londoners. Since climate change predictions are for more intense rainfall events, greening is part of London's climate change adaptation strategy to reduce surface water runoff and flood risk. Green roofs can achieve 50% [or more] attenuation.

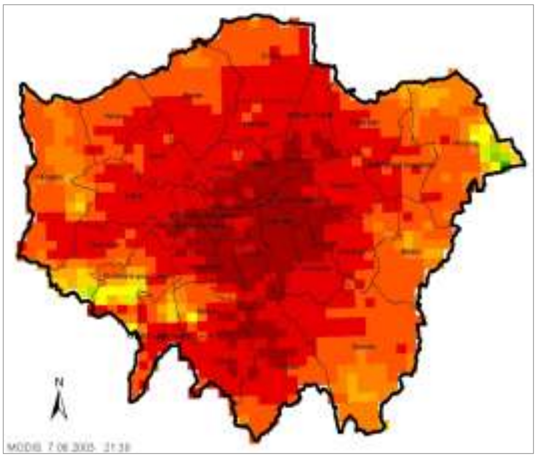

Figure 9 Surface temperatures for 1km^2 grid squares across London at 2130hrs on 7th August 2003

Greening also reduces the Urban Heat Island effect. ASSCUE (Adaptation Strategies for Climate Change in the Urban Environment) found that greening ten built up areas of Manchester can reduce temperatures during warm periods by 3-4 ºC; LUCID (Local Urban Climate model and its application to the Intelligent Development of cities) aims to model the effect of greening on the UHI for London. Figure 9 from the MODIS infra-red satellite shows that central London was 5 ºC hotter at 2130 on 7th August 2003 than a green area such as Richmond Park.

The Central Activities Zone (CAZ) is 3341 ha (Figure 10). 18% of CAZ is green not including water with a large proportion of that being the Royal Parks. The majority of CAZ comprises impermeable hard surfaces. An additional 5% of green cover would be about 30 ha; to put this in context, Green Park is 19 ha, whilst one or two new parks are possible, it is inconceivable that 30 ha of new park can be created and therefore a vast amount of retrofitting will be required. It is not yet known whether 5% will be enough or even 10%.

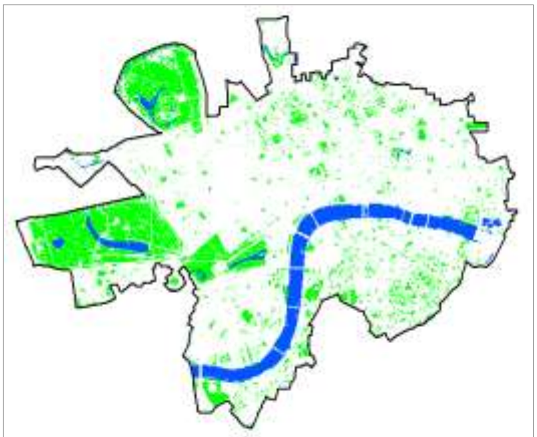

Figure 10 The Central Activities Zone

Between June 2002 and March 2008 about 460,000 trees were planted and the Mayor's Street Tree Programme has planted more than 5,000 trees by April 2010. The 2 million addition trees target will be difficult to meet because London is an old city with a complex infrastructure underlying its roads, pavements and buildings.

Roofs comprise 16% of the area of London; in the CAZ roofs comprise approximately one-third of total area. Useful guidelines about substrate depth for water attenuation that are available include Living Roofs and Walls and the upcoming Green Roof Code. The Planning process could include planning advisory notes and green roofs could be incorporated into borough planning guidance (SPDs). The GLA has been leading by example with green roofs on some of its buildings, for example Transport for London's (TfL) West Ham bus garage under underground railway headquarters. It is debatable whether public funding is necessary to make retrofitting more financially attractive to individuals and larger investors whether it is less a case of money and more about the GLA spreading the word and facilitating.

Drivers Jonas Deloitte supported by EDAW AECOM, was appointed by the Commission for the New Economy and Manchester City Council to explore the feasibility of substantially increasing the installation of green roofs on new and existing buildings across Greater Manchester to ensure it is resilient to the impacts of climate change and a model of low-carbon economic transition, whilst affording excellent quality of life and environmental benefits. The three part study comprised i) a strategic analysis of the barriers and opportunities for green roof delivery across Greater Manchester, ii) five building-specific feasibility studies for green roof retrofits, and iii) a Green Roof Guidance for policy-makers, developers and building owners http://www.djdeloitte.co.uk/uk.aspx?doc=33709.

Bird (2004) monetised the benefit of greenspace, he outlined the effect that green space can have on levels of physical activity. He estimated that an urban park in Portsmouth providing 20% of total local physical activity, could save the economy £4.4 million annually, including £910,000 to the NHS and that a 3 km footpath on the edge of Norwich would save the economy £1 million, including £210,000 to the NHS. "To increase physical activity levels in a green space, the space should be accessible (within 2 km of home), have a good surface with no obstructions such as stiles, but above all, it should feel safe. There is a need for imaginative ways to promote a wildlife-rich green space, and for it to be marketed to different age groups. The green space must appear attractive; being natural, but access routes and facilities must be well kept. It is possible to have sensitive wildlife-rich areas visible from smaller well kept areas, without promoting physical access to them, as the view of nature is a main motivator."

Since 2000, 2% of London's area has been paved over; this trend should be reversed or compensated for. Somehow it will be important to change from the current situation to one where it is socially unacceptable to seal surfaces and increase the area of rapid run-off surface, the question is how to do this?

5 Opportunities for implementing green infrastructure in the UK

Bob Bray, Robert Bray Associates, www.sustainabledrainage.co.uk

Figure 11 Examples of aesthetic as well as hydraulic value SuDS as implemented in Malmo

'The philosophy of SUDS is to replicate, as closely as possible, the natural drainage from a site before development' (The SUDS Manual CIRIA C697 p1-1). The objectives are to minimise impacts on quantity and quality of runoff and maximise amenity and biodiversity opportunities. Over 10 years we have learnt how to do it. Starting in 1996 with 'Natures Way' a video that introduced a new way of managing rainfall on developments, followed in 2000 with 'Sustainable urban drainage systems' Guidance C521 and Guidance C522, then 2003 PPG25 'Development and Flood Risk' which recommends SUDS and in 2007 the 'Revised PPS25 – an updated recommendation' and 'The SUDS Manual CIRIA C697' but it is still not the mainstream approach of first choice for the majority in the UK.

There are numerous examples of GI such as Portland in Oregon (seen already) where a bioretention courtyard that looks like a box-hedged planting takes the first 15 mm of rainfall. The Sustainable Village Davis County in California (http://www.ecocomposite.org/building/villagehomes.htm which is now 30 years old but because of lack of vision elsewhere has not been replicated. Augustenborg was a depressed 1970's housing development in Malmo, Sweden, it was retrofitted with SuDS (Figure 11) which improved its quality of life. We can learn from these and other examples and take comfort that it is not cutting-edge, untested, risky technology, but something that is well established, tried and tested and liked by those living and working in the area if it is done properly. Certainly, a careless person could step into a rill and get

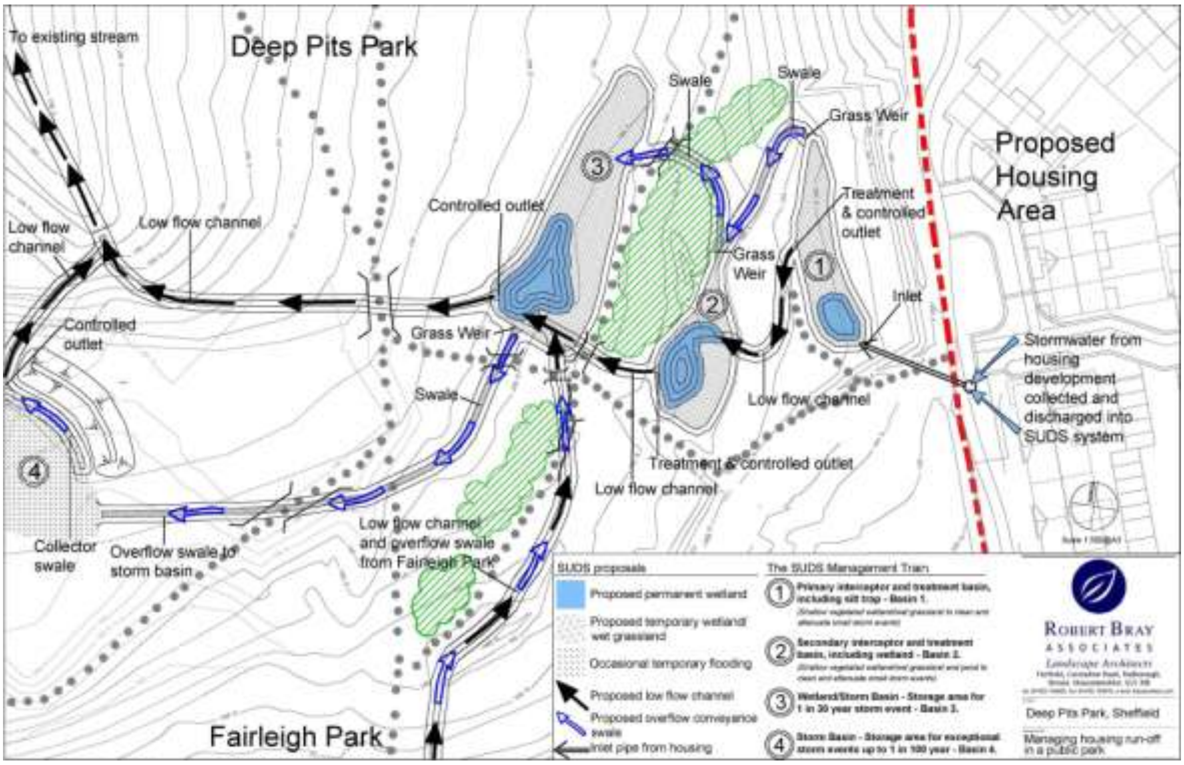

Figure 12 Example of accommodating SuDS within a park

a wet foot, if somebody really tried they could lie face down and drown or bang their head on one of the decorative stones but comparable hazards are widespread in living environments. Misguided "Health and Safety" considerations in the UK have led to some SuDS schemes where retention basins have ugly concrete features and fencing and therefore entirely lacking in any aesthetic appeal. In contrast to this, the urban re-development at Manor Park in Sheffield incorporates SUDS into Deep Pits Park, a public open space (Figure 12).

Basin 1 in Deep Pits Park is a shallow vegetated wetland and wet grass area that it intended to clean storm flows and attenuate them; it is the primary interceptor and treatment basin in the scheme including the grit trap. Basin 2 is the secondary interceptor and treatment basin, it comprises a wet grass area, a shallow vegetated wetland and a pond; it further cleans storm flows and attenuates them. Basin 3 is a storage area for 1 in 30 year events and Basin 4 is for exceptional (1 in 100 year) storm events. The sports arena controls 1 in 350 year storm events.

Other examples were described from the Lamb Drove Sustainable Drainage Showcase Project at Cambourne Village in Cambridgeshire. It was part of the FLOWS Project funded by the European Regional Development Fund "for communities living with flood risk in a changing climate". It cost £11k less than a 'traditional' [grey] drainage solution and has reduced runoff by 75%. However getting acceptance for this non-conventional solution was not easy mainly because adoption issues were complicated to sort out and because the Highway Engineer was a "blocker" in the process. Springhill Housing in Stroud, Gloucestershire.

Riverside Court in Stamford, Cambridgeshire is a high density riverside housing development (104 units per hectare) which has permeable roads and courts (some of it over voided stone storage) discharging to a canal and rill system. It was merely damp when the rest of the town was flooded. Again, 'Health and Safety' had concerns about the rill and the canal.

SuDS were incorporated when Red Hill School was rebuilt. It featured enhanced biodiversity in the school grounds and a swale maze. Another school, Exwick Heights in Exeter uses permeable paving, a green roof, swales, the playing fields provide storage for excess stormwater.

The Integrated Urban SUDS model used in developments at Harlow and Sheffield is based on the premise that all surfaces are SUDS collectors and potential storage structures. The SUDS **management train** begins in each **sub-catchment** where **permeable pavement** collects, cleans and stores runoff in voided stone (or plastic) construction. Each sub-catchment releases 'clean' water in a controlled manner to **gutter channels** leading to **urban watercourses**. Water flows on the surface to **landscape nodes** that manage any contamination of the urban watercourse. The cleaned water flows to **constructed wetlands** on the edge of the set with **seepage** and thence into local streams as in natural streams. The SUDS system is complemented by **flood routes** that convey exceptionally heavy rain to the edge of the development. **Courts and parking areas** are the first tier in the road hierarchy and allow fully permeable surfaces with voided stone storage, subject to consideration for below ground service routes. The second tier comprises **local streets** also that receive low intensity traffic at 20 mph can also use permeable surface and below ground storage (constrained only by underground infrastructure). The third tier is **main streets** with increased traffic loads at 30 mph, turning areas and junctions require impermeable surfaces and greater strength. The fourth tier comprises **main roads and boulevards** also required impermeable surfaces.

Bob Bray's experience was that factors that hinder application of SUDS and/or that need to be overcome are issues related to:

- "our rain is different"
- who will adopt the scheme and maintain it?
- getting people to use realistic cost assessment methods
- what is the value of SUDS infrastructure and who owns it?
- land drainage issues
- over zealous "health and safety"

- people responsible for roads and highways who don’t see surface water as part of their problem
- lack of the institutional support that is needed to deliver SUDS
- the so called “5m rule” which is a *guidance* in Planning Regulations that soakaways should not normally be within 5m of a building, however permeable paving, water gardens and swales are not soakaways and their subterranean effect is much less. But some officials turn ‘guidance’ into ‘rule’ and then misapply it so that GI is prevented.

The water and sewerage companies have changed their attitudes in the last five years because they have realised that keeping surface water on the surface is the only way to prevent sewer surcharge. In addition it would help with their carbon reduction obligations.

6 Surface water flood risk in London and the Drain London Project

Kevin Reid, Principal Programme Officer, Development & Environment, GLA

The extent of surface water flood risk was hardly recognised until about 4 years ago because records were patchy. This is partly because of the changes in responsibility over the years from local authorities to the Greater London Council to Thames Water Authority and then to the Environment Agency. Fortunately London has not suffered anything like the 11" rain that hit Hull, but if it had the effects would have been very severe and the whole flooding agenda would have much greater priority. "Drain London" is a response to these inconsistent records, unclear responsibilities, climate change, increasing population and increasing complexity (http://www.london.gov.uk/drain-london).

Drain London will use a risk-based approach to identify and prioritise surface water flood risk. It will build the capacity through partnerships of key stakeholders within London to manage flood risk – different physical scales, sectors and disciplines and deliver change on the ground, not reports and models. It will take a hierarchical approach:

- Tier 1 subdivides London into a number of areas that share risk; it will create a framework for the subsequent tiers and establish the project management
- Tier 2 involves identifying and prioritising risk at area-level and then developing strategic-level Surface Water Management Plans
- Tier 3 provides detailed analysis of high-priority risk areas, consideration of a Green Roof Fund to encourage SUDS and development of two Community Flood Plans

Many planning applications have significant implications for drainage of their sites. Major developments can employ drainage engineers but small builders will not have this resource. So that is one part of the skills gap the second part is whether the engineers are versed in SUDS.

Figure 13 Examples of surface water flooding in London

Drain London will not ignore the importance and necessity of retrofitting GI for rainwater. The only lack of space in London [for GI] is in people's minds.

7 Why Dwr Cymru Welsh Water has chosen to be a green rainwater exemplar

Jeremy Jones, Dwr Cymru Welsh Water Sustainable Drainage Advisor
DCWWW Surface Water Management Strategy – Green Space Wales
http://www.dwrcymru.com/English/Company/Operations/surfacewater/index.asp

Based on experience of urban creep (e.g. Figure 14), research from around the world and the predictions for the effect of climate change on rainfall, DCWW has concluded that 'business as usual' as far as drainage is concerned will not be fit for purpose (Figure 15).

Figure 14 'urban creep' in a suburban housing development: left, original impermeable surfaces in 1984; impermeable surfaces in 2009; projected impermeable surfaces in 2034

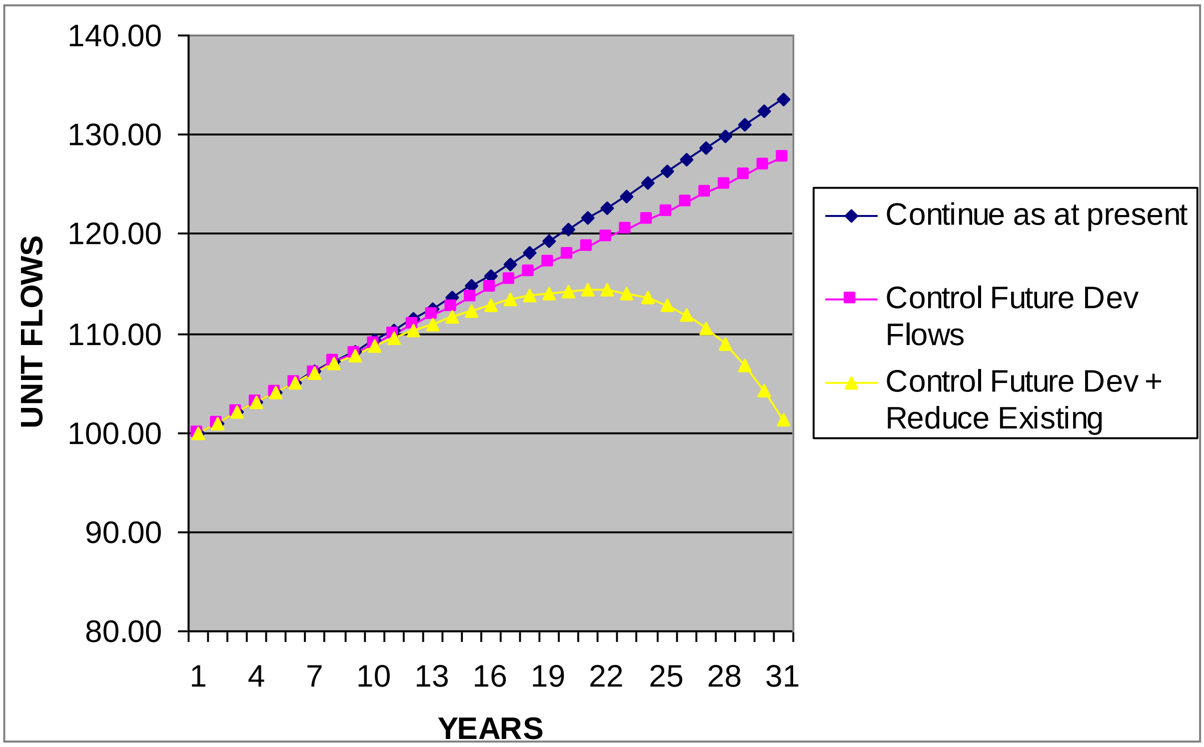

Figure 15 Effect of different strategies on drainage flows projecting development and climate change

DCWW's modelling predicted that if there is no control on 'sealing', the flow of drainage water will increase by 35% in 31 years because of progressive increases in roofed and paved areas plus the effect of climate change on rainfall. Replacing existing sewers with larger ones and building storage in the sewer network to cope with this extra volume reactively, which would be business as usual, would involve unacceptable disruption and cost. If new developments were controlled so that the volume of runoff from their sites does not increase but 'creep' continued in existing developments, this figure would be reduced to 28% increase over 31 years, again unacceptable. It was only by working with existing developments to disconnect runoff from the urban drainage network that the flow could be brought back to today's flow. Even this disconnection strategy would result in a peak increase in flow of about 14% during the period of its implementation. This peak will occur in about 20 years' time, i.e. 4 business planning (AMP) cycles or the life of 4 governments. In political terms this is very long term and during the implementation things will get worse before they get better but DCWW and the Welsh Assembly have had the courage, integrity and vision to recognise that it needs to be done. Unfortunately Ofwat took a lot of convincing. DCWW wanted to validate here in the UK some of the examples of sustainable stormwater practices that are proven overseas. These can be examples for the water industry to adapt to climate change but Ofwat insisted any work had to be linked to flooding.

Surface water is a combination of highway runoff, car parks, roof water, driveways, etc., infiltration of groundwater into sewers, watercourse inflow, river overflow and overland flow from agricultural land. Once it gets into the drainage network all or most of it will have to be pumped and will have to be treated, both of which require electricity, i.e. carbon emissions.

Consider the example of Cardiff: in 1984 there was 7,450 m^2 of impermeable surfaces, this had increased to 9,215 m^2 by 2009 (+20%) and if the trend continued would be 10,055 m^2 in 2034 (+35%).

Many features of the urban landscape in the UK have no benefit to urban hydrology but as Figure 16 (which transposes the raingardens from NE Siskiyou Green Street, Portland to a suburban road in Wales) shows, this need not be the case. Traffic and parking restrictions could be built to make a contribution to surface water management as well as being visually more attractive – they could be multifunctional.

Figure 16 Photo-manipulation replacing sterile 'grey' traffic calming with multifunction raingardens

Typically in Wales and the rest of the UK, even where there is quite extensive planting, such as supermarket carparks, the plantings have no hydraulic connection with the paved surfaces, they even have to be watered with potable water. All the runoff from the impermeable surfaces goes to the drains and has to be pumped and treated. It need not be that way if designers and planners were aware of SuDS.

DCWW is getting very positive results from talking with site owners and developers, for example in the case of development of a new Asda Store on a brownfield site at Newport, the developer wanted to discharge to the combined sewer but DCWW was able to adopt an old highway drainage water retention pond; this removed a potential 2.3 ha of impermeable surface, which would have discharged 27,600 m^3 rainwater per annum and all for minimal investment by DCWW.

Discussions during the planning of urban redevelopment in Pontypridd, S. Wales Valleys removed a potential 0.7 ha of impermeable surface which would have been an annual contribution of 12,600 m^3 rainwater. In Tenby town centre a potential 15 ha of impermeable surface have been removed, which would have been an annual contribution of 180,000 m^3 rainwater. The investment from DCWW in both cases was minimal; it just meant finding out about the schemes at early enough stages, talking to all of the people involved and persuading them of the multiple benefits of GI.

Figure 17 RWH tank with gravity feed to cistern

DCWW has 4 rainwater harvesting trial sites using a novel form of implementation (figure 17) that features a storage tank at roof gutter level, which has the advantage that the water can feed lavatory cisterns by gravity, whereas 'conventional' underground storage necessitates pumping.

DCWW's business plan for sustainable drainage demonstrations has been approved to a total of £23.3 M plus an additional £6 M from EU funding. This will be a test bed for England and Wales. DCWW considers that key to achieving this will be getting all the relevant parties in a scheme that influences surface water management cooperating and talking. One of the biggests costs is "engagement and communication".

8 Retrofitting surface water management measures

Jonathan Glerum, CIRIA

CIRIA has been working on SUDS for several years and has a useful catalogue of publications (e.g. Digman et al., 2006; Woods-Ballard et al., 2007 and Newton et al., 2007). The Cambridge Sustainable Drainage Design and Adoption Guide (Wilson et al., 2009) is also very useful.

Guidance on retrofitting surface water management measures (RP922) is being project managed by Jonathan. On the basis of all this experience, CIRIA considers that just dealing with new developments will not be adequate; retrofitting is imperative.

Quality, quantity and amenity all need to be considered in a holistic approach; the measures for keeping surface water on the surface have multiple benefits and have been proved amply by examples overseas such as Portland in Oregon, Malmo in Sweden, Auckland in New Zealand and several cities in Australia where weather extremes (prolonged drought and floods) have meant that surface water can be either valuable as a resource or, at other times, a serious risk.

RP922 will consider structural measures that can be introduced where there are already surface water management systems (e.g. drains, sewers, pipes, culverts, etc.) but where their performance is now or will become unacceptable.

The Drivers have already been discussed, they are:

- Flood risk management
- Climate change
- Water quality and the water framework directive
- Provision of amenity and making better places to live
- Biodiversity
- Regeneration of urban locations

The challenges that have emerged during the work on the Guidance have included how water has been managed in urban settings where often in the past we have turned our backs on rivers or covered them over, now the move is to daylight rivers and housing with a river/canal/water view has premium value. There has been a lack of joined up thinking amongst the many stakeholders and not enough talking between them. Funding has also been an issue that is the reverse side of the multiple benefits of GI because a budget-holder for one of the benefits sees no reason to fund the other benefits. Finally there is the question of ownership of GI when it is in active use, another reverse side of the multiple benefits. These issues dwarf the technical issues associated with delivery.

The Project Steering Group for RP922 is multidisciplinary and includes:

- Planners/Urban Designers
- Sewerage undertakers
- Regulators/Government representatives
- Drainage Engineers
- Product designers

The objectives of RP922 are to outline the benefits for flood risk, water quality, amenity and biodiversity and sustainability and how GI can help mitigate the effects of climate change. It is intended to address the key barriers to retrofitting and will use case studies to provide confidence. RP922 provides a process to assist with the planning, design and delivery of retrofitted GI. It will also provide guidance on engaging and communicating with a wide range of sectors and disciplines.

RP922 gives practical guidance on retrofitting that is easy to use, supports decision making, covers all options and shows what can be done.

To be successful, retrofitting must engage with and get the buy-in of many stakeholders so that they work together [rather than against] to produce good design that delivers the multiple benefits that are possible and they understand the maintenance and education aspects.

Retrofitting green infrastructure for rainwater is different, but it is not difficult except for the "soft" issues of getting the buy-in and the funding.

Figure 18 Infiltration planter for downspout disconnection - not a soakaway

9 Green roofs

Dusty Gedge, European Federation of Green Roof Associations

London already has 50 ha of greenroof. In 2004 the total was only 8ha. This is quite an impressive and largely unrecognised achievement. It is more than Chicago and intermediate between Stuttgart (40 ha) and Basal (60 ha), albeit they are smaller cities so their proportion is greater. Stuttgart has the largest area of greenroof in Germany; the sickness-absence rate at Deutsche Post's green roofed office is the lowest, and the black-roofed the highest of its offices.

[Publicity for and celebration of green-roofs is important because it brings them into the mainstream, which will eventually put peer and client pressure on developers to apply green-roof technology (editor)].

It has been estimated that 32% of the land area of Central London is green roofable (Gedge et al., 2008). Within a 6km circle centred on Trafalgar Square this equates the 10,000 ha of green-roofable roofs. To give that some context the area of Hyde Park plus Kensington Gardens is 252 ha. If all these suitable roofs were converted to green-roofs it would add 40 additional Hyde Parks plus Kensington Gardens to the task of modulating runoff, reducing urban heat island and increasing biodiversity.

Daniel Roehr, Assistant Professor, Landscape Architecture, University of British Columbia http://www.sala.ubc.ca/people/faculty/daniel-roehr is doing interesting things with green infrastructure and quantifying its effectiveness.

The business district in the former Docklands, East London has an impressive representation of green roofs.

According to the London Plan, the Mayor will, and the boroughs should, expect all major developments to incorporate living roofs and walls, where feasible. The boroughs should reflect this in their Local Development Framework policies. It is expected that this will include roof and wall planting that will deliver as many of the following objectives as possible:

- Accessible roof space
- Adapting and mitigating for climate change
- Sustainable urban drainage
- Enhancing biodiversity
- Improved appearance

Boroughs should also encourage the use of living roofs in smaller developments and on extensions where the opportunity arises

The Mayor's preferred option is for extensive eco-roofs with an average depth between 4 - 6in (100 - 150 mm)

• Combination of native herbs and sedums
• Topographical variety

• Should meet local regional and national BAP[2] targets
• Average water holding capacity of 26 litres/7.6 gallons

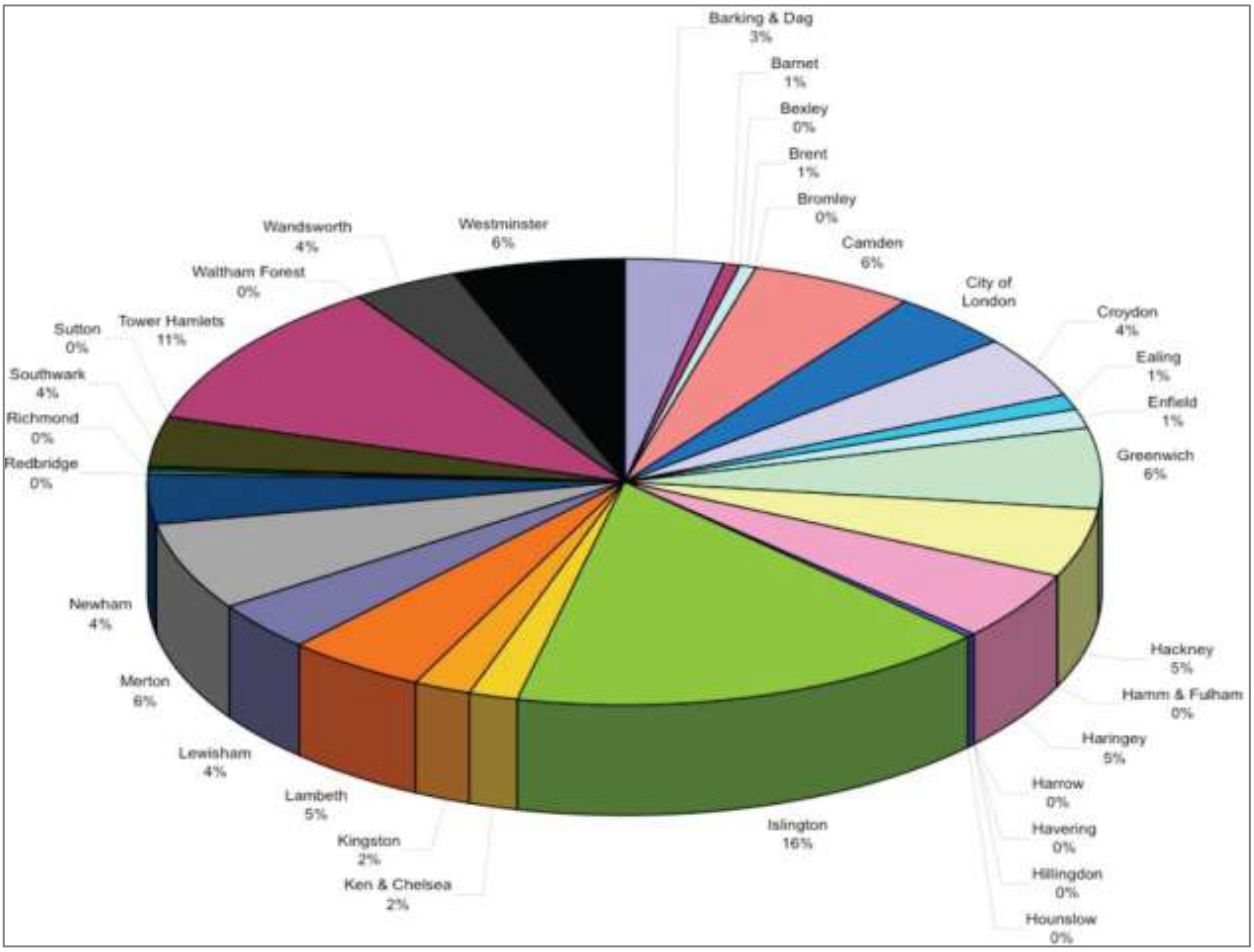

Figure 19 Greenroofs on London's boroughs - how they contribute to the total

There is an incorrect perception that a building can have either green roofs or solar production but not both. Actually the technologies are compatible, indeed solar photovoltaics (PV) benefit from green roofs. Tthere is substantial evidence from Germany that the use of both PV and green roofs provides dual benefits in terms of energy production and energy saved (Knaupp and Staiss, 2000). PV A-Frame panels at roof level work more efficiently when installed on a green roof rather than a on a conventional surface. Crystalline silicon photovoltaic panels lose approximately 0.5% efficiency per °C above 25°C. The green roof serves as a natural cooling mechanism, thereby maintaining the panels' efficiencies. The green roof element not only saves energy during the summer time but can also increase efficiency of PV by reducing fluctuation of temperatures at roof level and by maintaining a more efficient microclimate around the PV Panels.

Some Boroughs have set targets, for example Islington has a target of 1 ha of additional green roof per year. Lewisham, Tower Hamlets, Camden, City of Westminster and City of London have all set targets or goals.

Figure 20 A functional greenroof designed for biodiversity but not everybody's idea of beauty

[2] Biodiversity Action Plan

Biodiversity / habitat creation roofs can also be very effective for run-off modulation, especially for the short duration summer storms that are becoming more frequent as a result of more energy being pumped into the atmosphere through climate change.

The objective in designing biodiverse roofs is to create habitat characteristics and therefore it is necessary to look at the micro not the macro, to facilitate colonisation. Wind and sun affect diversity so creating wind barriers and/or shade to increase diversity.

Ingleby, (2002) surveyed architects, ecologists, local planners and engineers in London to identify perceived barriers to full-scale implementation of green roofs. Most concerns related to a perception that green roofs were a relatively new technology for the mainstream UK construction industry and the following:

- lack of common standard
- fire hazard
- maintenance
- cost
- structural Issues
- leakage and damage to waterproofing
- lack of expertise
- lack of policy.

The lack of a British Standard is often cited as a real barrier to wholesale uptake of green roofs. The major suppliers of green roofs in the UK are members of the German FLL – the Landscape Research, Development & Construction Society http://www.fll.de/, which provides standards for landscaping in Germany. The standards used in, Austria, Hungary, Italy, Japan, North America and Switzerland are variations, or based on the FLL.

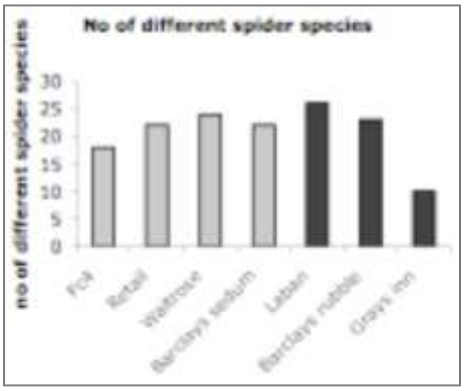

Figure 21 Numbers of spider species on sedum (grey bars) and biodiverse (black) roofs in London

The FLL covers all aspects of green roofs from waterproofing, soils, vegetation, treatment on intensive green roofs [tree planters, etc], balconies, installation methods and procedures, and maintenance. The guidance stipulates DIN (German Institute for Standardisation) standards for specific areas of greening. These standards are seen by some to be over rigorous, which FLL is willing to concede [pers. comm. Gedge 2004]. Internationally there are standards that can be used and all have a degree of commonality. These could be the basis for a British Standard. The largest companies supplying green roofs in the UK are recognised as leading green roof suppliers both in the UK and Germany.

There is a perception that dry vegetation during the summer months could lead to fires being started on green roofs but the FLL standards also have strict guidelines on this issue. These include high levels of fire resistance and fire proofing for membranes and other layers beneath the soils and vegetation. Furthermore there are strict guidelines regarding the use of firebreaks and the amount of combustible material permitted in green roof soils.

Extensive roofs are only considered to be fire resistant if:

- the substrate/soil is at least 30mm deep
- the substrate/soil contains less than 20 per cent organic matter

▪ there is a 1m wide gravel or slab ‘fire break’ every 40m

In Germany the use of a green roof is considered to provide a protective barrier preventing waterproofing elements from igniting. For this reason it is possible for building owners to get fire insurance premiums reduced by 10-20% in Germany. Millions of square metres of green roofs have been installed in Germany and Switzerland over the last 25 years to these standards, thus it is clear that fire risk should not be viewed as a real barrier to uptake in the UK.

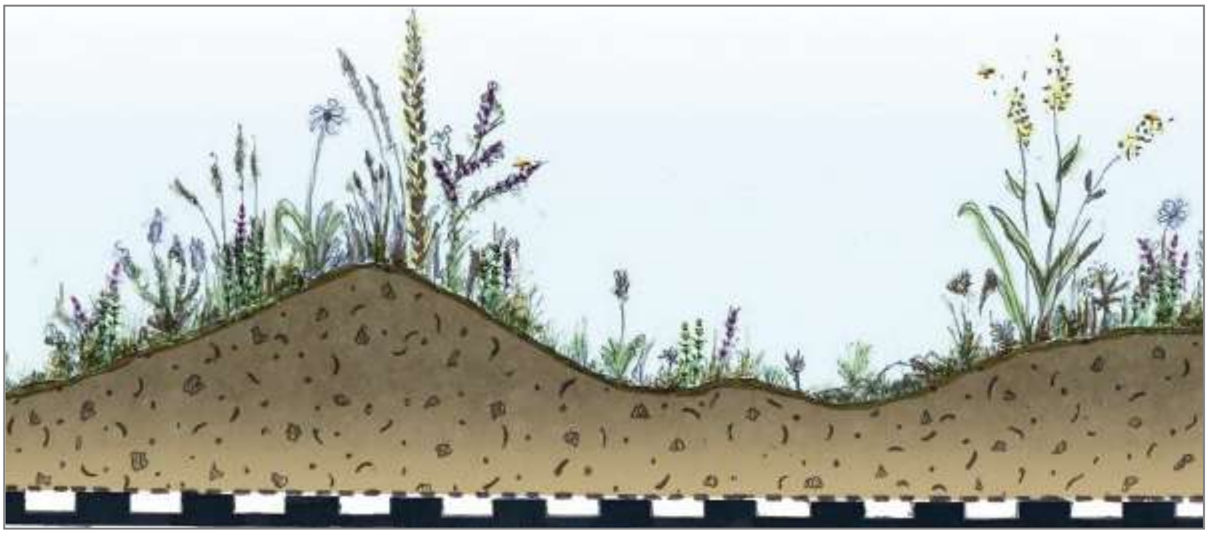

Figure 22 Ecological complexity in an open mosaic habitat

Maintenance of a green roof will depend on the roof system and what is desired from it. Intensive and semi-intensive green roofs are in many ways a high-rise version of a garden, and therefore will require similar levels of upkeep. This includes weeding, mowing, hedge trimming, fertilising and watering.
Semi-intensive wildflower meadows need an annual mow to maintain floristic diversity, but where maintenance has been neglected, it has had no impact on the building, it just reduces the ecological value and beauty of the meadows.

Extensive green roofs, which are generally not amenity spaces, need very little maintenance. A one to two year inspection will normally suffice to weed out unwanted plants, remove deep roots and, if necessary provide fertiliser. For the first year such work is generally covered by the installation team, after which it becomes the responsibility of the building owner or the building management team.
Contrary to common perception the use of a green roof can have a positive impact on maintenance in that intentional vegetation within the system keeps out unwanted vegetation that can harm the integrity of the building’s fabric. For example, on grey roofs buddleia and other shrubs can become established and cause problems. The presence of a root barrier and competition from other plants can limit this significantly.

The cost of a green roof depends on the system used, the height of the building, the number of intrusions, the size and type of system, the depth of insulation required and many other factors. An indicative cost for an intensive green roof is £140/m^2 inclusive of waterproofing and insulation. The use of large trees, furniture, planters and irrigation increases cost. For example, the planting scheme at Jubilee Park in Canary Wharf included trees, fountains, irrigation system, etc.; this resulted in costs as high as £453/m^2 (Gedge et al., 2008). However, these costs can be balanced to a certain extent by increased building ‘value’. An indicative cost for a semi-intensive green roof is in the region of £120-140/m^2, but again could be more depending on the types of plants used, water features and furniture.

Grant et al. (2003) estimated that a single plot with a green roof could realise a saving of £173,000 through a reduction in surface water amelioration costs. The study then considered the cost of increasing the structural requirements for the buildings in question to hold a substrate based green roof; these were considered conservative at £53,000. The cost saving to the plot, through the use of a green roof to reduce storm water storage, was thus in the order of £120,000.

Net present value calculations show that extensive green roofs provide better returns on investment than shingle or paving based inverted roofs; extensive substrate based roofs that are either hydro-seeded or bio-diverse provide better returns on investment than a basic bare roof. Semi-extensive roofs also provide better returns on investment than paving based inverted roofs. Living roofs are cost effective when the cost in use is applied over the life of the asset. If the roof is also accessible to occupiers, then the financial argument is even more compelling.

Roof gardens and terraces are not new to London. The roof garden at Barkers of Kensington was installed in the 1930s. The large-scale use of extensive and semi-intensive green roofs though is relatively new especially at a commercial level. A number of projects were completed in London in the late 1980s and early 1990s, but the use of green roofs in new developments has only risen to the fore since 2000. In this time, companies in the UK have gained an excellent track record on delivering green roofs, although there continues to be a lack of understanding and expertise of the full range and performance of green roof systems outside the industry. However, the overall perception that there is a lack of expertise in the UK regarding the provision and implementation of green roofs is wrong.

10 Discussion and Conclusions

The following points came out from discussions:

1) Dealing with surface water by replacing all combined sewerage with separate sewerage, installing larger sewers, underground storage tanks and end-of-pipe interceptors would be unaffordable and unacceptably disruptive.
2) Dealing with surface water management through the mechanism of planning permission for development is welcome but by itself it will not deliver sufficient control of surface water at source.
3) Retrofitting green infrastructure to control surface water at source is going to be essential in order to cope with intense of rainfall events, which are becoming more frequent as a consequence of the increased energy and moisture being pumped into the atmosphere by climate change.
4) Application of green infrastructure is hindered by the classic hurdles put in the way of technologies and techniques that are not already in common use elsewhere:
    a. Our rainfall is different
    b. Our streets are too narrow and there is no space – actually all city centres are crowded because land is valuable, but there are opportunities
    c. SUDS are OK where there's lots of space but not in cities – refuted by cities overseas
    d. Growing plants / managing surface water is not my department's responsibility
    e. Engineers rush to be second
5) GI is essentially fragmented and comprises many small installations that will not figure on asset registers – it might be perceived as more attractive and career enhancing to engineer large tunnelling, etc. projects.
6) The incentive for property owners to disconnect the surface water from their properties from entering the urban drainage system is inadequate in the UK. In Germany stormwater is regarded as a pollutant and therefore in accordance with the 'polluter pays principle', when a property is disconnected from the drainage system there is no charge. Ofwat recommended in 2003 that properties should pay according to the area of impermeable surface (from which rainwater was discharged) rather than the rateable value (Ofwat, 2009) but uptake by water companies has been slow. Perhaps Ofwat's charging formula could be refined to account for the effectiveness of GI. The government backed down on making this universal in the face of vociferous protest from charities, etc. If the "discharger pays" principle did apply, occupiers of properties with large surface water drainage charges would have greater incentive to disconnect.
7) Civil engineering courses do not teach GI, SUDS, SuDS, etc. to undergraduates, therefore graduates do not think about GI solutions when they assess drainage.
8) Even when engineers do attempt to assess the potential for GI they often use inappropriate information, i.e. they use drift geology rather than soil information. Drift geology does not map surface deposits less than 2 m deep. They also tend to consider infiltration only and don't appreciate the 'upward drainage' by evapotranspiration of vegetation and the modulation that GI can affect, i.e. reducing peak height of runoff.
9) Planners are frequently "blockers" when it comes to application of GI for rainwater. They have been known to raise inappropriate obstacles such as the "5 meter rule" [which is actually *guidance* in Planning Regulations that soakaways should not normally be within 5m of a building, but permeable paving, water gardens and swales are not soakaways and their subterranean effect is much less].
10) Over zealous "health and safety" can be a blocker, e.g. that pedestrians might fall into rain-gardens etc. This has not been a problem in litigious America so it is fanciful to suppose it will be a problem in the UK.
11) Departments responsible for roads and highways are often blockers because they do not perceive that runoff from their paving is their issue, they just need to get it to a drain and then it is somebody else's problem.
12) GI for rainwater management has many benefits but many budget holders might need to cooperate to realise them. If a roads department wants to control traffic flow or parking it might be easy to install kerbs and hard surfaces but that has no value for runoff modulation, biodiversity, beautification or urban heat island. The sewerage company is not involved with the decision

process and probably neither does the local authority's parks/amenity department or SuDS Approving Body.

13) There is insufficient awareness of GI in the UK. Examples from the USA of using interpretive boards to explain GI features, not only on the ground where they are visible but green-roofs where visibility is much less should be adopted. If members of the public were aware of what GI could do and if they could see and understand them they would be less tolerant of projects that do not exploit opportunities for building GI.
14) Control of surface water at source is going to be essential to prevent property and infrastructure flooding. Control could be green, grey or green-grey combined but evidence discussed in this workshop showed that the whole life benefit/cost was better for green. End of pipe solutions like the Thames Tideway Tunnel will stop CSO spills to rivers but it will not prevent a single property from flooding. They do not reduce urban heat island effect. They do not add aesthetic or amenity value to cities. They increase the global warming potentials of cities compared with GI.

Figure 1 An example of a missed opportunity for GI at the SE corner of Lincoln's Inn Fields, London. A traffic control constructed in 2010 that could have absorbed runoff.

11 **Recommendations**

The case for green infrastructure for rainwater management is well proven but it is not being adopted fast enough in the UK. It is not yet the first [default] choice for those responsible for urban drainage. Those responsible for other aspects of urban infrastructure do not ask whether their project could have even greater benefits to society by being adapted/used for rainwater/stormwater management in addition to the primary purpose for which it was planned. There are still too many blockers. It is too easy to say “no” and not enough incentive to say “yes”.

It is important that there should be “push” from the public, “pull” from senior management and politicians and increased willingness from the professionals. To achieve this, the following are recommended:

1) Undergraduate civil engineering courses should all include green infrastructure for rainwater management in their teaching. GI for rainwater management should also be included in architecture, town planning, horticulture and landscape architecture syllabuses.
2) Greater publicity should be given to GI for rainwater management including the collateral benefits of reduced GHG emissions, reducing urban heat island effect, biodiversity and beautification. This should include information at street level as well as in the media. This will raise awareness amongst professionals as well as the electorate.
3) There should be greater [and more widespread] financial incentive to disconnect rainwater from the urban drainage system either through the “polluter pays system” as in Germany or by stronger promotion of the surface water rebate by which water companies reduce the bills to properties that do not discharge surface water, albeit the current method of calculating the rebate is woefully unsophisticated.
4) Any plan for development, improvement or change in urban areas should be tested to see whether there is an opportunity for GI that has not been recognised/employed. This should apply to local authority projects (including roads) as well as third party projects. The paradigm should change from “where can GI be fitted” to “why isn’t GI being used”.
5) The water and sewerage companies, with Ofwat’s encouragement/direction, should be working more closely with local authorities to develop GI that will control surface water runoff at source and keep it out of [or modulate its release to] the piped drainage network.

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Appendix 1. Workshop programme

Objective - to align run-off modelling with the needs of the Water Industry

Facilitator Dr Tim Evans, FWR

0900 **Registration**
Coffee/tea

0930 **Introduction and welcome**

0940 **Experiences of using green/grey combinations for sustainable stormwater management**
Tom Liptan, Landscape Architect, Sustainable Stormwater Division, City of Portland, OR, USA

1040 **The Mayor's strategies and actions in relation to Urban Greening/green roofs**
Matt Thomas, GLA Urban Green Space Team

1100 **Coffee/tea and networking**

1120 **Opportunities for implementing green infrastructure in the UK**
Bob Bray, Robert Bray Associates

1140 **Challenges/limitations to implementing green infrastructure**
Richard Ashley, University of Sheffield and Flood Resilience Group, UNESCO IHE, Delft

1200 **Identifying barriers and challenges to uptake**
Discussion / Exercise

a. Legislation?
b. Ownership?
c. Technology?
d. Funding?
e. Education / awareness?
f. …….?

1300 **Lunch and networking**

1400 **Surface water flood risk in London and the Drain London project**
Kevin Reid, Principal Programme Officer, Development & Environment, GLA

1415 **Why Welsh Water has chosen to be a green rainwater exemplar**
Jeremy Jones, Dwr Cymru Welsh Water

1430 **Retrofitting green infrastructure for rainwater**
Jonathan Glerum, CIRIA

1445 **Green roofs**
Dusty Gedge, European Federation of Green Roof Associations

1500 **Are there particular types of retrofit that we should actively promote or focus on first?**
Panel Discussion

1530 **Tea/coffee and networking**

1550 **Strategy for getting green [with grey] implemented more widely How do educate or raise awareness to promote uptake – who do we target?**
Discussion / Exercise

a. Government?
b. Local Authorities?
c. Householders / public?
d. Developers?
e. DIY / manufacturers?
f. Awareness raising, media, etc.

1630 **Close**

Appendix 2. List of Invited Delegates

Richard	Ashley	University of Sheffield and UNESCO-IHE, Flood Resilience Group		r.ashley@sheffield.ac.uk
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Appendix 3. Useful websites and downloads

American Rivers **The Value of Green Infrastructure - A Guide to Recognizing Its Economic, Environmental and Social Benefits** (2010) provides a framework to quantify the air quality, energy use, and many other benefits that green infrastructure for rainwater management provides. It allows communities to more accurately compare different infrastructure investments and choose the option that provides the greatest long-term benefit. Extensive bibliography.
http://www.americanrivers.org/library/reports-publications/the-value-of-green-infrastructure.html (accessed February 2011)

Center for Neighborhood Technology (CNT) **Green Values® Stormwater Toolbox**
Lots of useful information including Green Solutions Manual, Green Values National Stormwater Management Calculator, Green Values Chicago DOE Stormwater Ordinance Compliance Calculator, Original Green Values Stormwater Management Calculator and links and case examples.
http://www.cnt.org/natural-resources/green-values/green-infrastructure (accessed February 2011)

DCWWW **Surface Water Management Strategy – Green Space Wales**
http://www.dwrcymru.com/English/Company/Operations/surfacewater/index.asp

Depave has been created to inspire and promote the removal of unnecessary concrete and asphalt from urban areas. Depave is a project of City Repair, a nonprofit organization based in Portland, Oregon, USA
http://depave.org/

Living Roofs On Green Roofs and Brown Roofs www.livingroofs.org (accessed February 2011)

European Federation of Green Roof Associations http://www.efb-greenroof.eu/index.html (accessed February 2011)

FFL (Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V.) www.fll.de (accessed February 2011)

Natual England; **Green Infrastructure Guidance** (NE176)
http://naturalengland.etraderstores.com/NaturalEnglandShop/NE176

New York State **Stormwater Management Design Manual** (August, 2010)
Provides designers with a general overview on how to size, design, select, and locate stormwater management practices. It is intended to address runoff reduction and planning and design of green infrastructure. Many valuable comments were received during the public notice and are incorporated into the updated chapters.
http://www.dec.ny.gov/chemical/29072.html (accessed February 2011)

Philadelphia Water Department. **"Green Stormwater Infrastructure."**
www.phillywatersheds.org/what_were_doing/green_infrastructure (accessed February 2011)

Portland Bureau of Environmental Services:
- A Sustainable Approach to Stormwater Management
  http://www.portlandonline.com/bes/index.cfm?c=34598
- Portland Ecoroofs http://www.portlandonline.com/bes/index.cfm?c=44422 and
  http://www.portlandonline.com/bes/index.cfm?c=44422&a=262750

Rotterdam: The Water City of the Future – case study
With 60% of the country living below sea level, the Netherlands has developed sustainable water management systems to cope with changing weather patterns and extreme downpours. Green roofs and

flood controlling water plazas are some of the measures helping Rotterdam to stay ahead of the game, says Linnie Mackenzie
http://www.waterworld.com/index/display/article-display/0977216762/articles/water-wastewater-international/volume-25/issue-5/editorial-focus/rainwater-harvesting/rotterdam-the-water-city-of-the-future.html?cmpid=EnlWaterWorldInternationalJanuary132011

Toronto, Canada was the first city in North America to require green roofs on new developments, a Bylaw passed in 2009 requires green roofs on new commercial, institutional and residential development with a minimum Gross Floor Area of 2,000m^2 as of 31st January 2010. The green roof coverage requirement ranges from 20-60 per cent of Available Roof Space for commercial, institutional and residential development. Residential buildings less than 6 storeys high are exempt. Financial incentives are available to help install green and cool roofs on Toronto's commercial, industrial and institutional buildings. It has quantified the effects of greenroofs http://www.toronto.ca/greenroofs/findings.htm

Water Environment Research Foundation

- Using Rainwater to Grow Liveable Communities – Sustainable Stormwater Best Management Practices **list of case studies** http://www.werf.org/livablecommunities/studies_list.htm
- New WERF Tool Helps Stormwater Managers SELECT the Right BMP A wide array of different BMPs and LID practices are available for application on a developing watershed or for retrofit in developed areas. WERF's recently launched SELECT model lets stormwater managers examine multiple scenarios for controlling stormwater pollution and ultimately select the best BMP for the job. More