An insight into the USA approach
Sustainable drainage systems in Portland and Seattle

Summary of a joint UK Water and Sewerage Company visit to the USA

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Front cover images:

Left shows a detention basin in Madison Valley, Seattle where during times of exceedance, surface water floods from the grilled opening, filling the detention basin that is used by the community as a recreational area. The detention basin was built to manage flood risk, and is located where residential properties once stood.

Right shows a street planter in Portland in the city centre which receives flows direct from the highway, allowing infiltration into the ground. Built in 2005, it is designed to integrate into the existing urban landscape, maintaining the on street parking whilst supporting good pedestrian movement.

Executive Summary

Improving river water quality by reducing sewer discharges has been a major focus in the United States of America for over 20 years. Initially, large tunnels were the typical solution, to store and convey flow to treatment. Over the last 15 years, a wider range of approaches have been implemented. Sustainable drainage systems (SuDS) have been used for some time on new and re- development projects. However over the last 15 years, some States have started to apply SuDS in a retrofit scenario. The drivers for retrofitting have also evolved to managing flood risk and sewer rehabilitation as well as enhancing river water quality.

The UK water industry's interest in using SuDS has substantially increased over the last few years. Yorkshire Water recognising its importance organised and led a joint UK Water Company visit with Anglian Water and Wessex Water to the USA. The trip's aim was to collate key learning points and successes from cities where retrofitting had been applied for over 10 years. Two locations were selected as noted leaders of SuDS retrofitting, Portland in Oregon and Seattle in Washington. Both had successfully retrofit SuDS in programmes, and share similar climatic conditions to the UK.

Two different leadership models were seen. In Portland, successive Mayors were instrumental in setting the direction of surface water management and supporting the city to supplement large grey infrastructure programmes with SuDS. In Seattle, the drive came from the municipality to start using SuDS as an alternative approach to managing surface water. Both cities have undertaken SuDS programmes that intercept and treat surface water before discharging to the ground or watercourse.

Underpinning the successful retrofit programmes has been their approach to engagement. Substantial time and effort is placed on engagement, initially understanding what is important to residents before considering what can be done.

Community involvement in the design and subsequent maintenance has supported the acceptance of using SuDS. Publicising and explaining the SuDS and benefits was frequently witnessed using information boards.

The overarching approach in the two cities has focused on controlling flows close to source, rather than using large end of pipe solutions.

SuDS have been retrofitted on private property and in the public domain. In Portland, over 26,000 properties have had downspouts disconnected, often discharging to a private raingarden. Commercial properties have green roofs, bio-filtration swales and street planters. The urban design was an important aspect in designing measures that fit in or enhance the local context.

Both cities accepted the wider benefits of using SuDS. Undertaking benefit cost assessments had been limited until recently to hydraulic and water quality improvements. Generally, the SuDS approach proved to be cheaper than increasing grey infrastructure. The funding for this work has been through borrowing paid off over time by increasing the sewerage rates.

This report highlights the key learning points from the trip and what has contributed to the successful application of SuDS. Its next step is to transfer the learning and identify how it can be applied in the UK context. The report demonstrates that a mixture of SuDS and grey infrastructure improvements can be successfully implemented to improve water quality in rivers and reduce flood risk. Its success is underpinned by the level and type of engagement.

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INTRODUCTION

This report summarises the key learning points from the joint Water and Sewerage Company visit to Portland and Seattle in November 2011. It is a factually based report, collating the visiting team's discussions with the municipalities and the supporting information received.

The report sets out the purpose of the visit and why Portland and Seattle were chosen. It presents the key learning points across a range of subjects relevant to implementing SuDS.

ACKNOWLEDGEMENTS

The team wishes to thank Portland's Bureau of Environmental Services, Seattle Public Utilities and GeoSyntec for sharing their learning and experiences from their stormwater management programmes. In particular thanks goes to Emily Hauth and Tracy Tackett in organising the trip, interviews and site visits.

COMMON TERMS USED IN THE REPORT

The following terms are used in the report:

- Green Infrastructure (GI) are measures that manage stormwater in a sustainable way using vegetation and trees to store, slow down and treat surface water runoff.
- Sustainable drainage systems (SuDS) are similar to green infrastructure, but also use harder engineering approaches.
- Best management practices (BMP) are activities or approaches that reduce the pollution of water
- Low impact development (LID) is a stormwater planning approach in new or redevelopment that uses green infrastructure measures
- Portland Bureau of Environmental Services (BES) – Portland's municipality department who are responsible for managing stormwater
- Seattle Public Utilities (SPU) - Seattle's municipality department who are responsible for managing stormwater

KEY LEARNING POINTS

Key learning points are highlighted in boxes as shown below.

Key learning point from the visit

PURPOSE AND AIM

Surface water management is changing. Whilst our approach in the UK to manage surface water through underground sewers, tanks and shafts have led to great advances and improvements (public health, water quality and flooding), we now have a legacy of aging infrastructure that is inflexible to cope with the demands of a changing climate and urban development. It is widely recognised that continuing with the same approach, retrofitting grey infrastructure alone is unsustainable.

Retrofitting sustainable drainage (SuDS) or green infrastructure (GI) is widely accepted in most developed countries as a modern alternative to manage surface water differently (in combination with grey infrastructure). There are many examples of such work in the USA Australia and Europe where this is becoming common place.

In the USA, this retrofitting approach is a work-in-progress, starting in earnest over 15 years ago. An assessment of cities across the USA showed two of the early pioneers of this approach were Portland and Seattle. Other cities were also recognised in taking on this approach and have developed ambitious long term plans to retrofit green infrastructure, such as Philadelphia.

In recognising that retrofitting SuDS is likely to be an effective tool to managing surface water in the future, Yorkshire Water is seeking to identify good approaches in this area. To address this, Yorkshire Water, supported by MWH, co-ordinated and led a joint UK water and sewerage company knowledge learning and sharing visit with Anglian Water, Wessex Water and Arup to Portland and Seattle, USA. These cities were selected for having similar climatic conditions to the UK and substantial experience with regards to using SuDS as an alternative to and in conjunction with conventional piped systems.

The purpose of the visit in November 2011 was to enhance our knowledge and understanding of the use and implementation of SuDS in new build and particularly retrofit scenarios, learning how fundamental issues and barriers were overcome. This report captures the discussions between those from the UK visitors and officers from Portland and Seattle, recording the learning and references some of the many documents made available. The objectives of the visit were:

- To learn about their approach, costs and effectiveness of integrated and retrofit SuDS solutions.
- To see an assortment of measures successfully retrofitted under a range of circumstances, first hand and in detail.
- To understand how different challenges were overcome including; regulatory and legislative, engineering, incentives, social, engagement, socio-economic, community acceptance, operation, maintenance, financial and institutional.
- To learn from experts who have successfully delivered measures both in an opportunistic manner and to a strategic plan.
- To obtain guidance, data, reports and case studies, that can support retrofitting within the UK (by Water and Sewerage Companies), as well as photographs of how they currently look to support the case studies.
- To develop relationships with people who have been retrofitting for many years, establishing long term social working networks for future support.
- To use the data, information, knowledge, experience and relationships collected from the trip to support the development of the business case in this area for both the short term and long term in the context of the wider water industry.
- Develop a greater evidence base to engage the economic regulator (Ofwat) and the environmental regulator (Environment Agency) on the role of retrofitting SuDS by Water and Sewerage Companies.

VISITING LOCATIONS

Portland – City of Portland, Bureau of Environmental Services

Portland is located within the state of Oregon in the North West of the United States. The city has a population of 575,000, increasing to 2 million across the metropolitan area. Its average rainfall is approximately 940mm per year and 13 cm of snow[1]. The Bureau of Environmental Services (BES) has municipal responsibility for managing surface water, as well as the foul sewerage.

Portland first started to implement green infrastructure in the 1990s. Tom Liptan, a Landscape Architect by profession, was our key contact, and has been the local champion of retrofitting SuDS in the Portland area. Other key contacts that were made during the visit included:

- Emily Hauth (sustainable stormwater coordinator)
- Daniela Brod (green infrastructure co-ordinator)
- Amber Clayton (private stormwater retrofit programme manager)
- Tim Kurtz (city engineer, sustainable stormwater management division)
- Anne Nelson (environment programme co-ordinator)
- Jim Hagerman (economics, financial planning and regulatory development)

GeoSyntec Consultants

A short meeting with GeoSyntec consultants was arranged through Arup with Eric Strecker. Eric Strecker has worked with Portland amongst other municipalities and is an author on a wide range of research papers and Best Management Practice (BMP) documents. This gave an opportunity for a wider discussion, obtaining references to guidance and provided a different, pragmatic and technical learning perspective. This included issues and concerns to be aware of.

Seattle – Settle Public Utilities (SPU)

Seattle is located within the state of Washington in the North West of the United States. It lies approximately 160 miles North of Portland. The climatic conditions are similar to the Yorkshire region, experiencing over 960mm of rainfall per year and an average of 30cm of snow[2]. Seattle Public Utilities manages and provides the foul and surface water drainage to 170,000 customers. Outside of these areas, King County provides drainage facilities. Within the greater metropolitan area of Seattle, there is a population of over 1.3 million. Seattle first started to implement green stormwater infrastructure in the late 1990s.

Key champions of 'green stormwater infrastructure' were Tracy Tackett and Nian She. Tracey was the key contact for the visit. Other staff members from SPU and King County included:

- J Paul Blake, Director of Community Relations Development
- Tracy Tackett (Green Stormwater Infrastructure Programme Manager)
- Celia Kennedy (Capital Project development and System Improvements)
- Emiko Takahashi (Economist)
- Bob Spencer (Rain Wise programme – rebate for raingardens and downspout to control CSO spills and citizen volunteering – private)
- Susan Harper (outreach campaign manager)
- Shanti Colwell (The Ballard Project)
- April Mills (Stormwater infrastructure group)
- Drena Donofrio (Maintenance and Operation of Green Infrastructure Manager in Public Locations)
- John Philips of King County, (Wastewater treatment, infiltration, sedimentation and climate change).

[1] http://en.wikipedia.org/wiki/Portland,_Oregon,

[2] http://en.wikipedia.org/wiki/Seattle#Surrounding_municipalities

KEY LEARNING POINTS

During the five day visit, a number of question and answer sessions were held on site and during meetings. The learning points of these discussions are captured in this report. References are made to the reports and information collected during the visit.

Different leadership approaches address the same legislation

Legislation was an important driver in changing the business approach to stormwater management in Portland and Seattle. The key driver for both Seattle and Portland was water quality improvement. This was imposed by the Clean Water Act of 1972 and supported by other legislation such as the Water Quality Act, 1987, the Endangered Species Act, 1973 and the Safe Drinking Water Act 1974. Subsequent Acts have strengthened the requirements further. Surface water management was therefore a political issue to ensure compliance was met with the above Acts. Each community (city and state) had to choose how to meet the Act's requirements. Portland for example chose a high standard of CSO control (a low number of spills from CSOs) to avoid private prosecution (from individuals) and the risk of failure against the legislation.

New water quality legislation was a key driver for a different approach to manage surface water

Portland's Mayor was a driving force behind the level of surface water management and approaches to be adopted. In Portland, Commissioners have individual responsibility for the different bureaus. These politicians do change, and this can influence the strategic direction, although fundamentally this has not been seen. Business planning is undertaken in the short (yearly) and long term (such as Portland's 20-year program to control combined sewer overflows (CSOs), which included constructing three tunnels.) Neither city has been restricted by medium term regulatory cycles. Ultimately the politicians are accountable for progress and meeting the compliance. The general public were engaged to understand what was important to them and what they cared about. The underlying message outlined serious concerns over deteriorating conditions to the Willamette River. This provided the momentum to construct solutions delivering improved water quality.

Portland's Mayor was a driving force in supporting the surface water management approach

The initial approach to address the water quality issues were through conventional solutions (such as the CSO tunnel construction). However, since the 1990s, other approaches have been first trialled, and are now being used in a combined grey and green infrastructure approach to reduce the size of the conventional solution (as seen with the Big Pipe project). The move to green infrastructure (GI) was initially driven by an individual champion, Tom Liptan with a vision that saw the opportunity to manage surface water differently and create wider benefits. Green infrastructure was seen as a way to treat the diffuse pollution rather than below ground storage and treatment at wastewater treatment works. However, it was realised that to achieve the delivery of green infrastructure schemes and meet the regulatory outputs, further engagement with the local communities on acceptable solutions was critical.

A grey/green infrastructure approach is now commonly used to manage surface water

Water quality is important to residents and the utility operators with flooding (basement sewer backups) having less prominence until recently (in both Portland and Seattle). This in part may have been due to the reporting mechanism of flooding historically, and the known impacts. Until recently it was noted that there had not been a culture of reporting or identifying flooding. Many properties are constructed with basements and these can be vulnerable to basement sewer backups property flooding. Visually flooding is not often seen, with exceptions arising from overland flows during extreme events. The awareness of basement flooding is now far greater, as highlighted through an on-going scheme, Tabor to the River in Portland and through the work implemented at Madison Valley in Seattle. At Tabor to the River, basement flooding and rehabilitation form part of the drivers for improving the system and building green infrastructure to cost effectively remove surface water from the combined sewer system. http://www.portlandonline.com/bes/taborfactsheet).

The environmental compliance is monitored by the US Environmental Protection Agency (USEPA). In Portland, at the start of the water quality improvement programme, the BES wished to avoid being sued by individuals (which was considered to be a real threat at the time) or prosecuted by USEPA (with a penalty of $50k per 24 hour spill). To manage water quality issues, agreements were set between USEPA and BES on the number of spills from combined sewer overflows. BES agreed to a higher standard of protection than necessarily required to provide both improved water quality and certainty for the future. A programme of works started as an estimated $1bn. BES and the USEPA agreement was amended, which resulted in a revised cost of $1.4bn. This programme of works was constructed over a 20 year period.

A 20 year programme of works costing $1.4bn delivered the water quality benefits

Although the responsibility for stormwater management rests with the municipality, BES and SPU still have internal barriers and challenges to overcome (e.g. working with different departments with different responsibilities such as the highways department).

In Seattle, there is additional focus to integrate stormwater management with the transportation department to create a more effective strategy and approach to managing stormwater jointly. This has to overcome political issues as the highway has always had a historical right to connect to the combined sewer system. As a result of this, SPU is now dealing with the legacy issue of pollutants such as zinc and copper, preventing them entering the watercourses.

Funding linked with a strategic approach enables drivers to be addressed in the long term

Portland has constantly received support from the Mayor whilst the work in Seattle has been driven by SPU. This has led Seattle to have a more financially focused programme of delivery. Seattle is now shaping the city vision and understanding the impact this could have on rate increases.

In Portland, the long term control plans developed by the municipalities are funded through rate payers and borrowing. Thirty to forty percent of the annual expenditure services this debt. Stormwater charges have increased over a 20 year period to provide the funding for the necessary improvements. Charges are currently based on a standard plan area for residential property (although they are considering changing this in the future using bandings). Non-residential, charging is based on the area drained. Rebates are provided for areas that reduce surface water inputs. Surface water charges form a large percentage of the bills. For example, in Portland, stormwater costs (only) are approximately $240 per year for residential properties. This was a flat rate for residential properties, however changing to an 'area' based charging system is being considered. Commercial properties cost $10.73 per 100m2 of impervious area. Stormwater rebates are available for residential and non-residential properties.

Long term control plans help to deliver schemes and are funded by the rate payers

BES works to a 5 year plan, with detailed yearly planning, subject to agreement by elected Politicians on the proposed rate increases. This is necessary to service the long term debt, therefore current rates do not respond necessarily to the current programme but to service the debt. This is similar to the UK Water and Sewerage Companies where the regulatory outputs and budgets are balanced to enable the debt and profit to be managed. Business plans are promoted with appropriate schemes to meet the required budget and regulatory obligations.

Over a 20 year period in Portland, stormwater and sewer charges have increased five-fold, typically a 6% year on year rise. Rate increases were higher than the inflation. In order for residents to accept this, appropriate, targeted publicity and stakeholder / customer engagement was critical. The benefit of increased funding was now being realised, directly and indirectly with the reduction of CSO spills and lower flood risk. Some properties have also seen an increase in property values as a result of 'green street' programmes. A high level analysis to evaluate the benefits on property prices (using the results of SPU's work) using green infrastructure indicated there was a small increase in value (Ward et al, 2008). However despite good engagement, there are now the economic constraints on the rate of increase for customer bills, and some work has been held back to balance income and expenditure.

Some property values have increased where green infrastructure has been retrofitted locally

Some green infrastructure currently being implemented in Portland was seen as providing future headroom to the existing system. The removal of flows from the combined sewer system will enable the storage tunnel to satisfy capacity requirements over a longer design horizon. A key part of the BES strategy was to continue this approach. In schemes now such as 'Tabor to the River', green infrastructure forms part of the solution to deliver the current day requirements. Removing flows from the combined system will help to reduce the risk of flooding and lengthen the asset life of the sewers (limiting future sewer rehabilitation requirements).

The use of green infrastructure is providing future headroom to the existing drainage system

In Portland, a property disconnection programme has reduced inflows into the combined sewer and helped to reduce the CSO operation. In Portland, where the ground conditions are appropriate, 56,000 downspouts have now been disconnected from the public sewer system across 26,000 residential homes, keeping more than 1.2 billion gallons of stormwater out of the combined sewer annually. This has been achieved through a targeted programme of work across Portland.

This work was undertaken by the BES or by the homeowners with grant aid from BES. Despite the targeted programme finishing in Portland, the bureau still assists those who wish to disconnect their property. It still uses a permit system, as developed for the programme. As part of the water rebate, the BES worked with the private residents to help them maintain their measures, such as raingardens. Where the private measures are not maintained, the residents lose their rebate. Portland, also operate a scheme, where 1% of the construction budget from projects in the city right-of-way that are not subject to their Stormwater Management Manual (City of Portland, 2008) are collected. This goes into the 1% green fund for green street construction projects.

Redevelopment of significant residential sites within urban areas occurs infrequently. One such site at High Point, Seattle included proposals for a range of private and social housing. Here the existing housing stock had been demolished and a completely new stormwater drainage approach used to manage the runoff from the property and the highway (Figure 1).

SPU adopted a policy that such opportunities should be identified and maximised wherever possible, to retrofit measures and manage stormwater.

Figure 1 – High point, where major redevelopment of a residential area took place and the stormwater drainage is now predominantly managed on the surface. Here a shallow swale in the verge drains the highway.

Incentivisation encourages private property retrofitting

Incentives are in place for customers to reduce the storm water runoff from their property and curtilage, in areas where this is appropriate (Figure 2). Portland offers a 35% reduction in rates to residential property owners where the roof is disconnected. The remaining 65% accounts for stormwater runoff from the highway and public right of way and remains fixed. The bills include this breakdown of charges to help residents understand what the stormwater management is for. A dedicated programme was set up to reduce the stormwater inflow from property roofs (as outlined above) typically involving disconnection with flows being directed to the garden.

Customers are incentivised to reduce their storm water runoff

To confirm the level of rebate in Portland, residents complete and submit a simple form to calculate the reduction. An audit of this is undertaken with 3% of all applications fully checked on site, with the results showing a great deal of honesty. In industrial areas, this is often more complex, and a greater amount of information is required, calculating the amount of impermeable area disconnected from the public sewer systems. Here staff members visited the sites as a previous attempt for self-certification through filling in forms was shown not to work. Currently there are 1200 non-residential properties registered as disconnected.

A dedicated programme of downspout disconnection was set up to remove roof water from the combined sewers

Figure 2 – Example of downpipe disconnection in Portland on a residential property.

Customer engagement was critical to the success of the disconnection programme (see Stakeholder and customer engagement section for further information). In one area it was made mandatory (but was not enforced by BES) which achieved a 50% uptake. The engagement was about 'raising awareness and selling the message' regarding the impact stormwater has on the rivers. Along with disconnection, other grants are also available such as a 'treebate' (Figure 3). (http://www.portlandonline.com/bes/treebates).

Customer engagement was critical to the success of the disconnection programme

Seattle provides a refund which is available for customers who reduce their inflows to the sewer, such as with raingardens, cisterns (self-draining water butts) and downspout disconnection. SPU operates a Rainwise programme where a one off payment of up to $4/ft2 is given to the property owner (depending upon infiltration rates and the type of measures installed. The work is mostly paid for by SPU depending upon the size of the area being drained. Seattle is currently undertaking a focused programme of works in one district, Ballard. This is to reduce CSO discharges. A variety of measures have been incorporated, including independent street side retrofits in grass verges, as well as integrated measures in the highway resulting in narrower carriageways.

Figure 3 – Front cover of the treebate leaflet.

Involving the public creates a sense of ownership

Green infrastructure measures such as street planters, bioretention areas and raingardens are owned by private individuals, private associations or the municipality. Green street measures (i.e. street planters) that are privately built transfer to public ownership after 2 years. Measures that are in private ownership are written into the deeds of the property. This was particularly challenging between 1999 and 2002 prior to a standardised process being developed and agreed. The process now makes the disconnection of property roof drainage far simpler (http://www.portlandonline.com/bes/downspouts).

Where the city assisted with measures for targeted private properties (see private property retrofit program) , the capital costs for such work had to be taken from a non-operational budget, as this was essentially capital expenditure on private land (as BES does not own the asset).

Although measures in the public right of way remain the responsibility of BES or SPU, residents take ‘personal ownership’ for the day to day maintenance of them. In Portland, ‘Green Stewards’ are trained in what to do and how to maintain measures such as street planters, and importantly what they should not do. This is unpaid voluntary work, but demonstrates the level of buy-in and support through good engagement with parts of the community (Figure 4 shows an established vegetated stormwater planter in an urban residential area, maintained by the local residents).

Residents take personal ownership for the day to day maintenance of the retrofitted measures

Figure 4 – Stormwater planter where the day to day maintenance is undertaken by the residents. They partially dictate the scale of plant growth.

In Seattle and Portland, to encourage the personal ownership and acceptance of the measures, the community have the opportunity to help select the type of plants from a selection list.

Engaging stakeholders and the public facilitates successful retrofitting

Both BES and SPU recognised the importance of early engagement with the community on green infrastructure. A key part of their success was fostering an internal culture so that green infrastructure forms part of the asset management approach. This was clearly evident during the meetings we had with BES and SPU, and the passion and belief of the individuals for this type of work. BES has worked hard on developing the right culture for over 6 years. This started by changing people's knowledge internally on the benefits of green infrastructure over traditional approaches through demonstration projects and effectiveness monitoring.

Engagement started from within to create and foster the right internal culture for green infrastructure

The engagement approach taken with customers and communities firstly aimed to help the public understand what the problem was, before engaging them on what the solution could be. This was achieved through frequent discussion and the provision of explanatory literature they were able to quickly identify the issues within each neighbourhood. This helped to overcome the view of '*not in my back yard'* for solutions. Once customers and communities understood the problem, there was a greater appetite for them to know what they could do and how much they could make a difference. BES looked to provide the connection between need and solution. SPU adopted a different approach and sought customer thoughts and ideas before presenting their own.

Understanding what is important to the communities and individuals before working out the solutions was critical to gaining support

The research prior to starting the engagement was very important. BES learnt that firstly they had to understand what was important to customers and communities. One way they achieved this was using focus groups (which established that the river was important to the public). The social infrastructure has subsequently been built in communities to help ensure that the community has well maintained facilities in 5-10 year's time. Again, the importance of the engagement to understand what motivates people is critical. This research was undertaken by Portland State University to understand what motivates people with respect to the right of way (outside of their property) and their own property.

In Portland, part of the social infrastructure is to create local ambassadors who are members of the local community. Educational programmes have been developed to communicate in different ways, creating a sense of community. This enables peer to peer education, which is often well received by members of the local community. This allows information to be easily shared. It also links with other social education programmes such as with schools and universities as well as some more non-traditional ways of engaging and learning include; art, street fairs, monthly newspaper adverts, cycling tours, school visits, (Shandas et al, 2010).

In Seattle, community engagement has been achieved through a variety of methods also. As well as holding forums and meetings, SPU have worked with advocacy groups such as Sustainable Seattle who want to build a better environment to raise the profile and explain the work. Community based social media marketing and articles in local magazines and the press have been used to engage the wider audience. The aim was to engage with as many people as possible. SPU recommended Fostering Sustainable Behaviour, a book by Doug Mckenzie-Mohr.

Having the right people in a team with the right skills is essential when engaging communities

The level of resources for community engagement and outreach (to communities to help them understand the problems and potential solutions) has grown substantially. In Portland, a team of 10 to 12 people now work on engagement. A key element was creating advocates and ambassadors on the projects which then created a more diverse team. Having suitable people with the appropriate skills and experience to this was important. Tailored engagement through a combination of engineers and social scientists was found to be a successful approach.

Messages, signs and symbols help explain the design and engage with the public

A key part of the design was the messaging and information boards displayed at many sites (Figure 5), explaining the work. This was seen at retrofit, new development and redevelopment sites. This applied to both the public and private measures built. For example, in Seattle, raingarden signs were displayed in private properties (Figure 6). Other messages or symbols were also used (Figure 7). BES provided a circular emblem to highlight this was part of the green streets programme. SPU, painted warnings next to highway gullies, with fish and pollution advice, to highlight where the outfall was, so encouraging people to think about what was discharged to their drainage systems and discouraging illegal discharges (Figure 8).

Figure 5 – Information board explaining the purpose of the planters and how they work.

Figure 6 – A 'Rainwise' sign where a resident has disconnected the roof, with water entering a raingarden.

Figure 7 – Badging of a 'green street' project in Portland.

Figure 8 – Example of raising awareness of the impact that pollutants can have in the local creek

The development of Seattle's first SEA (street edge alternative) street used a novel approach to gain community support. The SEA street is where SuDS have been retrofitted to manage all the stormwater along the street. The highway width has been reduced and re-aligned from a straight line to gentle bends. To gain interest, a competition was set up between 20 residential streets of housing where this could be built. The block with the most petitions won, with the street being retrofitted. It has a completely different look and feel compared with its neighbouring streets (Figure 9). Residents that we spoke to stated they were 'very happy' with the street. It was clearly an initial test bed for community engagement, as residents also commented that they could have been more involved with the design itself at the time, and stopped construction when high berms (raised soil) were being built (this subsequently changed the design). Many of the residents maintain the measures still, and the measures have matured with substantial plant growth.

Seattle used a competition to gain public interest for retrofitting green infrastructure

Retrofitting has not always been successful. This in part was due to the engagement approaches taken and the lack of engagement. During the construction process of measures in Ballard, SPU did receive complaints at the speed of construction and some residents were not satisfied with the performance of the measures. This resulted in negative publicity which has taken some time to overcome. An offer was made to remove measures where residents were not satisfied, and in some cases, this has taken place. It was recognised that the approach to engage with the residents was not best practice in some locations, and an improved process has been developed for future work. A lessons-learnt report following these problems was produced (SPU, 2011).

Figure 9 - Images at the junction of the SEA street. Left shows the view south, with no retrofit. Right shows the SEA street retrofitted with various SuDS measures.

Negative publicity can take substantial effort to overcome when applying new measures

Anecdotal evidence indicated that areas with a low socio-economic population were not seen as a barrier to downspout disconnection and retrofits on private property. It was often that more affluent people or those not local to the area did not want to be disconnected. BES's view was that the local people really understood the problem, and how they could play their own part in supporting the programme of work. This is a testament to the level of engagement previously undertaken to help communities understand what the problem was, and then how it could be addressed. In addition, the incentivisation of reduced sewerage and stormwater rates helps to offset the increases in the rates. Language was not seen as a barrier in communicating with the community (with multiple language leaflets for example). An important part of the engagement process was the engagement with the schools and pupils, involving them with green infrastructure based activities.

The engagement process included schools and community groups

In Portland, properties are tagged so when a home is sold, it can be explained to residents the reason for disconnection and why they should not reconnect. However, there are still a number of obstacles that frequently occur. In Portland, some disconnected properties were re-connected when being sold, a practice encouraged by estate agents. It was also discovered that some new owners reconnected downspouts due to personal preference. In Seattle, sensitive issues that created a 'resistance to change' were a reduction in car parking, the perceived health and safety risk, and a change in the aesthetics and local urban design. These have generally been overcome through good and continuous engagement. However this often takes some time to achieve.

Good engagement can help overcome important issues to residents such as parking and health and safety

Measures are selected that suit the local conditions and location

A range of measures are used by BES and SPU depending upon the local conditions and constraints. New development follows a 'Low Impact Development' approach, which requires, by default SuDS measures to be used. The type of SuDS depends upon whether infiltration is possible (and to varying degrees of infiltration). The sites visited included new development, redevelopment and retrofit.

Typical measures used included:

- Green roofs (on residential, commercial and 'out' buildings)
- Downspout disconnection, flowing into a cistern and then to raingarden
- Swales
- Detention basins
- Wetlands
- Tree planting
- Downspout disconnection, flows direct to garden
- Bio retention areas / street stormwater planters (infiltration and under-drained)
- Hard channels and rills
- Retention basins
- Permeable and porous
- Infiltration basins

Permeable pavement was used infrequently in Portland, as there was concern with performance and maintenance requirements, as well as recognising, in comparison with other measures, the higher cost to construct in the retrofit scenario. Seattle has started to use porous and permeable pavement. Feedback indicated they were structurally ok, although the construction of them was critical, such as the sub-base. Figure 10 shows a porous paving approach for off street parking, where the stone filling had to be occasionally replenished. Modular geo-cellular storage systems were not used. There was also a general move away from detention/retention basins in isolation with more distributed measures.

The primary focus for the measures used targets improved water quality in rivers by reducing the CSO spills. However, these measures also contributed to flood risk management. The types of measures chosen in particular provided natural treatment of stormwater runoff.

Trees are an important green infrastructure measure that provide a wide range of benefits

In some areas, SuDS were used as a 'top up' to a conventional system, whilst in others, they formed a key part of the strategic approach to meet the driver such as for flooding (e.g. Tabor to the River) or for sewer rehabilitation. In Seattle, tree planting is seen as an important aspect to capturing water even before it lands on the ground whilst providing a wide range of other benefits. For example, a single mature tree with a 30 foot crown can intercept over 700 gallons of rainwater annually with evergreen trees capturing more rainwater in winter months than deciduous trees.

Figure 10 – example of porous paving for car parking in a redevelopment area

The trees capture and hold rainfall in leaves and branches, helping to slow the runoff and can decrease stormwater volume by 35% or more for small storms (City of Portland, 2006). Trees improve water quality by filtering water and holding soils in place. Their shade reduces footpath heat, which in turn lowers run-off temperature. Tree pits can provide additional benefits by accepting run-off from footpaths or other paved areas. Trees provide the greatest stormwater and environmental benefit when their canopy covers impervious areas and intercepts water before it hits the ground. BES also indicated that they had seen an increase in property value of $7.5k on average where tree planting had taken place (USDA Forest Service, 2008).

SPU differentiated property management measures that intercepted downpipes and stored rainwater. Rain barrels (water butts) stored water for personal use such as gardening. These did not qualify for a discount. Cisterns temporarily stored the water and slowly released a consistent rate of flow to a private raingarden (Figure 11).

Figure 11 – Two cisterns intercepting downpipes on a large residential building. One discharges via a pipe to the raingarden and one via a covered stone trench.

Cisterns typically hold 200 gallons (757 litres), and recently SPU has been looking at 620 gallon (2346 litres) cisterns. This would allow a proportion to be used for personal use, with the remainder released to a raingarden. In addition, the larger size would cope with rainfall that can typically lead to flooding.

Cisterns and raingardens are used on private property to enable roof water disconnection from the sewers

The individual measures contribute to the overall system performance

A performance criteria approach is used for the stormwater drainage. For water quality, CSOs have agreements on the number of spills per year. This varies between municipalities on the local agreement with USEPA. For flooding a 1 in 25 year return period standard is applied for the below ground system performance.

There were no specific design standards (in terms of level of service) for the measures constructed (e.g. 1 in 25). Standards were used for the level of infiltration, where this was a design feature. Measures reliant on permeability were often (but not always) tested prior to installation. Typically a minimum of 2 inches per hour rate was required for the local infiltration rate. It was also expected that the filter material would be refurbished during the lifetime of the measure. There are many measures that enable infiltration into the ground. Currently it is unknown as to whether these measures have increased infiltration into the sewer system, as it was accepted that this must have happened to a degree.

Design guidance provides consistency and clarity

In the retrofit scenario, the existing drainage system remains in place to take excess flows when the measures were overwhelmed. The exceedance design was found to vary. Many of the measures were designed with an ‘escape route’ for excess flow. Even private raingardens in Seattle were designed to this. A common failure receptor for the measures was for flow to be deliberately steered to a gully. For larger measures, such as the wet pond in High Point, Seattle, a 1 in 500 year return period standard had been used.

BES and SPU have developed stormwater design guidance which was made available (e.g. Figure 12). In Portland, the guidance is updated regularly, incorporating lessons learnt. It is expected this will continually evolve. There was a general view that the measures were over engineered which provided a greater level of redundancy or if there was a partial failure.

With the removal of surface water, there was no known connection or link with sewer blockages (as a result of low flow). Disconnections had reduced basement flooding, as a common flooding mechanism was water escaping from broken defective gullies close to the property.

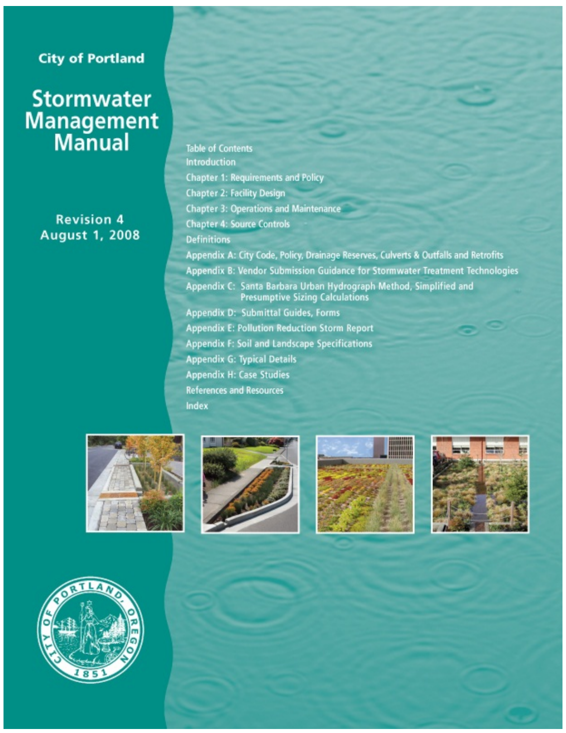

Figure 12 – Portland's stormwater management manual

Standard designs enable measures to be designed and constructed

Seattle were taking a strategic approach to retrofitting, working on key areas, such as Madison Valley (where there was a history of flooding) and Ballard, where CSO spill reduction was a key driver. In Portland, this had been more opportunistic and quite widespread (retrofitting sites where possible – which when infiltration was achievable provided good benefits). However more recently, they were focusing on smaller defined areas, such as the Tabor to the River catchment.

Strategic and opportunistic retrofitting approaches have both been successfully applied

The level of pre-investigation varied across the sites. Different types of measures had produced mixed results in performance, in part due to the ground conditions. In some places, the expected infiltration was not achieved. Infiltration is very dependent upon a range of factors allowing for ground slopes, topography, soils and below ground conditions. Therefore local variations in soils can lead to measures that do not perform as expected. In a few cases, measures were removed as result of poor performance and in part due to the level of engagement that had taken place at the time (discussed in Stakeholder and customer engagement). An example of this is shown in Figure 13. In some situations, the roadside street planters were being turned into swales for conveyance purposes. During a meeting with Eric Strecker of GeoSyntech, The Orange County website (http://www.ocwatersheds.com/) was referred to for good guidance with regards to permits, infiltration and BMP design for a flood risk and water quality management perspective.

Figure 13 – Location where the measures had been removed. Note the kerb inlet blocked and recently filled in earth next to the kerb. Also, the hazard sings required in Seattle (top right).

The type and size of the measures being constructed relate to the design approach and sizing methodology. BES use a simplified, presumptive or performance approach accounting for small, to medium to complex or large retrofits. However, all measures must be designed to accommodate exceedance. The BES (2008) (http://www.portlandonline.com/bes/swmm) and SPU (http://www.cityofseattle.net/util/About_SPU/Drainage_&_Sewer_System/GreenStormwaterInfrastructure/index.htm) design manuals provide guidance on how to undertake the different levels of design and the amount of pre-investigation required.

In Portland, there was limited evidence of individual hydraulic modelling for design, as the measures followed a standard design. BES confirmed that all the measures (and contributing areas) were added into their hydraulic model to replicate and simulate the benefits of retrofitting.

An advantage in the USA is the hierarchical utility order of water, wastewater, and gas and electricity hierarchy. This means that SPU could have other services repositioned at that utilities cost. As a result of this, this approach is being reviewed because of cost to those utilities. Generally, green infrastructure measures, such as street planters were built over utilities, as long as there was the acceptable clearance from ground level to utility. Where there minimum amount of cover was provided, the services did not have to be moved and no extra protection was required.

Eric Stricker highlighted concerns of the historical water balance and biofiltration, with the potential future problems that may result. There are on-going discussions in the USA as to how much water can be retained on site. Infiltrating more water than would occur naturally may change the habitat. e.g. an ephemeral stream system can develop habitat and unwanted biodiversity which alters the original habitat. Groundwater modelling is being used to consider this. A good example of this is the City of Fresno, California, who infiltrate 90% of surface water runoff. This infiltrates into the aquifer providing water resources below the city. They actively manage the organic soil layers so most pollutants are trapped within the first few inches. Using this approach they found that the infiltrated water was of a better quality than from normal greenspace. Eric highlighted that it is more important to worry about pollutants that are mobile (e.g. road salts and grit). .There were cases where some pollutants (e.g. mercury) were emerging because of the anaerobic conditions created. This highlighted the importance of selecting the type of media under the planting zone. Research into the performance of biofiltration media has been undertaken by Pitt and Clark (2010).

The detailed design of the measures was instrumental in them being a success visually and for performance. There was a noted conflict between the aesthetic appearance, and what works best, in providing treatment. Some residents preferred less planting, others more. In Seattle, this all forms part of the engagement process. In Portland, the design was now dependent upon the designer, with varied levels of quality of design. This includes both the structural and civil design of street planters as well as the type of planting selected. In some areas, the kerb side bioretention areas failed on minor detail (Figure 14) such as wooden pegs to hold a plastic strip to keep stone in place (acting as an informal kerb path).

Figure 14 - bioretention area where a plastic strip (in the foreground to the left) was held in place by shallow wooden pegs, likely to degrade and break allowing stone against the kerb to fall away.

Other areas of poor design were seen at inlets and outlets, both in terms of entrance approach and level. Figure 15 shows the entrance to a planter, where flows do not enter in straight, and hence require the extra block to direct flow into the planter. Later designs allow flows to pass straight along the existing kerb and into the planter.

The aesthetic designs varied creating different visual impacts. Some measures appeared to 'fit in' to their surroundings and the existing urban context better than others. For example Madison Valley in Seattle had evolved over time from initially a simple detention basin to now being a more attractive park (Figure 16). At Mount Tabor School in Portland, the measures appearance and design matched the location. Other examples show where art has been used to celebrate and demonstrate the management of storm water (see Figure 17, where rainwater comes down a chute to a raingarden). The level of maintenance was a key aspect in the visual appearance.

Measures can be designed to fit in and enhance the existing urban context

Figure 15 – Entrance detail to a street planter. Note the added raised shallow kerb to try and divert flow into it.

Some measures were visually impacted by road safety requirements and markings. Such as in Figure 18 where the kerbs are painted yellow for no parking, or the use of hazard signs in Seattle on bioretention areas in the highway (See Figure 13).

Many of the measures were under-drained, which particularly for grass lined swales improved their aesthetic appearance. Earth berms were used to keep water higher (on sloping sites) and trees (and their surrounding area) were also used to perform this function. Specifications have been developed for the topsoil and filter media (including a certain percentage of fines passing through certain sieves). Different types of planting were used dependent upon the hydraulic design, e.g. would the planting be frequently submerged. Seattle designed for 50mm of standing water in grassed swales, where-as 250mm of standing water was appropriate in planted areas.

Figure 16 – Madison Valley multi-functional flood storage area and local park.

Some measures in Portland had vertical drops of up to 0.3m (Figure 18), although there was no reported health and safety related incidents. Planting was often varied, and there was little concern over invasive species. For example, with green (eco) roofs, weeds were not perceived to be a major problem, and dealt with during maintenance visits.

Little concern was expressed over alien species which could be managed through regular maintenance

Figure 17 – Chute with fish that directs rainwater into a private raingarden. The business owners were proud to celebrate their part in managing water in Portland.

Some measures in Portland had vertical drops of up to 0.3m (Figure 18), although there was no reported health and safety related incidents. Planting was often varied, and there was little concern over invasive species. For example, with green (eco) roofs, weeds were not perceived to be a major problem, and dealt with during maintenance visits.

Figure 18 – street planter in Portland with yellow kerb to indicate no parking. Note the relatively high drop close to the exit from the school steps. Also the planting is protected until more substantially grown by the barriers in front of the inlets.

Many of the sites in Portland had been installed across a wider area where the removal of flows from the sewer system would make a difference (in CSO spill reduction), but not necessarily in a strategic manner (e.g. picking off street by street). However, over 1000 bioretention /street planters have now been constructed across Portland. The downspout disconnection programme had targeted areas specifically where the improvements were required, with over 56 000 downspouts on over 26 000 properties being disconnected. In the Tabor to the River project, a more structured approach to retrofitting is now taking place. In Seattle, streets were targeted more specifically to reduce inflows into the existing system.

Over 1000 bioretention street planters have been built and 56 000 downspouts have been disconnected

Connectivity between measures across driveways and junctions was achieved through shallow, grated channels (Figure 19) or more simply with a small diameter pipe beneath a driveway crossing.

All the disconnection locations are logged within a GIS data base. This is critical to be able to model them and record any maintenance issues with the owners. All the properties disconnected are modelled, to replicate the predicted benefits within the sewer system.

All measures are logged in a GIS data base

The design of property disconnection varies. In Portland, no pre-survey work was undertaken. No bespoke permits are required, as a standard system has been developed (similar to UK building regulations). This took some time to develop at the start of the disconnection programme, but once in place has simplified the process (available on Portland's website (http://www.portlandonline.com/bes/downspouts). Not all properties could be disconnected, such as historic buildings. Seattle undertook a greater involvement in the design and construction of the measures. Raingardens were positioned 2ft away for every 1ft deep, and had to be a minimum of 5ft away from the building.

Figure 19 – Grated channel to pass flows under driveway

Both Portland and Seattle had tree and vegetation guidance. This guidance contains a small number of trees that are appropriate to plant. This is to limit the impacts on below ground infrastructure.

Selecting the appropriate measures for different land use

A range of measures were constructed across different land uses. However, from the visit it was apparent that certain measures were more commonly used for specific land use types. For example:

- Street planters / bioretention areas were used in highways both in built up downtown areas (Figure 20) and residential.
- Street planters / bioretention areas in pedestrian areas to take flow from the footpath as well as connected downspouts.
- Retrofit green and eco-roofs were used across downtown areas, and new/re development elsewhere on commercial buildings and flats, designed to provide a balance between aesthetics and functionality.
- Hard channels and rills (Figure 21) Swales (Figure 22 and Figure 23), detention basins, wetlands, retention basins, infiltration basins, were used across larger areas, operating as more of a network (source-pathway-receptor approach) to manage flows from streets.
- Downspout disconnection to a rainwater cistern, to ground or a raingarden took place in residential areas, including some larger properties.
- Bioretention was commonly used for car-parks and commercial properties

Figure 20 – Street planter in downtown Portland

Certain measures are more commonly used for specific land use types

Whilst most measures enhanced the amenity and bio-diversity, some measures clearly were multi-functional, such as in Seattle in Madison Valley where a small park doubled up as a detention basin for surface water sewer surcharge during heavy rainfall events providing stormwater storage of 1.7 million gallons or 6435 m3 (see Health and Safety section).

Some highways had been designed with a single cross fall to one side of the street. No kerbing was present, allowing sheet flow rather than point source flow into a bio-infiltration swale (Figure 23). This was applied in a residential area.

Some measures are clearly designed to be multi-functional

Different professions are aware of the importance of green infrastructure. Architects recognise they can make a difference and will work with the owners of properties or for new development (this is supported by the local legislation with regards to new or redevelopment). The architects have the opportunity to change the views and perceptions of the developed.

Figure 21 – Rill to take flow to a detention area fitting in with the local urban design.

Figure 22 - Shallow swale in a street, with simple driveway crossing in the verge and trees in close proximity

Figure 23 – Sloping carriageway towards a bio-infiltration swale

Frequent maintenance can be undertaken by the public

Maintenance varied dependent upon the type of measure and who owned them. Measures on private property were typically the responsibility of the private owner. Those located in public open space were the responsibility of the municipality. However, in residential areas, the general public often took on the day to day maintenance of some of these measures, such as planters. In Portland, 'Adopt a green street programme' enables the public to take responsibility for the measures. From the sites visited, there was clear evidence that such maintenance did take place. The level of maintenance was limited to tasks such as litter cleaning and vegetation management. Silt removal and general repairs remained the responsibility of the local municipality due to the potential contaminants from highway runoff.

However, some residents still removed silt and sediment such as in Figure 24 (where the public regularly removed sediments from the fore bay).

The public took responsibility for day to day maintenance of measures, as well as keeping gullies clear

In Portland, indicative maintenance allows for 4 times per year for many measures (classified as 2 major and 2 minor). However, typically, it is on a needs basis once they are constructed. Despite having substantial experience in this area, it was still recognised that they were still learning about the level and frequency of the maintenance. This was important as the requirements for the same types of measures can vary between the sites.

The maintenance had also helped to amend the design detail for different types of measures. In particular, inlets were a key issue, typically either blocking or diverting the flow away from the inlet, such as shown in Figure 24 and an improved design, in construction at the time of the visit in Figure 25.

In Seattle, the public are also a critical part in maintaining assets and reducing the risk of flooding. Seattle has a campaign called Taking winter by storm (http://www.seattle.gov/util/Services/Drainage_&_Sewer/Keep_Water_Safe_&_Clean/AdoptADrain/index.htm). This provides guidance on how the public can be prepared for winter. It also includes how the public can Adopt-a-drain. This enables individual gullies to be kept clear of leaves and debris to enable stormwater to enter them during heavy rainfall.

Figure 24– well established street planter inlet, with a concrete sediment bay. Note the re-profiling of the highway to divert flows into the planter.

Seattle jet washed their permeable pavements annually to remove moss. Seattle had undertaken studies to assess their maintenance requirements and performance (D'Onofrio, 2009). The general opinion though was that they were better as footpaths, with highways being of traditional construction. In a redevelopment of social housing at High Point, SPU worked with the housing association who undertook the majority of maintenance. Asset failure and renewal remain the responsibility of the SPU.

Seattle also used the Conservation Corps (which provides work within training for young people) to undertake maintenance. There was a general view that this service cost more but delivered a lower quality. One aspect was the level of supervision, as well as the ownership of the individuals for the work they were undertaking. This has resulted in some poor maintenance and repeat work.

Figure 25– street planter in construction during the visit. This shows the updated design for flows to enter along the kerb line, and wider inlet to reduce blockage likelihood.

Managing health and safety enables water to be on the surface

There was a perceived difference in the level of acceptable risk between the locations visited and UK practice. Some measures already highlighted had substantial drops to the soil level from ground level that could be considered a trip or fall hazard (such as shown in Figure 18). This was surprising due to the culture of litigation. However, there were no apparent health and safety reported problems as a result of such designs.

Retention and detention basins were used to manage surface water. The detention basin in Seattle at Madison Valley, was also a recreational park. During heavy rainfall events, water levels will rise within the park. Signs were clearly displayed around the entrances to the park, highlighting that it could fill with surface water during heavy rainfall (Figure 26).

Figure 26 – Detention basin in Madison Valley, where the surface water sewer surcharged and spilt into the basin. Clear signage was used to show the potential danger.

One concern was the concentration of pollutants within silts and sediments. These were regularly tested to ensure that pollutants were not accumulating to dangerous levels. Road salt or grit is not used to combat snow, rather sand and gravel is preferred as this impacts less on the soils.

Once constructed, many of the measures were tested, both for every day events and more extreme events. To achieve this, simulation was often undertaken, using water from hydrants or tankers to test its performance

Pollutant testing was undertaken to understand potential impacts on the soil and when they would build up

A whole life cost approach used is evolving to consider a wider range of benefits

The assessment of the benefits of retrofitting GI appears to stop short of the triple bottom line analysis as seen in other cities in the USA such as Philadelphia. Triple bottom line analysis assesses the social, environmental and economic impact (positive and negative), in this case of retrofitting SuDS.

BES had started to look at benefits in more detail, undertaking a global survey of economic assessments. Their current approach quantified benefits using metrics rather than money. For example, BES investigated moving from grey to green infrastructure and quantified what the benefits would be through this approach, although these were not monetised. BES had previously come from a cost avoidance approach in the longer term, by providing longevity to the existing assets and less pressure on their use.

A range of benefit assessment approaches were now being used, including monetisation

However Portland's benefit assessment approach is changing as they look to move to a risk management approach and linking back to the levels of service they provide. A key aspect of this is considering reactive against proactive risk, to mitigate the need for future investment by using green infrastructure. BES are currently developing a decision support tool to help identify what to use and where, which will be underpinned by economic analysis.

As part of the Tabor to River scheme, an area of 200 acres was identified as requiring major combined sewer rehabilitation with an estimated cost of $144M. A cost analysis for the provision of green facilities - infiltration and vegetation was $11m. Remodelling and costing the remainder of the network came to $75M for rehabilitation, demonstrating that adopting a mix and match approach to grey/green infrastructure the total cost was reduced from $144M to $86M. They have also developed a pipe grading system for crisis (red, yellow, green) and have demonstrated that by removing surface water they can defer infrastructure investment.

In Seattle, SPU have been assessing the costs and benefits of GI for a number of years. Their focus is typically on cost effectiveness rather than a full cost benefit analysis. Some benefits were monetised, whereas others were not and were assessed using a multi-objective decision analysis (MODA) approach. For example at Madison Valley, a higher cost solution (by $10M) was adopted based on the subjective analysis of a societal and environmental evaluation, due to the increased benefits. The analysis is underpinned by a number of assumptions in this area, rather than in most cases documented evidence.

Two papers were received that investigate the Lifecycle costs of GI for the CSO Long term control Plan and Programme Business Case – RainWise Programme. The first identifies that working on private land through the use of disconnection, cisterns and raingardens is more cost effective than working in the right or way (typically highway and verge). The second document identified that a CSO focused Rainwise Programme (cisterns and raingardens) is more cost effective than traditional solutions in terms of $/gallon.

In the assessments completed, there has been some sensitivity analysis. This focused on changing the discount rate (when assessing whole life costs or benefits) from 3% to 5%. Other assumptions have not been assessed to date.

Constructing measures in private land is as important as in the public domain

In Portland, BES provides advice and support to disconnect downspouts as the work is undertaken by the property owner. BES checks a small percentage of disconnections completed on residential properties and all disconnections on non-residential properties. Measures constructed in public open space are inspected by BES post construction and compared with the original design. During the visit a number of street planters were observed being constructed (Figure 25). The construction appeared to be of high quality and robust.

In Seattle, SPU contractors work with the individual property owners to design and then build a raingarden and cistern. SPU also employs a half full time equivalent to undertake inspection of the disconnection once complete to ensure it complies with their standards. In public open space, the existing GI is considered important, and a survey is undertaken prior to work commencing. For example trees are protected and given an appraised value. If contractors damage the existing GI, they have to pay for the damage.

Monitoring plays an important part in understanding the long term performance

Performance monitoring takes place on a small number of measures (e.g. street planters, green roofs). This typically focuses on flow, and not water quality. Portland carry out post project monitoring generally for 2 years and spend an estimated $100k per year on long term monitoring. As part of this, a research budget was provided.

Monitoring information is available in numerous reports (e.g.: City of Portland, 2010). Eric Strecker advised that the BMP (Best Management Practices) database (http://www.bmpdatabase.org/) contains further information globally and should be reviewed. This includes guidance on how to plan and undertake SuDS monitoring, as well as monitoring data and published papers.

Monitoring occurs on a small number of measures to test their performance over time

In Seattle, the analysis of the sediments and silts removed is the responsibility of the certified haulage companies who undertake the toxicology analysis. These are passed back to the SPU to understand the implications. There was awareness that there could be a pollutant issue with some compost allowing phosphate release, however this subsided after a couple of years.

Success and failure drives learning and improvement

Both BES and SPU were happy to share and discuss their successes and failures. Failures were clear learning opportunities, both from a technical as well as from an engagement / social interaction perspective (e.g. Seattle Lesson Learnt Report).

Technical failures were often down to small but important detail, such as the inlet to planters. There were a small amount of instances were site investigation had not been undertaken and infiltration was not successful.

In Portland, of the 56,000 downspout connections from 26,000 properties there have only been 27 claims for water in the cellar with each claim being less than $1,000. The reason for failure was due to infiltrating to close to the property.

Failures were used as learning opportunities

Failure (or acceptance of the measures) was more likely to occur when the level of engagement fell short of standard practices. This had happened in Portland and Seattle, and indicates the importance of stakeholder and customer engagement. For example in Portland, where good engagement had been undertaken, there was a good response to 'voluntary' disconnection. In Seattle, where limited engagement had been undertaken, there were 'pockets of resistance' to the measures, as this has resulted in some measures being removed.

Seattle viewed that Portland were far greater at celebrating success and publicising the good work they do than themselves. They recognised they needed to work harder at this to promote their work.

Portland are recognised as world leaders in retrofitting, having a high global profile through international engagement. This has been underpinned by their approach to trialling retrofitting, their programmes of building measures and the dissemination and sharing of knowledge.

RETROFITTING SUDS IN THE UK?

The opportunities to retrofit SuDS in the UK are similar to that in the USA. The retrofitting successfully achieved in Portland and Seattle clearly demonstrates that it is possible to retrofit SuDS measures in the public right of way and on private property. Many problems and barriers perceived in the UK have been overcome, and many of the lessons and approaches taken in the USA can be transferred to the UK. An example of this is how building regulations were overcome through developing an acceptable design code to enable residential private property retrofits. Using this knowledge (that is freely available and shared) will be vital if the UK is to also become successful in retrofitting.

Many of the conditions (including funding, legislation, and environmental regulation) are similar to the UK. Despite the perception there is greater space, retrofitting has successfully been applied in dense urban areas, as well as common challenges being overcome (e.g. reduction in parking, building regulations).

There are notable key differences though such as the approach to incentivisation, long term control plans (e.g. over a 25 year period for strategic work), the assessment of wider multiple benefits and the acceptance and understanding of the level of engagement required to make retrofitting SuDS a success. All of these can be successfully overcome. However failure to address some areas may limit the uptake of retrofit SuDS, in particular to address the drivers and deliver the outcomes that Water and Sewerage Companies are tasked with.

The aim of the visit and this report was to highlight the key lessons and insights collated during the visit to Portland and Seattle. The next step will be to build upon these lessons and outline where and how these can be applied within the UK to help overcome barriers to implementation.

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APPENDIX A
DOCUMENTS COLLECTED

The following documents were obtained from Portland and Seattle during and after the visit. These are located in the folders that are associated with this report and available on a separate CD. Numerous other documents are available from their websites with key starting points presented below:

- Portland's website; A sustainable approach to stormwater management

  http://www.portlandonline.com/bes/index.cfm?c=34598

- Seattle's website; Green stormwater infrastructure

  http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/GreenStormwaterInfrastructure/index.htm

Reference	Report Title	Keywords	Date if known	Where from	File name	File location
A1	International Stormwater BMP Database	BMP Database	unknown	Web Page	http://www.bmpdatabase.org/	n/a
A2	Technical guidance document for the preparation of conceptual/preliminary and/or water quality management plans (WQMPs)	Design guide	May-11	Orange County	OC_TGD_5-19-11[1].pdf	Orange
A3	Natural Treatment Systems Design Guide	Design guide	2005	Irvine Ranch Water District	Natural Treatment Systems	Other
A4	Evaluation of Biofiltration Media for Engineered Natural Treatment Systems	Research	May-10	GeoSyntec h	techreports_10-10-19_FinalMediaReport051010[1].pdf	Other
P1	Portland's Green Infrastructure: Quantifying the Health, Energy and Community Livability Benefits	Benefits	2010	Portland	Grey to Green Benefits Full Report[1].pdf	Portland
P2	Barrington Square Apartments	Case study	2004	Portland	Barrington Square Apartments.pdf	Portland
P3	Flow Test Memorandum - Glencoe Raingarden	Case study	2004	Portland	Glencoeflowtest 20041026final.pdf	Portland
P4	Flow Test Report - Siskiyou Curb Extension	Case study	2004	Portland	Siskiyou Flow Test 20041026final[1].pdf	Portland
P5	Laad Tower Eco Roof	Case study	unknown	Portland	LADD Report minus techtable.pdf	Portland
P6	Page 19 LCC	Case study	2004	Portland	Page19 Warehouse Parking Lot.pdf	Portland

Reference	Report Title	Keywords	Date if known	Where from	File name	File location
P7	Raingardens for Existing Impervious Area Located in Eastside Combined Sewer Basins	Case study	2011	Portland	Web Raingarden Program Guide 120111[1].pdf	Portland
P8	Route to the river - SE Clay Green Street Community Design Plan	Case study	2009	Portland	Route to the River.pdf	Portland
P9	South West Montgomery Green Street	Case study	2008	Portland	SW Montgomery Green Street Plan[1].pdf	Portland
P10	Tabor East Apartments	Case study	2004	Portland	Tabor East Apartments.pdf	Portland
P11	Climate Action Plan	Climate Change	2009	Portland	CAP_Status_Report_2010_WEB[1].pdf	Portland
P12	Downspout Disconnection Factsheet	Design guide	2011	Portland	How to manage stormwater_Downspout Disconnection_2011.pdf	Portland
P13	Green Street Construction Guide	Design guide	unknown	Portland	Green Street Construction Guide[1].pdf	Portland
P14	Rain Barrels Factsheet	Design guide	2011	Portland	How to manage stormwater_Rain Barrels_2011.pdf	Portland
P15	Sewer and Drainage Design Manual	Design guide	2007	Portland	2007 Sewer Design Manual.pdf	Portland
P16	1% for green supports construction of Green Street facilities	Financial	2008	Portland	one percent for green.pdf	Portland
P17	Portland’s StormWater Marketplace	Financial	2007	Portland	2007 CNS Presentation.pdf	Portland
P18	THE EFFECT OF LOW-IMPACT-DEVELOPMENT ON PROPERTY VALUES	Financial	2008	Portland	Property values and NDS_05A_Bruce_Ward.pdf	Portland
P19	2010 Stormwater Management Facility	Monitoring	2010	Portland	2010 Monitoring Report SUMMARY REV.pdf	Portland

Reference	Report Title	Keywords	Date if known	Where from	File name	File location
	Monitoring Report Summary					
P20	Stormwater Management Facility Monitoring Report	Monitoring	2008	Portland	2008 Stormwater Management Facility Monitoring Report.pdf	Portland
P21	Non Residential Stormwater Permits	Permits	unknown	Portland	5.6.10 FINAL nonres stormwater permit factsheet.pdf	Portland
P22	Post 2011 Combined Sewer Overflows Facilities Plan	Planning	2010	Portland	C-CSO[1].pdf	Portland
P23	Recommended Draft Portland Plan	Planning	2012	Portland	Recommended Draft Portland Plan 3.9.12 TEXT[1].pdf	Portland
P24	Stormwater Management Plan	Planning	2011	Portland	April 2011 Stormwater Management Plan.pdf	Portland
P25	Soils	Soils	2009	Portland	20111109_Soils_&_Mulch__METRO_O&M.pptx	Portland
P26	Green Street Cross Bureau Team Report	Summary	2006	Portland	cross-bureau team report_may06.pdf	Portland
P27	Vegetation Survey Report for Landscaped Stormwater Management Facilities	Vegetation	2007	Portland	2007_veg_assessment_report2.pdf	Portland
P28	City of Portland Stormwater Management Manual	Design guide	2008	Portland	2008_SWMM_CD	Portland
P29	Tabor to the River Program An Evaluation of Outreach Efforts and Opportunities for Engaging Residents in Stormwater Management	Engagement	2010	Portland	Tabor to the River Outreach.pdf	Portland

Reference	Report Title	Keywords	Date if known	Where from	File name	File location
P30	Trees	Engagement	2006	Portland	Trees.pdf	Portland
P31	**The value of street trees in Portland, Oregon**	Research	2008	USDA Forest Station	Tree research.pdf	Other
S1	Madison Valley Stormwater Project	Case study	Unknown		MV Project Briefing for Australian Delegation 9-14-11-Final.pptx	Seattle
S2	Ballard Roadside Raingardens, Phase 1 – Lessons Learned	Lessons learnt	Aug-11	Seattle	Ballard Roadside Raingardens, Phase 1 – Lessons Learned.docx	Seattle
S3	Life-cycle cost of Green Stormwater Infrastructure for the CSO LTCP	Life cycle assessment	2011	Seattle	Appx J-2 GSI Economic Analysis Report for LTCP.ForEPA&Herrera.8.31.11..docx	Seattle
S4	Green stormwater operations and maintenance manual	Design guide	2011	Seattle	NDS O&M Manual.pdf	Seattle
S5	NDS Landscape Maintenance Categories (LMC) and Characteristics Checklist	Design guide	unknown	Seattle	NDS Field Checklist.pdf	Seattle
S6	NDS KPI Reporting Form	Monitoring	unknown	Seattle	NDS O&M KPI.pdf	Seattle
S7	High Point Community Natural Drainage and Landscape Maintenance Guidelines	Design guide	2010	Seattle	High Point Maintenance Guidelines.pdf	Seattle
S8	Practically Easy Landscape Manual	Design guide	2005	Seattle	Practically Easy Landscape Manual.pdf	Seattle
S9	landscape Maintenance and Calendar Guide	Design guide	unknown	Seattle	landscape Maintenance and Calendar Guide.pdf	Seattle

Reference	Report Title	Keywords	Date if known	Where from	File name	File location
S10	Plant identification	Design guide	unknown	Seattle	Plant Identification.pdf	Seattle
S11	Environmentally Critical Areas - Best Available Science Review Supplemental Report)	Scientific review stormwater management	2009	Seattle	bas review_final_30jun09_latestreleased_dpdp017711.doc	Seattle
S12	RAINWISE REBATES A WIN FOR RESIDENTS	Rainwise programme	unknown	Seattle	Rainwise rebates.pdf	Seattle
S13	RainWise Rebate Overview	Rainwise programme	2009	Seattle	Rainwise overview.pdf	Seattle
S14	RainWise - Managing stormwater at home	Rainwise programme	2009	Seattle	Rainwise guide.pdf	Seattle
S15	Rainwise detail sheet 4 to 8c	Rainwise programme	2011	Seattle	Rainwise Detail Sheet	Seattle
S16	Infiltration test and certification	Rainwise programme	2011	Seattle	infiltration test form.pdf	Seattle
S17	How to start a RainWise project	Rainwise programme	2011	Seattle	how to start a rainwise project	Seattle
S18	RainWise Homeowner Frequently Asked Questions	Rainwise programme	unknown	Seattle	faqs.pdf	Seattle
S19	Contractor Overview	Rainwise programme	2010	Seattle	Contractor overview.pdf	Seattle
S20	Cistern Warranty	Rainwise programme	2011	Seattle	Cistern Warranty.pdf	Seattle
S21	RainWise Detail Sheet 9 to 12	Rainwise programme	2011	Seattle	Cistern Detail.pdf	Seattle
S22	Porous pavement evaluation of cleaning methods and recommended BMPs	Maintenance	2009	D'Onofio	Porous pavement maintenace.pdf	Seattle

APPENDIX B
AREAS OF FOCUS BY UK TEAM

Regulation and Legislation (Drivers)

- To gain a clear understanding of the underlying reasons for changing the Municipalities' approach to managing surface water.
- Are there different regulatory and/or legislative drivers that apply for new development, brown field development, regeneration and retrofitting into existing areas.
- How was/is the evidence base and needs established to move to a wider surface water management approach

Funding and future strategy

- How are SuDS (LID) funded and costs generated at a programme level for predicting future expenditure,
- Does your approach encompass total water cycle management?
- How are price limits set for customer bills, and what level of justification and engagement are required?
- Have you demonstrated that through using surface water management measures, you have been able to defer other future infrastructure investment and upgrades?

Incentivisation

- What form of incentivisation has been used with customers, if any for retrofitting and surface water management, and how did this work?
- What engagement was undertaken to facilitate this?
- Did this have any regulatory or other cost implications and how were these assessed?

Ownership

- How have you agreed ownership and responsibility of different SuDS?
- Are SuDS in public and private ownership (including land ownership)?
- Are there any maintenance agreements in place to ensure they continue to function as designed?
- What is your approach to reviewing and testing new systems and products?

Stakeholder and customer engagement

- What has been (if any) society's attitude to surface water management, particularly relating to increased individual costs through bills?
- What evidence base was collected to support a surface water management approach?
- What societal issues were identified and how these were overcome?
- How has society as a whole (particularly the general public) been engaged, through what approach and processes, and what lessons have been learnt?
- What approaches were used to change attitudes and perceptions to managing water on the surface?
- Is it possible to meet with and talk to residents to learn their views when first measures and changes were first proposed, how they feel now, and how do they make best use of the measures? If not, are there any summaries or reports, that capture this?
- How have the relationships with other Authorities and stakeholders changed or adapted through taking a surface management approach?

Performance (Levels of service)

- Gain a clear picture of how the performance characteristics (hydraulic and water quality) and maintenance requirements of individual measures are understood and assessed?
- What design specifications and guidance manuals are followed?
- What design standards are in place to confirm size, type, design, planting, construction etc and how these have been developed?

Types of measures

- What were the different challenges between implementing retrofit and new build SuDS?
- How these were overcome?
- What approach has been taken when retrofitting, e.g. was it a strategic approach that targeted specific areas, with measures being fully joined up, or was it an opportunistic/nibbling approach where small individual retrofits have been undertaken?
- How have these approaches worked and the benefits assessed (including water quantity, quality, enhancement of the urban area, biodiversity etc)?

Design and modelling

- How are individual SuDS components modelled to confirm the impacts (hydraulic and water quality) individually or across wide catchment areas, and how is uncertainty in performance or maintenance accounted for?
- What investigation works are undertaken at each site?
- What approaches are used to select the measures, particularly when there are multiple options?
- What design team approach is taken? Does it use a wide range of professions working together? How are different interests balanced (managing water quality/quantity and amenity)? Does this include designing measures within the context of each urban area, i.e. accounting for urban design?
- Have there been problems with litter, vandalism etc and how have they been overcome?
- What form of siltation and pollutant controls are used and who maintains them?

Estates/land use

- What is your approach to identifying suitable sites and balancing the needs for the land?
- Are dual functional assets created?

Maintenance

- What operation and maintenance programmes are applied, what is their frequency, costs and activities? Is the quality of maintenance checked?
- Have there been maintenance problems, eg, due to poor design and how were these overcome?
- What maintenance education and guidance is available and provided to those undertaking the work?

H&S

- What health and safety issues or concerns (actual and perceived) have been identified (in particular with the general public)?
- How were these addressed and did this change your approach to design in the future?
- Economics and WLC, benefits and assessment approaches
- How are whole life costs and benefits calculated for solutions?
- What positive benefits have been gained from installing SuDS?
- How these were identified, estimated, monetised, confirmed and monitored
- What resource and effort was needed to complete this?
- What confidence levels have been applied and at what stages (e.g. programme level and individual project level?
- What guidance is followed and the evidence base behind them

Construction

- What was your supervision approach to construction and has this evolved over time? Do you undertaken periodic post construction inspections?

Monitoring

- What monitoring has been undertaken of the different SuDS measures to assess their effectiveness, is monitoring data available, and how has it helped to develop maintenance programmes?

- What happens when SuDS fail, both hydraulically (design for exceedance), and water quality, either by design (or incorrect design), misuse, O+M?
- Have the SuDS installations delivered the benefits identified at the start, e.g. adequate water quality protection?

Successes and failures

- Gain an understanding or indication of any negative impacts of installing SuDS
- At what stage, and how, were these negative impacts identified?
- How have they been managed and at what cost?
- Where measures have failed, how were they overcome, and what learning was taken and reused?
- How are successes celebrated?

APPENDIX C
PORTLAND AND SEATTLE PROGRAMME ITINERARY

City of Portland Stormwater Facility Tour

Monday November 14, 2011

09:00 – 10:20	Portland Building, 10th floor Introductions and presentation: Tom Liptan / Tim Kurtz; Brian Smith
10:30 – 10:50	Portland Building Ecoroof
11:00 – 11:30	Headwaters at Tryon Creek (8833 SW 30th Ave)

The Headwaters Project is a complete re-development of a 3-acre derelict site. Completed in 2007, it has almost every green approach used in Portland. Facilities include ecoroofs, flow-through planters, green streets, raingardens, permeable pavement, and the daylighting of 400 ft of previously piped and buried creek. Three acres of city natural areas were also improved with stream upgrades and restoration plantings. Other site improvements include sidewalks, bikeways, and street trees. http://digimag.rrd.com/spiderweb/ecostructure/200703/

11:45 – 12:00	17th and Taylors Ferry – Detention Basin

In 1999, citizens requested this vacant lot, owned by the Water Bureau, to become a pocket park. However, the site was too small for Portland Parks to provide services there. The neighbourhood then requested that the City transfer ownership to Environmental Services (BES) to create a water quality facility. The City is working with the local community to design and install a swale to treat water that runs off neighbourhood streets. This project will benefit Tryon Creek by reducing runoff flows and velocities and trapping pollutants, thereby enhancing water quality and stream habitat. Designs for the project are complete, construction will begin Spring 2006 and project will be completed Summer 2006.

12:15 - 1:15	Lunch
13:15 – 13:45	SE 45th and Clay – Tabor to the River Green Streets

The Tabor to the River project area extends over 2.3 square miles and integrates hundreds of green streets, tree plantings and pipe upgrades. These improvements will improve sewer system reliability, stop sewer backups in basements and street flooding, control combined sewer overflows (CSOs) to the Willamette River, and restore watershed health. More than 500 Green Streets will be constructed, saving the city an estimated $58 million in avoided pipe-only upgrades.

The Tabor to the River project is a partnership between the city and the community to create sustainable solutions to urban watershed problems. The result will be a sound, dependable sewer and stormwater infrastructure, more liveable neighbourhoods, and cleaner rivers and streams. http://www.portlandonline.com/bes/tabortoriver

13:50 -14:15 Mt Tabor Middle School (5800 SE Ash St). The Mt. Tabor Middle School project includes downspout disconnections, infiltration planters and swales, a stormwater curb extension, and drywells. BES designed and constructed the project in collaboration with Portland Public Schools. The project was a cost-effective alternative to upsizing the local combined sewer to provide enough capacity to protect residents from basement sewer backups. The results also

include additional benefits such as urban heat island cooling, making classrooms more comfortable and providing outdoor classroom environments for students and teachers.
http://www.portlandonline.com/bes/index.cfm?c=45388&a=217429

14:30 – 14:40 NE Cully Blvd (Drive by)

The Cully Blvd Green Street project rebuilt NE Cully Boulevard for improved pedestrian and bicycle safety. The new street adds sidewalks, a designated cycle track to separate bicycles from vehicles and several Green Street facilities to manage public stormwater runoff.
http://www.portlandonline.com/transportation/index.cfm?a=352413&c=39132

14:45-15:15 NE Holman Park

A collaborative project between the Portland Bureau of Transportation, Environmental Services, and the community to expand a "pocket park" footprint to include green street facilities. In doing so, the project improves pedestrian and bicycle safety by adding safe crossings and limiting vehicle access while also managing stormwater runoff. This is another example of the multiple benefits achieved through innovative, green infrastructure design.

http://www.portlandonline.com/transportation/index.cfm?c=50518&a=348896

Here is a link to a blog about the project with construction photos taken by some of the neighbours. You also get a sense of the public's response to the project.

http://bikeportland.org/2011/09/02/new-greenway-park-under-construction-on-ne-holman-58494?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+BikePortland+%28BikePortland.org%29

15:30 – 16:00 Buckman Apartments – New urban residential development, constructed in 1998

http://www.portlandonline.com/bes/index.cfm?a=68716&c=36848

16:10 Drive by retrofit facilities on MLK

Tuesday November 15, 2011

08:45 -13:00 Tour of Portland facilities with BES staff

09:00 - 09:20 Owens Corning – Industrial property retrofit

09:45 - 10:10 House Apartments (SE 38th and Division) – new development with a range of stormwater management treatments www.terrafluxus.com/archives.1275

10:15 -10:30 Neustra Cocina restaurant – commercial property retrofit

10:45 - 11:00 New Seasons Market – commercial property retrofit with stormwater management treatment www.portlandonline.com/bes/index.cfm?a=172797&c=44953

11:15 - 11:45 RiverEast Onsite Sustainable Stormwater Management (SE Water & Clay Streets).

RiverEast Center is in a highly visible location near the Eastbank Esplanade, a popular pedestrian and bike path that parallels the Willamette River. Developers of the site and the renovated commercial office building worked with the city to create a model stormwater system that treats runoff from the roof, parking lot, public plaza, and adjoining city streets on private property. To expand the public's access to the river, a city street was turned into the public plaza that connects surrounding neighbourhoods to the esplanade. One unique feature of the site is the shared stormwater facility on the east side of the parking lot, which captures and treats street runoff from Water Avenue in the privately owned and maintained swale.
http://www.portlandonline.com/bes/index.cfm?c=36848&a=267793

12:00	Return to Portland Building
12:00 - 13:00	Lunch time Q&A
13:00	Self Guided tour

A) Walking Tour of Downtown Facilities

Cyan Condominiums / 1700 SW 4th Ave. A private re-development of a full city block completed in 2009. Includes both public right-of-way and private vegetated planters.

SW 4th & College Green Street. Public works project providing water quality treatment for a portion of 4th Ave, a high traffic street.

SW 5th Bus Mall Swales. Provide water quality treatment installed as part of the light rail expansion.

Montgomery Green Street Concept Plan - Montgomery Street from SW 4th, through campus to SW 12th Street. Stop at the Urban Studies Plaza and the plaza between SW Broadway and SW 9th) ???

This concept incorporates a series of stormwater planters along SW Montgomery through the Portland State University campus. This 'Green Connection' links the PSU campus life to surrounding neighbourhoods, businesses, housing, retail, theatre and parks. Two blocks have been completed with a third Green Street block expected in one to two years.

Stephen Epler Hall Stormwater Plaza - Montgomery and 12th Stormwater becomes the focus of this public space. Stormwater is captured from 2 building roofs and conveyed artistically to a series of vegetated planters. The water is filtered before it's captured in an underground cistern for use in the Stephen Epler Hall building.
http://www.pdx.edu/sites/www.pdx.edu.sustainability/files/media_assets/sus_epler_case_study.pdf

SW 12th & Montgomery Green Street planter – turn right from Montgomery onto 12th

This is a retrofit of an existing planted area. This Green Street design is the first of its design type and works well for built-out urban areas.
http://www.portlandonline.com/bes/index.cfm?c=45386&a=123776

South Waterfront (3700 SW River Pkwy) -. Take the Street Car to South Waterfront District, get off SW Bancroft. Walk North on Moody to Lane or Gaines St, green streets along Moody.. Take right walk, to riverfront trail, to Pennoyer St. to Caruthers Park, look across the street at the ecoroof at the Mira Bella front entrance. Take the tram to top of hill at OHSU for a great view of the City and surrounding mountains

South Waterfront is a 130 acre re-development area along the Willamette River. Previously an industrial area, numerous brownfield sites have been cleaned up for the construction of high density, mixed-use development. Projects are incorporating greenway improvements, green streets, and ecoroofs. The first projects were completed in 2006 – the Meriwether condominiums with 44,000 sf of ecoroofs and the OHSU Hospital building with 25,000 sf of ecoroofs, flow-through planters, swales, and park areas.

On your way to South Waterfront, you will encounter multiple construction projects happening. The following are links to the project information:

SW Moody Project http://swmoodyproject.com/

Gibbs Street Pedestrian Bridge http://www.gibbsbridge.org/GetInvolved.aspx

Portland / Milwaukie Lightrail Bridge http://www.trimet.org/pm/construction/bridge

B) On return, continue on Street Car to the Pearl District in NW Portland and get off at 10th and Glisan, walk one block to 10th @ Hoyt Condominium - artistic downspout disconnections

Walk north to next block to the Jean Vollum Natural Capital Center / Ecotrust Building - Stormwater parking lot swales, building downspouts disconnected to planters, ecoroof on top floor.

Jamison Park across the street – active recreation, no stormwater management, but lovely park.

Walk 2 blocks north to Tanner Springs Park – passive recreation: no stormwater but re-circulating water that gets filtered through a biotope design. Artwork designed by Herbert Dreiseitl.

Wednesday November 16, 2011

09:00 – 12:00 Eric Strecker, Geosyntec Consulting, Portland

SEATTLE PUBLIC UTILITIES

Thursday November 17, 2011

Seattle Municipal Tower, 700 Fifth Avenue, 49th floor, Conference room 4901

09:15	Coffee
09:30	Introductions, review of agenda: J Paul Blake, Directors Office
09:45	Yorkshire Water presentation: Brian Smith, Sewerage Optimisation Manager
	Learning Lessons – Sustainable Drainage
10:30	Seattle GSI overview: Tracy Tackett, Green Stormwater Infrastructure program manager
	Overview on the history of Seattle's implementation of green stormwater infrastructure (GSI).
11:15	Depart for GSI project tours
11:45	Site Visit: High Point (Tackett, Spencer)
	Meeting location: 35th Ave SW and SW Juneau Street
12:30	Lunch
13:30 – 16:30	Site Visits:

1. Northgate Mall – west parking lot – bioretention for stormwater code
   Meeting location: (From i-5 North, take At exit 173, take ramp right for 1st Ave NE toward Northgate Way. Turn left onto 1st Ave NE, Turn Right into parking lot. When in parking lot turn left. Meet near Panera Bread)
2. Pinehurst Green Grid – Natural Drainage System Project
   Meeting location: NE 113th St. and 20th Ave NE.
3. Ballard Roadside Raingardens Pilot
   Meeting location: 28th Ave NW and NW 67th
4. Ballard RainWise – Seattle's program offering rebates to residential customers who build raingardens on private property

Friday November 18, 2011

09:00	Madison Valley Storm Water Detention Basins - Meet Celia Kennedy at 30th Ave E. and E. John Street. Explanation of the project and visit to second site on Madison Avenue.
09:45	Madison Avenue site
11:00	Economics Presentation by Emiko Takahasi, Room 4901 Municipal Tower
12:00	Lunch (Food Court, Columbia Tower)
14:00	Thornton Creek Water Quality Channel
16:00	Return to Seattle Municipal Tower, 700 5th Avenue, Room 4901, for discussion
17:00	Close

Back cover images:

Left shows the signage at a detention basin in Madison Valley, Seattle. It clearly and simply advises the community to not enter the park during storm events. These signs are located at entrances around the park.

Right shows a drainage outlet from a Portland State University building that transfers flow across the cobbled footpath to a series of street planters which are also a water feature in the public open space. These infiltrate into underground tanks that are further treated and used to flush toilets and irrigate other landscape features.

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