Seattle: Managing stormwater

Overview

- Increased stormwater runoff in Seattle due to urbanisation caused water pollution, affecting local freshwater ecosystems
- Drainage fees are based on the amount of impervious land, and discounts will soon be given to customers who have private drainage systems, to incentivise them to deal with stormwater on site
- Pilot projects have replaced existing inadequate stormwater systems with natural drainage systems, and are being monitored so that lessons can be learned

Context and policy drivers

The city of Seattle, situated on Puget Sound between the Cascade and Olympic mountain ranges, is well known for its lush natural setting. Among the city's celebrated natural resources are rich local fisheries. Pacific salmon, steelhead trout, and other species return from the open ocean to spawn in Seattle's rivers and streams. However, rapid growth and sprawl has led to increased stormwater runoff from new buildings, parking lots, and roads, generating concerns about the impact of water pollution on the local aquatic habitat. Dwindling fish runs have resulted in several species of Pacific salmon being added to the federal endangered species list[22]. As a result, the City of Seattle and the Washington Department of Ecology have launched programmes to protect and improve the health of Seattle's freshwater ecosystems, particularly through management of stormwater in urban areas.

In response to flooding in 1986, Seattle City Council expanded the responsibilities of the existing Sewer Utility to include drainage, forming the Drainage and Wastewater Utility (DWU). This new utility was tasked with regulating stormwater runoff, alleviating flooding, reducing water pollution caused by runoff and responding to federal stormwater regulations, in addition to managing the City's sewer system. To gain efficiencies and consolidate City functions, Seattle Public Utilities (SPU) was formed in 1997 by combining the DWU, Seattle Engineering Department, Seattle Water Department and Seattle Solid Waste Utility[23]. SPU provides more than 1.3 million customers in King County with a water supply, as well as sewer, drainage, and solid waste services for the City of Seattle.

Description of Seattle's Comprehensive Drainage Plans (CDPs)

The City completed two Comprehensive Drainage Plans (CDPs) in 1988 and 1995, focused on major flooding problems in specific drainage basins in the city. However, a major storm in 1996 resulted in 300 landslides during the winter and spring of 1996/1997, causing damages of more than $30 million (£17 million) to city facilities and millions of dollars in damages to private properties. This storm meant that the scope of the drainage programme was expanded. The 2004 CDP charts a long-term course for drainage in Seattle with a specific emphasis on 2005-2010 Capital Improvement Programmes. It was adopted by the Seattle City Council in January 2005 and SPU is now moving forward to implement the policies and direction laid out in the Plan.

The 2004 CDP expands Seattle Public Utilities' (SPU) role in stormwater management from a conveyance focus to include other elements associated with drainage management, and has created four distinct programmes each with its own goals and objectives. These are:

- Stormwater conveyance and flow control (discussed further below),
- Aquatic resource protection:
    - Water quality,
    - Habitat,
- Public asset protection.

The 2004 Comprehensive Drainage Plan emphasises localised solutions to stormwater problems in the city right-of-way, with a preference for natural drainage system design over catch basin and pipe systems where there will be a cost-effective benefit to aquatic systems and where site conditions are appropriate. This policy shift provides flexibility for creation of new drainage infrastructure that provides higher levels of environmental protection in key watersheds that do not currently have piped drainage systems.

As part of the 2004 Seattle Comprehensive Drainage Plan, projects are being undertaken to address stormwater management, through the Stormwater Conveyance and Flow Control programme. Key policy changes in the Stormwater Conveyance and Flow Control programme from earlier CDPs include[24]:

- Expanding service beyond the trunk, or mainline stormwater conveyance system, to cover local stormwater conveyance from non-arterial streets and surrounding neighbourhoods (see Figure 23 below),
- Varying the level of flood protection according to city service priorities,
- Emphasising Natural Drainage Systems (NDS) (see section below),
- Protecting existing informal drainage systems (ditches) that drain to creeks, because of their critical function in stormwater quality and quantity management.

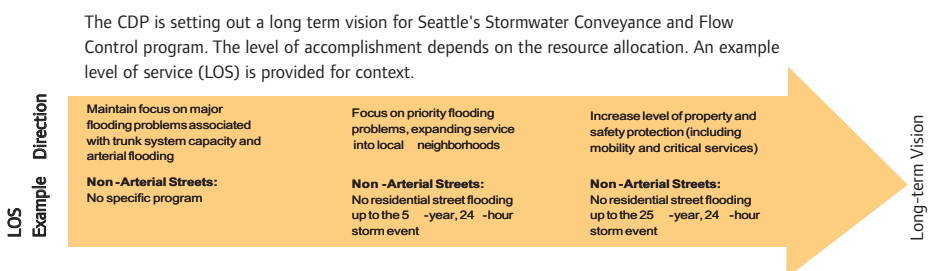

Figure 23: Seattle's vision for its Stormwater Conveyance and Flow Control Programme. (Source: Seattle Public Utilities, City of Seattle, WA[25].)

Seattle drainage fees

Drainage fees fund 99% of the drainage operating revenue requirement for SPU. Drainage fees are collected from seven classes of customers, of which six are in the commercial sector. All properties in Seattle, except city streets and state highways, are charged the drainage fee. Properties are charged based on percentage of impervious surface area and land parcel size (see table below[26]). Impervious surface area is a common basis for drainage fees, and has been chosen because it is one of the most important factors in determining the volume of stormwater runoff. The open space category is primarily reserved for city greenbelts. A new rate structure is being introduced in 2007 (see further details below).

Drainage fees based on impervious

Rate Category	Percentage Impervious Area	Annual Charge per Acre* of Total Parcel Area	
		2005	2006
Single Family Residential & Duplex*		$121.64 (£70)	$136.10 (£78)
Open Space**	0 – 2%	$139.88 (£80)	$173.77 (£100)
Undeveloped	0 – 15%	$243.48 (£140)	$302.19 (£174)
Light	16 – 35%	$404.02 (£232)	$501.84 (£289)
Medium	36 – 65%	$730.89 (£420)	$908.01 (£522)
Heavy	66 – 85%	$953.02(£548)	$1183.79 (£681)
Very Heavy	86 – 100%	$1182.89 (£680)	$1468.73 (£844)
*Single Family rates are per parcel. Rates for other properties are per acre.			
**A run-off of 10% is expected even where no impervious surface is present.			

Payment assistance[27]

The city assists qualified senior citizens, disabled customers and low-income customers by providing discounts on their utility services.

Senior citizens and disabled customers can save up to 50% of their SPU drainage bill (and their water, sewer and garbage bills) if they are:

- A senior citizen over age 65,
- A disabled person who receives certain disability payments,
- Blind,
- On life support,

AND their income is at or below 70% of the state median income.

Low-income customers can save up to 50% of their SPU drainage bill (and their water, sewer and garbage bills) regardless of age or disability if their household income is at or below 200% of federal poverty level. Residents of federally subsidised public housing are not eligible.

Rainwater harvesting discount

SPU offers a 10% reduction in the drainage fee for any new or remodelled commercial building that uses a qualifying rainwater harvesting system. The rainwater harvesting system must be sized to use or infiltrate the amount of rain that falls on the roof of the building during a one-year, 24 hour storm event in order to qualify for the 10% discount.

Systems that incorporate indoor uses of rainwater must be permitted by Seattle-King County Department of Public Health in order to qualify for the rate reduction. Systems that rely solely on the capture and indoor use of rainwater may qualify for the reduction, provided that the system is sized to meet the performance requirement. Qualifying for the 10% reduction does not exempt the property from the applicable stormwater and drainage code requirements for the building and site. Again, a new rate structure is being introduced in 2007 (see further details below).

Changes to the rate structure from 2007[28]

SPU has recently reviewed its drainage rates, as it wants to incentivise commercial and private property landowners to install systems that manage water flows and water quality on-site. Private stormwater management systems reduce the need for SPU infrastructure and so reduce the cost to SPU of serving these customers. The new rate structure is expected to come into effect in 2007. The existing system of tiered drainage rates shown in the table above will continue to operate, and in addition to this a new system of drainage rate 'credits' (discounts) will be provided to customers with private drainage systems on their land. These credits are offered only if the customer installs particular approved technologies that meet defined performance goals for:

- water quality treatment, and/or
- reductions in the runoff of water from the site – including annual average volume and peak flow rates.

Customers will be rewarded with credits for each performance goal that they achieve. Seattle has modelled the performance of a wide array of traditional and non-traditional technologies, and intends to credit both Code-required and other technologies that provide a demonstrable benefit to the City's stormwater management system.

The rate credits have been set based on the average embedded cost to SPU of providing drainage services. However, SPU estimates that the cost of private treatment facilities will probably far outweigh the rate credit benefits. To augment the rate credit and further encourage customers to manage stormwater on-site, SPU has developed additional non-rate incentives, including:

- Geographically-targeted grants for customers in parts of Seattle where there are particular existing problems with stormwater runoff, if they install the technologies listed above. The intention of these grants is to enable SPU to avoid constructing new capital facilities.

- Technical assistance from SPU staff and guidance materials: In the past, a lack of design and installation guidance has been a barrier to residents and developers installing on-site stormwater management systems.

- Regulatory incentives: The City regulates on-site stormwater management for new developments through its Stormwater Code, which outlines requirements for flow control and water treatment. The drainage rate credits and the Stormwater Code will be aligned – i.e. they will have the same performance goals and the same list of approved technologies.

Seattle pilot projects: Natural drainage systems (NDS)

Context and policy drivers

In 1998, the City of Seattle announced that it would fund a series of small and innovative projects to celebrate the coming millennium. Employees of SPU proposed pilot projects replacing existing inadequate stormwater systems using natural drainage systems. A team of engineers, architects, planners, and staff drawn from a wide range of City agencies set out to demonstrate that natural drainage systems could meet or exceed the performance of existing stormwater infrastructure, improve aquatic ecosystem health, and remain cost-effective[29].

Description of the pilot projects

Natural drainage systems are civil structures and biological systems engineered to use soil and plants to fulfill the function of traditional infrastructure, such as gutters, catch basins, and sewage pipes. Impervious surfaces are replaced by surfaces that absorb water, and therefore avoid concentrating surface pollutants from passing cars in runoff waters.

Principles of the NDS approach adopted for the pilot projects in Seattle include the following[30]:

- Addition of natural vegetation along city streets, in a network of swales, gardens, and cascades, allowing stormwater to be absorbed directly into the ground or channels for drainage,

- Replacement of impervious surfaces by porous surfaces and stormwater gardens that result in less runoff,

- Traffic and street reconfiguration: Narrower streets generate less runoff, so streets were redesigned not only to be narrower, but also to include new sidewalks (pavements) for pedestrians and slaloming curves to slow traffic. Although municipal traffic engineers and emergency-response professionals were initially concerned that narrower streets would slow traffic and the response of emergency services, the success of the pilot project gradually gained their acceptance and approval[31].

The first application of these principles was called the Street Edge Alternative (SEA) project, which began in a low-density residential neighbourhood of single-family homes. The City of Seattle has also gone on to apply these principles to increasingly large and dense urban projects, including the Broadview Green Grid, an entire neighbourhood encompassing 15 city blocks; the High Point Project,one of the largest

mixed-income housing redevelopments in Seattle's history, with 1,600 units on 34 blocks of new streets; and the Pinehurst Green Grid, a second large scale neighborhood project including 12 blocks. Three of these projects are described in the Boxes below. The municipal government is also examining application of the NDS approach in a variety of industrial, commercial, residential and mixed land use types[32]. All of these projects will be monitored to evaluate their performance. This monitoring, in combination with detailed tracking of project costs, will provide PSU with a template for applying NDS improvements elsewhere in the city.

Assessment of the effectiveness of the pilot natural drainage system projects[33,34]

Stewardship of natural resources

Studies of the SEA programme suggest that over the two-block area that was monitored during the first two years of operation, the transmission of pollutants through stormwater runoff was reduced by 98% and stormwater flow velocities were reduced by approximately 20%, compared to a conventional street and gutter system[35]. These sizeable reductions in runoff significantly reduce environmental pollutants, including such toxic organic compounds as hydrocarbons and pesticides, as well as oils and greases, nutrients, and heavy metals.

Health and productivity

Residents and community activists have enthusiastically supported the NDS approach in their neighbourhoods because it improves quality of life by adding trees and plantings that have visual and aesthetic appeal, by adding sidewalks where there were none before, and slowing the speed of local traffic. Some residents believe that their property values have risen after installation of the NDS systems, though no study has been done to date to evaluate this.

Efficient government

In addition to the inherent environmental benefits of using the NDS approach, the City of Seattle has found that it is also more cost-effective. Seattle Public Utilities estimates that the construction of infrastructure based on the NDS approach costs 25% less than traditional roadside stormwater systems, because reducing runoff at source reduces the need to build additional pipes and holding tanks. These cost savings do not include the additional economic benefits of carbon sequestration, additional trees and other plantings, cleaner water, and replenished groundwater.

Education

Seattle's NDS projects have built local and international awareness of sustainable infrastructure, while also creating a body of research materials suitable for use by professionals and scholars. At the local level, residents have been involved in many stages of planning and implementation of individual NDS components. The strong link between the City and researchers from the University of Washington ensures that the effectiveness of the programme is studied quantitatively and can be rigorously applied elsewhere.

SPU also made active efforts to engage resident's organisations in the regular clean-up and maintenance of street gardens, minimising the ongoing costs of government maintenance.

Figure 24: 'Before' and 'after' photos of the Street Edge Alternative Project, constructed in 2000. (Source: © 2005, Seattle Public Utilities, City of Seattle, WA)

Seattle's Street Edge Alternatives Project, 'SEA Streets'

The Seattle Street Edge Alternative Project, SEA Streets, is located in the Pipers Creek watershed in northwest Seattle. For the project, impervious surfaces were reduced to 11% less than a traditional street, and surface retention was provided in swales. Over 1,100 shrubs and 100 deciduous trees were planted, all native vegetation and hardy cultivars.

Lessons learned

The original intention of the project was to retain flows and allow infiltration into the native soils throughout the length of the block, but this was not possible as some homes had an existing groundwater intrusion problem. To limit the potential for stormwater to adversely impact these residences, geotechnical engineers identified some swales that needed an impermeable liner. A six inch depth of natural clay material was the preferred material.

Broadview Green Grid Project

The Broadview Green Grid Project, involving 15 city blocks, created natural drainage systems to manage stormwater flow from approximately 32 acres, and is almost an entire sub-basin of the Pipers Creek watershed. SPU partnered with Seattle Department of Transportation (SDOT) to provide neighbourhood improvements as part of this project including integrating landscaping, calming traffic, and adding a sidewalk (pavement) on each north-south street into the natural drainage system design.

Natural drainage features on the project include swales, stormwater cascades, small wetland ponds, larger landscaped areas and smaller paved areas. Construction began in late August 2003 and completed in May 2004. Monitoring is being conducted and preliminary results should be available in late 2006.

High Point Redevelopment

Seattle Public Utilities (SPU) is partnering with Seattle Housing Authority (SHA) to integrate a natural drainage system into the High Point project - a 129 acre mixed-income housing redevelopment located in the Longfellow Creek Watershed in West Seattle. The High Point project is one of the largest Seattle residential developments in recent history. The project will create 34 blocks of new streets, complete with new utilities, street trees and sidewalks, and provide a total of 1,600 housing units. The project brings Seattle Public Utilities' Natural Drainage System Program to a new level, as the City attempts to integrate NDS throughout a large and higher density residential area. It will serve as an example for other large scale developments. Construction began in June 2003 and continues until 2008.

The High Point project makes up an independent sub-basin, and is estimated to be about 10% of the Longfellow Creek watershed, providing an unprecedented opportunity to improve the water quality and stream flows at a large scale for Longfellow Creek. Longfellow Creek is one of Seattle's priority watersheds, with the highest Coho salmon return counts for Seattle creeks. Longfellow Creek is one of Seattle's priority watersheds, with the highest Coho salmon return counts for Seattle creeks.

Figure 25: Narrow streets, bordered by beds of dense planting, minimise runoff and promote natural infiltration in the Broadview Green Grid neighbourhood. (Source: © 2005, Seattle Public Utilities, City of Seattle, WA)

Figure 26: High Point Redevelopment. (Source: Mithun Architects and Planners.)

Natural system design for High Point Redevelopment

The natural system design proposes to integrate 22,000 lineal feet (6,700 m) of vegetated and grassy swales throughout the development within the planting strip of the street right-of-way. These swales include sub-surface engineered soil to provide storage and infiltration opportunities. Each swale is designed to treat the runoff from the road and housing of the adjacent block.

At a system scale, natural drainage systems will provide water quality treatment for the six-month storm and ease the two-year, 24-hour storm to pre-developed pasture conditions, which will better protect Longfellow Creek. This distributed block-scale system provides much greater opportunity to cleanse, cool and infiltrate stormwater runoff than the traditional piped and centralised management approach.

The design team has developed a block-scale continuous hydrologic model to refine the design performance and predict how the system will perform under different storm events. Seattle Public Utilities will be working with the University of Washington to monitor the performance of the system at the block and sub-basin scale.

This project also differs from other natural drainage system projects because the redevelopment's street layout goals limited Seattle Public Utilities to a very traditional curb, gutter, and sidewalk approach.

Source:
www.ci.seattle.wa.us/util/About_SPU/Drainage_&_Sewer_System/Projects/Natural_Drainage_Systems/HIGHPOINT_200312031213514.asp

Footnotes

22 Levitt, James N. and Lydia K. Bergen. 2004. Using Nature's Plumbing to Restore Aquatic Ecosystems: The City of Seattle's Natural Drainage System. Report on Conservation Innovation. Available from Program on Conservation Innovation at the Harvard Forest, Harvard University. See http://harvardforest.fas.harvard.edu/research/pci/RCI_Fall_2004.pdf/

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24 Seattle Comprehensive Drainage Plan, 2004.

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26 www.seattle.gov/util/Services/Drainage_&_Sewer/Rates/DRAINAGER_20031202090054 5.asp

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28 Seattle Public Utilities Drainage Rates and Incentives. Executive Response to Council Resolution 30720. Recommendations to the City Council, July 11, 2005, Seattle Public Utilities, City of Seattl, WA.

29 Levitt et al (as above).

30 Hsu, D., Dickinson, J., Kulikowski, R.R., Marton, D., Mauldin, C. 2006. Sustainable New York City. Design Trust for Public Space and the New York City Office of Environmental Coordination.

31 Levitt et al (as above).

32 Horner, Richard et al (2002). Hydrologic Monitoring of the Seattle Ultra-Urban Stormwater Management Projects. Water Resources Series: Technical Report No. 170.

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34 Hsu et al (as above).

35 Horner et al (as above).