green cities great lakes

using green infrastructure to reduce combined sewer overflows

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GREEN CITIES, GREAT LAKES

Using Green Infrastructure to Reduce Combined Sewer Overflows

August 2008

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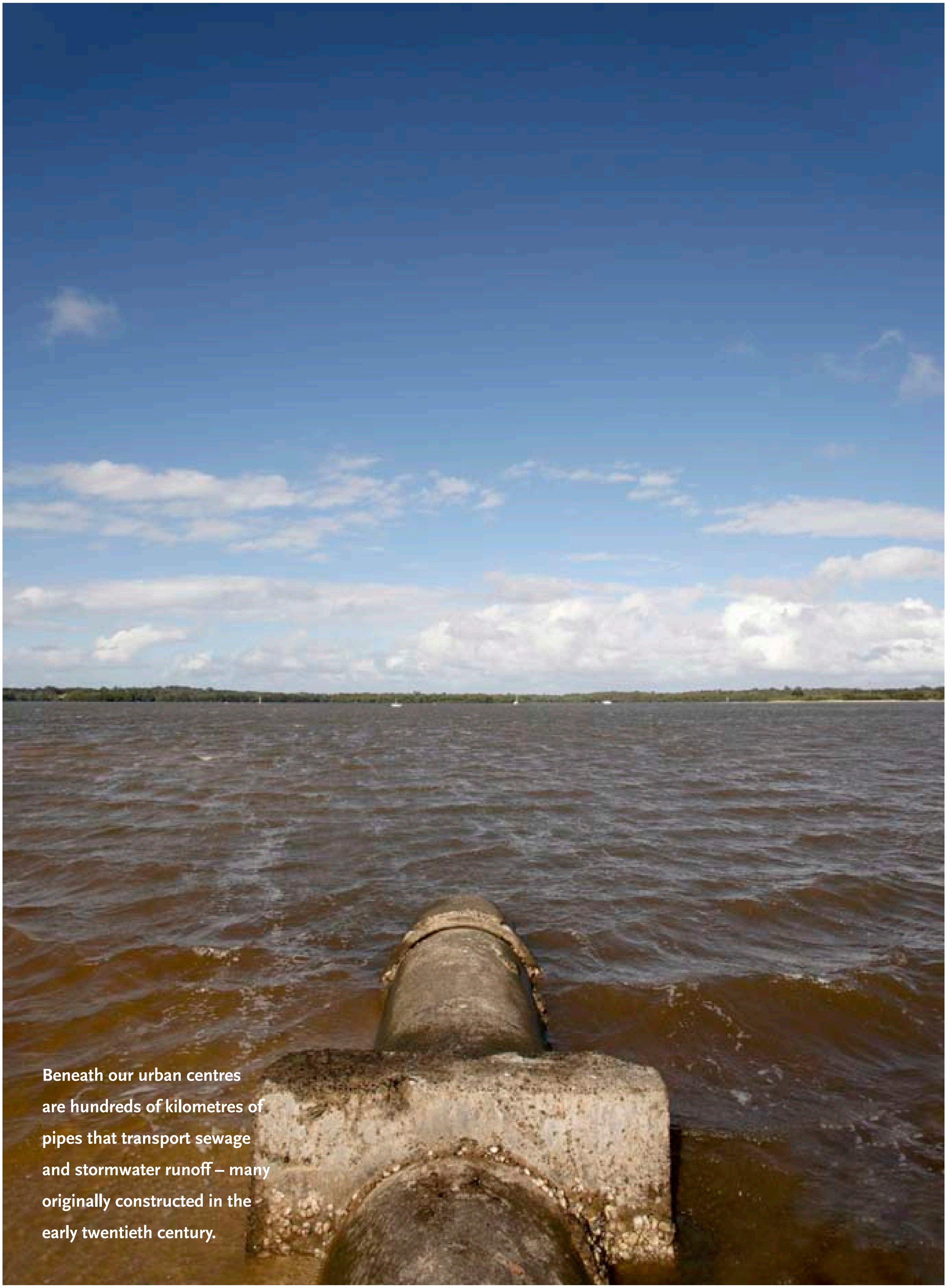
Contents



Beneath our urban centres are hundreds of kilometres of pipes that transport sewage and stormwater runoff – many originally constructed in the early twentieth century.

Summary

The Great Lakes Basin is an ecological treasure. It holds one fifth of the planet's surface freshwater, supporting an amazing abundance of life and stimulating incredible growth in the region's economy and sprawling cities. Formed after the last ice age, the Great Lakes Basin has a seemingly endless supply of water, but is in fact largely non-renewable because only 1 per cent of the water in the basin is naturally replenished each year. Further, this vast, fragile ecosystem is under threat and its health is deteriorating.

We routinely see the symptoms: beaches closed to swimming, fish that are unsafe to eat, diminished biodiversity, excessive algae and weed growth, and increasing costs to treat drinking water. The region's industrial and agricultural operations, which historically used the Great Lakes as a receptacle for much of their waste and runoff, is often believed to be the major culprit. However, one of the largest single sources of pollution remains largely unseen, literally buried under our cities.

Beneath our urban centres are hundreds of kilometres of pipes that transport sewage and stormwater runoff – many originally constructed in the early twentieth century. Without foreseeing the huge population growth that was to come, these pipes were often designed to accommodate both stormwater and municipal sewage in a single pipe referred to as a combined sewer.

With increased urbanization much of our green spaces like wetlands and forests were paved over with hard surfaces that quickly channel vast amounts of rainwater into the combined sewers. Thus when it rains, this rush of water that would overwhelm the treatment plants at the end of the pipe is instead released directly into the local water body. These releases are referred to as combined sewer overflows (CSOs).

With increased urbanization much of our green spaces like wetlands and forests were paved over with hard surfaces that quickly channel vast amounts of rainwater into the combined sewers.

It is estimated that these overflows from cities around the Great Lakes amount to hundreds of billions of litres of a foul cocktail of raw sewage and stormwater each year – more than 90 billion litres from 20 cities alone. Thus, combined sewer systems pose a serious threat to the health of the Great Lakes and are a potentially expensive problem to fix.

But, thankfully, there is hope. While our cities grapple with replacing their antiquated infrastructure, this report calls for a different approach, one that focuses primarily on preventing water from entering our wastewater systems in the first place.

For this we can look to nature. Natural systems such as wetlands and forests have evolved over millennia and provide a helpful blueprint. These natural spaces use an interconnected system of trees, soil and plants to catch and slowly filter precipitation. Not only do these systems naturally remove many common contaminants in runoff, they slow down the flow and retain much of the water.

These natural systems can be replicated into urban systems in a variety of ways and are commonly called "green infrastructure." Often described as an interconnected network of natural areas that maintain natural ecological processes, green infrastructure refers to both natural corridors like parks and wetlands, as well as engineered, human-designed systems that mimic nature, such as green roofs.

Green infrastructure manages stormwater at the source by capturing runoff and retaining it before it can reach the sewer system. Simply put, green infrastructure can help "get the rain out of the drain."

Green infrastructure manages stormwater at the source by capturing runoff and retaining it before it can reach the sewer system. Using green infrastructure instead of, or in combination with, hard infrastructure solutions, such as pipes and storage tunnels, reduces stormwater runoff volumes. This in turn reduces CSOs and mitigates the amount of pollution entering local water bodies. Simply put, green infrastructure can help "get the rain out of the drain."

This report represents the first in-depth analysis of the use of green infrastructure in mitigating the impacts of CSOs and restoring the health of the Great Lakes. It provides an overview of the problem as well as several case studies and practical examples of communities that have already invested in innovative green infrastructure solutions to their stormwater and CSO problems.

MOUNTAIN EQUIPMENT CO-OP
TORONTO STORE GREEN ROOF
KAMIL BIALOUS PHOTO

Introduction

The Great Lakes Basin

The Great Lakes Basin is the largest freshwater ecosystem on earth and holds one fifth of the world's surface fresh water. The Great Lakes include Lake Superior, Lake Huron, Lake Michigan, Lake Erie and Lake Ontario, all of which are interconnected by rivers, channels and smaller lakes. The Great Lakes ecosystem contains a wealth of biodiversity; it is home to 46 species of plants and animals that are found nowhere else in the world and nearly 280 species that are considered "globally rare."

Although the Great Lakes are often thought of as an open system flowing to the sea, only 1 per cent of the water actually leaves the basin each year. Currently, 42 million people live in the Great Lakes Basin, with almost half drawing their drinking water directly from the Great Lakes.

Although the Great Lakes are often thought of as an open system that eventually flows to the sea, only 1 per cent of the water in the Great Lakes leaves the basin each year, flowing to the Atlantic Ocean via the St. Lawrence River. About the same amount is replenished each year, while the rest is a one-time gift from nature – the remains of melted glaciers from the last ice age.

With all its natural riches, the Great Lakes region has seen tremendous economic growth in the past century. Currently, 42 million people live in the Great Lakes Basin, with almost half drawing their drinking water directly from the Great Lakes. Sprawling cities, major industries, mining and manufacturing all place heavy burdens on the Great Lakes' delicate ecosystems, and serious threats to the health of the Great Lakes include toxic contamination from various sources in both Canada and the U.S.

Pollution enters the Great Lakes via many different routes: point source effluent discharges like sewage treatment plants and industrial wastewater, nonpoint sources like stormwater runoff from cities and agricultural lands, and deposition of pollutants from the air. Although each of these sources deserves further study and analysis, this report is limited to one of the largest sources of pollution plaguing the Great Lakes – municipal sewage and stormwater from combined sewer overflows (CSOs). The report represents the first in-depth analysis of CSOs, and contains recommendations for the use of green infrastructure in mitigating CSO and stormwater impacts.


Cities around the Great Lakes release hundreds of billions of litres of raw sewage and stormwater in combined sewer overflows each year.

The Problem: Combined Sewer Systems

Combined Sewer Overflows and Bypasses

Combined sewers are an antiquated system that transports both sanitary sewage and stormwater in the same pipes. During wet weather events like rainstorms, the volume of flow commonly exceeds the capacity of the sewer system. When this happens, untreated raw sewage mixed with stormwater is released directly into local water bodies from outfalls referred to as combined sewer outfalls. The release of sewage from such outfalls is referred to as a combined sewer overflow (CSO).

Without further mitigation, CSOs will worsen as population density continues to increase in older neighbourhoods that have combined sewers. Climate change is also expected to lead to more frequent and larger CSOs due to increased occurrence of storms with heavy rainfall causing sewers to be overwhelmed with stormwater runoff.

In some cities, stormwater and sanitary sewer systems are connected by "cross connections" that allow stormwater and sanitary sewage to mix. Cross connections can be both accidental or intentional and can lead to the same type of overflow problems.

During wet weather such as heavy rainstorms or spring snowmelt, sewage treatment plants also commonly have bypasses and spills. Bypasses occur when the treatment facility is overloaded. Some of the sewage flow is deliberately redirected and discharged into local water bodies with little or no treatment. Bypasses may also occur during routine maintenance activities when the treatment plant is temporarily out of operation and during power failures.

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Impacts from Sewage and Urban Stormwater

The antiquated sewer systems found in many Great Lakes cities continue to regularly release huge quantities of partially treated or untreated sewage directly into the lakes and rivers within the Great Lakes Basin through spills, bypasses and combined sewer overflows.

Typical municipal sewage is a foul cocktail of water, human waste, micro-organisms, disease-causing pathogens and hundreds of toxic chemicals. The principal pollutants found in sewage include pathogenic bacteria and viruses, oxygen-depleting substances (measured by Biological Oxygen Demand or BOD), and various suspended solids and nutrient pollutants like phosphates – each of which carry a heavy ecological toll when released into a fragile ecosystem.

Large concentrations of toxic chemicals, such as oil, polycyclic aromatic hydrocarbons (PAHs) and pesticides, tend to wash from the urban environment into the sewer system when it rains or when snow melts. Toxic metals such as cadmium, lead, mercury, silver, zinc and synthetic organic chemicals such as brominated flame retardants and PCBs are commonly found in sewage and pose serious dangers to human health and the environment.

Fecal coliforms levels in CSO effluent can be in the order of 100,000 to 10,000,000 coliform units per 100 millilitres of water. A beach in Ontario is not considered safe for swimming if the water exceeds 100 fecal coliform per 100 ml.

Typical municipal sewage is a foul cocktail of water, human waste, micro-organisms, disease-causing pathogens and hundreds of toxic chemicals.

The State of the Problem

The *Great Lakes Sewage Report Card* released by Ecojustice (then Sierra Legal) in November 2006 identified CSOs as a significant source of pollution in the Great Lakes. The report, which was based on a survey of 20 cites in the Great Lakes Basin, found that in one year 92 billion litres of raw sewage mixed with stormwater was released into the Great Lakes via CSOs by those cities alone. Further analyses of the CSO problem are presented below, followed by proposed solutions to CSOs through the adoption of green infrastructure techniques.

Combined sewer overflows and bypasses are not publicly reported in Ontario, and it is therefore difficult to obtain a complete picture of the extent of the problem.

Lack of Public Reporting

Combined sewer overflows and bypasses are not publicly reported in Ontario, and it is therefore difficult to obtain a complete picture of the extent of the problem. The Ontario Ministry of the Environment (MOE) collects some information from municipalities on sewer system overflows, including CSOs, although based on the information obtained from the province the reporting is inconsistent and often incomplete and is rarely provided to the public.

Community Right to Know

Although municipal sewage treatment plants are required to report spills and bypasses to the regulatory authorities, these reports often do not include volume information. Provincial records show that some CSOs are being reported to the provincial government, but it is suspected that many CSOs are not reported. The Ontario government does not report the information it receives from municipalities regarding these sewage releases to the public.

Municipalities should be required to report all releases of sewage untreated or partially treated via all types of incidents (bypasses, overflows and spills). The information collected should be summarized, and sewage plant or municipal-specific reports should be prepared and provided to the public. Annual progress reports on reductions in CSOs, bypasses and other events resulting in sewage releases should also be prepared and made public. Reports should also be available to the public directly through the operators of sewage treatment plants, and municipalities should be required to provide more detailed compliance reports to their residents and post them on their websites.

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Information Gathering

In order to help gain a better understanding of the extent of CSOs and bypasses in Ontario, a survey was sent to 34 cities throughout the Great Lakes Basin, including cities on the shores of the Great Lakes and on inland watercourses that drain into the Great Lakes. Unfortunately, the response rate was low. Even after several follow-up attempts, only eight cities completed the survey. The remaining cities either refused to participate or did not provide a response. The responses were used to provide information on CSOs as well as information on the use of green infrastructure presented in the case studies in Appendix I.

Upon request, the federal and provincial[1] governments also provided information they have collected with respect to CSOs and bypasses. The following discussion is based on the information and results obtained through these inquiries.

Results of Information Gathering

According to information obtained from the province of Ontario there are 107 combined sewer systems in Ontario. In 2006 there were 1,544 releases of raw or partially treated sewage reported to the provincial government, although this information does not include all of the sewage treatment plants in Ontario.[2] Of the incidents reported, 1,256 were caused by wet weather. 432 cases were reported to include overflows and 323 incidents included combined sewer overflows. A total of 881 wet weather incidents were reported as bypasses. Some incidents included both overflows and bypasses. In most cases the volumes of sewage released was unknown.

Of the 1,544 incidents reported, 1,256 – 81 per cent – were caused by wet weather.

The provincial government estimates there were 10.9 billion litres of bypasses in Ontario in 2006, broken down by watershed in Table 1. No similar information was available on CSO volumes. In addition, there were 7.5 billion litres of secondary bypasses (when the sewage only receives primary treatment) in 2006, which is also presented in Table 1 on a watershed basis.

Table 1: Ontario Municipal Sewage Treatment Bypasses by Watershed, 2006

Watershed	Total plant bypass	Total Secondary bypass	Total flow
	(litres)		
Lake Huron	1,367,601,000	168,765,000	166,644,113,000
Lake Erie	3,700,941,000	1,136,131,000	244,561,923,000
Lake Ontario	5,437,183,000	6,089,267,000	1,011,177,338,000
St. Lawrence River	25,071,000	0	62,284,041,000
Ottawa River	5,972,000	75,263,000	187,617,300,000
James Bay Shore	315,280,000	1,089,000	20,849,869,000
Lake Superior	57,857,000	57,511,000	23,716,153,000
Total:	10,909,905,000	7,528,026,000	1,716,850,740,000

Based on information obtained from the surveys and the provincial government, Ecojustice has compiled detailed information on overflows and bypasses in specific communities across Ontario (Table 2). The full text results will be the focus of an upcoming investigative report. Below are data from six representative samples.

Table 2: Municipal Overflows and Bypasses, 2006

City	Responded to survey	Number of CSO outfalls	Total reported combined sewer overflows (litres)	Total bypasses (total and secondary) (litres)	Total known or reported incidents[a]
Toronto	Yes	80	9,900,000,000	4,033,900,000	34
Hamilton	No	23	-	4,605,568,000	31
Niagara Falls	Yes	25	74,728,000	478,327,000	19/151[b]
St. Catharines	Yes	65	312,000,000	123,524,000	42/69[c]
Windsor	Yes	26	unknown	2,652,500,000	129
London	Yes		unknown	251,000,000	24
Owen Sound	Yes	13	10,130,000	6,577,000	5

NOTES:

[a] Note: All results are based on 2006 data, except for St. Catharines CSO data, Owen Sound data, or where noted differently below, which are based on 2007 data. Incidents refer to either sewage treatment plant bypasses or sewer overflows or sometimes both.

[b] The city reported 19 CSO events that occurred in 2007. Provincial records show 151 incidents involving the release of partially treated or raw sewage due to wet weather in 2006.

[c] The city reported that the worst CSO location can overflow up to 42 times a year, but plans will reduce this to once every two years. Provincial records show 69 sewage release incidents occurred in 2006.

Infrastructure Deficit and Funding Sources

Each year, as governments in Canada delay maintenance and repairs for infrastructure, an "infrastructure deficit" is incurred, adding to our overall "infrastructure debt." The current infrastructure debt in Canada is estimated to be $100 billion, and growing at a rate of $2 billion per year.[3] According to Statistics Canada, wastewater infrastructure is the oldest type of infrastructure in Canada, at 63 per cent of service life in 2003.[4] The estimates for the amount needed immediately to fix only water and wastewater infrastructure is $31 billion nationally.[5] A 2005 report estimated that Ontario's water and wastewater infrastructure would need $30 to $40 billion in investment over the following 15 years,[6] while at the same time there has been a steadily declining trend in average annual federal capital investment in wastewater treatment.[7] Thus, our debt continues to climb and local governments have had to contribute an increasing amount of overall spending.

Upgrading Ontario's antiquated water and wastewater infrastructure will cost between $30 and $40 billion.

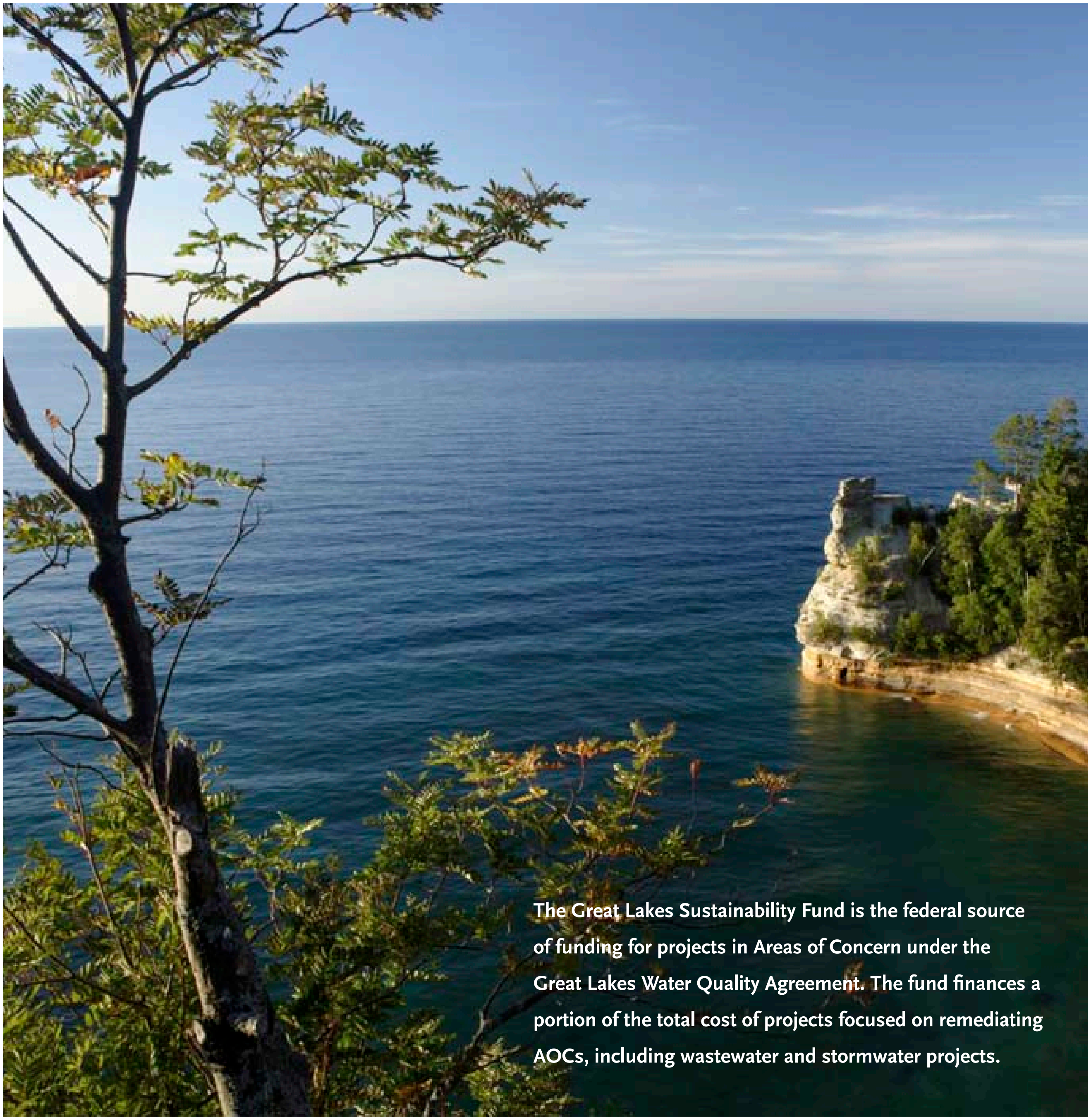
While there are federal and provincial funding sources available for infrastructure upgrades and maintenance, the amounts available do not match the need, and wastewater projects are often forced to compete with other infrastructure projects from the same funding sources. Below is a brief description of some of the funding programs that could direct monies to wastewater projects.

The federal government, through Infrastructure Canada, committed federal funding of $33 billion from 2007 to 2014 to Canadian municipalities for infrastructure needs, of which wastewater infrastructure would be a portion.[8] The largest source of funding to this plan is the Gas Tax Fund.[9] The Association of Municipalities of Ontario estimates that Ontario communities will receive $4.9 billion from 2005 to 2014.[10]

In May 2005, Ontario introduced through the Ontario Ministry of Public Infrastructure Renewal a $30-billion five-year infrastructure funding plan.[11] It included potential funding for water and wastewater systems in partnership with the federal and municipal governments, but also included other infrastructure funding, such as public hospitals, courthouses, roads, bridges, and other public buildings.

The Great Lakes Sustainability Fund[12] is the federal source of funding for projects in Areas of Concern (AOCs) under the Great Lakes Water Quality Agreement. The fund finances a portion of the total cost of projects focused on remediating AOCs, including projects that improve municipal wastewater and stormwater quality.

The Federation of Canadian Municipalities administers the Green Municipal Fund,[13] which provides low-interest loans and grants to municipal governments.



Ontario's Legal and Policy Framework

This section provides a brief summary of laws and policies relevant to the management of municipal sewage.

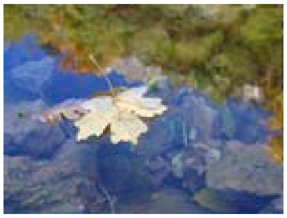
Great Lakes Water Quality Agreement (GLWQA)

Growing concern over water pollution in Lakes Erie and Ontario led to the adoption in 1972 of the bilateral *Great Lakes Water Quality Agreement* (GLWQA) between Canada and the United States. Article V of the agreement established requirements regarding pollution from municipal sources.[14] The agreement undergoes a review every five to six years and is presently under review. It was last revised in 1987.

The GLWQA identified 43 ecologically degraded Areas of Concern (AOCs)[15] in the basin.[16] Several AOCs are impacted by sewage discharges from combined sewer overflows, namely the St. Mary's River, St. Clair River, Detroit River, Niagara River, Hamilton Harbour, Toronto and Region and Bay of Quinte.

As described in a recent report by Great Lakes United, it is generally agreed that the potential of the GLWQA has not been achieved.[17] The report examines the reasons for this failure to achieve more under the GLWQA and found flaws in the nature and functioning of government institutions and processes around the GLWQA.[18]

After each renegotiation of the GLWQA, Canada and Ontario negotiate the Canada-Ontario Agreement (COA) Respecting the Great Lakes Basin, which lays out the roles of the federal and provincial government in implementation of the GLWQA.



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Federal – Proposed Fisheries Act Regulation for Municipal Sewage

Canada is developing a regulation under the federal *Fisheries Act* for municipal sewage that would exempt sewage treatment plants from charges relating to the deposit of deleterious substances in water frequented by fish if a minimum treatment standard is obtained. It is expected that the proposed regulation will be released later in 2009 and will require final effluent quality similar to that which is obtained using secondary treatment. Environment Canada is proposing some provisions regarding CSOs, and although the specifics with respect to the CSO provisions are still unknown, they will likely entail more rigorous monitoring and reporting of CSOs, as well as the preparation of long-term CSO elimination plans.

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Concurrently, the Canadian Council of Ministers of the Environment has prepared a broader Canada Wide Strategy for Municipal Wastewater Effluent,[19] which will set a national policy with respect to all aspects of municipal wastewater management from source control, through a model sewer use by-law, to final effluent quality objectives. Unfortunately the strategy as proposed will be unenforceable unless integrated into provincial or federal laws. Under the draft strategy, CSOs should be recorded in order to assess the frequency and severity of overflows and, where possible and feasible, the volume should be estimated or measured. The strategy encourages these actions to be taken starting with the major CSOs or those causing the greatest concern. It also calls for the elimination of dry weather overflows.

Under the strategy, three national overflow standards[20] are suggested for CSOs:

- No increase in CSO frequency due to development or redevelopment;
- No CSO discharge during dry weather, except during spring thaw and emergencies; and
- Floatable materials will be removed, where feasible.

Summary of Relevant Ontario Law and Policy

Ontario Water Resources Act (OWRA)

The legislative authority of the Ontario Ministry of the Environment (MOE) to manage water comes primarily from two acts: the *Ontario Water Resources Act* (OWRA) and the *Environmental Protection Act* (EPA). Through the OWRA, the MOE regulates water supply, sewage disposal, and sources of water pollution. This deals largely with the regulation of sewage discharges and approvals for sewage works. The EPA prohibits the discharge of contaminants to the natural environment except where specifically permitted by a permit referred to as a Certificate of Approval. Thus, sewage treatment plants as well as industrial dischargers of wastewater effluent require Certificates of Approval to discharge effluent.

CSO and Stormwater Management Guidelines and Manuals

The MOE publishes numerous guidelines relevant to sewage works and sewage treatment. These publications set out requirements and protocols for managing combined sewer systems and sewage bypasses. Although these guidelines are not enforceable, applications for permits for municipal sewage treatment plants are assessed according to the requirements in the guidelines.

MOE *Procedure F-5-5* provides objectives for the treatment of wet weather flows. The guidelines require the equivalent of primary treatment for at least 90 per cent of all wet weather flow during an average runoff season. Primary treatment is defined as the removal of a minimum of 50 per cent of total suspended solids (TSS) and 30 per cent of five-day biochemical oxygen demand (BOD5), prior to discharge. However, this is only a guideline and thus not legally enforceable.

MOE also publishes manuals and guidelines for the management of stormwater,[21] which include advice on various green infrastructure techniques that can assist in the reduction of CSO frequency and volumes through the better management of stormwater in areas with combined sewer systems. There are no enforceable standards for the management of stormwater; however, municipalities may have their own stormwater management requirements.

Sustainable Water and Sewage Systems Act

The *Sustainable Water and Sewage Systems Act,* 2002, which has yet to be proclaimed and thus is still not in force, makes it mandatory for municipalities to assess and recover the full cost of providing water and wastewater services.

Municipal Sewer-Use By-laws

Ontario's *Municipal Act* allows municipalities to pass by-laws prohibiting or regulating the discharge of any matter into a sewage system. The draft *Canada Wide Strategy for Municipal Wastewater Effluent* contains a model sewer-use by-law. In addition, many municipalities already have sewer-use by-laws in place, though some are considerably more comprehensive than others. The City of Toronto's sewer-use by-law was considered to be very stringent and comprehensive when it was first introduced in 2000.

Ontario has several acts that provide some protection to green areas such as greenbelts and ecologically significant areas such as moraines and wetlands, control urban sprawl and encourage intensified growth. A review of those laws is beyond the scope of this report, but it is worth noting that they may benefit green infrastructure projects by protecting wetlands and green spaces that mitigate stormwater runoff, although these areas are most commonly rural and not in close proximity to combined sewer systems.

Ontario has several acts that provide some protection to green areas such as greenbelts and ecologically significant areas such as moraines and wetlands, control urban sprawl and encourage intensified growth.


WARNING
UNSAFE FOR SWIMMING
Water temporarily POLLUTED
because of high bacteria levels
which may pose a risk to your health

Traditional CSO Reduction Strategies

Hard or grey infrastructure, such as underground storage tunnels and tanks, is often used to abate CSOs and typically targets the end-of-pipe or the conveyance system (sewer system) rather than the source of the problem – the stormwater runoff.

Conventional stormwater and CSO mitigation efforts have almost exclusively been focused on end-of-pipe solutions.

One solution to combined systems is to separate the stormwater and sanitary sewer systems. However, stormwater contains extremely high levels of fecal coliform as well as heavy metals, nutrients and synthetic organic chemical. Under a combined system, CSOs occur when the flows are greater than the capacity of the system but at the same time some stormwater is being treated to the extent that there is surplus capacity to treat the extra flow that occurs during wet weather.

Sewer separation is expensive and very disruptive. Some communities have chosen this option if the area of combined sewers is small, but it is often not practical or affordable for large areas.

"Real time control" is a method that attempts to reduce CSOs by maximizing existing capacity to store wet weather sewage flows in the sewer system. It is accomplished by using weirs and gates to hold back sewage flows until the flow subsides and the plant has enough capacity to accommodate the flow. Increasing the capacity of the sewer system in this way, the need for expensive underground storage tanks and tunnels is decreased. Real time control requires extensive technical knowledge of the sewer system, which can be problematic in older areas that may not have accurate records.

The most common means of managing high flows in a combined system during wet weather is to install large underground tanks and tunnels. These tanks intercept and hold the additional flow until there is capacity to treat the intercepted overflow at the sewage treatment plant.

The tanks and tunnels may be coupled with treatment facilities designed to treat the overflow. End-of-pipe treatment of CSOs can either provide some level of treatment to all wet weather overflows or in some cases are designed to capture the "first flush," which is considered the most contaminated portion of a CSO.

None of these techniques, however, address the problem directly, which is excessive stormwater runoff entering combined sewers systems. Conventional stormwater and combined sewer overflow mitigation efforts have failed to adequately address the problem because they are almost exclusively focused on end-of-pipe or conveyance solutions. Most experts agree that to eliminate CSOs, measures are needed at all stages from source to the end-of-pipe.

Hard infrastructure approaches to CSOs can be effective but are generally very costly and difficult to incorporate into highly developed urban areas. Most cities cannot afford to spend the millions, or billions, of dollars required to manage their sewage overflows using these techniques alone and, thus, are looking for other options.

Using trees, vegetation, and wetlands, or engineered systems that mimic natural landscapes, green infrastructure manages stormwater at the source by capturing runoff and retaining it before it can reach the sewer system.

PHOTO COURTESY URBAN STRATEGIES INC.

Green Infrastructure

What is Green Infrastructure?[22]

"Green infrastructure" is a relatively new concept that uses many old techniques. Commonly thought of as the interconnected network of forests, wetlands, waterways and other areas that maintain natural ecological processes,[23] green infrastructure also refers to engineered, human-designed systems that mimic nature in function. Integrating the conservation and enhancement of natural green spaces with engineered green infrastructure systems can dramatically reduce the impacts of development and environmental damage in the urban environment. A similar term, Low Impact Development (LID), is defined as an ecologically friendly approach to site development and stormwater management that aims to mitigate development impacts to land, water, and air.[24] For the purposes of this report, green infrastructure can be used interchangeably with LID, which encompasses all green infrastructure techniques and also incorporates traditional practices such as conveyance and storage, as well as architecture, landscaping and energy conservation.

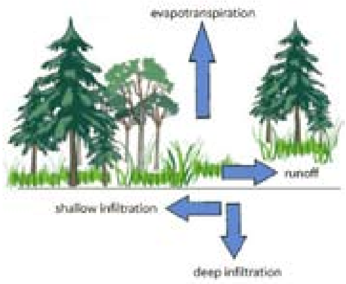
The typical urban landscape contains a high degree of impervious surfaces like paved roads and sidewalks. These hard surfaces cause greater volumes of stormwater runoff to be discharged into combined sewers and local water bodies during wet weather.

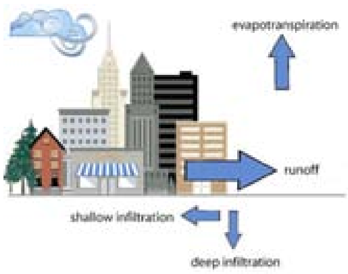
The typical urban landscape contains a high degree of impervious surfaces like paved roads and sidewalks. These hard surfaces cause greater volumes of stormwater runoff to be discharged into combined sewers and local water bodies during wet weather. Green infrastructure offers an innovative and sustainable approach to stormwater management by providing benefits similar to natural undeveloped systems that naturally filter and slow the flow of stormwater.

Using trees, vegetation, and wetlands, or engineered systems that mimic natural landscapes, green infrastructure manages stormwater at the source by capturing runoff and retaining it before it can reach the sewer system, thus restoring some of the natural hydrologic function of urbanized areas. Once the runoff infiltrates into soils, vegetation and microbes naturally filter

By stopping the stormwater runoff at its source, green infrastructure addresses the root cause of combined sewer overflows.

ILLUSTRATION ADAPTED FROM CLEAN WATER EDUCATION PARTNERSHIP





and break down pollutants, allowing the cleansed water to be re-used, evapotranspirated, or allowed to recharge groundwater or surface water. In addition, individual trees take up water which transpires back into the air, and raindrops from leaf surfaces evaporate back into the atmosphere, helping to filter pollutants from the air. On a larger scale, forests protect watersheds by filtering rain and buffering water bodies from pollution.

Thus, green infrastructure relieves the strain on hard infrastructure so that stormwater runoff volumes can be reduced. This limits the frequency of CSOs and reduces the amount of polluted stormwater runoff entering local water bodies.

In contrast to hard infrastructure solutions, there is flexibility in how and where green infrastructure techniques can be integrated into densely developed settings. Green infrastructure can be used almost anywhere soil and vegetation can be incorporated into the urban landscape, and the benefits are particularly significant in urban areas where there is limited green space and a high degree of environmental degradation. Green infrastructure can also be efficiently used, with certain modifications, in cold climates such as the Great Lakes Basin.

Green Infrastructure: Economic Benefits

Economic analysis has clearly demonstrated that green infrastructure measures can be a cost effective means of reducing CSOs.[25] Green infrastructure is generally less costly than traditional stormwater management practices, such as constructing pipes, tunnels, storage systems and stormwater ponds, and increasing capacity at treatment plants. Storing and treating stormwater runoff is more costly than reducing the amount of stormwater generated at the source by minimizing impervious surfaces and maximizing infiltration. Although some small-scale retrofit green infrastructure projects can be more expensive than conventional approaches, green infrastructure is generally cost-effective when incorporated into larger redevelopment projects or when major infrastructural improvements are needed, as the green infrastructure costs are often minimized relative to the scope and cost of the overall project.[26] Overall, integrating green infrastructure techniques with traditional hard infrastructure is an economically viable option for many municipalities struggling with aging infrastructure and CSO problems.

Other Benefits of Green Infrastructure[27]

In contrast to traditional hard infrastructure, green infrastructure has many environmental benefits other than just stormwater management and CSO reductions, such as:

Moderate climate change impacts – Green infrastructure techniques can reduce impacts from climate change by conserving water supplies and reducing surface water discharges that could contribute to flooding. In addition, green infrastructure uses less concrete and asphalt than hard or grey infrastructure. The production of concrete and asphalt results in an enormous amount of greenhouse gas emissions due to the use of fuel and raw materials. Reducing the use of concrete and asphalt is good climate change policy. Other benefits include increased carbon sequestration by vegetation.

Improved air quality – Trees and vegetation improve air quality and smog levels by naturally filtering out airborne pollutants.

Mitigation of urban heat island effect – Summer temperatures in urban centres are higher than in surrounding less urbanized areas. This is called the urban heat island effect. Trees and vegetation lower the temperature by providing shade and reducing the amount of heat absorbing materials. Porous surfaces also help mitigate the urban heat island effect.

Enhanced Groundwater Supply and Stream Flow – Green infrastructure techniques allow stormwater to infiltrate the soil, which filters and removes pollutants and recharges the groundwater and stream base flow levels. This conserves water supplies, and provides protection for both ground water and surface water sources of drinking water.

Erosion Reduction – Reduced stormwater runoff volume and velocity can reduce erosion due to high flow rates in local water bodies.

Energy conservation – Trees and vegetation planted around buildings help lower ambient temperatures and reduce energy demands for heating and cooling by providing shade and insulation.

Improved biological diversity – Vegetated green infrastructure increases biological productivity in cities. For example, trees, wetlands and rain gardens offer food and habitat to wildlife from birds to small mammals.

Community Benefits – Trees and green space improve community aesthetics in an urban environment by providing recreational opportunities and contributing to a sense of well being. Property values can also increase when trees and green space are present.

In contrast to traditional hard infrastructure, green infrastructure has many environmental benefits other than just stormwater management and CSO reductions.

PHOTO COURTESY CITY OF TORONTO

Types of Green Infrastructure

To manage stormwater effectively, green infrastructure should be implemented at multiple scales: site or lot, neighbourhood, and regional. Localized, site-specific practices, such as green roofs, downspout disconnections, rain gardens, and porous pavements are designed to maintain natural hydrologic functions for individual sites by absorbing and infiltrating precipitation where it falls. Street-scale practices involve the above as well as innovative street planning with space for road swales and bioretention areas. On a regional scale, the interconnected network of open spaces and natural areas, such as forested areas, floodplains, and wetlands, improve the overall quality of waterways while also providing wildlife habitat and other benefits.

Site-specific treatments include practices that store runoff for later use, such as downspout disconnections with rain barrels.

Site-Specific Green Infrastructure

Site-specific treatments involve on-lot practices that infiltrate rooftop runoff, divert runoff to a pervious area, or store runoff for later use. This includes practices such as green roofs, downspout disconnections with rain barrels and cisterns, permeable pavements and bio-retention areas.

Green Roofs

The green roof is currently one of the most popular green infrastructure practices for the management of stormwater runoff and CSOs. Designed to function as a permeable environment, a green roof is a vegetated area incorporated onto a building's roof. It can be built on commercial, industrial, and residential buildings, and can be applied to new construction or retrofitted to existing buildings.[28] The green roof retains some stormwater runoff on-site, where it is absorbed into the soil and vegetation, and gradually released back into the atmosphere via evapotranspiration, with pollutants retained in the soil. This increases on-site filtration, reduces both the volume of stormwater runoff entering the sewer system and the frequency of CSO events, slows the rate of roof runoff, and improves runoff water quality.[29]

United States Green Infrastructure Partnership

In 2007, the Green Infrastructure Partnership was formed between the US Environmental Protection Agency and four national organizations to promote green infrastructure as a cost effective and environmentally preferable approach to wet weather management and reduction of CSOs. The partnership produced a plan called the "Managing Wet Weather with Green Infrastructure Action Strategy 2008," which outlines ways that municipalities can bring green infrastructure approaches into mainstream use. Neither Canada nor Ontario has any such formalized partnership.

The water retention capacity of a green roof varies depending on the intensity of rainfall, climatic conditions, soil depth and the type of vegetation used.[30] For small rainfalls, there will be little runoff and most will ultimately return to the atmosphere by evapotranspiration. For larger storms, green roofs can significantly delay and mitigate the discharge of runoff from roofs. The amount of stormwater retained is also directly proportional to the area covered by the green roof. Therefore, the larger the area of the green roof, the more stormwater is mitigated.

Runoff absorption rates will also vary between seasons due to temperature, wind, evapotranspiration rates and vegetation cover. In most climates, green roofs will need plant species that can tolerate harsh growing conditions or an irrigation system to sustain vegetation.[31] Though green roofs do not remain "green" throughout the entire year in colder climates, they are still effective since snow can protect the vegetation layer as it builds up on the green roof. The soil and vegetation of the green roof can retain snowmelt in the same way as it does rainfall, thereby reducing the volume of runoff. In climates with extreme temperatures, green roofs provide additional building insulation, which makes them more financially justifiable for many facilities. For example, a demonstration winter green roof (composed of an evergreen species planted in thick soil) in Ottawa showed a reduction in energy used for heating by more than 10 per cent during the cold season.[32]

The benefits associated with green roofs include on-site stormwater management, improved air quality, and energy savings from lower building heating and cooling needs, both for individual roof microclimates and citywide green roof development. Green roofs have been shown to effectively reduce peak flows related to wet weather events, and if implemented on a wide scale, will reduce the volume of stormwater discharged into adjacent waterways. For example, Chicago City Hall's 20,300 square foot green roof, which was built in 2001 as a demonstration site, can retain over 75 per cent of the volume from a one-inch storm.[33] A smaller, typical residential green roof in Oregon has been shown to retain up to 90 per cent of all rainfall, becoming less effective only during continuous and heavy rainfall.[34]

A Ryerson University study[35] evaluated the municipal level benefits and costs of wide-scale implementation of green roofs in Toronto. The study assumed that green roofs would be installed on all city flat roofs more than 3,750 square feet and would cover at least 75 per cent

Green roofs are currently one of the most popular forms of green infrastructure.

PHOTO COURTESY
C ITY OF TORONTO

of the roof. Using this assumption, more than 12,000 acres of green roofs, representing 8 per cent of the total land area in the city, could be installed in Toronto. The study findings estimated nearly $270 million of municipal capital cost savings and more than $30 million in annual operational savings with this number of installed green roofs. In addition, one billion gallons of stormwater would be retained annually, and there would be three additional "beach open" days per year, where bacterial levels from polluted stormwater runoff would not be so high as to warrant beach closures.

Cities such as Toronto, Chicago, Portland, Oregon and Washington, DC actively encourage green roof development with incentives. Chicago and Portland are both North American leaders in green roof technology and use green roofs to meet regulatory requirements with respect to stormwater runoff management and combating the urban heat island effect.[36] For example, Portland's Green Building Policy requires that all new projects that receive funding from the Portland Development Commission are constructed with a green roof and/or Energy Star rated roof material.[37] Other incentives include allowing developers extra floor space if they add green roofs. Toronto's Green Roof Incentive Program is discussed in the Toronto case study later in this report.

Although green roofs are becoming more common in some cities, their mainstream use still faces many challenges and barriers, including higher installation costs and lack of government support. In Toronto, estimated installation costs are $8 to $12 per square foot for conventional roofs versus $15 to $25 for extensive green roofs.[38] However, green roofs last twice as long as do conventional roofs, and energy savings result from less need for heating and cooling for buildings with green roofs. Despite this, many cities still do not actively encourage green roofs and have not removed obstacles, such as zoning laws that discourage or hinder the installation of green roofs. These barriers need to be overcome if green roofs are to become a widely accepted practice for stormwater management and CSO control.

Green roofs last twice as long as do conventional roofs, and energy savings result from less need for heating and cooling for buildings with green roofs.

GREEN ROOFS ON JACKMAN PUBLIC SCHOOL, PHOTO COURTESY CITY OF TORONTO

Downspout Disconnection Programs

A downspout disconnection involves disconnecting a building's roof drainage system from the combined sewer or stormwater collection systems. Instead, the runoff from the roof is redirected onto permeable areas such as lawns or gardens, or into rain barrels or cisterns to be stored and re-used. This technique prevents rooftop runoff from flowing directly into the sewer system during wet weather events, therefore allowing green infrastructure components to manage the stormwater runoff at the source.[39] Downspout disconnections also aid in reducing the risk and severity of basement flooding caused by sewer back up in urban residential areas. The best option and method for disconnection will depend on the feasibility at a specific site and the preferences of the homeowner.

Rain barrels and cisterns are low-cost storage devices that can be used to capture excess roof runoff and provide a source of water for gardens and compost. Because residential irrigation can account for up to 40 per cent of domestic water consumption, water conservation measures such as rain barrels can be used to reduce the demand on the municipal water system, especially during hot summer months.[40]

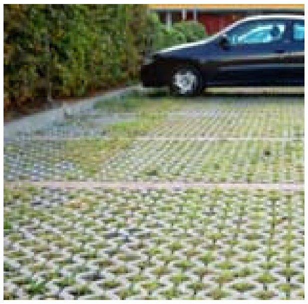
The use of downspout disconnection together with rain barrels is being encouraged in a number of cities, such as Toronto, St. Catharines, and Kingston in Ontario and Portland, Oregon. Programs are implemented in various ways. For example, Toronto's Downspout

Disconnection Program has been made mandatory as of 2007 (it was voluntary from 1998 to 2007). Portland offers homeowners financial incentives for each disconnection, and Kingston has a subsidized rain barrel program. These are discussed in greater detail in the case studies in Appendix I of this report.

Permeable Pavements

Permeable pavements provide stormwater retention capabilities similar to a natural system by allowing stormwater to infiltrate directly or pass through them. Examples of permeable pavement include permeable asphalt, permeable concrete or interlocking concrete pavers. Unlike traditional hard surfaces like concrete and pavement, permeable pavement reduces the strain on stormwater and combined sewer systems by filtering and storing runoff. Often used in alleys, parking lots or other paved areas with low traffic volume, permeable pavement is usually built with porous features that encourage infiltration and an underlying stone reservoir that temporarily stores surface runoff before it infiltrates into the subsoil.[41]

Permeable pavements provide stormwater retention capabilities similar to a natural system by allowing stormwater to infiltrate directly or pass through them.



Similar to green roofs, the water retention capacity of permeable surfaces varies depending on the intensity of the wet weather event and weather conditions; however, they are useful year-round as they can manage both rainfall runoff and snowmelt. Other benefits include less maintenance needs for permeable pavements compared to conventional materials.[42] Although permeable pavements are generally more costly to construct than traditional hard surfaces, the reduced maintenance requirements can result in significant cost savings over the long term.[43] Permeable pavement can therefore provide for long-term and effective stormwater management if it is properly maintained.

Rain Gardens and Road Swales

Various landscaping features can be used to provide on-site treatment of stormwater runoff. These systems use soil and plants to store and filter runoff, thereby reducing the quantity of stormwater entering the sewer system.[44]

One common type of landscaping feature is a rain garden, also called a bioretention area. A rain garden is a vegetated landscape at lower elevation than its surroundings, designed to absorb stormwater runoff. Rain gardens are commonly located adjacent to parking lots, sidewalks or road medians. Surface runoff is directed into shallow, landscaped depressions. These features are one of the few retrofit (a structural management practice incorporated after development has occurred) options that can be employed in highly urbanized areas.

Rain gardens can be used in various climates, and are even effective in colder climates, where they can be used as snow storage areas during winter seasons. By using native plant species that are tolerant of local climatic and soil variations, rain gardens can maintain sufficient biological activity throughout all seasons by preventing filter media from freezing.[45] For example, the same rain garden adjacent to a parking lot can be used to retain and filter rainfall runoff during warmer seasons and also to store snow during colder seasons.

A second type of landscaping feature is a road swale, essentially a green stormwater drainage ditch. Road swales are shallow channels, often containing dense vegetation, designed to trap particulate pollutants, promote infiltration and reduce flow velocity of stormwater runoff.

Street-Level Green Infrastructure

Green Streets

Each of the types of site-specific green infrastructure in the previous section can be integrated across a community or neighbourhood to comprise a system of green street design elements. These "green streets" or "green neighbourhoods" are designed to maximize the use of permeable and vegetated surfaces and the ability of the street's tree canopy to capture stormwater. The planning and construction of green street design is also part of a broader regional approach to stormwater management.

Street trees (collectively referred to as the urban forest) can reduce stormwater runoff by intercepting rainfall on leaves and branches before it hits the pavement.

PHOTO COURTESY URBAN STRATEGIES INC.

Portland is a prime example of a city that has retrofitted a number of streets with vegetated curb extensions, swales, planter strips, permeable pavement, and street trees to filter and store stormwater. For example, the Northeast Siskiyou Street landscaped curb extensions were installed in 2003 at a cost of $15,000.[46] Flow tests showed a reduction in peak flow from a 25-year storm event (about two inches in six hours) by 88 per cent, enough to protect local basements from flooding. They also reduced total runoff (2,000 gallons in the simulation) to the combined sewer system by 85 per cent. Portland's green street installations have also been commended for their aesthetic value as green space. An additional example is the green street planters on the Portland State University campus, which include four adjacent planters that capture and treat runoff from 8,000 square feet of street surface. Stormwater collects to a depth of six inches, and once exceeded, exits the first planter and is routed into adjacent planters.

Regional Green Infrastructure

Green infrastructure can also be used on a regional basis in highly developed urban areas through conservation and protection of natural spaces. On a regional scale, this includes networks of parklands, ravines, urban forest areas and wetlands.

Street trees (collectively referred to as the urban forest) can reduce stormwater runoff by intercepting rainfall on leaves and branches before it hits the pavement. Trees with mature canopies are able to absorb the first half-inch of rainfall.[47] An increase in tree cover from 25 to 50 per cent on a residential lot can reduce runoff from about 10 to 20 per cent.[48] The urban forest has numerous additional benefits, including filtering and reducing the pollutant loading in surface runoff, improving air quality, and storing and sequestering atmospheric carbon in the wood of tree trunks.

Wetland and stream restoration projects reduce the strain on stormwater and combined sewer systems while improving water quality and wildlife habitat. For example, Toronto has restored several wetlands, including Chester Springs Marsh, a 7.5-acre wetland restored on the site of an old landfill.[49] This wetland was restored to prevent nutrients and pollutants from reaching the Don River, and the recovered area has seen a substantial increase in the number of species that visit the site, spurring city plans to build and restore several more wetlands.

A complete glossary of green infrastructure techniques is provided in Appendix II on page 47.

Functions of Green Infrastructure Techniques

Each of the green infrastructure techniques described above provides stormwater runoff mitigation benefits, and though they differ in function, each results in reduced frequency of CSOs. A comparison of techniques by function is provided in Table 3.

Table 3: Hydrologic Function of Green Infrastructure Techniques

Green infrastructure technique	Slower rate of runoff	Infiltration[a]	Retention[b]	Detention[c]	Water quality control[d]	Reduced CSO frequency
Green						
Roof	√		√	√	√	√
Downspout disconnection	√	√				√
Rain barrel/ cistern			√			√
Permeable pavement	√	√			√	√
Vegetated swale	√	√		√	√	√
Bioretention/ rain garden	√	√	√	√	√	√
Infiltration trench		√			√	√
Urban						
Forests	√		√		√	√
Restored/ constructed wetland	√	√	√	√	√	√

NOTES
[a] Permeation of water into the ground.
[b] Long-term storage of stormwater that could be lost through evapotranspiration or stored in man-made containers for re-use.
[c] Short-term storage and release of stormwater following a wet weather event, which controls discharge rates.
[d] Filtering of pollutants from the stormwater.

Toronto has restored several wetlands, including Chester Springs Marsh, a 7.5-acre wetland restored on the site of an old landfill. This wetland was restored to prevent nutrients and pollutants from reaching the Don River, and the recovered area has seen a substantial increase in the number of species that visit the site, spurring city plans to build and restore several more wetlands.

CHESTER SPRINGS MARSH
PHOTO COURTESY
CITY OF TORONTO

Cities in Ontario Using Green Infrastructure to Mitigate CSOs and Stormwater

A summary of techniques being used in some of the municipalities that participated in our survey or have published online information on green infrastructure is presented below in Table 4. Some of the green infrastructure techniques used may be of very limited scope, such as small pilot projects, while others may be part of a city-wide program. The table offers a comparison of Ontario cities to Portland, Oregon, showing that Ontario cities appear to be underutilizing green infrastructure.

Table 4: Comparison of Green Infrastructure Usage

City	Established municipal programs and funding	Green roofs	Rain gardens	Permeable pavement	Rain barrels	Downspout disconnection	Urban forests / wetlands / natural space protection	Interest in learning more about green infrastructure
Toronto	√	√	√	√	√	√	√	√
Windsor		√			√	√		√
London						√	√	√
St. Catharines					√	√	√	√
Niagara Falls								√
Hamilton								
Owen Sound								√
Kingston					√	√		√
Waterloo		√						
Portland	√	√	√	√	√	√	√	√

Recommendations

Mainstream adoption of green infrastructure faces obstacles, including perceptions that green infrastructure is costly to introduce or retrofit into densely developed urban areas, and is not adaptable to a cold climate. This is despite the fact that green infrastructure can be less costly than traditional methods of managing stormwater and combined sewer systems, and can also be effective even in colder climates. Local decision makers and organizations must take the lead in advocating for the implementation of green infrastructure into their communities. The following policy recommendations can be used to encourage the adoption and use of green infrastructure in municipalities.

Improving transparency with respect to sewage discharges including combined sewer overflows will encourage governments to invest in solutions and will bring communities on side.

RECOMMENDATION 1: Improve transparency and public reporting

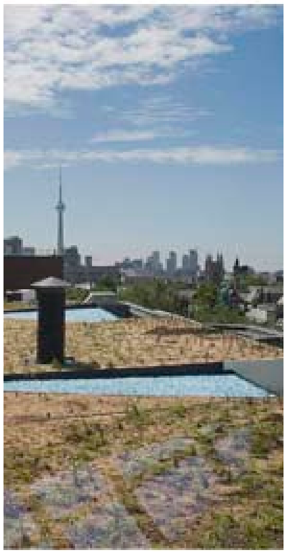
Improving transparency with respect to sewage discharges including combined sewer overflows will encourage governments to invest in solutions and will bring communities on side. Mandatory timely public reporting of sewage discharges (spills, bypasses, and combined sewer overflows) will ensure this issue is given the attention and investment it needs.

RECOMMENDATION 2: Incorporate green infrastructure into development planning

All new development or redevelopment should integrate some level of green infrastructure and stormwater source control. Cities should build green space into new development plans and preserve existing green spaces and street vegetation. The active preservation of existing urban trees and open green space will help in the management of stormwater runoff while lessening the need for additional stormwater controls. Incorporating green infrastructure into the earliest stages of community development can negate or limit the need for larger-scale, more expensive stormwater controls. Minimizing imperviousness, preserving existing vegetation, and incorporating green space into designs all decrease the negative impact that urbanization has on water quality.

Green techniques should be incorporated into plans for infrastructure repairs and upgrades and into long-term control plans for managing CSOs.

Provincial and local development and planning policies should be revised to prioritize green infrastructures use. A policy emphasis should be placed on reducing impervious surfaces, preserving vegetation, and providing space for bioretention areas and other green infrastructure.



When faced with the challenges of regulatory requirements, infrastructure limitations, and financial constraints, green infrastructure can offer a way of fulfilling each.

ROYAL ONTARIO MUSEUM, PHOTO COURTESY CITY OF TORONTO

RECOMMENDATION 3: Reform stormwater and wastewater policy

Municipalities should revise prohibitive stormwater and wastewater policies, such as local zoning requirements and building codes, which discourage the use of green infrastructure, to remove barriers to green infrastructure use.

Examples of effective polices that have been used by municipalities include:

- Expedited permitting for green infrastructure;
- Building code provisions for on-site stormwater control;
- Green development standards, green roofs requirements, and permeable parking lot requirement; and
- Favourable zoning allowances.

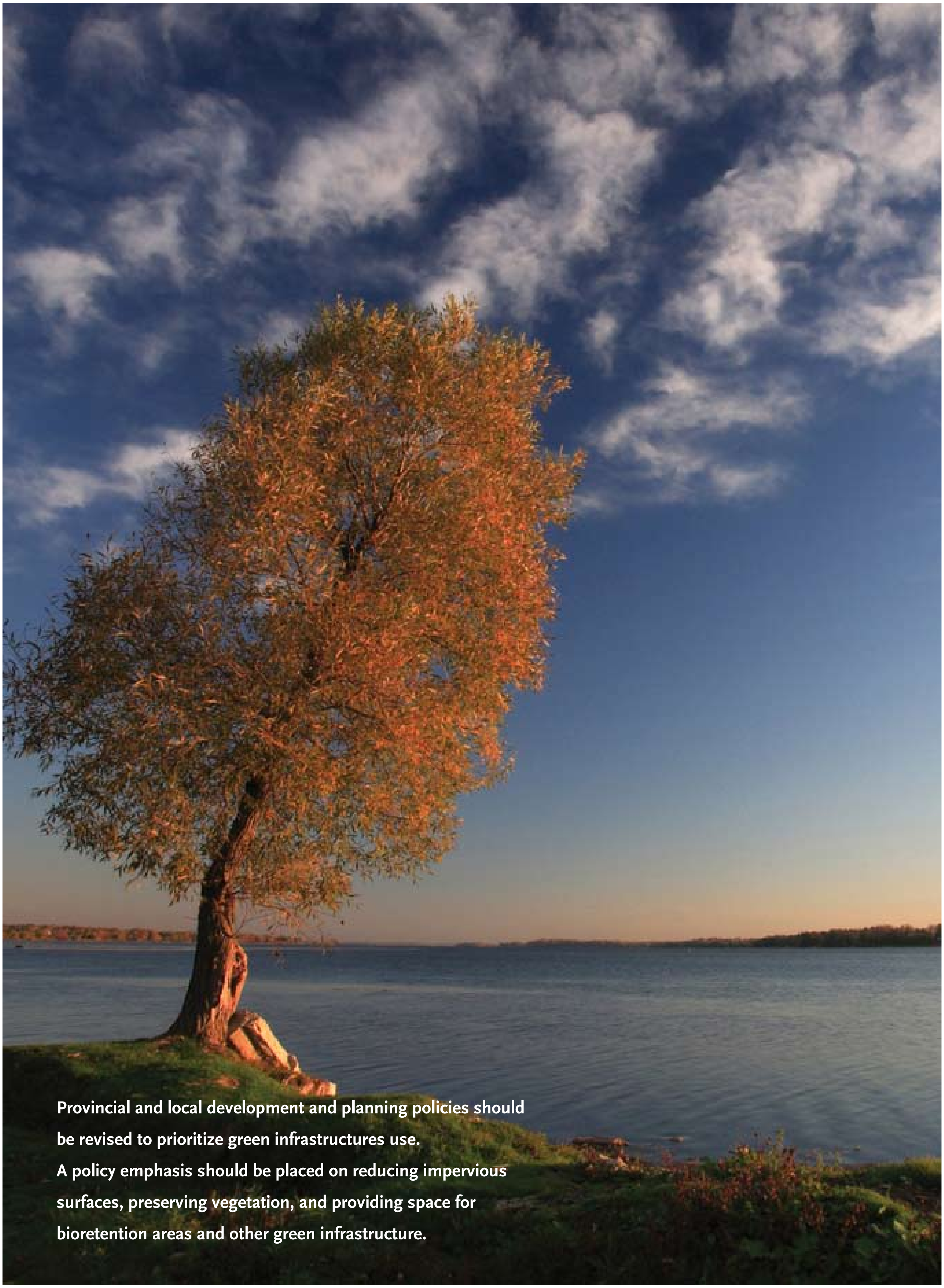
The use of green infrastructure needs to be a priority for stormwater and CSO management programs and polices by bringing green infrastructure technologies and approaches into mainstream stormwater management. Local stormwater management policies should be revised to encourage green infrastructure though requirements such as: minimizing and reducing impervious surfaces, protecting existing vegetation, maintaining predevelopment runoff volume and infiltration rates, and providing water quality improvements.

Cities with combined sewer systems are required to develop long-term plans to reduce sewer overflows enough to meet water quality standards. Those plans should prioritize the use of green infrastructure for the management of CSOs. For example, Portland, Oregon, requires on-site stormwater management for new development and redevelopment in both CSO and separate sewer areas of the city, and encourages the use of green infrastructure to comply with the regulation.

Strong regulations increase the opportunities for municipal decision makers to actively promote and introduce green infrastructure. When faced with the challenges of regulatory requirements, infrastructure limitations, and financial constraints, green infrastructure can offer a way of fulfilling each.

RECOMMENDATION 4: Establish funding sources and incentives programs

Establish dedicated funding for stormwater management that rewards green design. Adequate funding is critical for successful stormwater and CSO management programs. The billions of dollars necessary to mitigate stormwater pollution and CSOs require federal funding to augment provincial and municipal funding. To encourage its use, dedicated stormwater funding sources could identify a preference for green infrastructure or establish a funding scale based upon the relative use of green management techniques.


Provincial and local development and planning policies should be revised to prioritize green infrastructures use.
A policy emphasis should be placed on reducing impervious surfaces, preserving vegetation, and providing space for bioretention areas and other green infrastructure.

Many jurisdictions are creating stormwater utilities similar in function to water and wastewater utilities. Stormwater utilities allow for the assessment and collection of a user fee dedicated to a stormwater management program. Other jurisdictions dedicate a portion of collected local tax revenue to a stormwater fund. Establishing a dedicated fund removes stormwater management from general revenue funding, which is subject to variable funding and competes with other general taxation programs for money. Stormwater utilities, where allowed by enabling legislation, are popular because of the ability to determine a user rate structure and as a complement to incentive programs. An added incentive for cities that charge stormwater utility fees is to provide discounts on this fee for properties with on-site stormwater management.

Financial incentives are also successful in encouraging the incorporation of green infrastructure, such as green roofs, into communities. For example, grant programs for installation or retrofits, including pilot programs, can offer a flat rate per square metre of green roofs. Other incentives to encourage residential and commercial use of green infrastructure include allowing additional building square footage for buildings with green roofs.

By limiting sprawl and discouraging development in sensitive areas, smart growth may increase population densities and reduce imperviousness areas.

Green loans could be potentially incorporated into existing programs, and different types of tax incentives could be offered for integration of green infrastructure into communities. Cities should also fund or subsidize a downspout disconnection program, or create mandatory programs such as Toronto's downspout disconnection program with funding to assist low income households.

RECOMMENDATION 5: Encourage through smart growth and community involvement

Encourage and use smart growth. Smart growth can be used to limit sprawl and reduce the introduction of impervious surfaces. Smart growth policies can identify and protect sensitive environmental areas and direct development to locations with adequate infrastructure. By limiting sprawl and discouraging development in sensitive areas, smart growth may increase population densities and reduce imperviousness areas. Smart growth strategies should be coupled with green infrastructure to limit the stormwater and infrastructure effects of a potential increase in urbanization.

Get the community involved. Green infrastructure presents an opportunity for community outreach and education. Downspout disconnections, rain barrels, rain gardens, and green roofs may individually manage a relatively small volume of stormwater, but collectively can have a significant impact.

There may be value in starting small with demonstration and pilot projects, and monitoring them and then modifying the designs for improved function and effectiveness before implementing more widely.

RECOMMENDATION 6: Share information and learn from others

Reach out to other jurisdictions to find out what they are doing and what lessons have already been learned. Then specific strategies can be developed that are designed to meet the particular needs of a community. There is no shortage of great examples out there that cities can draw from as they start to incorporate green infrastructure into their communities.

Resources

US Environmental Protection Agency: Managing Wet Weather with Green Infrastructure: http://cfpub.epa.gov/npdes/home.cfm?program_id=298.

US Environmental Protection Agency: Smart Growth & Water Resources & Tools: www.epa.gov/watertrain/smartgrowth/resources/resident.htm.

Natural Resources Defence Council: www.nrdc.org/water/pollution/rooftops/contents.asp.

Low Impact Development Center, Inc.: www.lowimpactdevelopment.org.

City of Portland: Sustainable Stormwater Management Program: www.portlandonline.com/bes/index.cfm?c=34598.

Stormwater Infrastructure Matters (SWIM): http://swimmablenyc.info.

Water Environment Research Foundation: Using Rainwater to Grow Livable Communities: www.werf.org/livablecommunities.

Waterbucket: www.waterbucket.ca.

Federation of Canadian Municipalities: www.sustainablecommunities.fcm.ca.

Great Lakes and St. Lawrence Cities Initiatives: www.glslcities.org.

University of Victoria Environmental Law Clinic: British Columbia Green Bylaws Toolkit: www.elc.uvic.ca/press/green-bylaws-toolkit.html.

Ontario Ministry of the Environment: Stormwater Management Planning and Design Manual: www.ene.gov.on.ca/envision/gp/4329eindex.htm.

Association of Municipalities of Ontario: www.amo.on.ca.

City of Toronto: Green Roofs: www.toronto.ca/greenroofs.

Green Roofs for Healthy Cities: www.greenroofs.net.

Riversides: www.riversides.org.

Toronto Region Conservation Authority: www.trca.on.ca.

Green Infrastructure Case Studies

Cities are beginning to incorporate green infrastructure as a component of comprehensive stormwater management plans aimed at reducing stormwater runoff, CSOs or both. The following case studies highlight examples of communities that are making innovative use of green infrastructure in their attempts to manage their stormwater and CSO problems.

PORTLAND, OREGON

POPULATION: 539,000

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, bioswales, rain gardens, infiltration planters, downspout disconnections with rainwater collection, sustainable street design

PROGRAM ELEMENTS: Used for direct CSO control; municipal programs and public funding

In Portland, an estimated 50,000 households have disconnected their downspouts, removing nearly one billion gallons of stormwater per year from the combined sewer system.

STEPHANE GAGNON PHOTO

Rainfall in Portland occurs mostly in small frequent storms, which is the type of precipitation event that green infrastructure technologies are most successful at mitigating. In 2004, Portland had 50 CSO events and discharged 2.8 billion gallons of combined overflow into local waterways. To manage their CSO problems, Portland combines traditional infrastructure with local level green infrastructure strategies. The city is also collecting significant data on the effectiveness of decentralized stormwater management technologies.

PORTLAND'S INNOVATIVE STORMWATER MANAGEMENT INCENTIVE PROGRAMS

Portland encourages sustainable stormwater management through policy initiatives and has promoted funding and education for innovative stormwater management over the past decade. Portland's stormwater manual encourages the use of green infrastructure techniques. The city provides funding for sustainable stormwater management projects through various grants, matching-grant programs, and the Green Investment Fund, which is a $500,000 per year grant program to support innovative building practices in the private sector.

The Clean River Rewards program, which came into effect in 2006, offers residential ratepayers a discount on their stormwater utility fees, based on the extent to which they can manage runoff from roof areas. Credits are offered for creating or maintaining tree coverage, disconnecting downspouts, installing rain gardens or drywells and other initiatives. The Downspout Disconnection Program, created in 2003, offers homeowners $53 per downspout disconnected from the combined sewer system. An estimated 50,000 households have disconnected their downspouts, removing nearly one billion gallons of stormwater per year from the combined sewer system.

Portland has long been considered a leader in green roof technology, installing its first green roof more than a decade ago. The city has since begun an initiative to install and monitor green roofs throughout the city. Portland also offers a zoning bonus, allowing for additional square footage for buildings featuring a green roof, and the adoption of a green building policy requires green roofs on all new city-owned and managed facilities and roof replacement projects.

FOR FURTHER INFORMATION

City of Portland, Bureau of Environmental Services: www.portlandonline.com/bes.

Portland Case Study. NRDC. Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows. www.nrdc.org/water/pollution/rooftops/contents.asp.

Water Environment Research Foundation:
www.werf.org/livablecommunities/studies_port_or.htm.

NEW YORK CITY, NEW YORK

POPULATION: 8.2 million

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, bioretention, tree cover, permeable pavement, wetland preservation and creation, green streets, rain barrels, cisterns, downspout disconnections

PROGRAM ELEMENTS: Used for direct CSO control; municipal programs and public funding

Currently, New York City Harbour receives about 27 billion gallons annually of raw sewage and polluted stormwater discharge from 460 CSOs. As little as one tenth of an inch of rainfall can overload the system and allow raw sewage to be discharged into the harbour.

CHICAGO, ILLINOIS

With a population of 2.9 million, Chicago is the current North American leader in green roofs. Chicago's green roof program began with a 20,300 square foot demonstration roof on its City Hall building in 2001. As of 2006, the city has around 300 green roofs, totaling three million square feet. The city encourages the use of green roofs by providing incentives in the form of grants, as well as a density bonus for green roofs, which allows developers to increase the number of units allowed on a piece of property. The city also has an expedited permitting process if a green roof is included in the building plan, and developer's fees are waived for processing the permit application.

FOR FURTHER INFORMATION: Chicago Department of the Environment: www.cityofchicago.org/environment

Chicago, the current North American leader in green roofs, began its program with a 20,300 square foot demonstration roof on City Hall in 2001. As of 2006, the city has around 300 green roofs, totaling three million square feet.

CHICAGO CITY HALL DWATERSON PHOTO

GREEN INFRASTRUCTURE LEGISLATION

In January 2008, New York City Council passed legislation, City Council Intro No. 630, to promote the use of green infrastructure into the city's existing streets, parks, and other public spaces and into existing and new development projects. The legislation is part of Mayor Bloomberg's PlaNYC 2030, which includes plans to plant a million new trees, improve parks in every neighbourhood, and provide tax incentives for green roofs. The by-law requires the development and implementation of a Sustainable Stormwater Management Plan, the first draft of which is due at the end of 2008. The new law also requires the city to notify the public of sewer overflows.

SUSTAINABLE STORMWATER MANAGEMENT PLAN

The city's Sustainable Stormwater Management Plan will establish standards for the control of stormwater runoff from new or existing public open space and construction of green roofs. It will include mandatory source control measures on public and private property, and will prioritize vegetative source control measures where feasible. It will also create incentives, such as tax incentives, grant programs, expedited permitting, and restructuring of water and sewer rates, to encourage the owners of new and existing private buildings to retrofit or construct such buildings with appropriate source control measures. The plan includes amendments to provisions in the building code, housing maintenance code, zoning resolution, and other laws and regulations applicable to new or existing public or private construction projects. The amendments address the implementation of source control measures and quantitative performance standards for the minimum amount of stormwater that must be retained, detained, infiltrated, and/or reused on-site.

The City of New York will create incentives, such as tax incentives, grant programs, expedited permitting, and restructuring of water and sewer rates, to encourage the owners of new and existing private buildings to retrofit or construct such buildings with appropriate source control measures.

FOR FURTHER INFORMATION

NRDC. New York City to Clean Up Waterways by Greening Roadways and Roofs.
www.nrdc.org/media/2008/080130.asp.

The New York City Council. Local Law Int. No. 630-A.
www.nyccouncil.info/html/legislation/legislation_llbyyear.cfm.

Stormwater Infrastructure Matters. www.swimmablenyc.org.

MANHATTAN GREEN ROOF
ALYSON HURT PHOTO

TORONTO, ONTARIO

POPULATION: 2.5 million

Types of green infrastructure used: Green roofs, bioretention, tree cover, permeable pavement, wetland preservation and creation, rainwater harvesting, rain barrels, cisterns, downspout disconnections

PROGRAM ELEMENTS: Used for direct CSO control; established municipal programs and funding

Sitting along the shore of Lake Ontario, Toronto is the largest city in Canada. Toronto's sewer infrastructure network includes 4,500 km of storm sewers, 79 CSO outfalls (33 of which connect directly to Lake Ontario) and 2,600 storm sewer outfalls (70 of which connect directly to Lake Ontario). Toronto's stormwater is a leading cause of pollution in Lake Ontario, and Toronto Bay and six neighbouring watersheds are part of an Area of Concern. As a result, Toronto has several green infrastructure initiatives, and has established and funds various municipal programs to address its stormwater pollution problems.

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WET WEATHER FLOW MASTER PLAN

Toronto's 25-year stormwater plan is called the Wet Weather Flow Master Plan (WWFMP). The plan outlines a strategy to deal with Toronto's surface water quality and quantity, sewage overflows, and habitat protection, and was developed with the recognition that wet weather flow should be managed on a watershed basis, accompanied by a hierarchy of solutions starting with source controls, followed by conveyance and then end-of-pipe solutions. It also recognizes that Toronto is a highly urbanized area and thus needs to incorporate projects that contain stormwater at source. The plan therefore contains source control elements such as the Downspout Disconnection Program and the Green Roof Incentive Program.

DOWNSPOUT DISCONNECTION PROGRAM

Although Toronto's Sewer Use By-Law permits downspouts currently connected to the city's combined sewer and storm sewer systems, it does not allow downspouts in new homes to be connected. It is estimated that downspouts in 350,000 residential properties (of approximately 500,000) are directly connected to the city's sewer systems, including 120,000 properties connected to combined sewers. Toronto's Downspout Disconnection Program was voluntary from 1998 until November 2007, during which time the city disconnected residences for free and provided rain barrels to protect residential foundations. Each year, $1.5 million in funding was provided, and efforts were targeted at areas that experience localized flooding or have significant impact on Toronto's beaches. Approximately 26,000 downspouts were disconnected through the voluntary program.

In 2007, City Council reviewed the program and due to limited participation, decided to discontinue the program and adopt a new Mandatory Downspout Disconnection Program. All downspouts are to be disconnected by 2009 at the cost of the homeowner, but low-income families will receive assistance. The mandatory program will initially target priority areas served by combined sewers. If feasible, homeowners in these areas will be required to disconnect their downspouts within three years, at which time property owners could face fines. More than 50,000 residents signed up following the announcement that the voluntary program would be discontinued.

RAINWATER HARVESTING

The City of Toronto is supporting the implementation of a rainwater harvesting pilot project at the Automotive Building at Exhibition Place. The new system would capture rainwater in a cistern from a roof catchment area for use in eight washrooms throughout the building, and prevent the runoff from entering the sewer system. Raw lake water could be used to augment the rainwater source during dry weather periods. The construction of the system is expected to be undertaken in conjunction with the proposed building renovations, due to be completed by the end of 2008.

GREEN ROOF INCENTIVE PROGRAM

Toronto City Council approved a Green Roof Incentive Pilot Program in 2007, offering grants of up to $20,000 as incentive for property owners to plant vegetation on building roofs. The program provides $50 per square metre of eligible green roof area up to a maximum of $10,000 for single-family homes and $100,000 for all other property owners in Toronto. The Toronto Environmental Plan also contains a number of recommendations promoting sustainable design including encouraging green roofs.

A Toronto pilot project would capture rainwater in a cistern from a roof catchment area for use in eight washrooms throughout the building, and prevent the runoff from entering the sewer system.

Toronto now has more than 100 green roofs. The city, along with Environment Canada, the Toronto and Region Conservation Authority, and Ryerson University have been evaluating the performance of urban green roofs by quantifying both the amount of stormwater mitigated by green roofs and cost offsets. These findings are being used by the city to develop stormwater management standards and guidelines based on the quantification of stormwater drainage benefits from green roofs.

MORE TORONTO POLICY INITIATIVES

Toronto has developed Green Development Standards to set standards and provide performance targets for sustainable site or building design. These standards are mandatory for city-owned properties, and encouraged for the private sector. Table 5 provides a summary of stormwater management standards for new mid- to high-rise residences, commercial, industrial and institutional developments.

Table 5: Toronto Green Development Stormwater Management Standards

Development feature	Toronto Green Standard (*core or minimum standard unless otherwise noted)	Possible implementation strategies
Stormwater runoff: Manage and clean stormwater that leaves the site	Remove 80 per cent of total suspended solids on an annual loading basis from all runoff leaving the site; Disinfect runoff from the site which discharges directly into Lake Ontario or Waterfront areas.	Mechanical or natural treatment systems such as constructed, vegetated filter strips, bioswales, sediment traps.
Stormwater retention: Minimize stormwater that leaves the site	Retain stormwater on-site to the same level of annual volume of overland runoff allowable under predevelopment conditions; Retain all runoff from small design rainfall events (typically 5 mm) through rainwater reuse, onsite infiltration, and evapotranspiration.	Green roofs, rain barrels, permeable paving, green streets instead of curb and gutter, downspout disconnection, infiltration trenches, absorbent landscaping.
Rain water harvesting: Use stormwater as a resource to reduce demand for potable water	Capture, store, treat and use at least 50 per cent of rain water for irrigation and/or flushing (*this is an enhancement that would further improve the sustainability of a development beyond the basic Green Standard).	Rain barrels, storage cisterns.

Toronto also published Draft Design Guidelines for "Greening" Surface Parking Lots in 2007, which includes planting trees and providing permeable surfaces, as well as developing landscaped and bioretention areas to manage parking lot stormwater on-site.

TORONTO'S REGENT PARK

Regent Park is one of the oldest and largest publicly-funded housing communities in Canada, and its aging infrastructure is deteriorating. The Regent Park Revitalization Plan is now underway to transform Regent Park into a healthy community, with green, sustainable designs. This includes stormwater controls that aim for improvements in stormwater runoff retention, quality and quantity, and emphasize natural stormwater infiltration, such as green roofs, permeable paving, cisterns, vegetated swales and greening of streets.

Regent Park is one of the oldest and largest publicly-funded housing communities in Canada, and its aging infrastructure is deteriorating. The Regent Park Revitalization Plan is now underway to transform Regent Park into a healthy community, with green, sustainable designs.

FOR FURTHER INFORMATION:

City of Toronto. Wet Weather Flow Master Plan Overview. www.toronto.ca/water/protecting_quality/wwfmmp/index.

City of Toronto Staff Report. Mandatory Downspout Disconnection within the Combined Sewer Service Area. www.toronto.ca/legdocs/mmis/2007/pw/bgrd/backgroundfile-7842.pdf.

City of Toronto Staff Report. Rainwater Harvesting Project at Exhibition Place. www.toronto.ca/legdocs/mmis/2007/pw/bgrd/backgroundfile-8874.pdf.

City of Toronto. Green Roof Incentive Program. www.toronto.ca/greenroofs/.

City of Toronto. Toronto Environmental Plan, 2000. www.toronto.ca/council/etfepfin.pdf.

City of Toronto. Green Development Standards, 2007. www.toronto.ca/planning/pdf/gds_standardjan07_03.pdf.

City of Toronto. Draft Design Guidelines for "Greening" Surface Parking Lots. www.toronto.ca/planning/urbdesign/greening_parking_lots.htm.

Toronto Housing Community. Regent Park Revitalization Study and Action Plan: Sustainability Study. www.regentpark.ca/revitalization.htm.

WATERLOO, ONTARIO

POPULATION: 114,700 (including non-resident post-secondary student population of 22,860)

TYPES OF GREEN INFRASTRUCTURE: Green roofs

The City of Waterloo conducted a feasibility study in 2004 to determine whether green roofs were an appropriate technology for the municipality, and to determine the specific benefits of green roofs for Waterloo. The feasibility study used Geographic Information Systems (GIS) to map out and determine which areas would reap the maximum benefit from green roofs. The study identified six primary benefits the City of Waterloo would gain by utilizing green roof technology, including stormwater management, a decrease in air pollution, reduction of the heat island effect, energy conservation, an increase in green space, and extension of the lifespan of the roof. The City of Waterloo City Centre was chosen as a demonstration site, and construction of a 1,650 m^2 green roof was completed in 2007.

INFORMATION SOURCE: City of Waterloo Green Roof Project.
www.city.waterloo.on.ca/DesktopDefault.aspx?tabid=1177

WATERLOO PARK BOARDWALK
SEBASTIAN SANTA PHOTO

ST. CATHARINES, ONTARIO

POPULATION: 130,000

TYPES OF GREEN INFRASTRUCTURE: Downspout disconnection, rain barrels, rain gardens, wetland construction and protection, strategic plan

The City of St. Catharines has various programs to encourage the use of green infrastructure to mitigate its CSOs. Since 1991, the city has required downspouts to discharge onto the surface for new construction, and requires the disconnection of all downspouts from the combined sewers. The Sewer Use By-Law was updated in 1991 to prohibit the connection and discharge of roof water into the sanitary or combined sewer systems. It also prohibits the connection of foundation drains or weeping tiles, with the exception of those connections constructed or approved prior to the passage of the by-law. The Disconnection Program includes a public education component as well as a field inspection program to ensure compliance with the by-law.

Rain barrels are offered to the public at a subsidized price, and rain gardens are encouraged in residential areas through a public education and outreach program, in conjunction with the Region of Niagara. In 2008, the city will commission a new one-hectare constructed wetland to treat stormwater runoff prior to discharge into a creek, at a cost of approximately $400,000. The city has also retained a number of urban creeks, many of which have a vegetative buffer. Finally, the city's Green Plan identifies St. Catharines' green spaces and proposes strategies to protect and enhance them.

Information provided through a survey completed by the City of St. Catharines.

FOR FURTHER INFORMATION: City of St. Catharines Environmental Services.
www.stcatharines.ca/cityservices/citydepartments/engineering/new_eng_environmental.asp

KINGSTON, ONTARIO

POPULATION: 117,000

TYPES OF GREEN INFRASTRUCTURE: Downspout disconnection and rain barrels

In 1992, the City of Kingston developed a long-term Pollution Control Plan that identified major infrastructure improvements to reduce or eliminate CSOs. The plan recommended CSOs to Lake Ontario and the Great Cataraqui River be reduced to address beach contamination and closures by building large storage tanks to control CSOs during high flows, upgrading the existing sewer pumping stations, and upgrading and maintaining the trunk sewers. The CSO storage facilities have been completed and pumping stations have been upgraded to increase the volume of flow that can be pumped to the treatment plant. The plan was updated in 2001 to target further improvements to the system. Utilities Kingston continues to work with the city to replace or repair aging sewers and invests $4 to $6 million per year towards this. Utilities Kingston has also evaluated various strategies to separate the sewer system, and plans to use the recommendations from this evaluation to provide a policy to improve the city's infrastructure.

Kingston has a downspout disconnection program and in the older combined-sewer area most downspouts have already been disconnected. The city also subsidizes the cost of rain barrels through its Rain Barrel Program, and has requirements for stormwater management provisions in new developments and redevelopments.

INFORMATION SOURCE: City of Kingston. Utilities Kingston. Combined Sewer Overflows. www.utilitieskingston.com/water/bypass/solutions.html

In 1992, the City of Kingston developed a long-term Pollution Control Plan that identified major infrastructure improvements to reduce or eliminate CSOs.

LONDON, ONTARIO

POPULATION: 352,000

TYPES OF GREEN INFRASTRUCTURE: Stormwater ponds, downspout disconnection, strategic plan

London has approximately 100 stormwater management facilities, including two engineered wetlands and 60 engineered wet ponds. Each of these are integrated with the natural environment to improve water quantity and quality and provide erosion control. Construction of approximately 80 wet pond facilities is planned for the next 10 to 20 years.

London requires stormwater management for all new developments, and downspouts are no longer permitted to be connected to the sanitary sewer system.

In 2007, London City Council supported developing a Green Infrastructure Plan as part of the city's long-term climate change adaptation strategy. The objective of the plan is to incorporate natural systems into the city's design standards to improve water quality, reduce overland runoff, and maintain the water balance. The plan timeline is two to three years.

Information provided through a survey completed by the City of London.

HAMILTON, ONTARIO

POPULATION: 490,000

TYPES OF GREEN INFRASTRUCTURE: None – only conventional hard infrastructure used for CSO control

Hamilton has approximately 600 kilometres of combined sewer system. When CSOs occur, they are diverted to Hamilton Harbour, Cootes Paradise, Chedoke Creek and Red Hill Creek at 23 locations. The Harbour is an Area of Concern, and the Hamilton Harbour Remedial Action Plan (RAP) was developed and updated in 2002 to guide clean up efforts.

The City of Hamilton's Pollution Control Plan (completed in 1991 and updated in 2003) recommended the construction of a number of CSO storage tanks. Six tanks are now in operation, providing a total storage volume of approximately 193,000 cubic metres.

The storage tanks generally reduce CSO frequencies by 85 to 95 per cent and CSO volumes by 90 to 95 per cent.

Combined sewage is treated at the Woodward Avenue Wastewater Treatment Plant (WWTP), which serves approximately 380,000 residents in Hamilton. The current treatment capacity and process of the WWTP does not allow RAP targets to be met. A Municipal Class Environmental Assessment was initiated by the City of Hamilton to determine the most cost-effective and environmentally sound means of increasing the Woodward Avenue WWTP's ability to properly handle CSOs. Identified measures include the construction of new treatment units, improved controls in the sewer system to allow maximized capacity and flow reductions to the treatment plant during wet weather events, storage/treatment at CSOs in the sewer system, and flow reduction or pollution prevention such as roof downpipe disconnection and reduction of infiltration. Hamilton also has plans for stormwater management ponds over the next 10 years.

Hamilton has approximately 600 kilometres of combined sewer system. When CSOs occur, they are diverted to several sites, including Hamilton Harbour, an environmental Area of Concern.

INFORMATION SOURCE: City of Hamilton Public Works. Water and Wastewater. www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PublicWorks/WaterAndWasteWaterDev.

Glossary of Green Infrastructure Techniques[50]

BIORETENTION AREA: Shallow landscaped depressions, such as rain gardens, vegetated buffers, swales and medians, commonly located in parking lots or residential sidewalk areas to absorb stormwater runoff. Landscaping features are adapted for on-site treatment of runoff, and soils and plants are used to store, filter and infiltrate some of the runoff, preventing it from reaching the sewer system. One of the few retrofit options in highly urbanized areas.

DOWNSPOUT DISCONNECTION: Disconnection of the roof drainage system of residential homes from the sewer system and redirection of stormwater either onto pervious vegetated areas such as lawns or gardens or into rain barrels or cisterns to be captured for re-use. Rooftop runoff is kept from flowing directly onto the street and then into the storm sewers.

GRASSED/VEGETATED SWALE (also called grassed channel, dry swale, wet swale, biofilter, or bioswale): Shallow, open channels that are densely vegetated and designed to attenuate stormwater runoff and replace curb-and-gutter systems. As runoff flows along channels, the vegetation slows the flow velocity of stormwater runoff, traps particulate pollutants, and promotes infiltration into the underlying soils.

Green parking lot techniques that reduce total impervious cover include using bioretention areas to treat stormwater.

GREEN PARKING LOTS: Techniques to reduce total impervious cover include utilizing alternative pavers in overflow parking areas, using bioretention areas to treat stormwater, and providing economic incentives for structured parking.

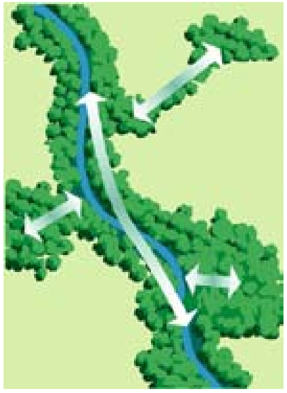
GREEN ROOF: Designed to function as a permeable environment, it is a vegetated area built onto a building's roof to retain rainfall. It is composed of a drainage layer, a root resistance layer and a waterproof membrane to support the growing medium and vegetation. It allows for on-site filtration, a reduced volume of stormwater runoff and frequency of CSO events, a slower rate of roof runoff, and improved runoff water quality.

INFILTRATION TRENCH: Can be built underground to help sustain trees through passive irrigation.

INNOVATIVE STREET DESIGN: Both the street and underlying street patterns relate to stormwater and its impacts. "Green streets" have narrower widths and infiltration opportunities, eliminate curbs and gutters, and are based on a network of well-connected streets that support multiple transportation modes.

LOW IMPACT DEVELOPMENT (LID): Integrates small-scale measures throughout a development site. Constructed green spaces, native landscaping, and innovative bioretention and infiltration techniques capture and manage stormwater on-site. In areas with slow drainage or infiltration, LID captures the first flush before excess stormwater is diverted into traditional storm conveyance systems. The result is development that more closely maintains pre-development hydrology. LID has been shown to be cost effective, and in some cases, cheaper than using traditional stormwater management techniques.

OPEN SPACE DESIGN: A design technique that concentrates dwelling units in a compact area in one portion of a development site in exchange for open space and natural areas elsewhere on site. The minimum lot sizes, setbacks and frontage distances for the residential zone are relaxed to create the open space. Benefits in comparison to conventional subdivisions include reductions in impervious cover, stormwater pollutants, construction costs, and the loss of natural areas.



A riparian buffer is an area along a shoreline, wetland, or stream where development is restricted or prohibited to protect and separate a stream, lake, or wetland from future disturbance and to provide stormwater management.

PERMEABLE PAVEMENT: Often used in parking lot designs, and frequently built with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. Permeable pavement may not require as much treatment as other materials and approaches and it can provide for long-term stormwater management if properly maintained.

PROTECTION OF NATURAL FEATURES (e.g. wetlands, riparian areas, floodplains, aquifer recharge areas, mature trees, woodlands, and other wildlife habitat): Undeveloped sites can have numerous natural features that provide stormwater attenuation benefits if preserved and protected from the impacts of development. Areas under redevelopment might also have open space, well-drained soils, or riparian areas that should be identified and considered for preservation early in the planning process.

RAIN HARVESTING: Interception and collection of roof stormwater runoff (i.e. from a catchment area) for use as a resource for non-potable water use, such as toilet flushing.

REFORESTATION: Forested buffers that lie between land and water are an essential part of the ecosystem. Reforestation programs attempt to preserve and restore forested buffers and natural forests.

RIPARIAN BUFFER: An area along a shoreline, wetland, or stream where development is restricted or prohibited to protect and separate a stream, lake, or wetland from future disturbance and to provide stormwater management. Buffers can be vegetated natural areas that divide land uses, or engineered and specifically designed to treat stormwater before it enters streams, lakes, or wetlands.

STORMWATER WETLANDS: Constructed wetlands are designed specifically to detain and treat stormwater runoff, and are among the most effective stormwater practices in terms of pollutant removal. A constructed wetland offers habitat values although it does not contain the same level of biodiversity as a natural wetland system.

URBAN FORESTS: Trees in urban areas can reduce stormwater runoff because tree canopies capture water on their leaves and branches to intercept rainfall before it hits the pavement, which also reduces pollutant loadings in surface runoff. They also help break up a continuous landscape of impervious cover, and provide small but essential green spaces.

VEGETATED FILTER STRIPS: Vegetated surfaces designed to treat sheet flow from adjacent surfaces by slowing runoff velocities, filtering out pollutants, and providing some infiltration into underlying soils.

WET RETENTION POND/DRY EXTENSION DETENTION POND: Stormwater control structures installed primarily in new developments to intercept stormwater on its way to surface wateors.

Notes

1 At first the Ontario government reported it did not collect such information, so a request under Freedom of Information law was submitted, which eventually led to an agreement with the province to provide us with the available data on CSOs and bypasses.

2 There are 215 sewage systems operated by the Ontario Clean Water Agency (OCWA), a provincial Crown agency, managing about 415,590,593 cubic metres of sewage per year, which is about 23 per cent of Ontario's sewage flow. However, the provincial government claims not to collect information from OCWA regarding overflows or bypasses from plants it operates. Once we learnt this, we sent a request to OCWA for information on bypasses and CSOs, but no information was received prior to completing this report. Thus, the numbers represented do not include CSOs and bypasses from OCWA.

3 Federation of Canadian Municipalities. 2007. *Danger Ahead: The Coming Collapse of Canada's Municipal Infrastructure*. For summary, see CBCnews.ca, "Infrastructure needs $123B to avoid collapse: study." November 20, 2007. Available at: www.cbc.ca/canada/ottawa/story/2007/11/20/ot-infrastructure-071120.html?ref=rss.

4 Valerie Gaudreault and Patrick Lemire. 2006. *The Age of Public Infrastructure in Canada*. Statistics Canada, Catalogue No. 11-621-MIE – No. 35.

5 Great Lakes St. Lawrence Cities Initiative. 2008. *Local investment in the Great Lakes and St. Lawrence*. Available at: www.glslcities.org/glinvestment.htm.

6 The Water Panel Strategy Expert Report. *Watertight: The case for change in Ontario's water and wastewater sectors.* May 2005. Available at: www.waterpanel.ontario.ca.

7 Great Lakes St. Lawrence Cities Initiative, see note 5, at 3.13.

8 The federal government announced the seven-year, $33-billion Building Canada Plan in the 2007 Federal Budget, and as per the 2008 Federal Budget, over half of this investment will flow to municipalities. The plan includes the Building Canada Fund, which will total $8.8 billion over seven years. Wastewater is included in the priority funding categories, which will be administered through the Major Infrastructure Component and the Communities Component. Projects will be cost shared, with the maximum federal contribution to any project being 50 per cent. Municipal infrastructure projects will generally be cost-shared on a one-third basis. The Building Canada Plan also provides $25 million annually to each province and territory over seven years, for a total of $175 million for each jurisdiction or an expenditure of $2.275 billion over the full period. This Provincial-Territorial Base Funding supports all the categories under the Building Canada Fund, as well as additional ones. Federal funding will be cost-shared with provinces and territories.

9 Announced in the 2005 Federal Budget, the Gas Tax Fund will reach $2 billion by 2009–2010, stay at that level through 2013–14, and be extended at $2 billion per year beyond 2013–2014 to become a permanent measure.

10 Available at: www.amo.on.ca/Content/NavigationMenu/SustainableMunicipalities/FederalGasTax/Media/default.htm.

11 Available at: www.pir.gov.on.ca/english/infrastructure/renew.htm.

12 Available at: http://sustainabilityfund.gc.ca/default.asp?lang=En.

13 Available at: www.fcm.ca/english/cscd/sustainablecommunities.html. The Government of Canada provided $550 million to establish the Green Municipal Fund.

14 Municipal sources include minimum treatment requirements, financial provision for sewage treatment infrastructure, establishment of construction and operation standards, and examination of measures

to stop CSOs and other overflows as well as measures regarding monitoring and enforcement activities.

In terms of provision related to pollution from municipal sewage, the renewed 1978 GLWQA contained much of the same language but set a deadline of 1982 for implementation. The 1978 agreement added in language regarding the need to establish programs for the achievement of phosphorus requirements from municipal sources and pre-treatment requirements for industrial plants discharging into sewers.

15 "Area of Concern" means a geographic area that fails to meet the General or Specific Objectives of the agreement where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life.

16 Twelve of these are in Ontario and five are in channels shared by Canada and the United States. *In 20 years, cleanup and restoration actions have been completed for only five AOCs.* Three of these have been delisted (Collingwood and Severn Sound, both in Ontario, and Oswego in New York State) and two have been declared to be in a "recovery stage" (Spanish Harbour in Ontario and Presque Isle Bay in Pennsylvania). In order to restore the AOCs, the federal governments and the public committed to develop a remedial action plan (RAP) for each AOC. Remedial action plans were drafted to lay out a course to their eventual clean up and delisting.

17 John Jackson and Karen Kraft Sloan. January 2008. A Way Forward Strengthening Decision-Making and Accountability under the Great Lakes Water Quality Agreement. Great Lakes United. p. 2-3.

18 During the review of the agreement public comments have emphasized the lack implementation, inadequate funding and a general lack of commitment by the governments as some of the reasons the GLWQA has failed.

19 Most recent version from October 2007 is available at: www.ccme.ca/assets/pdf/mwwe_cda_wide_strategy_consultation_e.pdf. p. 46.

20 Ibid. p. 55.

21 Ontario Ministry of the Environment. 2003 Stormwater Management Planning and Design Manual. Understanding Stormwater Management: *An Introduction to Stormwater Management Planning and Design; 2001 Stormwater Pollution Prevention Handbook*. Available by following the links at: www.ene.gov.on.ca/en/publications/forms/index.php#resources.

22 The background information for this section comes from two leading sources of green infrastructure research: 1) Natural Resources Defense Council (NRDC). *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. June 2006. Available at: www.nrdc.org/water/pollution/rooftops/contents.asp; and 2) Environmental Protection Agency (EPA). Managing Wet Weather with Green Infrastructure. Available at: http://cfpub.epa.gov/npdes/home.cfm?program_id=298.

23 As defined in: Benedict, M. and E. McMahon. 2002. Green Infrastructure: Smart Conservation for the 21st Century. *Renewal Resources Journal*.

24 Low Impact Development Centre. Municipal Guide to Low Impact Development. Available at: www.lowimpactdevelopment.org/lid%20articles/Municipal_LID.pdf.

25 NRDC. *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. June 2006. Chapter 4. Available at www.nrdc.org/water/pollution/rooftops/contents.asp.

26 Ibid.

27 Information adapted from: EPA's Managing Wet Weather with Green Infrastructure Action Plan 2008. Available at: www.epa.gov/npdes/pubs/gi_action_strategy.pdf.

28 NRDC. 2006. Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows. Available at www.nrdc.org/water/pollution/rooftops/contents.asp.

29 West Coast Environmental Law. 2007. The Green Infrastructure Guide – Issues, Implementation, Strategies and Success Stories.

30 U.S. Enviromental Protection Agency: Managing Wet Weather with Green Infrastructure. Available at: http://cfpub.epa.gov/npdes/home.cfm?program_id=298. Accessed on April 16, 2008.

31 Ibid.

32 Environment Canada. Green Roof Technology Adapted to Cold Climates. Envirozine: Environment Canada's Online News Magazine. Available at: www.ec.gc.ca/envirozine/english/issues/62/feature2_e.cfm. Accessed on June 27, 2008.

33 Dunn, D.A. and N. Stoner. 2007. Green Light for Green Infrastructure. Environmental Law Institute, Washington, D.C. Available at: www.eli.org.

34 Scholz-Barth, K. 2001. Green Roofs, Stormwater Management from the Top Down. Environmental Design and Construction. Available at: www.edcmag.com.

35 Ryerson University. 2005. Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto.

36 The urban heat island effect refers to summer temperatures in urban centres that are higher than in surrounding less urbanized areas.

37 City of Portland's Green Building Program. Available at: www.portlandonline.com/osd/index.cfm?c=41481.

38 City of Toronto. Making Green Roofs Happen: Presentation to the Roundtable on the Environment. November 23, 2005. Available at www.toronto.ca/greenroofs/pdf/ppt_nov2005_vs3.pdf Accessed on: April 21, 2008.

39 NRDC. 2006. Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows. Available at: www.nrdc.org/water/pollution/rooftops/contents.asp.

40 Urban Design Tools: Low Impact Development: Available at www.lid-stormwater.net/raincist_benefits.htm.

41 U.S. Environmental Protection Agency. Managing Wet Weather with Green Infrastructure. Available at: http://cfpub.epa.gov/npdes/home.cfm?program_id=298. Accessed on April 16, 2008.

42 Dunn, D.A. and N. Stoner. 2007. Green Light for Green Infrastructure. Environmental Law Institute, Washington, D.C. Available at: www.eli.org.

43 EPA. October 2000. Field Evaluation of Permeable Pavements for Stormwater Management, Olympia, Washington. Available at www.epa.gov/watertrain/smartgrowth/resources/resident.htm.

44 EPA. Bioretention (Rain Gardens). Available at: http//cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=72.

45 Landers, J. 2006. Stormwater: Test Results Permit Side-by-Side Comparisons of BMPs. Civil Engineering News. pp. 34-35.

46 NRDC. 2006. Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows. Available at: www.nrdc.org/water/pollution/rooftops/contents.asp.

47 Ibid.

48 Riversides. Toronto Homeowners' Guide to Rainfall: Urban Forest. Available at: www.riversides.org/rainguide/riversides_hgr.php?cat=2&page=54&subpage=93.

49 NRDC. 2006. Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows. Available at www.nrdc.org/water/pollution/rooftops/contents.asp.

50 Information adapted from EPA: Green Infrastructure – Technologies and Approaches. Available at: http://cfpub.epa.gov/npdes/greeninfrastructure/technology.cfm.

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