Stormwater Management in the Great Lakes and St. Lawrence Basin:

Cities Charting the Way Forward

Great Lakes and St. Lawrence Cities Initiative

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Great Lakes and St. Lawrence Cities Initiative
Alliance des villes des Grands Lacs et du Saint-Laurent

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Acknowledgements

The Great Lakes and St. Lawrence Cities Initiative would like to thank those cities and the staff involved in completing the Green CiTTS Survey on Stormwater Practices. The time and effort that went into collecting detailed information on their stormwater practices is greatly appreciated.

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Photo Credit page 1: The cities of Chicago, Toronto and Montreal

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Executive Summary

The Great Lakes and St. Lawrence River are a precious resource providing drinking water for over 40 million people. Because of the vital resources that the Lakes and River contribute to our economy, health and lives, we need to ensure their protection and restoration.

The Great Lakes and St. Lawrence Cities Initiative (Cities Initiative) is a prominent voice representing over eighty mayors from Canada and the U.S. in efforts to protect and restore the vitality of the Great Lakes and St. Lawrence River and improve the quality of life for the residents of the region. (www.glslcities.org)

This is the first report released under the Cities Initiative's *Green CiTTS (Cities Transforming Towards Sustainability) Program.* The program adopts a comprehensive approach to protecting our shared water resources, involving a broad range of municipal operations and responsibilities. The purpose of the *Green CiTTS Program* is to promote municipal leadership and to provide support to municipalities to further expand these activities. It is through the promotion and expansion of these activities that we will set the course for a sustainable future for the Great Lakes and St. Lawrence region.

In its first year, the *Green CiTTS Program* has focused on reducing the impact of stormwater runoff into the Great Lakes and St. Lawrence. Studies have identified stormwater as one of the leading sources of nutrients, toxics and bacteria to our Great Lakes and St. Lawrence.

In recent years, conventional stormwater management practices have been pushed to the limit, as municipalities face a convergence of forces, including 1) urban intensification, 2) climate change and 3) the cumulative impact on nearshore water quality. The impact of these forces is not exclusively a municipal concern, nor their sole responsibility. Solutions will be found through coordinated actions and mutual support amongst all levels of government, the private sector, and research institutions.

Chicago's Lakefront

PHOTO CREDIT: CITY OF CHICAGO

Based on a comprehensive survey of stormwater practices of members of the Cities Initiative, this report paints a fascinating portrait of municipal stormwater management in a state of transition across the basin, demonstrating the range of issues facing municipal stormwater practitioners, and the wide range of best practices already adopted by them in the face of these pressures.

Some highlights from the survey of 25 cities include:

- a large majority, 20 out of the 25 survey respondents felt that federal/provincial/state requirements are a main driver for stormwater action;
- Eighteen cities identified lack of funding as their main obstacle to stormwater implementation;
- Most cities have multiple municipal departments involved in stormwater management ;
- Most responding US cities have a formal stormwater management plan, while fewer than half of Canadian cities have one;

Combined sewer separation project in Grand Rapids

PHOTO CREDIT: CITY OF GRAND RAPIDS

- Twenty municipalities stated that they have stormwater performance standards for new industrial, commercial or institutional developments;
- Fifteen cities surveyed have measured or noticed changes to precipitation patterns in the municipality;
- Nineteen municipalities are applying low impact development measures in their community.

By focusing on municipal best practices, the report points to the way forward, in municipal stormwater management, identifying ten areas where improvements have resulted in more effective stormwater management and significant cost savings:

1. Government Regulation: The regulatory environment was identified as a primary driver (in the US) and barrier (in Canada) for municipal action on stormwater amongst municipal survey respondents. The U.S. federal stormwater permitting system has resulted in more developed and comprehensive stormwater programs at the local level. In Ontario and Quebec, the permissive nature of stormwater authority given to municipalities has resulted in varied approaches to municipal stormwater management, from comprehensive stormwater planning, to more diffuse stormwater activities.

2. Financing Stormwater Management: Securing a stable and sufficient source of funding for stormwater management is vital to maintain and improve stormwater practices, particularly to improve water quality in receiving waters. Some municipalities have secured a dedicated source of funding, by introducing a stormwater fee. Given the shared interest in improving nearshore water quality, financial support from other orders of government is also needed.

Runoff after a storm event in Lake Erie

PHOTO CREDIT: MODIS SATELLITE IMAGE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

3. Stormwater Plans: While municipal stormwater plans are the norm in the United States, fewer Canadian cities have them to guide their stormwater activities. By developing a comprehensive stormwater management plan that sets corporate goals and assigns clear responsibilities, municipalities have brought focus to their decentralized management structure. The trends toward adopting comprehensive stormwater plans is encouraging and should be further supported by provincial authorities.

4. Training, Inspections and Maintenance: Coordination amongst multiple municipal departments to deliver stormwater management was identified as barriers to effective stormwater management by a number of municipal stormwater practitioners. Cities have demonstrated how improving interdepartmental coordination, maintenance and inspections through training can pay dividends in the effectiveness of their stormwater program.

5. Public Education and Outreach: Public education and outreach is essential to secure public involvement and change behavior in support of reducing the impact of stormwater on receiving waters. It is in the most successful, well-run and well-organized stormwater programs that public education and public involvement programs prevail. More support on a basin-wide level from federal governments, towards raising public awareness of the linkage between stormwater and Great Lakes and St. Lawrence water quality, could help municipalities in this area.

6. Monitoring Impacts and Reporting on Progress: To address the growing concern over the impact of stormwater on water quality, cities are focusing more attention on measuring progress in reducing this source of pollution. However, drawing a direct link between stormwater control measures and improvement in water quality has proved a challenge for some municipalities. New monitoring protocols and support are needed from other orders of government to make stormwater monitoring programs more effective. Integrating federal, state, provincial and local monitoring data and collaborating on analysis is necessary to trace pollution to its source and take action.

7. Stormwater Management Requirements on Industrial, Commercial and Institutional (ICI) Sites: Effective stormwater management requires the active involvement of property owners and developers in the ICI sector. Through their site plan reviews and inspections, and by adopting on-site stormwater performance standards, and sewer-use ordinances or bylaws, municipalities provide a strong first-line defense from stormwater flow and pollutants. Although less common, requirements or incentives for the installation of stormwater controls in ICI properties undergoing retrofitting represents a great opportunity to reduce inflow and infiltration of stormwater into a municipal storm or sanitary collection system.

Porous pavement in an alley

PHOTO CREDIT: CITY OF CHICAGO

8. Low Impact Development: The use of low-impact development to complement existing stormwater controls is effective in reducing stormwater on-site in new and retrofitted development. It can also reap multiple benefits for municipalities, from enhanced aesthetics to deferred infrastructure costs. Further support and promotion from regulators and researchers, through demonstration projects, the sharing of performance data, and increased public and private sector awareness would go a long way to maximize its potential.

9. Urban Intensification and Stormwater-friendly Land-use Planning: Municipalities are at the beginning stages of designing communities in a stormwater friendly manner, that is, in a way that integrates planning with the natural hydrology of the region and allows for maximum infiltration and reuse of average stormwater flow at the conceptual stage of land-use planning rather than later, as properties are being developed. This is particularly important given the policy emphasis on urban intensification that will otherwise result in a concentration of stormwater flow in cities. It is vitally important that urban intensification plans anticipate and address the additional stormwater flow that comes with greater urban density.

10. Climate Change Adaptation: As impacts of climatic change are already being felt at the local level, municipalities are beginning to develop adaptation strategies that work best given their unique circumstances. Cities would benefit from technical and financial support from other orders of government and other experts, for undertaking climate change infrastructure vulnerability assessments. Further collaboration with research institutes and other orders of government to scale down regional climate change models and to review infrastructure design criteria in light of this information would also assist municipalities in their climate change adaptation planning.

1. Introduction: The Challenge Ahead

This is the first report released under the Cities Initiative's *Green CiTTS Program*. The program adopts a comprehensive approach to protecting our shared water resources, involving a broad range of municipal operations and responsibilities. The purpose of the *Green CiTTS Program is* to promote municipal leadership and to provide support to municipalities to further expand these activities. It is through the promotion and expansion of these activities that we will set the course for a sustainable future for the Great Lakes and St. Lawrence region.

In its first year, the *Green CiTTS Program* has focused on reducing the impact of stormwater runoff into the Great Lakes and St. Lawrence. Studies have identified stormwater as one of the leading sources of nutrients, toxics and bacteria to our Great Lakes and St. Lawrence.

This report provides one of the first accounts of the current state of stormwater management and challenges in the future as identified by municipal stormwater management practitioners across the Great Lakes and St. Lawrence basin. Based on a comprehensive survey of stormwater practices of members of the Great Lakes and St. Lawrence Cities Initiative, this report paints a fascinating portrait of municipal stormwater management in a state of transition across the basin, demonstrating the range of issues facing municipal stormwater practitioners, and the wide range of best practices already adopted by them in the face of these pressures. it also points to the way forward, identifying ten areas where municipal improvements have resulted in more effective stormwater management and significant cost savings.

Stormwater plume entering Lake Ontario

PHOTO CREDIT: TORONTO AND REGION CONSERVATION AUTHORITY

Municipalities have long been responsible for moving stormwater and snow melt away from properties and into combined sewer systems or nearby waterways in order to prevent flooding. This routine function is embedded in local planning policy, building permit approvals and public works operations across the Great Lakes and St. Lawrence basin. Over time, however, conventional stormwater management practices have been pushed to the limit, as municipalities face a convergence of forces, including 1) urban intensification, 2) climate change, and 3) the cumulative impact on nearshore water quality.

1. Many cities in the region with older development do not have on-site stormwater controls, relying instead on combined sewers to carry away stormwater. These densely built environments concentrate stormwater flows that then enter combined systems and waterways, taxing local infrastructure capacity and affecting nearshore water quality.

2. When it comes to more extreme episodic weather patterns caused by climate change, the devastating flooding along the Richelieu River in Quebec, and in the Mississippi River valley are harbingers of things to come. Municipalities are confronted with unpredictable storms that far exceed the capacity of their conveyance and treatment systems, which can result in extensive infrastructure and private property damage, and can even pose a threat to public safety.

3. The International Joint Commission has identified stormwater as one of the leading sources of pollution in the nearshore environment, an aquatic zone that is rich in biodiversity and essential to fish spawning.[1] Researchers have concluded that the combination of urban and agricultural runoff and industrial and municipal point sources of pollution are causing an ecological collapse of the nearshore environment.

The impact of these pressures is not exclusively a municipal concern, nor their sole responsibility. From governments to developers to insurers, to the public-at-large, the solutions will be found through coordinated actions and mutual support.

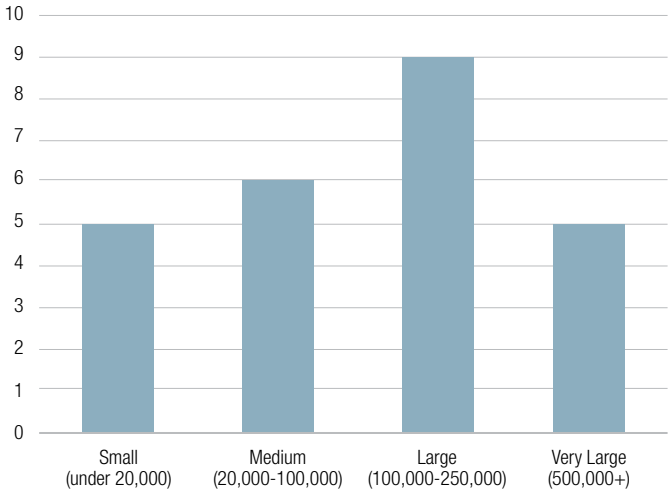
2. The Green CiTTS Survey

2.1 Survey Methodology

The Green CiTTS Survey on Stormwater Practices, available in both English and French, was sent electronically on March 8, 2011 to all Cities Initiative members (72 municipalities at the time). Participating members were given five weeks to complete the online survey.

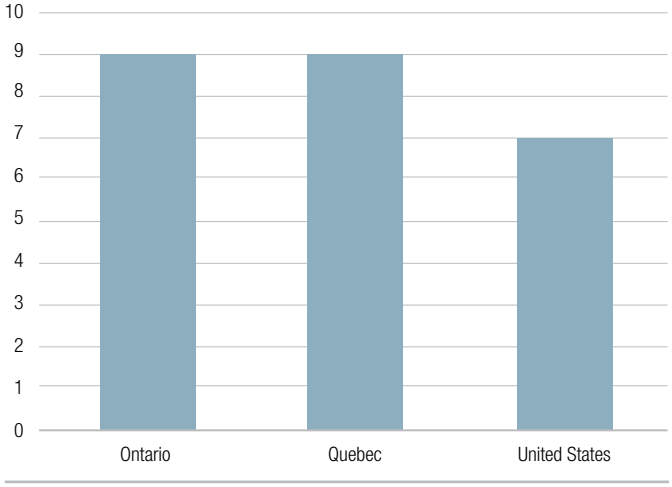
Twenty-five member municipalities completed the survey, a 35% response rate, representing approximately 70% of the total population of Cities Initiative members. Besides a revision to detect any errors, the data transmitted by municipalities was considered correct, with no secondary verification or external audits made. While the number of respondents (n=25) is not statistically significant, the geographic scale and the regional and shoreline diversity of respondent cities does represent valid and relevant information for a first-of-its kind analysis of the stormwater situation across the Great Lakes and St. Lawrence river basin.

Chart 1: **Number of respondants - by size**



No cities with a population 250,000- 500,000 answered the survey.

Chart 2: **Number of respondants - by region**



2.2 Survey Respondent Characteristics

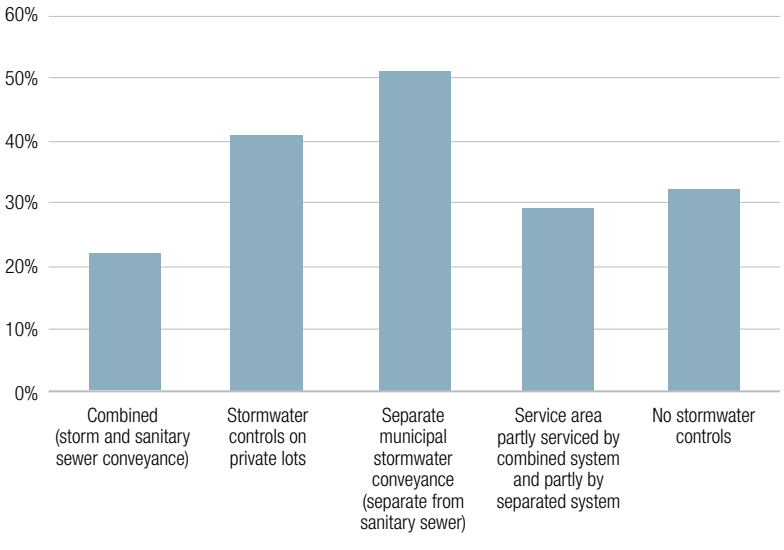
Municipalities ranging in size responded to the Green CiTTS Survey on Stormwater Practices. This provides a good representative sample of practices, as stormwater issues differ greatly from municipality to municipality. Larger cities tend to have a densely built environment and more impervious surfaces than their smaller counterparts. Budgets also tend to follow municipality size, as property taxes are usually the first source of income for municipalities. Most American and Ontarian municipalities that responded to the survey are either in the 0-20,000 inhabitant range or the 100,000 to 250,000 inhabitant range. Quebec respondents were more spread out across the population range, although a third of them are in the 20,000 to 50,000 inhabitant range.

Map of the 25 respondent municipalities

The type of sewer system used by municipalities is a determining factor for their stormwater management choices. The integration of stormwater into regular wastewater management, through a combined system, influences the whole treatment process, has regulatory implications, and can result in combined sewer overflows. A separated system eliminates combined sewer overflows, but introduces water quality issues of a different kind, associated with the discharge and runoff of untreated stormwater into receiving waters.

Most of the surveyed municipalities use a mix of sewer systems; with a combined system in older areas and separated sewers systems in newer areas. Four out of 25 respondents have fully separated systems.

Chart 3: How is stormwater conveyed in your municipality? (more than one answer possible)



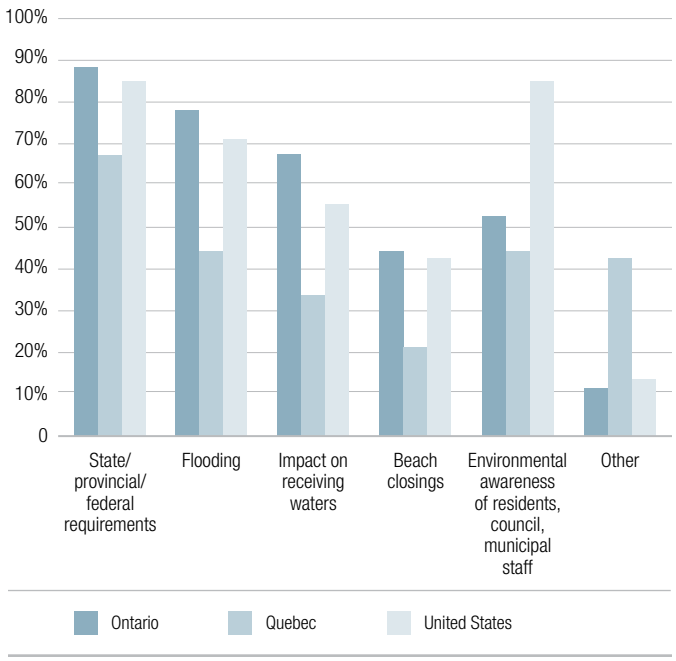
3. Municipal Stormwater Drivers and Barriers

3.1 Drivers for Stormwater Action

Stormwater management is an evolving endeavor. While some conditions will remain constant, such as flood control and peak-flow management, cities are taking action for new reasons, including water quality impacts, the effects of increased urban intensification, and climate change.

When asked about the drivers for municipal action on stormwater, a large majority, 20 out of the 25 survey respondents, revealed that federal/provincial/state requirements are a main driver for stormwater action.

Chart 4: **What are the main drivers for action on stormwater by your municipality area?**



Aside from mandatory requirements, environmental awareness is also a top driver in the U.S. cities, and was consistently identified in Quebec and Ontario. Flooding and impact on receiving waters are significant drivers for the Ontario cities. Impact on receiving waters and beach closings were the least identified drivers for stormwater action overall.

In general, there appears to be a greater focus on environmental awareness in the U.S. cities and a keener interest in source control and downstream water quality impacts in Ontario and Quebec. For example, the Town of Goderich, ON, emphasized erosion and development concerns, and the town of Levis, Quebec identified overloading the stormwater conveyance system as a major driver for action.

Stormwater plume entering Lake Ontario

PHOTO CREDIT: TORONTO AND REGION CONSERVATION AUTHORITY

Ellesmere Road in the City of Toronto during a major storm in 2005

PHOTO CREDIT: CITY OF TORONTO

Differing environmental and regulatory conditions will guide cities in particular directions in response to these drivers, in addition to each city's unique circumstances. In general, the U.S. cities in the Great Lakes region are finding ways to implement and normalize the use of green infrastructure for stormwater best management practices (BMPs). Duluth, MN, recently updated its stormwater development code to encourage the use of green infrastructure. The City of Milwaukee has a program to reduce the amount of inflow and infiltration from private sewers into the separate sanitary system.

Ontarian cities, on the other hand, have consistently been updating sewer-use bylaws and completing stormwater master plans. St. Catharines, ON is reviewing its city drainage manual to encourage the use of stormwater control measures, with an emphasis on low impact development.

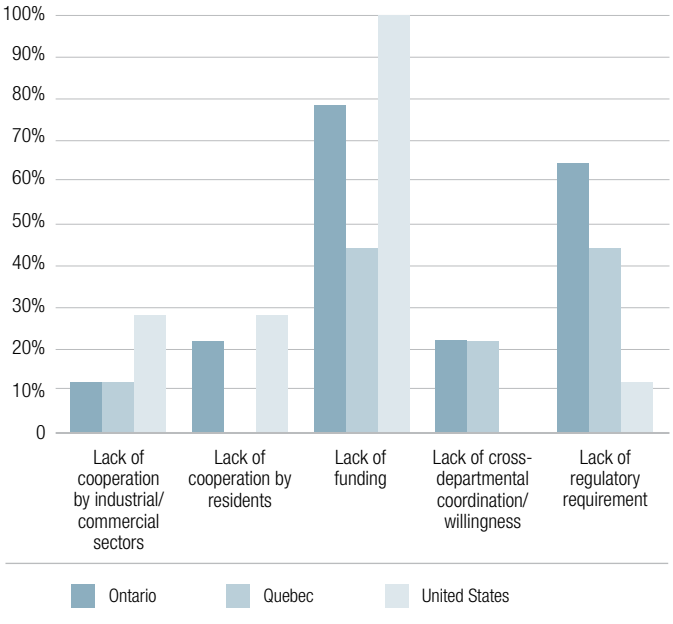
In Quebec, cities are focusing more on source control and overflow problems. For example, Quebec City is creating a manual for developers on better source control management, as well as engaging in projects oriented towards erosion, total suspended solids from outfalls and sedimentation issues regarding unstable riverbanks. The city is also trying to improve overflow of the municipal stormwater infrastructure. The City of Montreal is similarly investing $CAD 1.5 billion in sewer system maintenance and the construction of retention tanks. Likewise, the City of Repentigny is planning to regulate the flow and retention of the city's hydraulic stormceptors.

3.2 Barriers to Stormwater Action

Achieving a fully developed municipal stormwater management program is an incremental process and some cities continue to face barriers to moving forward on implementation. Adequate funding for program implementation and lack of regulatory requirement were cited most often as the largest barriers that local governments face.[2] Other barriers identified include: the challenge of engaging the public, private property owners and developers; coordination among internal municipal departments; and technical information on stormwater control measures.

Of the 25 respondents to the survey, 18 cities identified lack of funding as their main obstacle, and 11 identified lack of regulatory requirement, primarily in Ontario and Quebec. Four cities overall identified lack of cooperation in residential, business, and interdepartmental activities to be a considerable barrier to taking further action on stormwater.

Chart 5: **What are main barriers to taking further action on stormwater? – by region**



4. Focus on Specific Stormwater Practices

Using the results of the Green CiTTS Survey on Stormwater Practicesas a basis, this section focuses on ten aspects of stormwater management where municipalities are applying different approaches to improve their performance. In addition to comparing and contrasting approaches in the U.S. and Canada, examples of good practices from Cities Initiative members are highlighted, and some key conclusions on 'the way forward' are offered.

4.1 The Regulation of Stormwater Management

As the regulatory environment was identified as a primary driver and barrier for action amongst municipal survey respondents, it is important to understand how the regulatory requirements in the U.S. and Canada have shaped municipal stormwater practices. The following is an overview of stormwater regulatory requirements as they apply to municipalities or public utilities responsible for municipal stormwater management.

Combined Sewer Outfall

PHOTO CREDIT: TOWN OF AJAX

4.1.1 Stormwater Regulations in the United States

The U.S. regulatory environment is the longest standing and most comprehensive of the three jurisdictions reviewed in this report. Stormwater runoff management in the U.S. is legislated by the *Clean Water Act* (CWA). The CWA created the National Pollution Discharge Elimination System (NPDES), a comprehensive permitting system to regulate discharges from a point source into open waters, including stormwater runoff. NPDES permitting for stormwater discharges was phased in over a 10-year period. Phase 1 (1990) brought medium and large Municipal Separate Storm Sewer Systems (MS4s), industrial sites, and large construction sites into the NPDES program. Phase 2 (1999) brought in smaller MS4s located within "urbanized areas" (under 100,00 population as determined by the U.S. Census), and also smaller construction sites. Currently all communities with separate storm sewer systems must have NPDES permits for stormwater discharges, with the exception of small communities located outside urbanized areas.

Many communities in the U.S., particularly in the Northeast and Midwest, have combined sewer systems, handling both stormwater and sanitary sewage. The regulatory agencies issue an NPDES permit for such facilities that covers discharges from the sanitary system in dry weather (the CWA specifies that secondary treatment or better must be provided) and for the management and discharge of combined stormwater and sanitary sewage in wet weather. The U.S. Environmental Protection Agency (EPA) has a 'Combined Sewer Overflow (CSO) Control' Policy with guidance to municipalities on meeting CWA requirements.

Under the MS4 program system, communities covered by an NPDES permit must develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants from their system to the "maximum extent practicable." The stormwater management program must include measurable goals

and specific Best Management Practices (BMPs) for six minimum control measures:

(i) public education and outreach;
(ii) public participation/involvement;
(iii) illicit discharge detection and elimination;
(iv) construction site runoff control;
(v) post-construction runoff control; and
(vi) pollution prevention/good housekeeping.

EPA provides guidelines and best management practices to be used in each of the six control measures categories.[3]

4.1.2 Municipal Stormwater Approvals in Ontario

Unlike the U.S, there is no consolidated regulation that outlines requirements for municipal stormwater management in Ontario. Instead, it is primarily regulated through certificates of approval for municipal conveyance and treatment systems and municipal by-laws.

The regulatory framework for municipal stormwater management is provided under the *Ontario Water Resources Act* (OWRA) Section 53, site-specific stormwater infrastructure (a 'stormwater sewage works') requires a Certificate of Approval (CofA).

The *Municipal Act* provides municipalities with the authority to enact bylaws for prohibiting, regulating and inspecting discharges into connections to a sewer system. A number of Ontario municipalities have used this authority to pass sewer-use bylaws. The Ontario Building Code that applies to houses, buildings or structures also addresses some aspects of stormwater management, e.g. equipment or other features for the management of stormwater from roofs or to reuse stormwater for flushing toilets.

The 2003 'Stormwater Management and Planning Design' Manual (SWM)[4] assists the applicants for a CofA to plan, design and operate stormwater management.

Additional guidance for storm sewers can be found in the Design Guidance for Sewage *Works 2008 and the Stormwater Pollution Prevention Handbook.*[5]

In 2010, the Ontario Ministry of Environment reviewed its stormwater management policy in light of ongoing climactic changes. One of the main findings of the review is that 'An MOE policy framework is needed to support resilient municipal stormwater management systems and adaptation to climate change and other identified stressors, for new and existing developments'.[6] Such a framework could involve updating technical guidance or rules, increasing emphasis on source control, or partnering on programs such as public education, demonstration projects and incentives that are essential to support resilient systems.

Also in 2010, Ontario passed the *Water Oportunities and Water Conservation Act*, which recognizes the need for integrated long term planning of water, stormwater, and wastewater services.

St. Catharines Lakefront

PHOTO CREDIT: CITY OF ST. CATHARINES

4.1.3 Municipal Stormwater Approvals in Quebec

The Province of Quebec addresses municipal stormwater management primarily through land-use planning. The approach is similar to that of Ontario, but with a stronger emphasis on integrated land-use planning.

There are no mandatory provincial requirements specifically for stormwater; instead, best practices and examples are provided. Provincial stormwater management guidelines from different provincial water-related policies are integrated as part of regional county (in French MRCs, for municipalité régionale de comté) land-use plans and local municipalities' regulations.

Several pieces of legislation mention stormwater management, the most important being the *Environment Quality Act* and the *Planning and Urbanism Act*. In 2011, the Quebec Ministries of Environment (MDDEP) and Municipal Affairs, (MAMROT) released 'A Guide on Stormwater Management'.[7] The MDDEP also has a directive regarding sewer systems for new construction. The recommendations and best practices included in the directive can help developers acquire the MDDEP license to build the sewer systems included in a construction project, but they are not measurable mandatory requirements.

City of Montreal

PHOTO CREDIT: CITY OF MONTREAL

On the regional and local scale of stormwater management, the *Planning and Urbanism Act* contains requirements for municipal permits and certificates of authorization. Therefore, municipalities and MRCs can promulgate regulations concerning stormwater management, just as they also promulgate regulations about building density, parking, or any other construction-related issue.

On the larger scale of land-use planning, stormwater management in Quebec has to follow the principles of the National Water Policy on protection of the resource, the collective heritage character of water and the integrated watershed management that is being implemented in the province. Quebec also has a riverbanks and flood zones policy. The principles of these policies, which have no regulatory powers themselves, are integrated in the regional county land-use plans. Local urban planning regulations, which have to be based upon these regional plans, are enforceable.

4.1.4 Conclusion

In the U.S., the federal - stormwater permitting system has resulted in more developed and comprehensive stormwater programs at the local level. In Ontario and Quebec, the permissive nature of stormwater authority given to municipalities has resulted in varied approaches to stormwater management, from comprehensive stormwater planning to more diffuse stormwater activities.

4.2 Financing Stormwater Management

Limited financing for municipal stormwater management was identified as a primary barrier to expanding the breadth of activities.

4.2.1 Financial and Revenue Sources

Most municipal stormwater funding comes from a mix of sources including general appropriations, development-related fees, and matching funds from other orders of government. Of the various sources, general budget appropriations derived from property, sales, and income taxes have historically been the largest, notably in Canada, with 15 of the 18 survey respondents indicating that they use property taxes to fund stormwater management (eight in Ontario and seven in Quebec).[8] This reflects the reliance on general appropriations as a stable financial mechanism for stormwater but also indicates that stormwater is competing with other public works that take precedence, given greater compliance costs associated with water and wastewater services, for example.

Although general appropriations provide a stable funding source, relying on general revenues forces stormwater into competition with other important public services. A property tax also places the cost burden disproportionately on entities that may be contributing less to stormwater because the cost is not linked to the service or impact, but rather is based on property value or income, which often have little to do with stormwater flows.

Several cities in the Great Lakes-St. Lawrence region have tackled this financing barrier head on by implementing stormwater fees as a main source of stormwater funding. The fees are service-based and dependent on the amount of impervious surface, development intensity and/or land parcel size associated with each property. While adopting a stormwater fee system has proved contentious in some cities, it creates a dedicated revenue source while serving as a powerful incentive for better on-site stormwater management.

Three respondents, Milwaukee, WI, Duluth, MN, and Repentigny, QC, indicated the use of stormwater fees.

Duluth cityscape

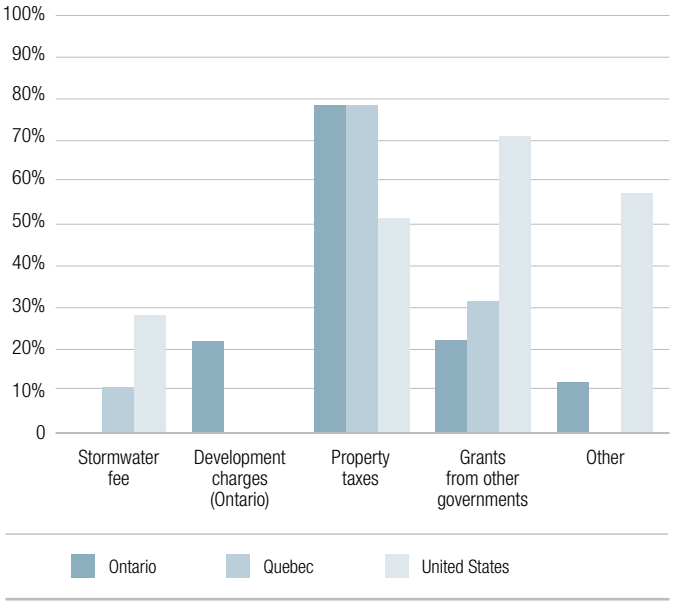
PHOTO CREDIT: CITY OF DULUTH

Milwaukee Stormwater Management Charge

The Stormwater Management Charge, introduced in the City of Milwaukee in 2006, is based on the impervious surface area of a property defined by the Equivalent Residential Unit, or 1,610 square feet per unit. The charge applies to residential, non-profit and tax exempt organizations, as well as non-residential and commercial property owners.

http://city.milwaukee.gov/ImageLibrary/Groups/WaterWorks/files/StormWaterManagementCharge_2011.pdf

Chart 6: From which sources of revenue does your stormwater budget come?



4.2.2 Funding Available from Other Levels of Government

Sources of funding from provincial or federal governments in Canada are limited. Environment Canada's Great Lakes Sustainability Fund offers approximately CDN $2 million per year for rehabilitation projects in Canada's remaining fourteen 'Areas of Concern'. Rehabilitation projects that contribute to 'beneficial uses' of the water (eg. swimming, drinking, fishing) are eligible. Various cost-sharing grants are provided jointly by the federal and provincial governments for major infrastructure projects, the most recent being the $4 billion Infrastructure Stimulus Fund, available to all Canadian cities for a full range of infrastructure projects, including wastewater-related projects.

The U.S. has considerably more funding available but must also address a greater need given the number of cities around the Great Lakes. The Clean Water State Revolving Fund (CSRF) is a major financial mechanism for wastewater infrastructure, providing $USD 68 billion in low interest rate loans since its establishment in 1987.[9] However, between 2005 and 2009 annual federal appropriations for the CRSF have decreased by 40 percent.[10] The 2009 Recovery Act contributed $4 billion to the CWSRF, of which 20 percent was dedicated to green infrastructure, water efficiency and energy efficiency improvements.[11]

Ten of 25 respondents cited grants and loans from other levels of government as a significant source of financing. Five of the seven U.S. cities indicated grants and loans as a primary form of financing, which reflects a heavy reliance to finance wastewater infrastructure through the CRSF.

With national and bi-national concerns with water quality and ecological impacts in the nearshore zone of the Great Lakes, there is a strong case for solid and committed financial support from other levels of government in support of stormwater activities.

4.2.3 Conclusion

A lack of stable financing is seen as a barrier to expanding stormwater activities by a number of Great Lakes and St. Lawrence cities. Property taxes represent the main revenue source, competing with many other local priorities. In most municipalities, there is no dedicated revenue source like water or wastewater rates, and in Canada, there is less funding from other levels of government where grant programs focus on larger infrastructure projects.

More predictable financing, supported by funding from other orders of government, would support municipal efforts to adapt and improve their stormwater practices to improve water quality in receiving waters across the Basin.

4.3 Stormwater Planning

Due to its 'non-point' nature, stormwater is managed in a decentralized manner, involving multiple municipal departments and requiring the participation of the residential and ICI sectors. One of the characteristics of effective stormwater programs is the adoption of a stormwater plan, which brings focus to the various stormwater activities internally within a municipality and with private property owners and developers.

City of Rochester

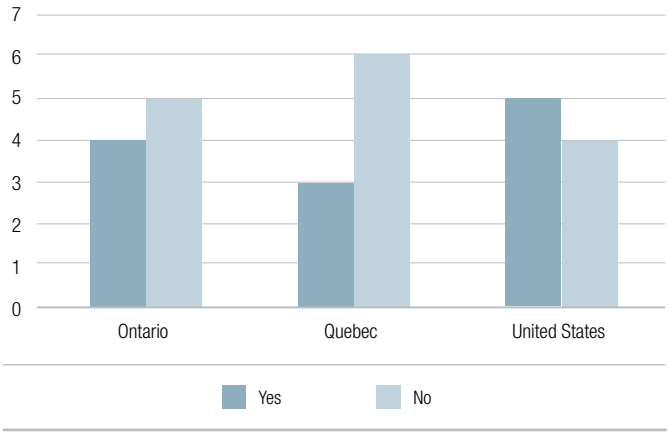
PHOTO CREDIT: CITY OF ROCHESTER

4.3.1 Stormwater Plans

While various approaches to stormwater management exist in Canadian cities, as compared to the more regulated American context, stormwater management plans that take a more comprehensive approach to stormwater activities are gradually becoming the norm.

According to the Green CiTTS Survey on Stormwater Practices, three Quebec respondents have a formal stormwater management plan, versus 6 that do not. However, because of the land planning system in Quebec, most stormwater planning is done in regional plans or master plans, depending on the size of the municipality. Of Ontario survey respondents, there was almost an even split between municipalities that have a plan and municipalities that do not. Most U.S. respondents have a formal stormwater management plan, reflecting USEPA requirements under the NPDES permitting system described in section 4.1.1, above.

Chart 7: **Do you have a formal stormwater management plan? by region**



Milwaukee Metropolitan Sewerage District Chapter 13 Surface Water and Stormwater Rules

The Milwaukee Metropolitan Sewerage District Chapter 13 Surface Water and Stormwater Rules (Rules) comprise a comprehensive stormwater management plan applied to all governmental units in the District's ultimate sewer service area. The Rules apply to a host of stormwater related activities including land-use in the jurisdiction as it pertains to sedimentation, construction and management of stormwater facilities, and review of all development activities to determine if they must comply with the Peak Runoff Management Requirements according to the Rules.

http://v3.mmsd.com/AssetsClient/Documents stormwaterweb/PDFs/ MSSD_Vol2Nov2010.pdf

4.3.2 Conclusion

Adopting formal stormwater management plans are an important step in the evolution of a city's stormwater activities. The trend in Canadian cities towards adopting a comprehensive stormwater plan is encouraging and should be further supported by provincial authorities.

Toronto's Wet Weather Flow Master Plan

4.4 Training, Inspections & Maintenance

Given the decentralized management of stormwater and the involvement of multiple departments and tiers of local governance, stormwater training can keep those involved in the chain of responsibility for stormwater better informed and up-to-date on changes in stormwater management.

4.4.1 Interdepartmental and Private Sector Training

Interdepartmental coordination amongst municipal departments with partial responsibility for stormwater management activities was identified as a barrier to effective stormwater management by a number of municipal stormwater practitioners in the U.S. and Ontario but less so in Quebec. Municipal stormwater management often involves multiple local departments, including public works, parks and recreation, land use planning, and in some cases, regional agencies.

According to the Green CiTTS Survey on Stormwater Practices, all municipalities except one have multiple departments involved in stormwater management. The majority of stormwater programs are led by the Public Works/Environment/Water or Wastewater departments. Planning departments are also heavily involved in stormwater management, as indicated by more than two-thirds of the responding municipalities. Transportation and parks departments are also significantly involved. Ontario Conservation Authorities, watershed-based agencies created originally to manage flood controls, have expanded their activities into a number of areas, including stormwater management. Quebec municipalities, other than Montreal, have kept stormwater management a responsibility of Public Works/Environment/Water or Wastewater and Planning departments/services.

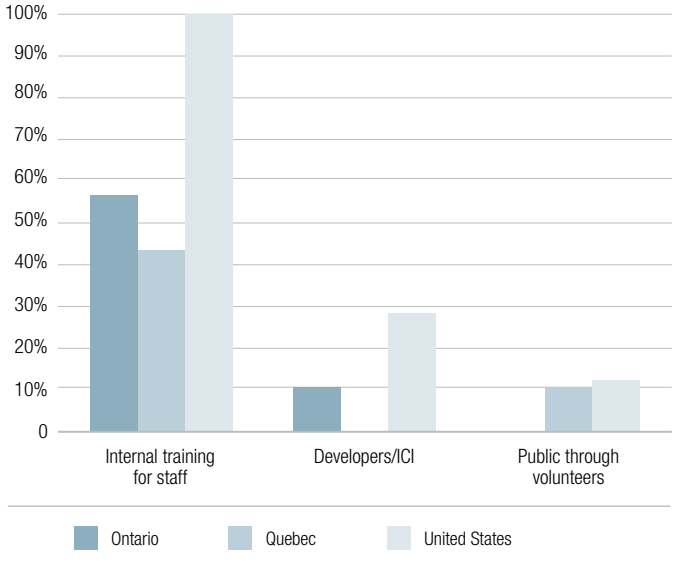
While all U.S. cities provide ongoing internal staff training, there is less training provided amongst Canadian cities. Sixteen out of 25 cities responded that internal training for stormwater controls was supported by the municipality, including all of the U.S. cities and about half of the cities from Ontario and Quebec.

City of Chicago's Enterprise Environmental Management Information System

The City of Chicago is in the process of deploying an Enterprise Environmental Management Information system to facilitate internal training and coordination for better facilities management among departments.

http://www.cityofchicago.org/city/en/depts/doit/provdrs/enterprise_systems.html

Chart 8: **What type of training on stormwater controls do you currently support?**



Stormwater retention pond

PHOTO CREDIT: TOWN OF AJAX

Training offered by municipalities to the private sector was less common. Only six cities indicated that they provide training for the ICI development sectors, including Duluth, MN, Milwaukee, WI, Cobourg, ON, Ajax, ON, Montreal, QC, and Varennes, QC.

Sufficient training for both public works staff in terms of appropriate planning, construction and post construction monitoring of stormwater control measures, as well as for private sector developers to meet the expectations and standards for site-level stormwater management systems and adequate training on design criteria and functionality of the infrastructure would go a long way in contributing to the proper construction and maintenance of stormwater systems. Proper landscaping, construction and maintenance of retention ponds can avoid sedimentation and malfunctioning of stormwater infrastructure.

4.4.2 Maintenance

In some municipalities, maintenance of stormwater infrastructure was identified as an area where additional work has led to improvements. In particular, some cities have updated their inventories of the dozens, even hundreds of aging retention ponds that were transferred to them post-construction by property developers. In some cases, recent municipal amalgamations have made this inventory process necessary.

Ontario municipalities including Toronto, St. Catharines, Hamilton and Haldimand County, indicated that they are in the process of creating databases of the location and state of ponds maintained by the municipality. Some cities in Ontario, including the City of Waterloo, have implemented strict monitoring and even cleaning protocols for developers to follow before ponds are transferred to the municipality.

Ensuring that retention ponds, oil and grit separators (OGS), and outfalls are transferred from the developer to the municipality in good condition, are inventoried, and that an appropriate maintenance plan is in place will go a long way in ensuring their proper functioning.

4.4.3 Inspections

Related to the proper operations of stormwater infrastructure is the effectiveness of inspections, including pre construction, during construction, and post construction. As a part of their permitting process, all municipalities have authority to review private development site plans and construction plans, including stormwater controls, and conduct inspections during construction.

Ten out of 25 respondents indicated that stormwater permitting was part of their regular development approval process and seven mentioned it was a federal/state/provincial responsibility, referring to the NPDES program in the United States and the Certificates of Approval (C of A) from the Ontario Ministry of Environment (there is a similar requirement in Quebec, depending on the characteristics of the project). Whether they require specific ICI stormwater permitting or not, all municipalities but one responded that they review site plans for stormwater control, as an integral part of the development approval process.

Building permit requirements dictate inspections by municipal building inspectors during construction, which occur in a majority of municipalities. They can also be the responsibility of regional counties (MRCs) in Quebec and Conservation Authorities in Ontario, or can be subcontracted to consultants. The inspection and enforcement of site-specific stormwater requirements on new construction relies heavily on the knowledge of those inspecting the sites. Building site inspectors, while knowledgeable about construction standards such as pipe installation and confirming grades and elevation, need to keep up to date with the most recent information about new stormwater systems such as swales and other green infrastructure. Some municipalities have kept their building inspectors' knowledge up to date through regular training. According to the survey, half of the respondents indicated that their building inspectors have received specific stormwater training.

Stormwater practitioners suggested that post-construction inspections of private properties were less common, given the prohibitive cost. Two-thirds of municipal respondents conduct post-construction inspections. Although resource intensive, ICI inspections during and post- construction are important to ensure compliance.

Offering training to update inspectors on stormwater innovations, and providing resources to extend inspections to post-construction and retrofitted development contributes to the proper functions of on-site stormwater controls.

4.4.4 Conclusion

Improving interdepartmental coordination, maintenance and inspections through training can pay dividends in the effectiveness of a municipality`s stormwater program.

4.5 Public Education and Outreach

Municipalities need the public's support to achieve their stormwater objectives, given that most stormwater flows from private property. Public education and outreach is intimately tied to the success of good stormwater management, especially for initiating new projects and for creating public awareness of the link between stormwater and water quality.

4.5.1 Education and Outreach Methods

In the U.S., both Phase I and Phase II Municipal Separate Storm Sewer System (MS4s) permit holders are required to incorporate education and outreach programs into their stormwater management plans. Though there are no federal or provincial requirements for public education and outreach related to stormwater in Canada, cities in both Ontario and Quebec are encouraged to address this necessary aspect of effective stormwater management through provincial level stormwater guidelines.[12]

Stormwater education and outreach

PHOTO CREDIT: TOWN OF AJAX, TORONTO AND REGION CONSERVATION AUTHORITY

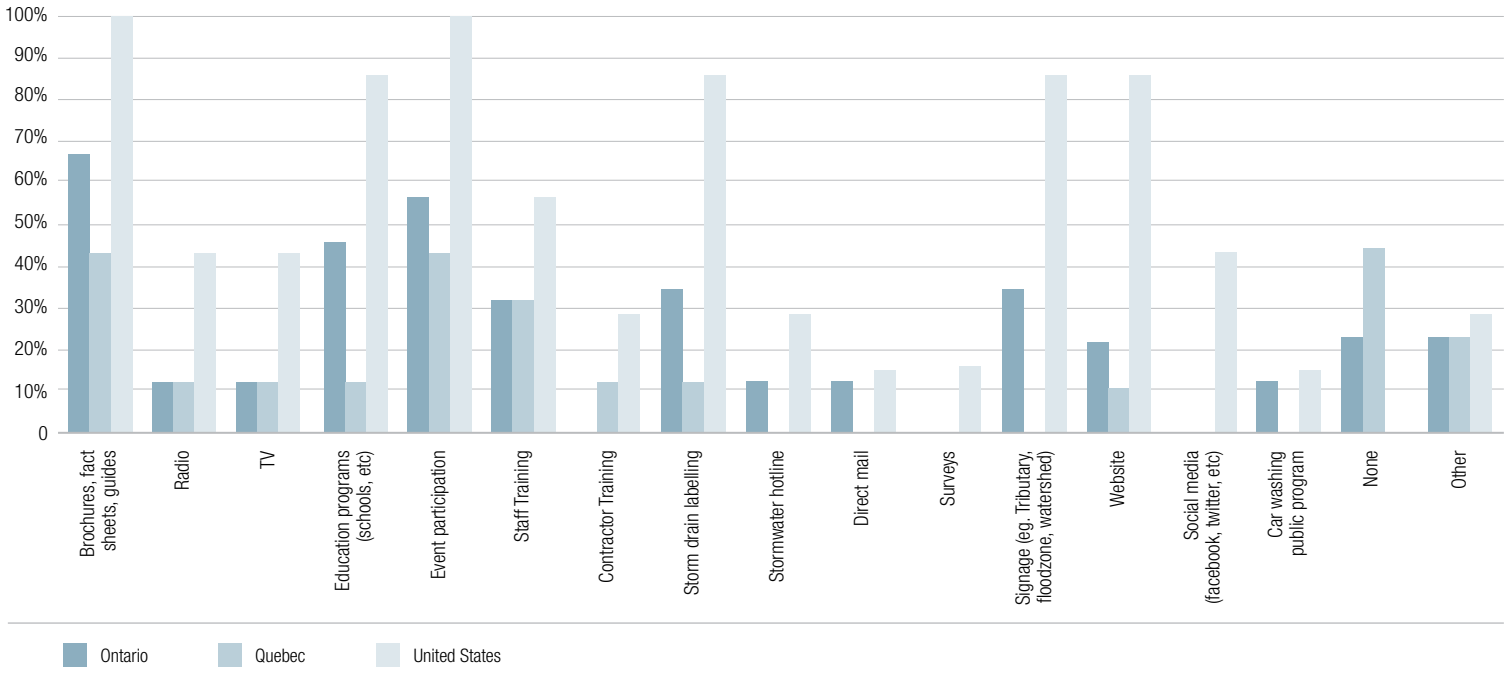
The Green CITTs stormwater survey results showed that various measures of 'Public Education and outreach/ Public participation and involvement' are implemented in more than 2/3 of the municipalities. The U.S. and Ontarian cities seem to focus more heavily on public outreach than cities in Quebec. Only two of six Quebec respondents indicated that they include public education in their stormwater activities.

The complexity of educational programs varies considerably across cities. In general, paper-based materials were more popular than social media methods. Brochures on stormwater were the dominant educational tool, with 17 out of 25 cities indicating the use of brochures.

Another common outreach method among all regions was event participation. The social media-based methods, on the other hand, such as Facebook and Twitter were used the least overall. However, six of the seven U.S. cities indicated the use of websites and signage. Cities in both Ontario and the U.S. commonly use storm drain labeling and education programming, while these practices are only apparent in one city in Quebec from the survey. Many cities are forming partnerships with external organizations to promote public education. All the U.S. and all but two Ontario cities described partnership as a key aspect for delivering public education on stormwater, while two cities from Quebec stated this approach.

An example of a more advanced education approach was highlighted by Montreal, which has formed a partnership with the Regroupement des eco-quartiers

Chart 9: **Which of the following activities are part of your stormwater education and outreach program?**



(Eco-Neighborhood Group), a non-profit organization which facilitated the formation of the *Patrouille Bleue* (Blue Patrol), a youth program emphasizing water awareness.

Montreal, Patrouille Bleue

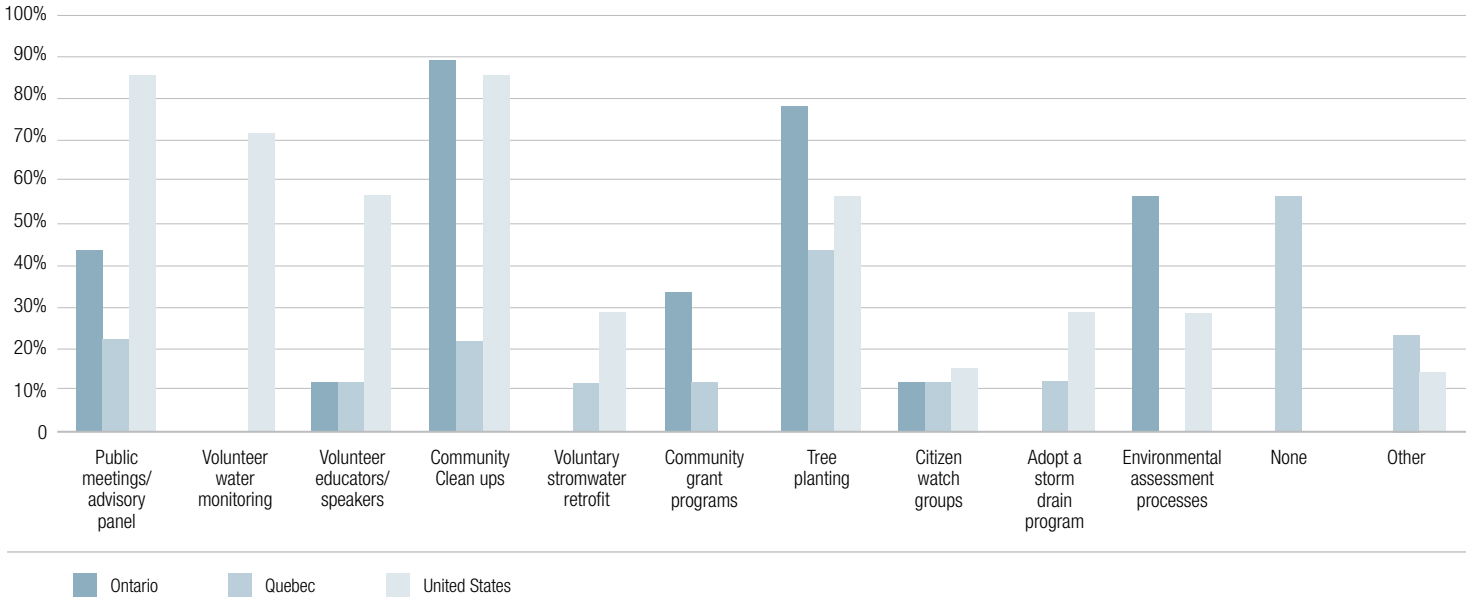
The Agglomeration of Montreal began the Patrouille Bleue (Blue Patrol) in 2010. With the help of the *Regroupement des eco-quartiers* non-profit organization, Montreal youth will hit the streets conveying information to the public on water conservation and freshwater management in general.

www.examiner.com/public-policy-in-montreal/montreal-s-new-blue-patrol-to-push-water-conservation or in French: http://www.eco-quartiers.org/index.html

Aside from utilizing public outreach materials and delivering information directly through pamphlets and brochures, some cities have found public involvement to be an effective means to improving public awareness and garnering support for local initiatives. Community meetings, tree planting, and public meetings/advisory panels were the most popular public involvement mechanisms conveyed in the survey. Tree planting and community clean-ups were most popular in Ontario. Tree plantings were similarly popular in Quebec as in the U.S., with about half the respondents from each country selecting this category.

Unlike the other regions, over half of the Ontario respondents indicated the use of environmental assessments for public involvement. Only two U.S and no Quebec cities indicated this practice. Three cities from Ontario and one from Quebec use community grant programs to engage the public.

Chart 10: **Which of the following activities were part of your public involvement component of your stormwater program?**



Montreal has done a great deal with respect to public outreach and involvement and has succeeded in several related projects. Specifically, Montreal implements an adopt-a-waterway program; provides training for greening parking lots and creating bio-retention facilities; and has incorporated a green alley program. Quebec City specified a 'yellow fish' storm drain stenciling program for public involvement, an easy and effective way to educate the public about stormwater.

YELLOW FISH ROAD™
TROUT UNLIMITED CANADA

Yellow Fish storm drain stenciling

YELLOW FISH, TROUT UNLIMITED CANADA

City of Duluth Regional Stormwater Protection Team

Duluth is part of the Regional Stormwater Protection Team which includes 16 regional governments and groups. The Regional Stormwater Protection Team delivers TV ads, brochures, and exhibits on stormwater impacts and mitigation strategies throughout Northeastern Minnesota and Northwestern Wisconsin.

http://www.lakesuperiorstreams.org/stormwater/rspt_press.html

4.5.2 Conclusion

Although public education and outreach for stormwater management may seem to be secondary in the hierarchy of management activities, it is in the most successful, well-run and well-organized stormwater programs that public education and public involvement programs prevail. More support for raising public awareness of the linkage between stormwater and Great Lakes and St. Lawrence water quality, even on a basin-wide level, could help municipalities in this area.

4.6 Objectives and Measuring Progress

Early stormwater management began with a focus on water quantity control, primarily to address flooding. With the realization of the amount of pollutants being transported by stormwater into receiving waters, improving stormwater quality is also becoming an important objective. Currently, other aspects of stormwater management are emerging, related to watershed management and shoreline and habitat protection, which represent another phase in the evolution of stormwater management.

4.6.1 Stormwater Objectives and Targets

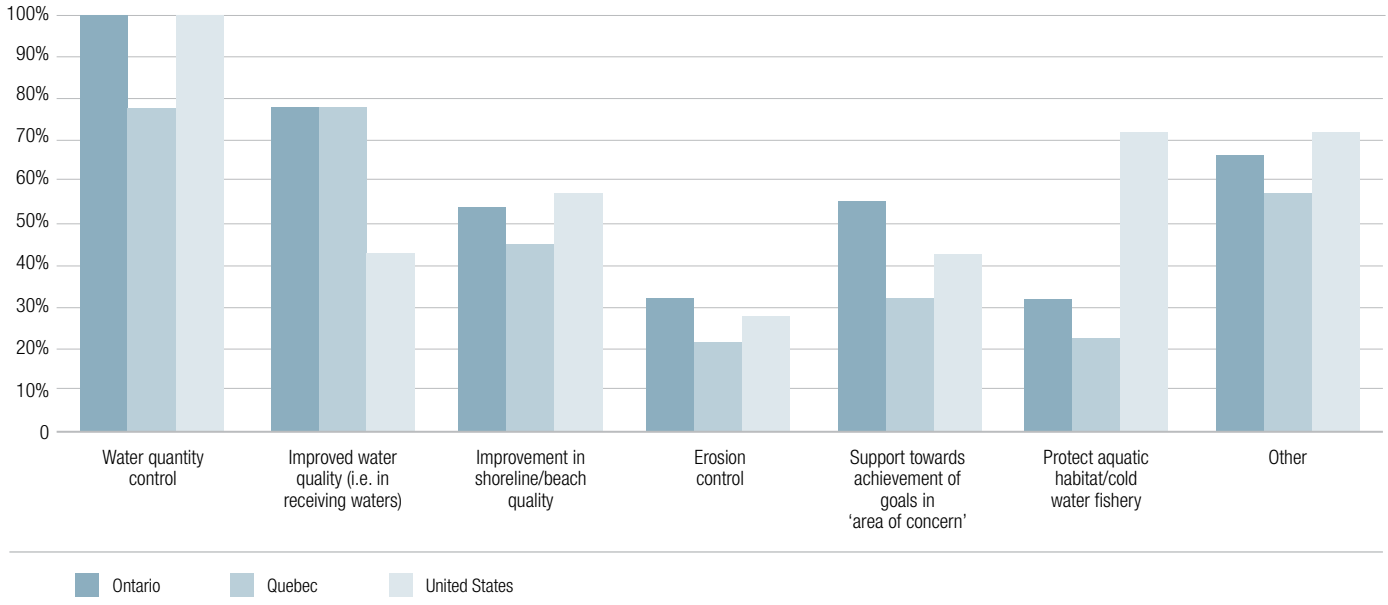
The objectives of stormwater plans and activities cans serve to align and direct measures taken to control flows and effects of stormwater runoff. Stormwater quantity control remains a major objective of municipal stormwater activities, as all but one respondent cited it. The second-most important objective is improved water quality in receiving waters, cited by a vast majority of respondents outside of Quebec. Shoreline/beach quality and erosion control form a third level of importance amongst stormwater management objectives. Protection of aquatic habitat, which was mentioned in the literature as an ultimate goal for stormwater management, was selected by roughly a third of the respondents as one of their objectives, evenly split amongst the three regions. It is important to note that respondents that do not have a stormwater management plan provided answers to this question.

While broad objectives are often established, more specific targets or performance standards are less common. Most cities reported no target or performance standard setting for reducing the quantity or improving the quality of stormwater entering waterways. Ontarian cities tended to emphasize the obligation for target setting as beyond the role of the municipal government. Where municipalities do adopt standards, reductions in stormwater volume and of E-coli entering receiving waters were the most common targets. Targets for chloride and phosphorus were less common.

Water quality monitoring at an outfall

PHOTO CREDIT: TOWN OF AJAX

Chart 11: **What are the primary objectives of your stormwater management activities? - by region**



A number of cities use alternatives to hard numeric performance standards to measure the progress of their municipal stormwater activities. About half the survey respondents, revealed use of such metrics. Fewer flooding complaints, avoided volume of combined sewage treated and water quality improvements were highlighted the most frequently, each with nine of the 25 respondents. Fewer bypasses and water quality improvements were the most common in Ontario with five of the nine Ontarian cities selecting these metrics. Beach closings was also a common indicator in Ontario, more so than in the other regions. Reduced volume of bypasses was the most common in Quebec. Reduced volume of combined sewage treated was the most common in the U.S.

Montreal also uses volume of water and ratio of impervious to pervious surface, along with the cost savings associated with avoiding new grey infrastructure as indicators of improvements from stormwater activities.

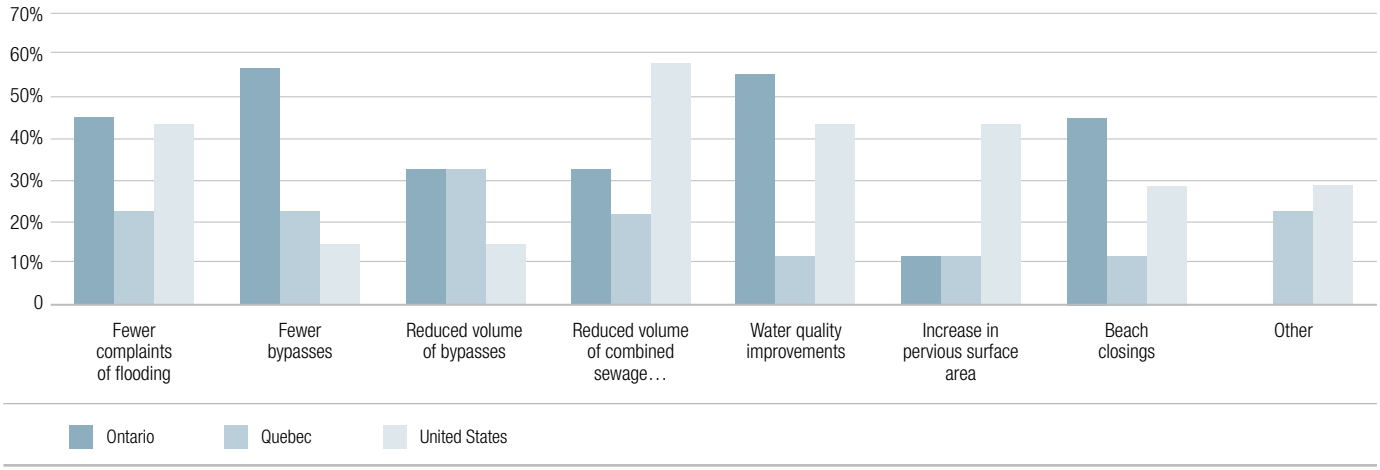
4.6.2 Measuring Progress

Measuring progress and tackling pollution sources is a further step that must be taken if municipalities and other orders of government are to address the impact of stormwater on water quality.

However, measuring the direct benefits of improved stormwater management practices in terms of pollution reduction in receiving waters remains a challenge.

The difficulty lays in the fact that water quality and quantity impacts on receiving waters are influenced by multiple factors, such as the characteristics of a particular storm event, influences from other sources of pollutants, and the landscape over which stormwater moves. The difficulty in tracking this causal linkage poses a problem for local decision makers who must decide how to allocate scarce resources. It also poses a dilemma for provincial, state and federal authorities grappling with crafting an effective response to degrading nearshore water quality.

Chart 12: **Which, if any, metric(s) do you use to measure progress/impact of your stormwater activities?**



Still, some municipalities have had some success in identifying the linkage between stormwater and water quality. For instance, Milwaukee, WI identified site-specific linkages to water quality improvements through monitoring nearshore retention ponds which have reduced E. coli concentrations in sand along the lakefront.

Montreal, QC, has implemented an online monitoring system for stormceptors, which provides information on the quantity of combined sewage sent for treatment. This data can then be used to target and monitor reductions in the quantity of treated sewage, providing an indicator of overall stormwater control measure performance.

Sampling and analyzing receiving waters is used as a way of discovering illicit discharges and is used by half of the respondents. Most municipalities use a mapping database of their sewer systems to conduct outfall inspections.

Grand Rapids Grand River Water Quality Monitoring

The City of Grand Rapids utilizes a long term river monitoring program to monitor for the percent saturation of dissolved oxygen, the change in temperature, pH, biochemical oxygen demand (BOD), total solids, fecal coliform, phosphate, nitrate, and turbidity. This practice is used to complement end-of-pipe monitoring and provides an effective means to tracing water quality concerns back to their source

http://grcity.us/index.pl?page_id=1958

Overall, 15 of the 25 survey respondents indicated having conducted some monitoring at stormwater outfalls or snow dump areas. Lack of funding and resources available for monitoring were also cited as barriers.

Interestingly, despite the federal mandate for outfall monitoring in the U.S., more monitoring seems to be done in Ontario and Quebec; although, three of the seven U.S. cities responded that some other form of monitoring took place or that monitoring was outside the responsibility of the municipality.

Ontario appears to be advanced in monitoring with over half the Ontario cities signaling monitoring for total suspended solids, phosphorus, and E. coli monitoring. Three cities in Ontario monitor for chloride too. Montreal and Levis in Quebec indicated sampling for nitrogen, biological oxygen demand, pH, and an assortment of heavy metals.

Some cities do have regular long-term monitoring programs. For example, Montreal's main land-use planning document contains water quality data spanning over the last 30 years.

City of Windsor Detroit River Bio-monitoring Using Freshwater Mussels

The City of Windsor is involved in an ongoing bio-monitoring study using freshwater mussels as a means to filtering bioavailable concentrations of PAHs and PCBs both of which are known carcinogens and are persistent pollutants in the Great Lakes and St. Lawrence watershed.

http://www.sciencedirect.com/science/article/pii/S0380133003704304

http://www.citywindsor.ca/000211.asp8

4.6.3 Conclusion

Setting objectives for municipal stormwater plans and activities serves to align and direct measures taken to control flows and effects of stormwater runoff. In order to go the next step to demonstrate progress in improving water quality, some municipalities have set numeric or performance targets. Drawing a direct link between stormwater control actions taken and improvements in water quality has proved challenging for some municipalities.

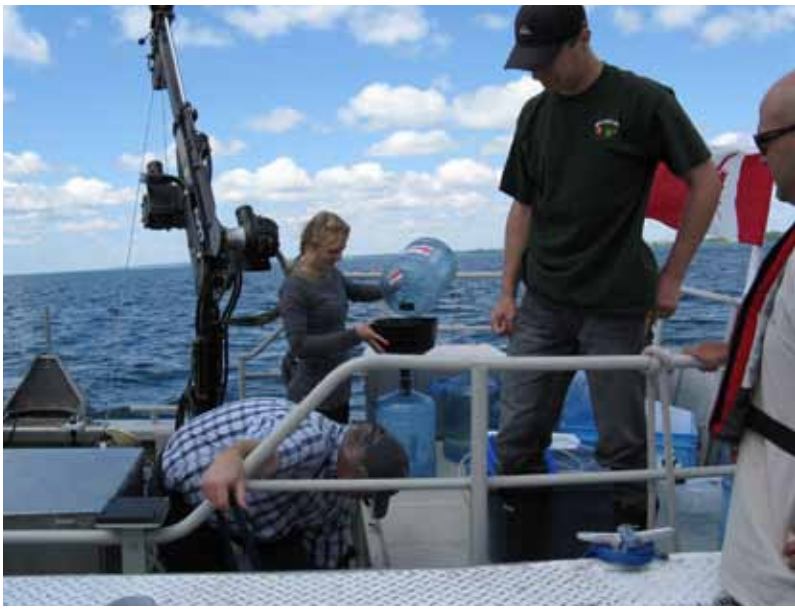
Monitoring for progress is an area in need of support from other orders of government. New monitoring protocols and support are needed from other orders of government to maintain and increase the effectiveness of stormwater monitoring programs, with a view to integrating federal, state, provincial and local monitoring data and collaborating on analysis that will assist in tracing pollution back to its source and remediating those sources of pollution.

4.7 Stormwater Management Requirements on ICI Sites

Effective stormwater management requires the active participation of owners and developers in the industrial, commercial and institutional (ICI) and residential sectors.

4.7 1 Requirements for New ICI Sites

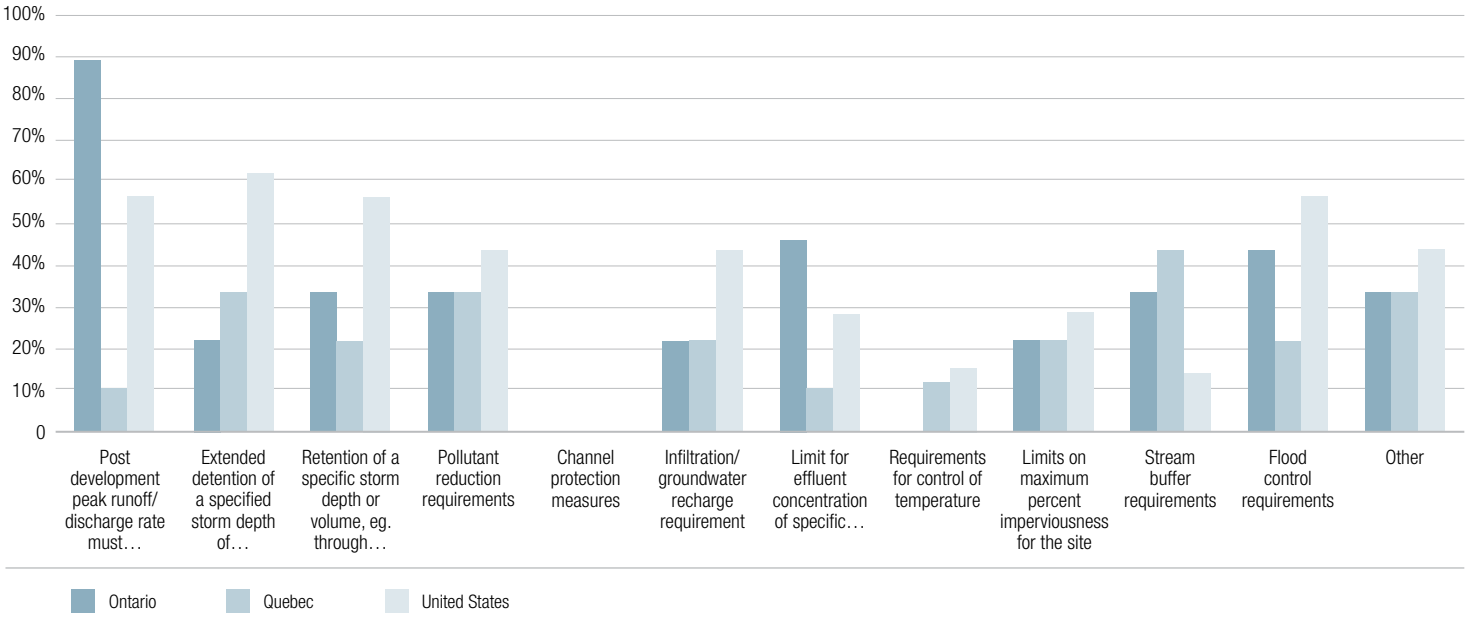
As site plan controls usually represent the first line of defense against increased stormwater flows, their application on large industrial, commercial



Water quality testing on Lake Ontario

PHOTO CREDIT: TOWN OF AJAX

Chart 13: **Which specific or numeric stormwater performance standards or design criteria requirements apply to development projects?**



and institutional sites that generate high volumes of stormwater flow are especially important.

In addition to site plan reviews and site inspections (see 4.4.3, above), municipalities have the power to enact regulations concerning stormwater management controls for new ICI building sites. Some municipalities use this authority, while others rely exclusively on state or provincial approvals. Twenty of the responding municipalities stated that they have numeric or specific stormwater performance standards for their control measures. Four of the five that do not have these are located in Quebec.

The most common performance standards applied to the ICI sector (roughly half the respondents) regulate flood control requirements, detention/gradual release of stormwater and keeping discharge rate levels to pre-construction levels. Some municipalities mentioned state/provincial/regional standards that are applied. Water temperature controls, which influence the quality of aquatic habitat, were rare among respondents. This is consistent with aquatic habitat protection representing the most advanced stormwater management goal that very few municipalities are pursuing.

Every municipality surveyed has the authority to use their sewer usage bylaw or ordinance to regulate what enters their sewage systems. Municipalities, in all jurisdictions studied, apply their regulatory powers to enact sewer usage bylaws or ordinances. This is by far the most common pollution prevention measure applied amongst all respondents. Local sewer usage bylaws differ in their content and the extent of their power. Duluth, MN has a bylaw stating that storm sewers are meant to convey stormwater (rainwater) exclusively. Any other substances are considered an illicit discharge and any dumping could be fined.

Chicago New ICI Development Stormwater Requirements

The City of Chicago stipulates specific design criteria and rules and regulations for new developments in the Department of Water's 2011 Regulations for Sewer Construction and Stormwater Management. The document provides excellent guidance for construction and operations and maintenance of sewer and stormwater facilities on private property.

http://www.cityofchicago.org/content/dam/city/depts/water/general/Engineering/SewerConstStormReq/2011Regulations.pdf

Vegetated swale in a parking lot

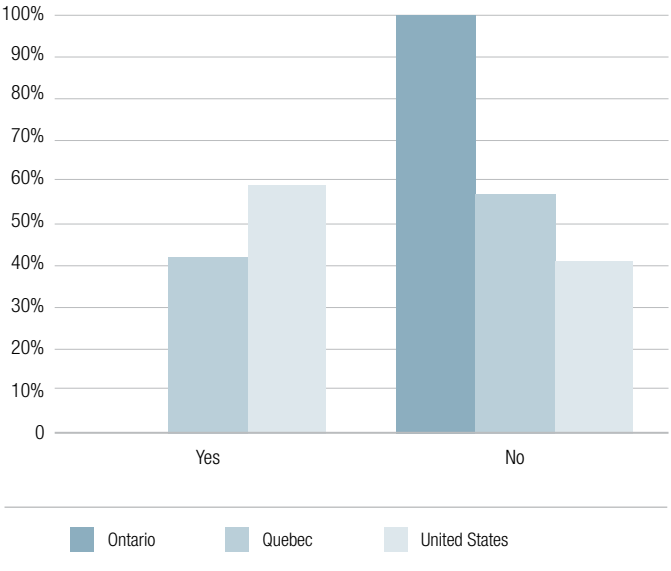
PHOTO CREDIT: CENTER FOR NEIGHBORHOOD TECHNOLOGY

4.7.2 Industrial and Commercial Sites –Retrofit Projects

As large areas of older cities were built before stormwater controls were introduced, installing or improving stormwater controls at existing ICI building sites that are being retrofitted presents an opportunity to reduce stormwater flow. However, retrofits also pose very specific challenges. Limited space, soil conditions and potential land-use conflicts are the main challenges noted. Because of these challenges, fewer municipalities address stormwater management practices for retrofits. Only those municipalities with more advanced stormwater strategies have adopted requirements or incentives associated with retrofits to existing developments. This represents an important gap in stormwater management as older cities have vast areas where stormwater contributes significantly to infiltration and inflow into sewer systems.

Only eight out of 25 of the responding municipalities have a retrofit program for stormwater. Most retrofit initiatives are concentrated in the U.S., although stormwater

Chart 14: **Do you have a stormwater retrofit program?**



practitioners in Quebec noted that when permitting is necessary for renovations, some stormwater controls can be included. The most common measure taken is to promote tree planting.

Compared to new ICI development, numeric performance standards are less common in retrofit projects. The individual nature of each project and the complexity of installing stormwater controls on developed land (or densely occupied land) explain why numeric standards are not as common in retrofits. From a limited sample, the most common performance standards touch on impervious surface limits, stormwater detention, and pollutant reduction requirements. Since most municipalities do not have regulations and standards for ICI stormwater retrofits, incentives, such as fee reductions (stormwater fee, sewer taxes, etc.) and recognition awards, could be a way to entice property owners to install stormwater controls.

4.7.3 Conclusion

Municipalities use a variety of methods to control the flow of stormwater from new ICI developments, including site plan review and inspections, stormwater performance standards, and sewer-use ordinances or bylaws.

Although less common, requirements or incentives for the installation of stormwater controls in ICI properties undergoing retrofitting represents a great opportunity to reduce inflow and infiltration of stormwater into a municipal storm or sanitary collection system.

4.8 Low-Impact Development (LID)

Cities across the Great Lakes and St. Lawrence basin are in constant development and revitalization. Whether developing 'greenfields' or retrofitting older sites, both represent opportunities to better control stormwater on-site. Increasingly, municipalities are integrating land use planning with stormwater controls according to low-impact development (LID) principles and and the use of green infrastructure such as pervious pavements, swales, green roofs and rain barrels.

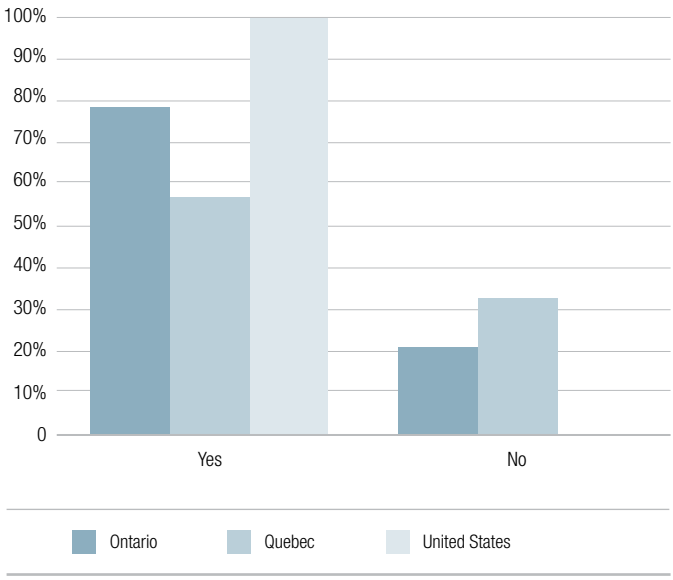
LID refers to planning and building practices that apply 'green infrastructure', such as natural features like greenspace and wetlands or engineered features such as rain barrels, swales, green roofs, and pervious surfaces, that serve to maximize natural absorption or reuse of stormwater on-site, and reduce the amount flowing off the property and into municipal collection systems. Municipalities can realize significant cost savings if they

Native garden on residential property

can limit the need to increase grey infrastructure capacity as a result.[13] Green infrastructure also has important aesthetic qualities that have increased people's enjoyment of their properties and even the value of their properties.[14]

Green infrastructure is being used extensively in the U.S. while adoption in Canada is catching up. Survey results showed that many Canadian cities implement some kind of basic green infrastructure. For example, many municipalities have made progress in reducing stormwater flow into their sewer systems through bylaws requiring downspout disconnections. In St. Catharines, ON over 17,000 private properties have been inspected to ensure they are in compliance. However, adoption of more advanced or widespread LID practices is limited in Ontario and Quebec, except in large centres.

Chart 15: **Are you currently applying any low impact development measures in your district/municipality?**



Milwaukee H_20 Capture Website

The Milwaukee Metropolitan Sewerage District has recently started a web-based green infrastructure guidance and education tool called h2ocapture.com. The website offers educational material on community level stormwater management with a green infrastructure benefit calculator and interactive map of green infrastructure locations.

www.h2ocapture.com/

4.8.1 Application of Green Infrastructure

Explicit municipal commitments to LID can serve as a strong driver for the adoption of innovative green infrastructure. Such a commitment was most common amongst U.S. respondents and evenly split among Ontario and Quebec respondents. Even those without a commitment to LID are adopting some practices, with 19 out of 25 respondents expressing that they are applying LID measures within their jurisdiction. This strongly suggests that the value of green infrastructure is increasingly being recognized by municipalities of the basin.

On public property, more than half the respondents use oil/water separators, vegetated swales, trees/tree boxes, extended detention basins, curb and gutter/storm sewer and catch basins to address stormwater. However, the extent to which these methods are used varies widely. Knowledge of the use of LID on private property is limited as data acquisition is a challenge, as municipalities are only made aware of LID implementation when a permit is required.

Planning for and using more pervious surfaces is a way of encouraging absorption of stormwater as close to the source as possible. Overall, half of the respondent municipalities do encourage pervious surfaces. These municipalities are located primarily in the U.S. and larger centers in Quebec. Measures taken to encourage

Porous pavement at Maxwell Street Market in Chicago

PHOTO CREDIT: CITY OF CHICAGO

pervious surfaces vary from municipality to municipality. Where stormwater fees are applied on a site by site basis, these are usually based on the proportion of impervious surface on a lot. Since the fees decrease when there is less impervious surface, they are a way to encourage the implementation of pervious surfaces. For example, some local planning requirements mandate a minimum number of parking spaces for new developments. The City of Montreal noted that its use of pervious surfaces had to be carefully considered in some areas of the city, due to frost-related risk to underground infrastructure.

Site design requirements have been a barrier to adopting green infrastructure as an alternative to grey infrastructure in some municipalities. These requirements are seen as less of a barrier in the U.S. compared to Canada. Soil conditions are key to make green infrastructure work properly. They are also a main reason why stormwater control regulations harmonization is difficult and why guidance is expressed in the form of best practices instead of numeric norms. Resistance to change and unfamiliarity with the application of LID is still a concern, but may be easing, as green infrastructure makes its mark and is proven effective. Municipal respondents pointed to the need for more LID pilot projects. These would create tangible results and credible data about the effectiveness of such measures.

Toronto Green Roof Bylaw

The City of Toronto passed a bylaw in 2009 requiring green roof construction for new residential, commercial and institutional development made after January 31, 2010 and new industrial developments made after April 30, 2012. Toronto also has an Eco-roof Incentive Grants program to promote the use of green roofs on commercial, industrial and institutional buildings.

http://www.toronto.ca/greenroofs/

4.8.2. Conclusion

The incremental integration of green infrastructure into a city's overall stormwater plan can be used to increase the absorption of stormwater on-site rather than conveying the water into the separated or combined collection system, thereby reducing costs associated with increasing collection system capacity. There remain challenges, including the lack of comprehensive performance data, public acceptance and maintenance, and limitations posed by soil conditions.The adoption of green infrastructure holds great promise and would benefit from further support and promotion by regulators and further analysis of performance by researchers to maximize its potential.

4.9 Urban Intensification and Stormwater-friendly Land-Use Planning

Urban growth and the trend towards urban intensification have been identified by the International Joint Commission as one of the greatest threats to Great Lakes water quality, given the concentration of polluted stormwater flow that is generated over impervious surfaces and drain into receiving waters.[15] Given that urban growth shows no signs of abating, the challenge for local authorities and regulators is to make urban land-use planning 'stormwater-friendly'.

Common Urban Planning Pattern

PHOTO CREDIT: GOOGLE EARTH

4.9.1 Integrating Stormwater Management and Land-Use Planning

One of the limitations with the current regulatory approach to stormwater management is that stormwater has been decoupled from urban planning. In Canada, provincial stormwater approvals are done on a site-by-site basis. And in the U.S., the emphasis on NPDES permits for individual site control rather than broader, stormwater-friendly land-use planning has led to a cumulative growth of stormwater impacts on urbanized watersheds. As explained in a 2008 report on stormwater management.

> "While the Clean Water Act gives EPA the authority to set stormwater management benchmarks for entire communities and watersheds, it provides little authority over the shifts in urban growth patterns that are necessary to avoid generating new sources of stormwater pollution."[16]

Some cities are beginning to integrate land-use planning and stormwater controls with the natural hydrology of the region.

'Trois-Rivières' Plan to Integrate natural areas into urban development

The City of Trois-Rivieres (QC) has implemented a strategy to integrate natural areas in urban development. The strategy's goal is to protect one hectare of land for every 1 hectare of land developed. After one year of implementation, the strategy has already had an impact on 31 site plans involving 125 hectares of lands under development and has resulted in 128 hectares of protected lands, of which 40% were transferred to the city by developers.

http://citoyen.v3r.net/portail/index.aspx?sect=0&module=5&module2=1&MenuID=1040&CPage=4)

4.9.2 Smart Growth and Stormwater

The use of Smart Growth principles including clustered development, narrower streets, reduced setbacks, and reduced imperviousness and land area are ways in which cities can improve stormwater management through the planning process in densely populated areas.[17] These principles in combination with water quality-based zoning models are available to facilitate a watershed planning process which emphasizes high clustered density development and encourages infill redevelopment rather than the expansion of low-density urban sprawl.

Many cities in the U.S. and Canada are changing course towards Smart Growth. Cities in the U.S. in particular have achieved Smart Growth goals while effectively incorporating stormwater design considerations.

However, if urban intensification proceeds without consideration of stormwater at the conceptual stage, the densification will naturally intensify stormwater flows into the waterways in which it is discharged, further exacerbating water quality impacts and creating an increased risk of flooding.

As many of the most recent master plans call for urban intensification, it is interesting to note how stormwater is being taken into account. With regards to intensification, the most common stormwater control policy is to require that stormwater flows remain at pre-construction levels. This policy has been adopted in 14 out of 25 municipalities that responded to the survey. More stringent requirements taken by four municipalities are a reduction in stormwater runoff after construction. Another approach, adopted by the City of Chicago, limits peak stormwater discharge rate from developing sites to a release rate that is based on the local and regional sewer capacity.

Green Grand Rapids Master Plan Update

The Green Grand Rapids Master Plan Update encourages an integration of stormwater management with urban planning and broader watershed management through a focus on redevelopment and mixed-use planning, utilizing green infrastructure in public rights-of-way and on private property. The new Green Grand Rapids Master Plan also includes updates to the zoning ordinance that contains provisions for parking maximums and impervious surface requirements.

www.ci.grand-rapids.mi.us/download_upload/binary_object_cache/greengr_Green_Grand_Rapids_Report_LowRez.pdf

4.9.3 Conclusion

Municipalities are at the beginning stages of designing communities in stormwater-friendly manner, that is, in a way that integrates planning with the natural hydrology of the region and allows for maximum infiltration and reuse of average stormwater flow at the conceptual stage of land-use planning rather than later, as properties are being developed. This is particularly important given the policy emphasis on urban intensification that will otherwise result in a concentration of stormwater flow in cities. It is vitally important that urban intensification plans anticipate and address the additional stormwater flow that comes with greater urban density.

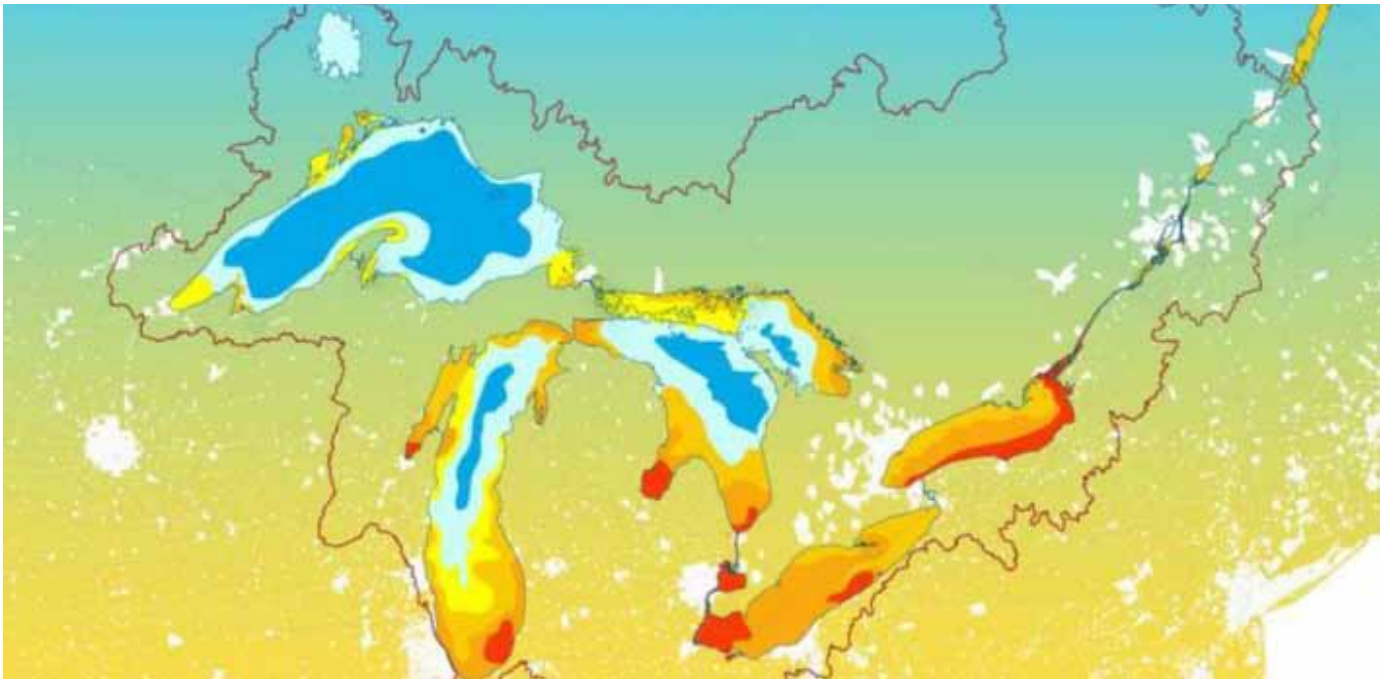
4.10 Climate Change Adaptation

Scientific studies have shown that over the past century the frequency and magnitude of intense precipitation events has increased, and that this increase is associated with anthropogenic climate change.[18] Anticipating and responding to gradual changes in local weather as a result of climate change poses a formidable challenge for municipalities.

4.10.1 Cities Preparing for Climate Change Impacts

Regarding future climatic changes, 15 of the 25 cities surveyed have measured or noticed changes to precipitation patterns in the municipality. This result is consistent with the literature on future climatic variability. Approximately half of the cities in the U.S. and Quebec that responded to this question have measured such changes, while six of the nine Ontarian cities stated observed increased extremes in wet weather. However, 18 cities have not yet conducted a municipal planning/ infrastructure/services vulnerability assessment regarding climatic changes. This suggests that municipalities are observing changes in weather patterns but have not yet put a strategy in place to adapt to these changes.

The most advanced stormwater programs have climate change policies or plans for making design and planning decisions that anticipate climatic changes. Nine cities claimed the establishment of a climate change stormwater policy or plan, the majority being from Ontario. The City of Trois-Rivières, QC developed a climate change plan to inform how to adapt to weather changes.



Average water temperatures in the Great Lakes and St. Lawrence River Basin. Climate change threatens to increase water temperatures.

PHOTO CREDIT: SKIDMORE, OWINGS, MERRILL AND THE INTERNATIONAL JOINT COMMISSION

Chart 16: Has your municipality adopted a policy or plan associated with mitigation of/adaptation to climate change?

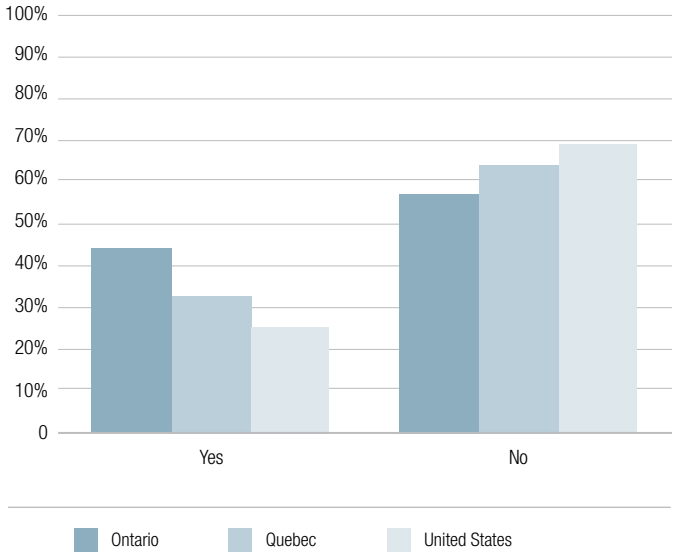
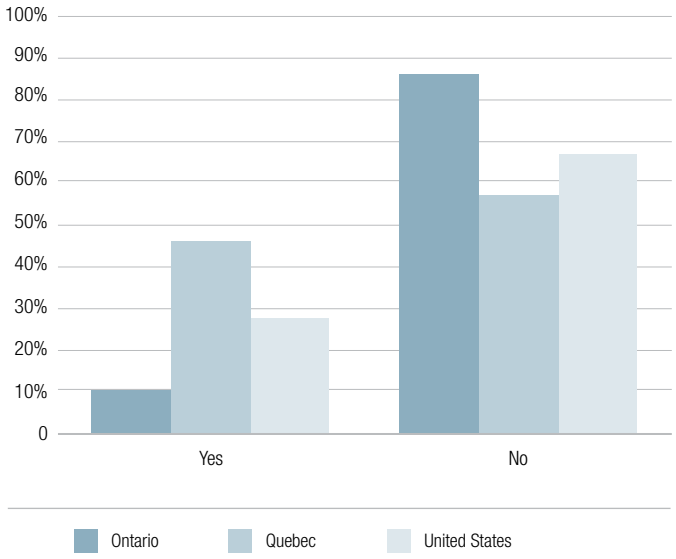


Chart 17: Have you assessed your vulnerability to climate change as it relates to municipal planning/infrastructure/services?



Chicago's Climate Action Plan

Chicago's Climate Action Plan includes adaptation strategies that directly address stormwater activities in the context of climate change. The strategies include collaboration with the Greater Chicago Metropolitan Water Reclamation District on a Watershed Plan that factors climatic changes and the use of vacant lots and green infrastructure for future flood control.

www.chicagoclimateaction.org/pages/adaptation/11.php

Climate Change Adaptation in the City of Toronto: Lessons for Great Lakes Communities

Toronto's *Climate Change Adaptation in the City of Toronto* identifies 'Areas of Vulnerability and Action' in light of future climatic changes and highlights anticipated problems with flooding as well as mitigation strategies through good stormwater planning

www.cleanairpartnership.org/files/Climate%20Change%20Adaptation%20in%20the%20City%20of%20Toronto%20-%20Lessons%20for%20Great%20Lakes%20Communities%20%28Penney,%20J.%202008%29.pdf

4.10.2 Information Gaps

In order to design infrastructure in anticipation of climatic changes, reliable information on anticipate weather changes is needed. While retrospective data is available, predictive climate change modeling for the Great Lakes and St. Lawrence region has not yet been scaled down to the local level. About half of the survey respondents verified they have access to retrospective information on local changes/trends in precipitation patterns required to modify stormwater activities accordingly. No one region appears to have better access to such information

than any other, suggesting that climate and weather information is available if cities seek it out, and many cities have access to local rain gauge data.

For the municipalities that reported a lack of information on climate/weather data, it was more commonly stated that the information that was available was not the right kind or in the right format conducive for planning and engineering purposes. Still, several cities did regard a total lack of data as the main obstacle and that more rain gauge data would provide a means to updating Intensity Duration Frequency (IDF) curves and changing infrastructure design criteria. An associated advantage for the Ontarian cities is that the Conservation Authorities provide weather data to the municipalities. In Canada, more broadly, cities have access to meteorological data from Environment Canada.

Some of the larger cities were able to work with external experts to develop more sophisticated predictive models. Quebec City, QC and Montreal, QC use data from OURANOS, an environmental organization specializing in climate change. Montreal as well as Chicago, IL identified the use of climate modeling to track and predict future changes in storms.

4.10.3 Adapting Infrastructure

The departure from historical weather patterns due to climate change goes to the core of the relationship between storm intensity, duration and frequency and the infrastructure design criteria used to engineer stormwater facilities. Rethinking design criteria to ensure that newly constructed infrastructure can withstand the anticipated intensity of storms and provide the necessary conveyance capacity to protect public safety are some of the challenges facing municipalities.

To adapt to these changing conditions, cities will need a new method of anticipating peak storm events, such as probability distributions of extreme magnitude storms, instead of the current quantification of the number of times a threshold storm is exceeded (eg 100 year storms based-criteria) in order to revise infrastructure design criteria.[19] To date, there are very few studies that attempt to make these estimates. Anecdotally, municipal stormwater professionals indicated a need for more information and support in this area.

When asked about meeting the service demands of more frequent extreme storm events, municipal respondents indicated measures including revising infrastructure design criteria, updating IDF curves, identifying infrastructure at-risk to flooding, and relocating entities or taking other action to prevent flooding in at-risk neighborhoods. Each of these changes was identified by approximately a quarter of the sample cities. Regarding infrastructure design changes, cities in general appear

Innovative stormwater management during storm

PHOTO CREDIT: CITY OF CHICAGO

to do IDF curves updating as frequently as revising infrastructure design criteria. However, there were regional differences for this question. U.S. cities do the least amount of system design changes. Only Milwaukee, WI indicated changing its design criteria. Ontario does more updating of IDF curves, while Quebec cities do the most out of each region, based on the survey results.

Nine cities indicated that they have identified neighborhoods at risk to flooding. In addition to making appropriate adjustments to the physical drainage system, many cities will also need to have adequate emergency response planning for extreme weather events to prepare for the possibility of severe flooding. This could include identification of and public outreach for at-risk communities, transition plans to relocate homes and businesses, and a regional conveyance plan that emphasizes watershed scale management over site-level management. Most cities tend to identify at-risk areas for addressing flooding problems that may be related to climatic variation. Eighteen of the survey respondents related this response. Regional conveyance plans and outreach and education targeted towards at-risk neighborhoods were less common in general. However, Quebec cities tended to convey use of these more frequently than all other response methods aside from identifying communities at-risk to flooding. While identifying flood-risk areas was common, none of the cities claimed the use of transition plans to relocate homes/business in affected areas. This suggests a potential area where municipalities need assistance, that is, what to do once flood-risk areas are identified.

4.10.4 Conclusion

Assessing their vulnerability to climate change impacts is an important first step for municipalities in determining appropriate adaptation strategies. Technical and financial support for undertaking such assessments would provide an important incentive in this regard.

The limited availability of predictive models of anticipated storm and precipitation patterns at the local level represents a significant information gap for municipal decision makers when justifying infrastructure design criteria changes that carry a hefty price tag. More collaboration with research institutes and other levels of government to scale down regional climate change models would assist municipalities in their climate change adaptation planning.

5. Looking Forward

Looking forward, the combined impacts of concern over water quality, continued urban intensification, and climate change will continue to drive changes in the stormwater practices of Great Lakes and St. Lawrence cities. This report demonstrates the range of issues facing municipal stormwater practitioners, and the wide range of best practices already adopted by them in the face of these pressures. It also points to ten areas where improvements would result in more effective stormwater management and significant cost savings:

1. Government Regulation: The regulatory environment was identified as a primary driver (in the US) and barrier (in Canada) for municipal action on stormwater amongst municipal survey respondents. The U.S. federal stormwater permitting system has resulted in more developed and comprehensive stormwater programs at the local level. In Ontario and Quebec, the permissive nature of stormwater authority given to municipalities has resulted in varied approaches to municipal stormwater management, from comprehensive stormwater planning, to more diffuse stormwater activities.

2. To improve water quality in receiving waters, more predictable funding within municipal budgets will be required to adapt and improve municipal stormwater practices, either through utility rates or stormwater fees. Given the shared interest in improving nearshore water quality, financial support to municipalities from other orders of government is also needed.

3. Formal stormwater management plans are an important step in the evolution of a city's stormwater activities. The trend in Canadian cities towards adopting a comprehensive stormwater plan is encouraging should be further supported by provincial authorities.

4. Coordination amongst multiple municipal departments to deliver stormwater management was identified as barriers to effective stormwater management by a number of municipal stormwater practitioners. Cities have demonstrated how improving interdepartmental coordination, maintenance and inspections through training can pay dividends in the effectiveness of their stormwater program.

Vegetated swale in parking lot

PHOTO CREDIT: CENTER FOR NEIGHBORHOOD TECHNOLOGY

5. Although public education and outreach for stormwater management may seem to be secondary in the hierarchy of management activities, it is in the most successful, well-run and well-organized stormwater programs that public education and public involvement programs prevail. More support on a basin-wide level from federal governments, to raise public awareness of the linkage between stormwater and Great Lakes and St. Lawrence water quality, could help municipalities in this area.

6. Drawing a direct link between stormwater control actions and improvements in water quality has proved challenging for some municipalities. Monitoring for progress is an area in need of support from other orders of government. New monitoring protocols and support are needed from

other orders of government to maintain and increase the effectiveness of stormwater monitoring programs, with a view to integrating federal, state, provincial and local monitoring data and collaborating on analysis that will assist in tracing pollution back to its source and remediating those sources of pollution.

7. Effective stormwater management requires the active involvement of property owners and developers in the ICI sector. Municipal site plan reviews and inspections, and on-site stormwater performance standards and sewer-use ordinances or bylaws provide a strong first-line defence from stormwater flow and pollutants from ICI sites. Although less common, requirements or incentives for the installation of stormwater controls in ICI properties undergoing retrofitting represents a great opportunity to reduce inflow and infiltration of stormwater into a municipal storm or sanitary collection system.

8. The use of low-impact development and green infrastructure to complement existing stormwater controls can reap multiple benefits for municipalities, from enhanced aesthetics to deferred infrastructure costs. Further support and promotion from regulators and researchers, through demonstration projects, the sharing of performance data, and increased public and private sector awareness would go a long way to maximize its potential.

9. Municipalities are beginning to design communities in a stormwater friendly manner, that is, in a way that is integrated with the natural hydrology of the region and allows for maximum infiltration and reuse of average stormwater flow at the conceptual stage of land-use planning rather than later, as properties are being developed. This is particularly important given the policy emphasis on urban intensification that will otherwise result in a concentration of stormwater flow in cities. It is vitally important that urban intensification plans anticipate and address the additional stormwater flow that comes with greater urban density.

Planters for rainwater infiltration

PHOTO CREDIT: CITY OF PORTLAND

10. In considering adaptive measures to climate change, municipalities would benefit from technical and financial support from other orders of government and other experts, for undertaking infrastructure vulnerability assessments. Further collaboration with research institutes and other levels of government to scale down regional climate change models and to review infrastructure design criteria in light of this information would also assist municipalities in their climate change adaptation planning.

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