1.0 INTRODUCTION

1.1 About This Document

The *Low Impact Development Stormwater Management Planning and Design Guide* (*LID SWM Guide*) has been developed by Credit Valley Conservation (CVC) and Toronto and Region Conservation Authority (TRCA) as a tool to help developers, consultants, municipalities and landowners understand and implement more sustainable stormwater management planning and design practices in their watersheds. Many jurisdictions have defined the term low impact development. For this document, the following definition, adapted from the United States Environmental Protection Agency (U.S. EPA, 2007) will be used:

> Low impact development (LID) is a stormwater management strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution by managing runoff as close to its source as possible. LID comprises a set of site design strategies that minimize runoff and distributed, small scale structural practices that mimic natural or predevelopment hydrology through the processes of infiltration, evapotranspiration, harvesting, filtration and detention of stormwater. These practices can effectively remove nutrients, pathogens and metals from runoff, and they reduce the volume and intensity of stormwater flows.

The *LID SWM Guide* provides information and direction to assist engineers, ecologists and planners with landscape-based stormwater management planning and the selection, design, construction and monitoring of sustainable stormwater management practices. The focus of this guide is on guidance regarding the planning and design of structural low impact development practices for stormwater management.

The practice of managing stormwater is continuing to evolve as the science of watershed management and understanding of our watersheds grow. Effective management of stormwater is critical to the continued health of our streams, rivers, lakes, fisheries and terrestrial habitats. CVC and TRCA believe that an improved understanding of the municipal and environmental planning process and the requirements for stormwater management will lead to improvements in management practices and an increasingly standardized and streamlined approach to addressing stormwater throughout the CVC and TRCA watersheds.

The *LID SWM Guide* is intended to augment the Ontario Ministry of the Environment (OMOE) Stormwater Management Planning and Design Manual (2003). The OMOE manual provides design criteria for “conventional” end-of-pipe stormwater management practices such as wet ponds and constructed wetlands but provides only limited information about lot level and conveyance controls. The OMOE manual does, however, emphasize the use of a “treatment train” approach to reduce the impacts of stormwater runoff. A treatment train approach – a combination of lot level, conveyance, and end-of-pipe stormwater management practices – is usually required to meet the multiple objectives of stormwater management, which include maintaining the hydrologic cycle, protecting water quality, and preventing increased erosion and flooding.

This *LID SWM Guide* focuses on a number of lot level and conveyance stormwater management practices that have been used extensively in Europe, the United States, British Columbia and at demonstration sites in Ontario. These practices have only recently been considered for broad application in Ontario as part of the treatment train approach. These low impact development practices include green roofs, bioretention, permeable pavement, soakaways, perforated pipe systems, enhanced grass swales, dry swales and rainwater harvesting. The *LID SWM Guide* recommends and supports the use of the treatment train approach for stormwater management. Accordingly, the reader is urged to refer to the OMOE manual (OMOE, 2003), as a guide for incorporating more traditional practices such as wet ponds and wetlands into the overall stormwater management planning and design process.

The *LID SWM Guide* is not intended to limit innovation or restrict the use of creative solutions for stormwater management. Indeed, the OMOE, CVC, TRCA and partner municipalities encourage the development of innovative designs and technologies.

1.2 History and Context

In 1993, the Ontario Ministry of the Environment and Energy and Ontario Ministry of Natural Resources released three policy documents that focused on integrating water resources management and urban planning:

- Water Management on a Watershed Basis: Implementing an Ecosystems Approach;
- Subwatershed Planning; and
- Integrating Water Management Objectives into Municipal Planning Documents.

These documents heralded a new approach to water management in Ontario. They emphasized the need for an increased focus on protecting the natural environment and the need to expand stormwater management practices to pay more attention to water quality and environmental concerns, in addition to addressing traditional water quantity concerns.

In 1994, the Ontario Ministry of Environment and Energy (OMOEE) released two practitioners’ guides to stormwater management planning:

- Stormwater Quality Best Management Practices; and
- Stormwater Management Practices Planning and Design (SMPPD) Manual.

The OMOEE SMPPD manual was intended to introduce practitioners to a broad range of stormwater management facilities that were designed to not only offset the effects of hydrologic changes of urban development on streams and rivers, but also address water quality and erosion impacts. The SMPPD manual also provided detailed guidance on how to design and build multi-purpose facilities and included sections on operations and maintenance, as well as environmental monitoring requirements.

In 2003, OMOE released a new Stormwater Management Planning and Design Manual, which significantly updated and expanded on the 1994 version. The 2003 manual:

- provided an overview of the impacts of urbanization on the hydrologic cycle and stream ecosystems;
- addressed the evolution of the watershed planning process and implications for the design process;
- incorporated water quantity, erosion control, water quality protection, and water balance principles into the selection and design of stormwater management practices (SWMPs);
- documented the performance of SWMPs that have been monitored;
- incorporated design considerations for SWMPs in cold climates;
- provided information on new "state of the art" SWMPs;
- addressed infill projects;
- updated operations and maintenance requirements;
- provided design examples for SWMPs;
- updated material related to planting strategies and the function of plant materials in SWMP design;
- provided examples of retrofitting SWMPs; and
- outlined integrated planning for stormwater management.

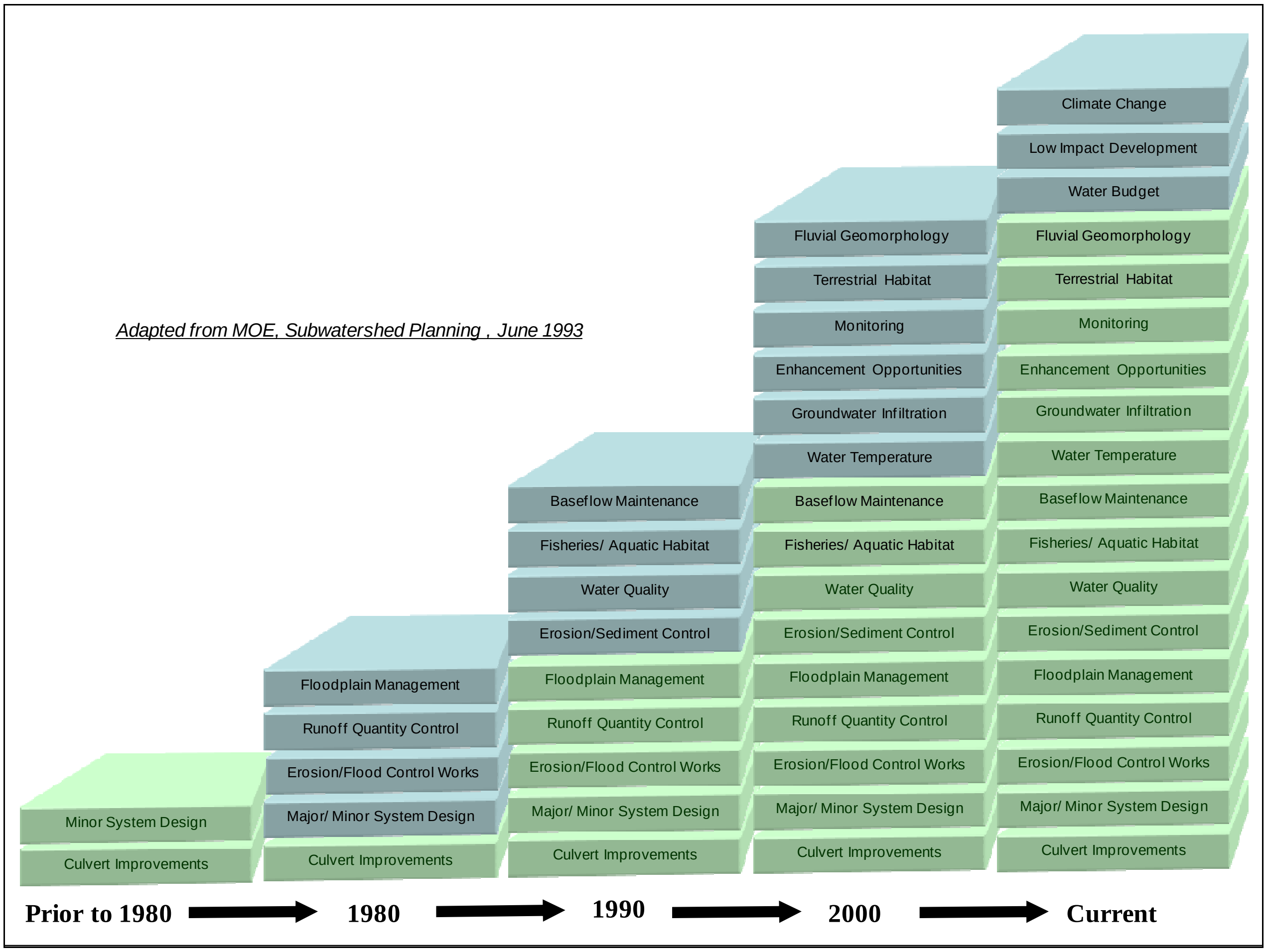
1.3 The Evolution of Stormwater Management

During the past three decades, the practice of stormwater management has evolved. In the mid 1970s, attempts to control runoff flow rates from urban developments were initiated. By the late 1980s, water quality became an additional focus and in the late 1990s, approaches to mitigate accelerated stream channel erosion were introduced. Lot level stormwater management approaches have been advocated in Ontario since 1995 (OMMAH, 1995), but widespread application has yet to occur. Today, with improvements in our understanding of watershed systems and the potential impacts urbanization can have on aquatic ecosystems, stormwater management addresses a broad suite of issues including fluvial geomorphology (stream channel forming processes), groundwater resources and the protection of aquatic and terrestrial habitats (Figure 1.2.1).

Municipalities, with the support of conservation authorities, review stormwater management facilities and plans designed to address this multitude of concerns. This has led to an increasing complexity in stormwater management planning and design including:

- increasingly complex stormwater management facilities and best management practices;
- the need to involve more inter-disciplinary expertise in studies to define environmental opportunities and constraints;
- expanding requirements for multi-purpose stormwater management facilities; and,
- increased emphasis on the treatment train approach and use of multiple types of controls to address environmental issues.

Figure 1.2.1 Evolution of stormwater management practice in Ontario



CVC and TRCA have been extensively involved in integrated watershed-wide environmental monitoring for many years. The results of this monitoring have shown that the environmental health of many watersheds continue to decline as urbanization increases. This environmental deterioration has taken place despite widespread compliance with provincial and conservation authority requirements for stormwater management planning and facility design. Conventional stormwater management, which focuses on controlling peak flow rate and the concentration of suspended solids, has failed to address the widespread and cumulative hydrologic modifications in watersheds that increase the volume of stormwater, increase the runoff rate, and cause excessive erosion and degradation of stream channels. Conventional stormwater management also fails to adequately treat other pollutants of concern, such as nutrients, pathogens and metals.[1]

CVC's recent Credit River Water Management Strategy Update concludes that continued use of what are currently considered "state of the art" stormwater management practices will lead to continued degradation of the watershed, jeopardizing the health of the Credit's world class fishery and other valued environmental resources (CVC, 2007b). To protect the health of the Credit River watershed, the updated water management strategy calls for an immediate shift to more proactive and innovative stormwater management systems that include low impact development practices. TRCA's Rouge River Watershed Plan (TRCA, 2007c), Humber River Watershed Plan (TRCA, 2008a) and Don River Watershed Plan (TRCA, 2009a) reach similar conclusions about the inability of conventional stormwater management practices to protect the health of rivers and the need for low impact development approaches. In addition, the Rouge River Watershed Plan concludes that widespread implementation of LID practices in new and existing developments could increase the resiliency of the watershed system to some anticipated impacts of climate change on baseflow and channel erosion (TRCA, 2007d).

Recent research (Aquafor Beech Ltd., 2006) has suggested that current practices to offset the hydrologic effects of urbanization are insufficient to prevent increased channel erosion and deterioration of aquatic habitats. In many cases, even small incremental changes in watershed hydrology commensurate with an increase in impermeable surfaces of 4%, can result in changes to stream channel characteristics and aquatic communities. To offset these impacts, an increased emphasis on maintaining natural water balance and replicating the predevelopment hydrologic cycle is required (Aquafor Beech Ltd., 2006).

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[1] Gaffield, S.J., R.L Goo, L.A. Richards and R.J.Jackson. 2003. Public Health Effects of Inadequately Managed Stormwater Runoff. *American Journal of Public Health*. September 2003. Vol. 93. No. 9. pp. 1527-1533; Kok, S. and J.Shaw. 2005. Wet Weather Flow Management in the Great Lakes Areas of Concern. *Proceedings EWRI 2005*. Copyright ASCE 2005; Marsalek, J. 2002. Overview of urban stormwater impacts on receiving waters. P. 3-14. *Proceedings of the Urban Water Management: Science, Technology and Delivery. NATO Advanced Research Workshop*. Borovetz, Bulgaria; Marsalek, J., H.Y.F. Ng. 1989. Evaluation of pollution loadings from urban non-point sources, methodology and application. *J. Great Lakes Res.* 15(3) 444-451; Rohrer C.A., L.A. Roesner, B.P. Bledsoe. 2004. The Effect of Stormwater Controls on Sediment transport in Urban Streams. *Proceedings World Water Congress 2004*. Copyright ASCE 2004; Saravanapavan, T. M. Voorhees and A. Parker. 2005. Stormwater Evaluation for TMDLs and Implementation in Urban Northeast Watersheds. *Proceedings EWRI: Impacts of Global Climate Change*. Copyright ASCE 2005; US EPA. 1997. *Urbanization and Streams: Studies of Hydrologic Impacts.* Office of Water. Washington DC. EPA841-R-97-009; Schueler, T. 2000. *Nonpoint Sources of Pollution to the Great Lakes Basin*. Great Lakes Science Advisory Board. ISBN 1-894280-14-8. Feb 2000; Schueler, T. 2002. Comparative Pollutant Removal Capability of Stormwater Treatment Practices. *The Practice of Watershed Protection*. Vol. 64. pp. 371-376; Schueler, T. and D. Caraco. 2001. *Sources and control of pollutants in urban runoff*. International Joint Commission. Windsor Ontario; Schueler, T. and J. Galli. 1992. Environmental Impacts of Stormwater Ponds. In *Watershed Restoration Source Book*, ed. P.Kumble, T. Schueler, Washington, D.C..

Finally the 2003 OMOE Stormwater Management Planning and Design Manual, though reflective of current technology is rapidly becoming dated, since much of the material it reviewed dates from 1999. In the last five years, over 30 state-of-the-science stormwater management manuals and guidelines have been released in locations such as Maryland, Washington State, British Columbia, Minnesota, Pennsylvania and Oregon. The objective of maintaining predevelopment water balance, use of the treatment train approach and application of low impact development practices are all becoming common practice in these jurisdictions.

Two recent documents, one prepared by the City of Toronto and the other prepared by the Greater Vancouver Regional District summarize how the approach to stormwater management needs to change.

> Rainwater should be treated as a resource to nourish and enhance the City's environment. Management should begin where precipitation hits the ground according to the priority of source, conveyance, end-of-pipe and finally, stream restoration measures (City of Toronto, 2006).
>
> There is a need for a change in the philosophy of treating runoff from one of stormwater management to rainwater management (GVRD, 2005).

This is why CVC and TRCA commissioned the development of a stormwater management guide to provide guidance on the kind of cutting edge practices that are needed to protect the health of the CVC and TRCA watersheds. The *LID SWM Guide* draws on published research, literature and local studies to provide planning and design guidance that reflects regional policies, practices and climate. It provides information and guidance on the following:

- how to integrate stormwater management into the urban planning process;
- how to design, construct and maintain a range of LID stormwater management practices; and
- the kinds of environmental and performance monitoring that should be carried out.

Acknowledging that it will not always be possible to maintain the predevelopment water budget of a site, predicted increases in runoff from land development that cannot be mitigated through stormwater infiltration practices should be minimized through practices that either evapotranspire (*e.g.,* green roofs, bioretention), or harvest runoff for non-potable uses (*i.e.*, rainwater harvesting). In areas where development has already taken place, LID can be used as a retrofit practice to reduce runoff volumes, pollutant loadings, and the overall impacts of existing developments on receiving waters. LID practices can include:

- conservation site design strategies (*i.e.*, non-structural LID practices);

- infiltration practices;
- rainwater harvesting;
- runoff storage and evapotranspiration;
- runoff conveyance;
- filtration practices; and
- landscaping.

Studies show that implementing LID practices can have multiple positive environmental effects including:

- protection of downstream resources;
- abatement of pollution;
- recharge of groundwater;
- improvement of water quality;
- improvement of habitat;
- reduced downstream flooding and erosion;
- conservation of water and energy; and
- improved aesthetics in streams and rivers.

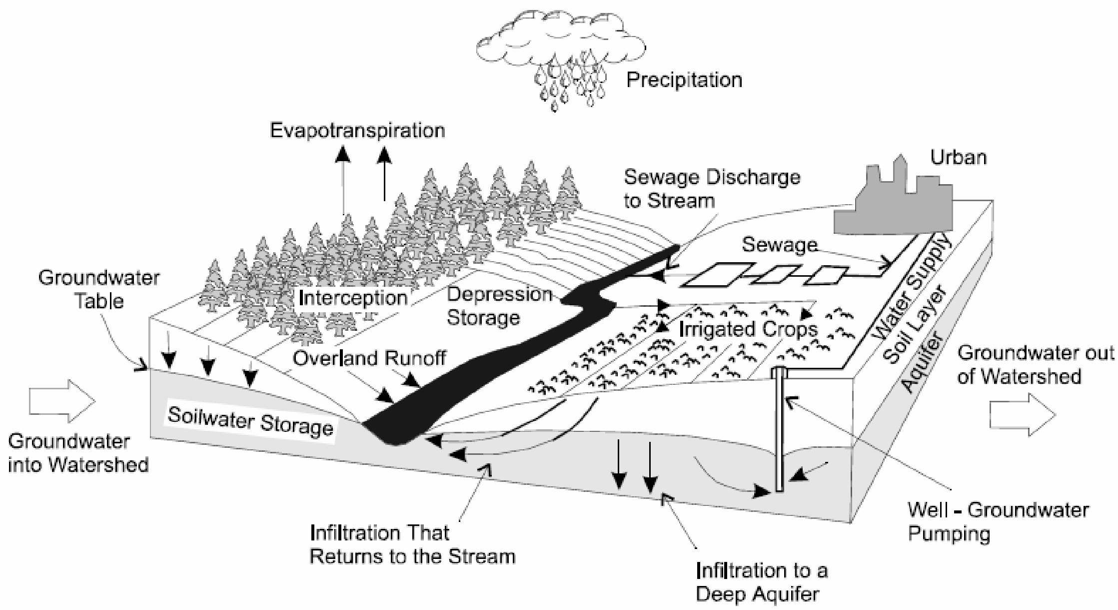
These combined benefits help to mitigate potential negative impacts of climate change on groundwater levels, risk of flooding and stream channel erosion.

1.4 The Impact of Urbanization

As indicated previously, early stormwater management plans developed in the 1980s focused on controlling water quantity, with the intent of ensuring that runoff from newly developed urban areas did not increase the potential for flooding downstream.

Figure 1.4.1 provides an illustration of the hydrologic cycle. When lands are urbanized, there are significant changes in the proportion of precipitation that infiltrates into the ground, evaporates back into the atmosphere and enters drainage features as surface runoff primarily as a result of clearing of vegetation and paving of the ground surface.

Figure 1.4.1; The hydrologic cycle



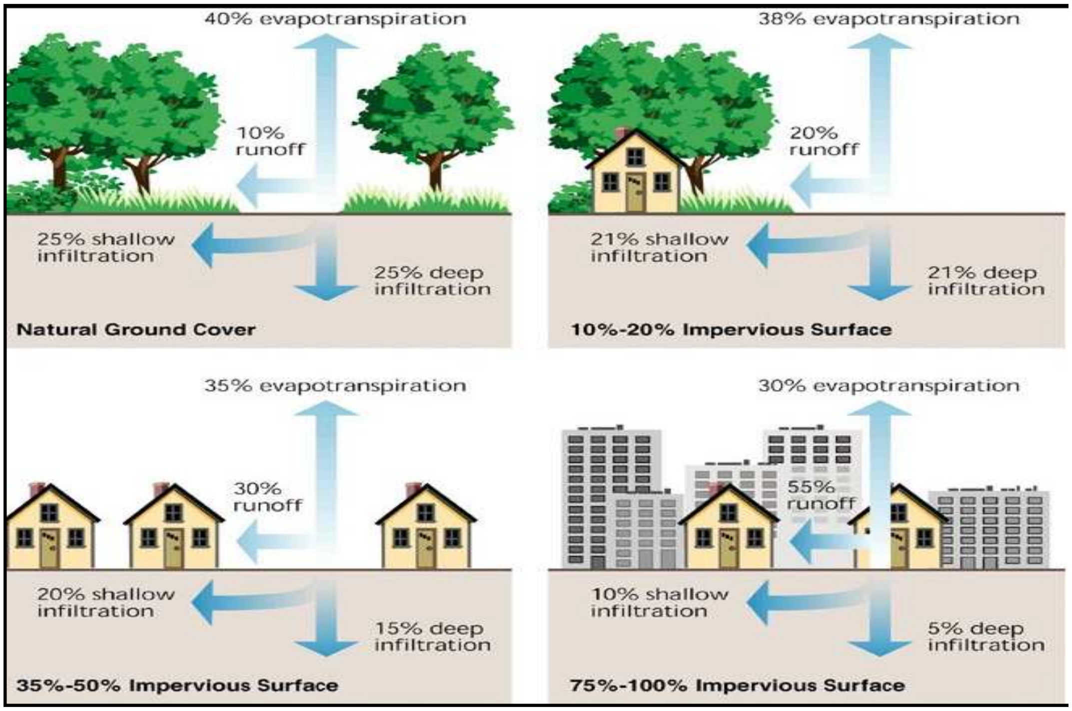
Source : After, M. L. Davis, D. A. Cornwell. **Introduction to Environmental Engineering**, 1991.

Definitions:
Overland runoff – water that travels over the ground surface to a channel
Streamflow – movement of water via channels
Groundwater flow – movement of water through the subsurface
Infiltration – penetration of water through the ground surface
Groundwater recharge – water that reaches saturated zone

Figure 1.4.2 illustrates the dramatic changes in the proportion of precipitation entering different flow pathways when land use changes from native vegetation to an urban landscape. In particular, there can be a 3 to 5 fold increase in the amount of runoff reaching streams, with a corresponding reduction in infiltration of water into the ground.

Not only is there a change in the total volume of stormwater runoff from urban areas, but the characteristics of the runoff change as shown in the Figure 1.4.3. For a given event, both the peak discharge (the peak rate of runoff) and the duration (the amount of time) that this higher peak flow occurs is increased in urban versus rural or forested watersheds (Figure 1.4.4).

Figure 1.4.2 The impact of conventional urbanization on the hydrologic cycle



Source: U.S. EPA, 2007

Figure 1.4.3 Flood hydrographs for urbanized and natural drainage basins

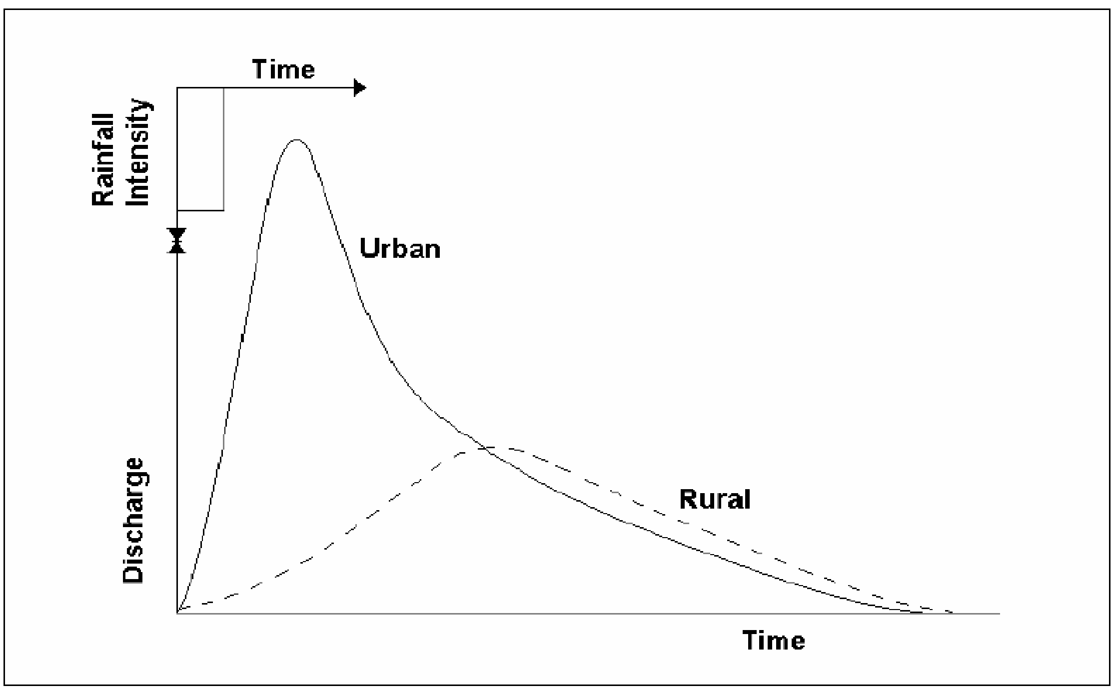
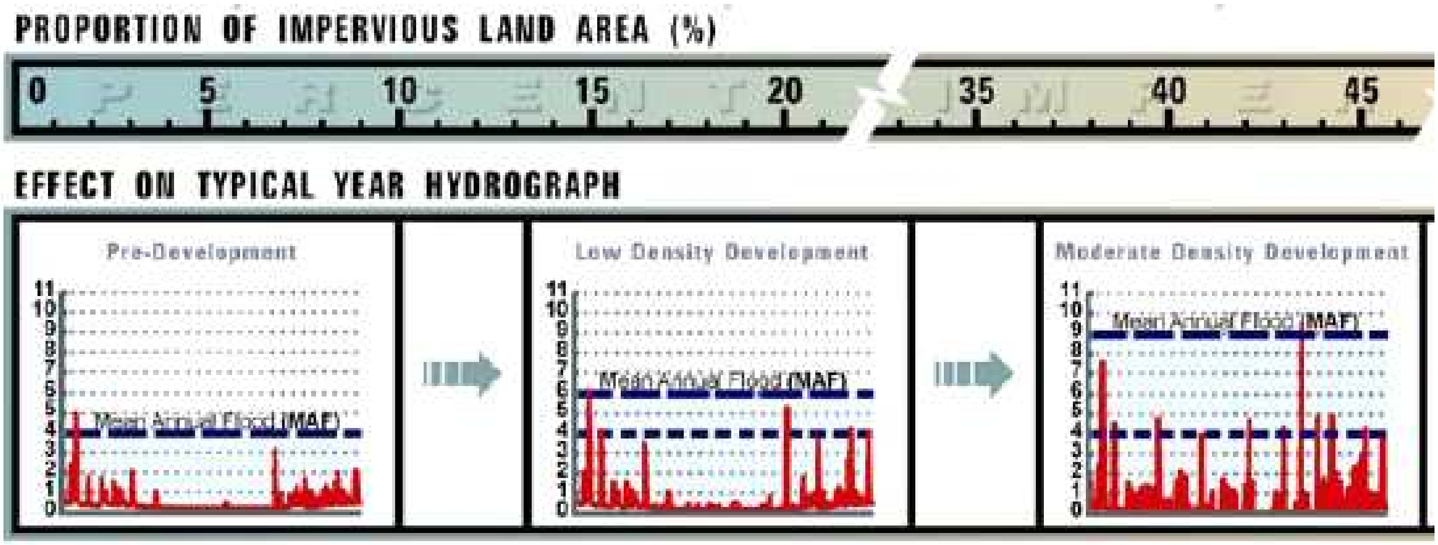


Figure 1.4.4 Changes in magnitude and frequency of peak flows as urbanization increases



Source: BC MWLAP, 2002

This means that not only is there an increase in potential for flooding downstream, but the hydrologic changes associated with increased imperviousness can cause other problems such as:

- alteration of stream flows;
- alteration of stream channels and associated aquatic habitat;
- increased erosion and sedimentation; and
- degraded water quality.

If effective stormwater management controls are not in place, increased imperviousness leads to a cascade of effects as shown in Table 1.4.1. Rivers in highly urbanized areas are sometimes referred to as "peaky" because they have too little flow under dry conditions, and too much flow (high volumes and high peak flows) when it rains. This leads to problems with flooding, erosion, water quality and alterations to stream channels and aquatic habitat.

Flooding and Stream Flows

While stormwater management ponds were originally used primarily to control the increase in peak flows from urbanization to address flooding concerns, it soon became apparent that both the peak flow and its duration needed to be controlled to address problems of erosion, sedimentation and habitat alteration. Since urban stormwater also carries a significant load of suspended sediments, nutrients and other contaminants, the amount of these materials entering a waterbody can be reduced simply by reducing the volume of stormwater reaching the waterbody. Thus controlling runoff volumes is part of the solution to addressing water quality impacts from urbanization.

Table 1.4.1 Ecosystem responses to urbanization

Results of Increased Imperviousness	Resulting Impacts					
	Flooding and Altered Stream Flows	Habitat Loss	Erosion and Sedimentation	Channel Widening	Streambed Alteration	Water Quality
Increased Flow Volume	✓	✓	✓	✓	✓	✓
Increased Peak Flow	✓	✓	✓	✓	✓	✓
Increased Peak Duration	✓	✓	✓	✓	✓	✓
Increased Stream Temperature		✓				✓
Decreased Base Flow	✓	✓				✓
Sediment Loading Changes	✓	✓	✓	✓	✓	✓

CVC's Credit River Water Management Strategy Update study showed that conventional stormwater best management practices have only limited benefits in restoring predevelopment runoff rates and represent only a small improvement over uncontrolled urban growth (Table 1.4.2; Figure 1.4.5). Only by implementing state of the science, treatment-train stormwater management technologies, did a significant reduction in runoff occur.

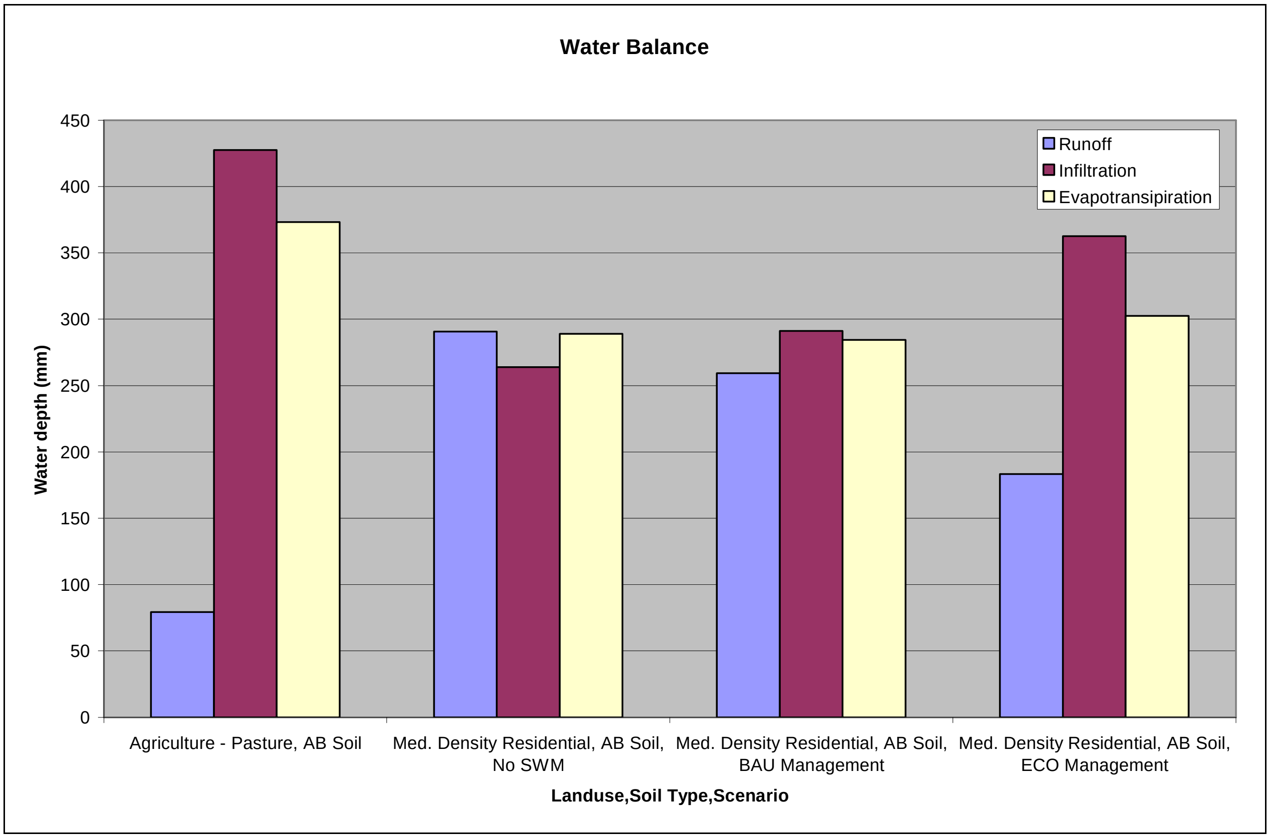
Table 1.4.2 Summary of water balance characteristics for different land uses, soil types and stormwater management strategies

Land Use	Soil Type	Scenario	Annual (mm)			
			Rainfall	Runoff	Infiltration	Evapo-transpiration
Agriculture - Pasture	Sandy Soils	Existing conditions	804	77	418	365
Medium Density Residential	Sandy Soils	No SWM*	804	291	264	289
Medium Density Residential	Sandy Soils	Business-as-usual management approach**	804	259	291	284
Medium Density Residential	Sandy Soils	"Ecotopia" management approach***	804	183	363	303

*SWM – Stormwater management;
** Business-as-usual (BAU) management approach assumes implementation of traditional stormwater management practices, such as detention ponds;
*** "Ecotopia" (ECO) management approach assumes implementation of a full treatment train of stormwater management practices, including lot level and conveyance controls and wetland treatment systems.

Source: CVC, 2007b

Figure 1.4.5 Comparison of runoff, infiltration and evapotranspiration rates for different stormwater management strategies



Source: CVC, 2007b

Erosion and Sedimentation

The changes in the water budget that accompany the urbanization of a watershed have a direct bearing on the morphology, stability and character of the receiving streams. These effects include:

- *Stream widening and bank erosion:* Stream channels enlarge to accommodate higher stormwater volumes and peak flows.

- *Streambed changes due to sedimentation:* Channel erosion and sediment loading from urban construction lead to deposition of fine material in streams covering coarser materials with mud, silt and sand.

- *Stream downcutting:* Another adjustment that occurs in response to flow increases is downcutting of the stream channel, which leads to a steepening of the stream profile or gradient, thus accelerating the erosion process.

- *Loss of riparian tree canopy:* The continued undercutting and failure of stream banks exposes tree roots that normally protect stream banks from erosion, leading to uprooting of trees that causes further weakening of the structural integrity of the stream banks

Many of these erosion and sedimentation effects are delayed until some time after the process of urbanization occurs. Stream channels can continue to enlarge and erode for decades after development occurs before they reach a new stable regime.

Water Quality

Urban stormwater is a source of a variety of pollutants including nutrients, contaminants, bacteria, and suspended sediment. Typical concentrations of these pollutants are shown in Table 1.4.3. Typical sources are listed in the Table 1.4.4.

In a recent review of the effectiveness of stormwater management practices, it was noted that one of the most effective ways of minimizing the potential for channel erosion, reduction in water quality loadings and degradation of aquatic habitat in the receiving channel downstream of an urban development is to minimize changes to runoff volume and discharge rate (Aquafor Beech Ltd., 2006). An equally important corollary to this statement is that a significant reduction in the delivery of pollutants from urban areas into receiving waters requires that sources of “clean” runoff are not contaminated or combined with polluted runoff.

Table 1.4.3 Comparison of urban stormwater runoff concentrations with provincial water quality objectives (PWQO)

Parameter	Units	PWQO	Observed Concentrations
Escherichia coli	CFU/100 mL	-	10,000 to 16 x 10^6
Total Suspended Solids (TSS)	mg/L	-	87 – 188
Total Phosphorus (TP)	mg/L	0.03 (interim)	0.3 – 0.7
Total Kjeldahl Nitrogen (TKN)	mg/L	-	1.9 – 3.0
Phenols	mg/L	0.001	0.014 – 0.019
Aluminum (Al)	mg/L	-	1.2 – 2.5
Iron (Fe)	mg/L	-	2.7 – 7.2
Lead (Pb)	mg/L	0.005 (interim)	0.038 – 0.055
Silver (Ag)	mg/L	0.0001	0.002 – 0.005
Copper (Cu)	mg/L	0.005	0.045 – 0.46
Nickel (Ni)	mg/L	0.025	0.009 – 0.016
Zinc (Zn)	mg/L	0.020 (interim)	0.14 – 0.26
Cadmium (Cd)	mg/L	0.0002	0.001 – 0.024

Source: Adapted from OMOE, 2003

Table 1.4.3 Major sources of common stormwater pollutants

Common Constituents	Major Sources Related to Urban Land Use
Sediment and Particulates	Construction, winter road sanding, vehicle emissions, pavement wear
Hydrocarbons (PAH's)	Spills, leaks, dumping, vehicle emissions, asphalt breakdown, wood preservatives
Pathogens (Bacteria, Viruses)	Illicit connection of septic systems to storm sewers, poor housekeeping (animal feces, bird feces from rooftops)
Chloride, Sodium, Calcium	De-icing salt applications
Cyanide	Anti-caking agent in de-icing salts and sand / salt mixtures
Nutrients (N, P)	Illicit connection of septic systems to storm sewers, detergents (car washing), lawn fertilizers
Cadmium	Tire wear, insecticides, wood preservatives
Zinc	Galvanized building materials, tire wear, motor oil, grease
Lead	Motor oil, lubricants, batteries, bearing wear, paint, vehicle exhaust
Copper	Wear of moving engine parts, metal plating, fungicides and insecticides
Manganese	Wear of moving engine parts
Nickel	Vehicle exhaust, lubricants, metal plating, wear of moving parts
Chromium	Metal plating, wear of moving parts
Iron	Steel structures, rusting automobile bodies
PCBs	Leaks from electrical transformers, spraying of highway right of ways, catalyst in tire construction

Source: Adapted from Burton and Pitt, 2002

Aquatic Habitats

Along with the alterations in hydrology, morphology and water quality that typically take place in a watershed as urbanization progresses, there can be a continued deterioration in the quality and quantity of aquatic habitat for fish and other forms of aquatic life. The impacts on habitat consist include:

- *Increased water temperature:* The combination of warmer runoff from impervious areas and SWM ponds, loss of riparian cover from erosion and reduction in groundwater infiltration can produce severely elevated temperatures in the receiving streams, which can contribute to reductions in dissolved oxygen and create conditions outside of the thermal tolerance limits for desirable fish species and other aquatic life.

- *Reduced groundwater levels and base flow conditions:* The loss of infiltration of rain adversely affects available groundwater resources, ultimately leading to a decline in stream baseflows, which can adversely affect instream habitat during periods when fish are most vulnerable to low flow conditions.

- *Degradation of habitat structure:* The negative effects on the quantity of aquatic habitats take several forms. Increased peak flows and velocities of flow can render some habitats unsuitable for fish; erosion and sedimentation can significantly alter valuable habitats and smother eggs.

- *Loss of channel structure:* As stream morphology degrades, the stream channel becomes straightened and the alternating sequence of pools and riffles is lost, reducing the diversity of habitats for fish.

- *Reduction in biodiversity*: Collectively the above effects will degrade the quality and reduce that variability of aquatic habitats leading to a corresponding reduction in the ability of the habitat to support the variety and abundance of aquatic life it once supported.

1.5 Legislative Framework

Conservation authorities (CAs) are directed by the *Conservation Authorities Act* to carry out a number of critical functions related to watershed planning and management. This includes preventing, eliminating, or reducing loss of life and property from flooding and erosion, and encouraging the protection and regeneration of natural systems. Under the *Conservation Authorities Act*, the powers of a CA include:

- to study and investigate the watershed and to determine a program whereby the natural resources of the watershed may be conserved, restored, developed and managed; and, to cause research to be done (Section 21); and
- to make regulations applicable in the area under its jurisdiction (Section 28).

Both TRCA and CVC administer their own individual regulations, which permit them to:

(a) prohibit, regulate or require the permission of the authority for straightening, changing, diverting or interfering in any way with the existing channel of a river, creek, stream or watercourse, or for changing or interfering in any way with a wetland;
(b) prohibit, regulate or require the permission of the authority for development, if in the opinion of the authority, the control of flooding, erosion, dynamic beaches or pollution or the conservation of land may be affected by the development.

Permit applications made under these regulations are assessed to determine if proposed works will affect the control of flooding, erosion, dynamic beaches, pollution or the conservation of land in accordance with the *Conservation Authorities Act*, and as guided by the two CAs' programs and policies. Both CAs have policies which implement their respective regulations and facilitate their role as commenting agencies under the *Planning Act* and the *Environmental Assessment Act* as described below.

Under the *Planning Act*, CAs are a prescribed agency, meaning they have the opportunity to comment on *Planning Act* applications circulated to them by their municipal partners. Municipalities are the approval authority for *Planning Act* applications and their decisions must be consistent with the provincial interest in planning expressed in the Ontario Ministry of Municipal Affairs and Housing (OMMAH) 2005 Provincial Policy Statement (PPS). Section 2.1 of the PPS provides direction for protecting natural heritage; Section 2.2 deals with water management; and Section 3.1 addresses the management of natural hazards and the need to direct development outside of hazardous areas. Because municipalities tend to have limited expertise with respect to Section 3.1, the Province entered into a memorandum of agreement (MOU) with Conservation Ontario, the umbrella organization that represents Ontario's 36 CAs, to delegate the responsibility of upholding the natural hazards section of the PPS to CAs. In this delegated role, CAs are responsible for representing the "Provincial Interest" on natural hazard matters where the Province is not involved.

Just as the Province recognized the expertise of conservation authorities, municipalities commonly rely on them for advice on natural heritage and water management. For regional municipalities, this relationship has been formalized through a series of MOUs with CVC and TRCA, while a mix of formal and informal agreements exist with local municipalities. Generally, these MOUs and agreements stipulate that the protection, restoration, and enhancement of the natural environment, and the safety of persons and property, is carried out in part through the review of, and preparation of comments on development applications, and that it is a shared responsibility of the municipality and the CA. Parameters for plan review and technical clearance are also established along with protocols for streamlining the planning process. Specific responsibilities typically include establishing requirements and conditions to determine the need for, and adequacy of, studies that assess impacts and propose mitigation measures related to surface and groundwater, natural features and functions.

As part of the overall planning process, CVC and TRCA are expected to review and comment on all environmental assessments (EAs) within their respective jurisdictions. Often, at the detailed design stage of infrastructure projects undergoing an EA process, a permit under a CA regulation is required.

In both their commenting roles under these two Acts, CVC and TRCA must also be aware of impacts to fish habitat, as both CAs have agreements with Fisheries and Oceans Canada to implement section 35(2) of the federal *Fisheries Act*, which states that no person shall carry on work that would cause the harmful alteration, destruction, or disruption of fish habitat.

The complexity of the planning and development process is apparent, so many of CVC's and TRCA's MOUs with their municipal partners recognize and secure the CA's expertise in water management, in order to help them "be consistent" with the water policies in Section 2.2 of the PPS. Section 2.2.1 states:

> Planning authorities shall protect, improve or restore the quality and quantity of water by: a) using the watershed as the ecologically meaningful scale for planning; b) minimizing potential negative impacts, including cross-jurisdictional and cross-watershed impacts; c) identifying surface water features, ground water features, hydrologic functions and

> natural heritage features and areas which are necessary for the ecological and hydrological integrity of the watershed; d) maintaining linkages and related functions among surface water features, ground water features, hydrologic functions and natural heritage features and areas; g) ensuring stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces (OMMAH, 2005).

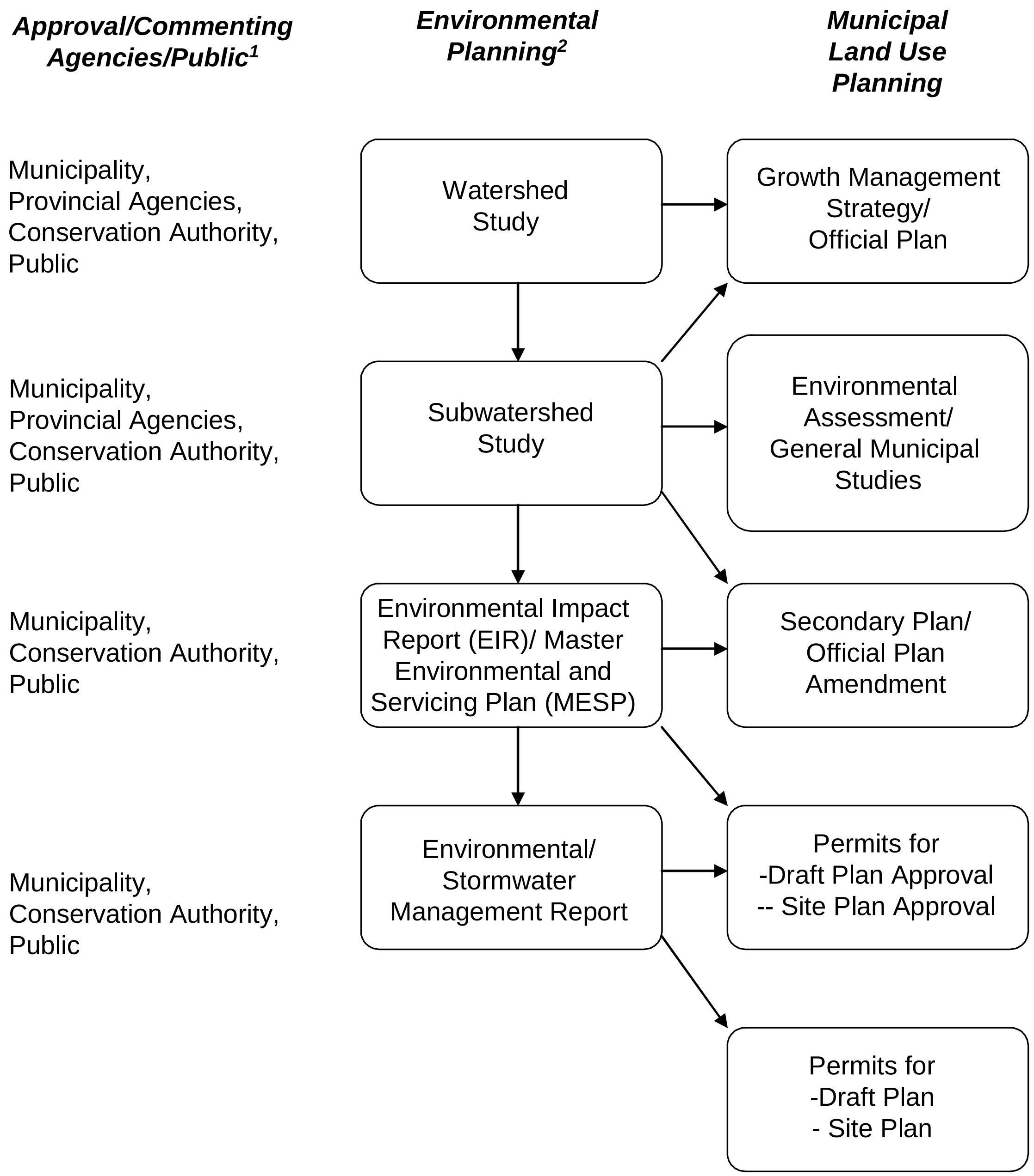
In CVC's and TRCA's role as advisors to our municipal partners on planning matters, and as ingrained in each agency's watershed management plans, the importance of achieving a post-development water balance that matches, as closely as possible, the pre-development water balance condition is emphasized. On sites that have been designed with conventional stormwater management, examination of post-development conditions has shown that natural features are not being sustained and natural hazards are being exacerbated. Therefore, the implementation of innovative stormwater management techniques is required to complement more traditional methods; these can include source and conveyance controls that infiltrate, re-use, or evapotranspirate run-off. This *Low Impact Development Stormwater Management Planning and Design Guide* outlines a host of these best management practices, collectively termed low impact development, which can be used to manage stormwater volume and protect the water resources and natural heritage systems over the long term. Accordingly, Section 2.2.2 of the PPS states that, "mitigative measures and/or alternative development approaches may be required in order to protect, improve or restore sensitive surface water features, sensitive ground water features, and their hydrologic functions" (OMMAH, 2005).

Innovative, non-traditional stormwater management needs to take place in not only areas of new development, but also in areas undergoing redevelopment. While development standards and practices have improved greatly since the earlier decades of urbanization, older developed areas have already taken their toll on watershed conditions. Impervious surfaces cover considerable portions of CVC and TRCA watersheds and a large proportion of these areas lack comprehensive stormwater control.

Therefore, in both development and redevelopment scenarios, a comprehensive outlook is necessary to effectively manage stormwater from a landscape perspective. This can be achieved by considering stormwater and LID as early in the planning process as possible, as further described in Chapter 2.

The general inter-relationship between the traditional municipal land use planning process and environmental (*i.e.*, watershed) planning is depicted in Figure 1.5.1. Ideally, this provides a hierarchy of plans that integrate environmental and municipal planning, and a process in which all relevant agencies provide input under their respective legislative mandates.

Figure 1.5.1 Relationship between municipal land use planning and environmental (watershed) planning processes



1. Approval/commenting agency/public involvement will vary from jurisdiction to jurisdiction
2. For a given jurisdictional area, one Environmental Planning component would generally be associated with one Municipal Land Use Planning component. Multiple arrows leading from the Environmental Planning component to the Municipal Land Use Planning component signify different approaches which are used in different jurisdictions.

Adapted from OMOE, 2003

1.6 Report Outline

Chapter 1 provides an overview of why the guide has been developed. It reviews the environmental impacts of urbanization and the current planning framework for stormwater management in Ontario.

Chapter 2 discusses how stormwater management facility planning and design can be better integrated into the development planning process, in particular, illustrating how better site design and identification of environmental opportunities and constraints early on in the process can lead to more effective stormwater management. The chapter also highlights the importance of planners, engineers, biologist, hydrogeologists and landscape architects working together to develop an overall plan.

Chapter 3 provides an introduction to low impact development, an overview of the LID design process and information to help practitioners select practices suitable to site specific conditions and stormwater source areas.

Chapter 4 describes ten structural low impact development practices for stormwater management. Guidance regarding site suitability, design, operation and maintenance is provided for each general type of practice.

Chapter 5 describes compliance, performance and environmental effects monitoring programs, as they relate to stormwater management systems.

Chapter 6 provides a master list of documents that have been referred to in this guide.