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The Water Balance Model for Canada: Improving the Urban Landscape through Inter-Provincial Partnerships

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K.A. Stephens[1], B. van Duin[2], T. van der Gulik[3], Y. Deong[4], L. Maclean[5], L. Bozic[6]

[1] Project Coordinator, British Columbia Inter-Governmental Water Balance Model Partnership; 4678 Keith Road, West Vancouver, British Columbia, V7W 2M6
(E-mail:*outreach@waterbalance.ca*)
[2] Member Steering Committee, Alberta Low Impact Development Partnership & Representative, Bow River Basin Council; 300 Atrium VII, 340 Midpark Way, SE, Calgary, Alberta, T2X 1P1
(E-mail: *bert.vanduin@westhoff.ab.ca*)
[3] Chair, British Columbia Inter-Governmental Water Balance Model Partnership & Senior Engineer, Resource Management Branch, British Columbia Ministry of Agriculture, Food & Fisheries; 1767 Angus Campbell Road, Abbotsford, British Columbia, V3G 2M3
(E-mail: *Ted.vanderGulik@gems8.gov.bc.ca*)
[4] Watershed Management Team Leader, City of Calgary; City Hall, 800 Macleod Trail SE, Calgary, Alberta T2P 2M5.
(E-mail: *Yin.Deong@calgary.ca*)
[5] Co-Chair, British Columbia Inter-Governmental Water Balance Model Partnership & Agri-Environmental Standards Coordinator, Environment Canada – Pacific & Yukon Region; 201 - 401 Burrard Street. Vancouver, British Columbia V6C 3S5
(E-mail: *laura.maclean@ec.gc.ca*)
[6] Co-Chair Steering Committee, Alberta Low Impact Development Partnership & Water Quality Research Engineer, Watershed Management Team, City of Calgary; City Hall, 800 Macleod Trail SE, Calgary, Alberta T2P 2M5
(E-mail: *Liliana.Bozic@calgary.ca*)

Abstract
Designed to evaluate the feasibility and effectiveness of site level rainwater management solutions, the **Water Balance Model for Canada** (WBM) is an internet-accessible decision support and scenario planning tool that can be found at www.waterbalance.ca. Developed by a British Columbia Inter-Governmental Partnership (IGP), the WBM is fast emerging as the tool of choice in making sustainable land development decisions because it demonstrates how to achieve a light 'hydrologic footprint'. The IGP comprises a consortium of local, regional, provincial and federal agencies.

The success of the WBM in British Columbia, particularly in promoting an understanding of how to improve the built environment and protect the natural environment, has generated interest in expanding the focus of the tool to reach a national audience. This paper elaborates on the decision by Environment Canada, the Canada Mortgage & Housing Corporation and the Province of British Columbia to create a truly national *Water Balance Model for Canada* that achieves three outcomes:

- enable local government jurisdictions and stewardship groups in other provinces to share in the knowledge gained in British Columbia;
- generate a nationwide discussion forum on sustainable drainage initiatives; and
- access additional sources of funding to accelerate the development of the WBM.

Keywords
Low impact development, rainwater management, source control, sustainable drainage, water balance

CONTEXT

Rainwater management in North America and throughout the English-speaking world is undergoing a major 'watershed' change — and British Columbia is in the vanguard of that change. Rainwater management is at the heart of a new approach to land development in balance with the natural environment. Rapid population growth, redevelopment of older neighbourhoods, and land use densification are creating opportunities to reverse past failures to minimize or even prevent the generation of runoff from rainfall events and its negative environmental impacts.

To help local government managers and design practitioners make better land development decisions, the Water Balance Model (WBM) was developed by a British Columbia Inter-Governmental Partnership (IGP), and has grown into a national initiative. The early success of the WBM as a non-proprietary web application for rainwater runoff modelling has principally been its ability to reach beyond the engineering community to provide a decision support tool for allied professions.

As the practice of rainwater management becomes more sophisticated, many of the greatest gains are now related to site planning and layout decisions. Further, as urban watersheds become more intensively developed, many of the most effective strategies for rainwater management arise out of effective collaboration between engineers and planners.

Until the WBM was developed, the missing link in urban watershed planning had been a tool that quantifies the benefits – in terms of reducing **rainwater runoff volume** – of installing source controls under different land use, soil and climate conditions. Using the WBM, engineers and others can evaluate land use planning decisions for their ability to meet rainwater management and watershed protection objectives.

The WBM was conceived as a **planning tool**, and has indeed proven to be an effective information and awareness tool. Basic principles of hydrology and urban impacts upon the hydrologic cycle are presented in a clear and easy to understand manner. Practitioners in a wide range of fields can quickly grasp the nuances and comprehend the magnitude of change and mitigation strategies that might be applied to eliminate impacts of urban development.

The user interface is friendly and presents the results of WBM analyses in a clear and readily understood manner. As a result, this new tool is facilitating a paradigm-shift in the philosophy of and approach to urban hydrology. Built around established soil science principles, the WBM creates an understanding of how to get rainwater into the ground and/or absorbed by trees and landscaping.

The rollout of the national WBM website in April 2005 has created the opportunity to make rapid and cost-effective progress in enhancing the WBM through inter-provincial partnerships. So far, the structure and content placeholders for provincial rainwater management communities-of-interest have been created for four additional provinces: Alberta, Manitoba, Ontario and Nova Scotia.

The IGP is actively pursuing inter-provincial partnerships to take ownership of and populate this first group of pages with local success stories. Content pages for the remaining provinces and territories will be developed when there are expressions of local interest and/or supporting funding.

To further sustain the success of the WBM, the IGP has been evaluating options for expanding the capabilities of the Hydrology Engine that is at the heart of the WBM. In this regard, an inter-provincial partnership with Alberta has provided the impetus for a review of the 3-Year Rolling Plan that the IGP has for model evolution.

EVOLUTION OF THE WBM

The genesis of the WBM's development was UniverCity, a sustainable community adjacent to Simon Fraser University atop Burnaby Mountain in the Greater Vancouver region. Translating high expectations for this "green" development into practical design guidelines meant revisiting accepted drainage engineering practice; this need for innovation eventually led to development of the WBM.

In 2001 the Stormwater Interagency Liaison Group (SILG), a technical committee of the Greater Vancouver Regional District, recognized the value of the water balance approach and funded the development of a working model to assess the affordability and feasibility of site design solutions for achieving performance targets.

The results of this applied research were incorporated in *Stormwater Planning: A Guidebook for British Columbia* funded by Environment Canada and published by the British Columbia Ministry of Water, Land and Air Protection in June 2002. This guidance document, founded on British Columbia case study experience, formalized a science-based understanding to set performance targets for reducing rainwater runoff volumes.

In July 2002 the IGP was formed to develop the WBM as an extension of the *Guidebook.* It began as a subgroup of SILG and quickly expanded to become a provincial group with municipal representation from four regions: Greater Vancouver, the Fraser Valley, Vancouver Island and the Okanagan Valley.

The IGP is now a consortium of over 20 local, regional, provincial and federal agencies and is co-chaired by the British Columbia Ministry of Agriculture, Food and Fisheries and Environment Canada. Its mission is to enable local governments and landowners to make informed land development decisions and meet performance targets for rainwater volume capture and runoff rate control under a variety of land use, soil and climate conditions.

The vision is that use of the WBM will become standard practice for land development decisions throughout BC. To achieve the vision over time, the IGP has partnered with the Real Estate Foundation of BC to build broad-based support for the '**design with nature**' approach to rainwater management via an outreach and continuing education program. Launched at the 2003 annual conference of the Union of British Columbia Municipalities, the program comprises seminars and training workshops for a range of audiences. The IGP has also collaborated with the Urban Development Institute to provide hands-on training for the land development community.

While land planning professionals are able to employ the WBM for design support, the WBM was never intended to be used by drainage engineers as a **design tool** when implementing drainage mitigation strategies. Nonetheless, the expectation is that the WBM can achieve greater acceptance and use by the engineering design community once there is:

1. Validation and demonstrated testing;
2. Design information such as runoff rates or stream discharges;
3. Ability to link more than a single land use or process;
4. A storage modelling capability other than the soil moisture reservoir;
5. Water quality modelling capability; and
6. A direct link to stream health impacts.

In the meantime, the IGP is systematically moving forward with a series of technical enhancements, including a built-in Hydraulic Properties Calculator and a Tree Interception Losses Module.

BRITISH COLUMBIA OVERVIEW

Water Sustainability Action Plan for British Columbia

The WBM is the centrepiece of the *Water Sustainability Action Plan for British Columbia*, a bottom-up provincial initiative. A core principle underpinning the Action Plan is that behaviour and practices can be influenced for the better**:** resulting in *cumulative benefits* over time. The Action Plan provides an umbrella for six inter-connected elements - ranging in scope from governance to site design - that are informing Provincial policy through shared responsibility. The other Action Plan elements are:

- Green Infrastructure Partnership
- WaterBucket Website Partnership www.waterbucket.ca
- Water $ave Toolkit for BC
- Convening for Action: A Roundtable on Water Sustainability
- A Watershed/Landscape-Based Approach to Community Planning

The goal of the Action Plan is implementation of *on-the-ground changes* in policies, programs, applied research, practitioner education and standards of practice that lead to full integration of water management and landscape (re)development. In an 'integrated landscape', water is the unifying element. The process for creating change is called 'convening for action' and is based on education. Convening for action means:

- Challenge practitioners and others to step back from their existing paradigms.
- Inform them regarding alternatives.
- Provide them with the tools and the experiences to do things differently.

Target Audiences

An essential element of the outreach and workshop training program undertaken by the IGP in promoting use of the WBM is to encourage the integration of perspectives through a collegial and interdisciplinary approach that enables design professionals to collaborate to achieve community liveability objectives:

- **Planners** ➔ Better Use of Space
- **Engineers** ➔ Tool for Functional Design
- **Landscape Architects** ➔ Green Solutions
- **Ecologists** ➔ Watershed Function
- **Educators** ➔ Social Marketing

The WBM is emerging as the modelling tool of choice in making sustainable land development decisions because it demonstrates how to achieve a light 'hydrologic footprint'. As evidence, the IGP is now seeing the following:

- Planners and engineers are accessing the web-based model in growing numbers,
- Engineers are seeing the potential of the WBM, and have asked for a more complete modelling tool.

When both of these groups are comfortable using the same tool, then successful and sustainable dialogue can foster innovation and promote sustainable development. The challenge in expanding the capabilities of the WBM is to provide **expanded functionality** for engineers, yet at the same time avoid **self-defeating complexity** that would make the model unattractive to the other target audiences.

Making Better Decisions

The IGP is also proactively promoting changes in land development practices so that the built environment will preserve and/or restore the natural water balance over time; and performance targets will be achieved for rainwater runoff volume reduction and flow rate reduction at the source, *where rain falls.* An over-arching goal is that the WBM will be used by all stakeholders to make better decisions:

- **Local Governments** – when communicating with the public.
- **Planners and Engineers** – when setting performance targets.
- **Developers and their Consultants** – when testing scenarios.
- **Environmental Agencies** – when monitoring watershed health.

Because rainwater runoff volume is something that local governments have the ability to control and measure, integration of rainwater management and a 'design with nature' approach provides a means to an end in terms of implementing landscaping-based solutions that achieve community liveability objectives. The WBM can be applied at three scales – site, subdivision and watershed. Furthermore, it can be used to quantify the benefits, at a neighbourhood or watershed scale, achieved by reducing rainwater runoff volume at the site level.

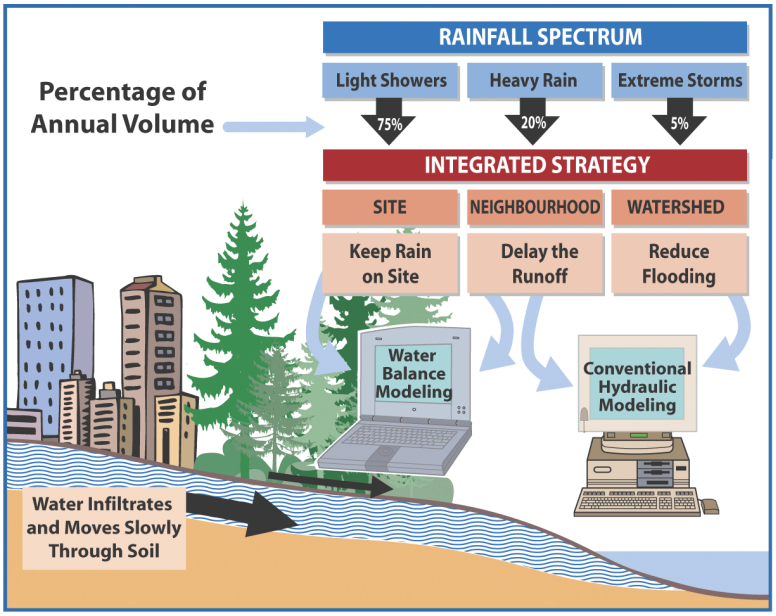
Managing the Rainfall Spectrum

The 'design with nature' approach strives to capture and retain most of the annual rainfall volume on development sites and along roadways. The focus is on preserving the natural rainwater absorption characteristics of a site slated for (re)development.

The key to implementing the strategy is that most of the annual rain volume falls as light showers. Although daily rainfall amounts range from light showers to heavy rain to extreme storms, only a handful of long duration downpours occur in any year and extreme storms are rare.

At the site level, a 'design with nature' strategy optimizes the use of soil, plants and trees, and surface treatments to capture rain where it falls. Recognizing that there is a practical limit to what can be achieved at the site scale once land clearing has altered the water balance, the integrated strategy for managing the complete rainfall spectrum has three tiered components. As shown in the graphic on the next page, these correspond to three scales — site, neighbourhood and watershed — to achieve two goals:

- Protect aquatic habitat through site and neighbourhood solutions that keep rain on site and delay runoff, respectively.
- Protect life and property through watershed-scale solutions that reduce flooding.



The WBM fills a modelling gap because it is a tool for two of the three components of the rainfall spectrum as shown above, namely: **volume reduction** (on-site) and **peak rate reduction** (off-site).

Source Control Options

The WBM enables users to quantify and evaluate the effectiveness of various source control options. Selection of an appropriate solution depends on the mix of land use, soil and rainfall conditions that is characteristic of a development site. In British Columbia, design guidelines have been developed for the following shortlist of preferred options:

- absorbent landscaping;
- rain gardens;
- green roofs;
- infiltration swale systems;
- infiltration trenches and soakaways; and
- pervious paving.

Looking ahead a few years, rainwater harvesting is anticipated to emerge as yielding an 'integrated solution' that achieves multiple objectives in the densified urban centres: mitigate drainage impacts and augment water supply. The precedent has already been established in the greenhouse industry.

An example of the early success of the insights gained from applying the WBM is that a number of municipalities in British Columbia have been prompted to implement policies requiring a minimum soil depth on development sites.

ALBERTA OVERVIEW

The opportunity for collaboration between British Columbia and Alberta first arose when the IGP Project Coordinator was invited as keynote speaker to a Low Impact Development Workshop that was organized by the Alberta chapter of the North American Lake Management Society. This workshop, held in September 2004, was the catalyst that brought together a cross-section of parties in Alberta interested in promoting sustainable drainage initiatives. The workshop led to the formation of an Alberta partnership and the start of an inter-provincial dialogue with British Columbia. The purpose in forming an inter-provincial partnership is to collaborate and share resources in order to facilitate improvements in land development practices in both provinces.

Alberta Low Impact Development Partnership

Capitalizing on the enthusiasm and early momentum generated by this workshop, the *Alberta Low Impact Development Partnership* (ALIDP) was created in November 2004. By March 2005 the early enthusiasm had resulted in approval of a Terms of Reference, election of a Steering Committee, and the decision to move forward with the inter-provincial partnership with British Columbia.

The ALIDP comprises municipal and provincial governments, provincial agencies, and non-profit organizations that have a stake in promoting improvements in land development practices so that degradation of the natural environment is prevented or reduced. The partnership's mission is to protect and maintain the integrity of the natural environment while promoting the growth and prosperity of Alberta's urban centres.

The #1 goal of the ALIDP is to facilitate the development of a 'Made in Alberta' LID strategy that is consistent with and achieves the desired outcomes of the Province's **Water for Life** initiative, namely:

- Safe, secure drinking water supply
- Healthy aquatic systems
- Reliable water quality supplies for a sustainable economy.

Through the inter-provincial partnership, the ALIDP can adapt the British Columbia experience in implementing on-the-ground practices that result in integration of rainwater management and drought management objectives. British Columbia has been grinding away on smart development and integrated water management issues for more than a decade. Just as British Columbia has been able to leapfrog Washington State by learning from the American experience, Alberta can similarly adapt British Columbian lessons learned in order leapfrog British Columbia with its LID strategy.

Creating Awareness

As part of its commitment to supporting the ALIDP during the start-up phase, the IGP has created the structure and content placeholders for an Alberta community-of-interest on the National Portal. This is now being populated with Alberta case study information provided by the ALIDP. Because Alberta does not have the same environmental history as British Columbia, an outreach and education program is critical to developing a common understanding among Albertans as to **why** it is necessary to maintain a water balance. This process has begun through projects on behalf of the Nose Creek Watershed Management Plan. There, the impacts of urbanization have been quantified as part of an Instream Flow Needs Study. The study findings illustrate how volume control is the only approach to truly minimize impacts on the morphologic regime of streams.

Adapting the WBM

Differences in drainage culture, starting points and terminology will be addressed in adapting the WBM to suit Alberta conditions – that is, a cold and semi-arid climate. The experience gained during the partnership-building with Alberta will be useful, not only in the ongoing efforts to implement the WBM nationwide, but also to advance sustainable drainage initiatives across Canada.

Terminology is an important consideration because different meanings for the same words can create confusion – for example, 'pre-design' connotes planning level in British Columbia, which is equivalent to 'functional design' in Alberta; whereas in Alberta 'pre-design' is equated to '75% completion' of the detailed design. Therefore, developing a common language has been part of the learning process for the inter-provincial partnership.

Expanded Capabilities. Prompted by 'needs-and-wants' identified by the ALIDP Technical Committee, the IGP completed a due diligence process to explore options for expanding the capabilities of the WBM. This resulted in identification of a preferred course of action**:** merging the WBM with the calculation engine of conventional (urban) drainage models such as the Canadian QUALHYMO model. This leap forward will provide five additional capabilities identified as being important to Alberta users:

1. Rainwater storage routing
2. Water quality
3. Stream erosion
4. Drainage area flow routing
5. Snowmelt runoff (and ultimately freeze-thaw)

The principal focus of the WBM remains source controls for runoff volume reduction. For drainage engineers, however, a practical modelling tool must also concentrate on the overflows from the site (i.e., once the source controls have reached capacity). Thus the significance of having the capability to store and route the outflow from a subdivision and/or neighbourhood through a detention pond or down a stream channel.

WATER BALANCE MODEL IN THE CLASSROOM

The IGP is reaching out to academia to bring the WBM into university classrooms. Two universities in Western Canada have recognized the value that the WBM provides as a learning tool. Their interest is cross-discipline.

University of Calgary

The WBM is being applied in a Masters Program class in ecological planning at the Faculty of Environmental Design. The course is about using ecological design principles in designing and building the urban environment on both a regional and site-specific scale.

The focus of the course is on using ecological and landscape processes as design 'tools' and the philosophy is that a sustainable approach is about designing human activities into the ecological systems that support us. In order to do this effectively it is necessary both to understand how those systems work and how the design of the built environment can incorporate and complement system processes.

The value of the WBM in this instruction process is the feedback that it provides on how different spatial configurations at the site design level result in different hydrologic process responses and reinforces the important relationship between process and form.

University of British Columbia

The WBM is one of the tools being introduced to 4th Year Civil Engineering students in a course dealing with the design of municipal infrastructure. For the stormwater component, students are first introduced to the complexity of rainwater management and the competing interests before going through the process of developing a master drainage plan for a residential subdivision. The application of on site controls to minimize runoff is seen as logical extension to current design and a necessary component to protect aquatic habitat influenced by urban runoff.

The WBM provides students with a tool to look at options for the design of on- site controls. For their design, students are expected to come up with residential lot modifications that will result in a 90% reduction in annual runoff. The existence of this tool gives credibility to the concept of on-site controls and a conceptual assurance that reductions can be achieved.

CONCLUSION

The rethinking of traditional approaches to urban hydrology is helping to achieve higher levels of watershed and stream protection by integrating land use planning with volume-based analysis of rainwater management strategies. Through the development of the WBM and application of 'water balance thinking-and-modelling', engineers are working with planners and other professions to promote changes in the philosophy, approaches and standards that shape the urban landscape. Many agencies now recognize this commonsense approach to rainwater management as having triggered one of the most significant advances in urban hydrology in a generation.

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