Re-Inventing Urban Hydrology – Going Back to Basics to Develop New Tools

by

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British Columbia is leading the way in North America in developing and implementing innovative approaches, criteria and tools for reducing stormwater runoff volumes at the source, where rain falls. Through ***Stormwater Planning: A Guidebook for British Columbia,*** science-based performance targets have been established for designing individual sites and entire neighbourhoods to function hydrologically as though they are still naturally forested. Getting to this point has involved the re-thinking of traditional approaches to urban hydrology and computer modelling.

Drainage engineers have traditionally thought in terms of flow rates, not volumes. In dealing with urban hydrology, we need to focus on how much rainfall volume has fallen, how we are going to capture it, and what we are going to do with it.

The volume-based approach that is being implemented in British Columbia picks up the baton that Dr. Ray Linsley (Note: Thomas Debo was a former colleague and friend of Dr. Linsley) started more than a generation ago. As a professor of Civil Engineering at Stanford University, and later as a consulting engineer, Linsley pioneered the development of continuous hydrologic simulation as the foundation for water balance management. He has received world-wide recognition for his vision and his contributions to the field of hydrology and continuous hydrologic simulation modelling:

- In the 1960s, Linsley championed the paradigm-shift from empirical relationships to computer simulation of hydrologic processes. He had little or no use for “simple hydrology” and the many simple equations that were used to represent the hydrologic cycle.
- Linsley fought a difficult war to replace the established procedures that had been used for many years, and that continue to be used in most urban hydrologic analyses throughout North America and in other locations around the world. He believed that continuous simulation was the only hydrology that should be used for most design and analysis applications.
- Linsley’s pioneering efforts resulted in development of the well-known HSPF Model. This continues to be the hydrologic simulation tool of choice in many parts of North America, notably Washington State where its use is mandated by the Department of Ecology, even though it is a complex model with great data input needs.

Somewhat ironically, the "hydrology engine" for HSPF and other contemporary models (such as SWMM) is based on 1930s and 1940s science. As reported by Linsley in a 1976 article:

- In 1933 - Horton first proposed the concept of infiltration, which is at the heart of continuous simulation.
- In 1934 - Zoch first suggested the use of routing to develop the runoff hydrograph.
- In 1942 - Linsley and Ackerman introduced the idea of continuous soil moisture accounting.

For the past thirty years, there has been a fixation on peak flow control through the use of detention ponds for all flood events from the 2-year through 100-year floods, and the conveyance of major flood events caused by urban developments of all kinds. The recently developed software focus has been on the user interfaces, but not on the hydrology engine; and certainly not on improvements in the science of infiltration.

Traditional applications of hydrology models such as HSPF and SWMM reflect "peak flow thinking" at a watershed or macro scale. But the models may not be appropriate for simulating what happens at the site scale, nor for assessing the effects of storm runoff volume changes caused by urban development.

The missing link in urban hydrology has been a tool that quantifies the benefits, in terms of reducing stormwater runoff volume at the site level, of installing source controls under a variety of circumstances. The water balance modeling approach was developed to demonstrate how to meet performance targets for water balance management at the site, neighbourhood, drainage catchment, and watershed scales. The Water Balance Model™ assists local governments to integrate land use planning with volume-based analysis of stormwater management strategies.

The power of the model is in the engine that interactively and transparently models how runoff is generated at the site level, including the processes that govern the movement of water through soil and vegetation. It provides a continuous simulation of the runoff from a site, neighbourhood, drainage catchment, or watershed. It allows the user to visualize the "how to" details of source control implementation.

The model enables users to model of all three components of the integrated strategy - illustrated in Figure 1 - for managing the complete spectrum of rainfall events. The three components are:

- *retain* the small frequent events;
- *detain* the large events; and
- *convey* the extreme events.

The output volumes and hydrographs generated by water balance modelling can become an input to a number of hydraulic routing models.

The *Stormwater Planning Guidebook* defines the target condition for a "healthy watershed" as follows - manage runoff volume so that an urban watershed behaves as though it has less than 10% impervious area. Figure 1 highlights the corresponding performance targets for rainfall capture (volume reduction) and rate control that characterize a healthy watershed. Water balance modeling defines option for achieving this target condition.

The accompanying article talks about a model that will be a decision support and scenario modelling tool. It will be used for evaluating the potential for developing or redeveloping communities that function hydrologically like naturally forested or vegetated systems. The tool will create an understanding of *how*, and *how well*, stormwater source control strategies for runoff reduction would be expected to meet performance targets and achieve watershed protection and/or restoration objectives.

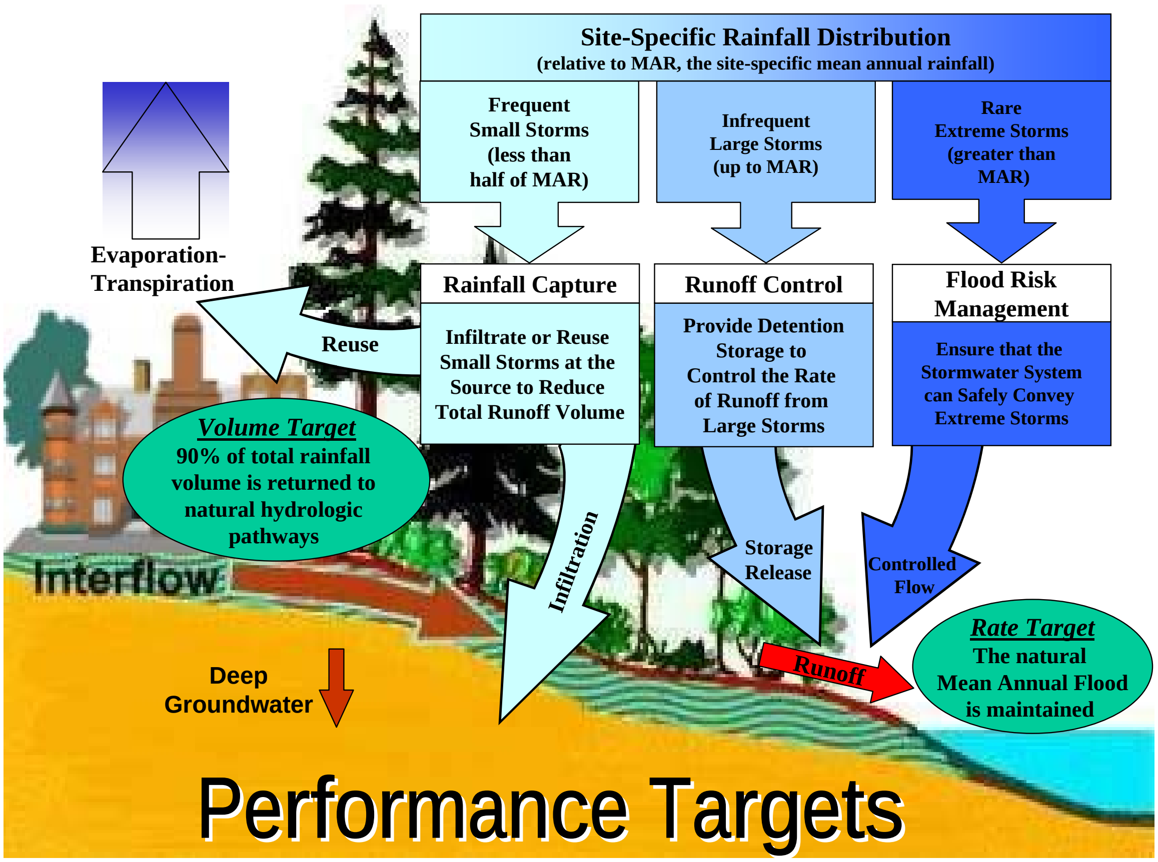

Figure 1. Managing the complete spectrum of rainfall events. Taken from *Stormwater Planning: A Guidebook for BC* (2002).

[1] Kim Stephens has been involved in a series of landmark initiatives over the past decade in British Columbia related to watershed-based stormwater management, low impact development, and water conservation. He was Project Manager for ***Stormwater Planning: A Guidebook for British Columbia,*** and is presently the IGP Liaison and Project Coordinator for the ***Inter-Governmental Partnership to Develop a Water Balance Model for BC.***

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