Stormwater Management

A Discipline in Transition

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Over the past three decades, water and drainage engineers have witnessed a vast change in the practice, design methodologies and regulatory framework encompassing the discipline of stormwater management. Along with a change in the regulations governing design and performance standards are changes in public expectations regarding protection of the environment and protection of life and property from flooding.

Today's society demands that the process of creating an urban setting pose no adverse impacts to the environment, as seen in the accompanying photos. The public also expects there will no longer be any flood-related damage to homes, businesses and transportation systems. As a result, the past decade has seen attempts to reduce the impact of land development on the aquatic environment through the creation of publications like *Stormwater Planning: A Guidebook for British Columbia,* which takes an entirely new approach to stormwater management.

Because engineers must always be learning, stretching the bounds of expertise and anticipating new requirements, we must similarly be driven to investigate the problems and issues that stimulated the development of the *Guidebook* in the first place. In so doing, we will be able to advance the science and engineering practice in a manner intended by the *Guidebook* proponents. Given the evolution of engineering practice in urban hydrology over the past decade, what can we expect to see in the next?

Beyond the Guidebook

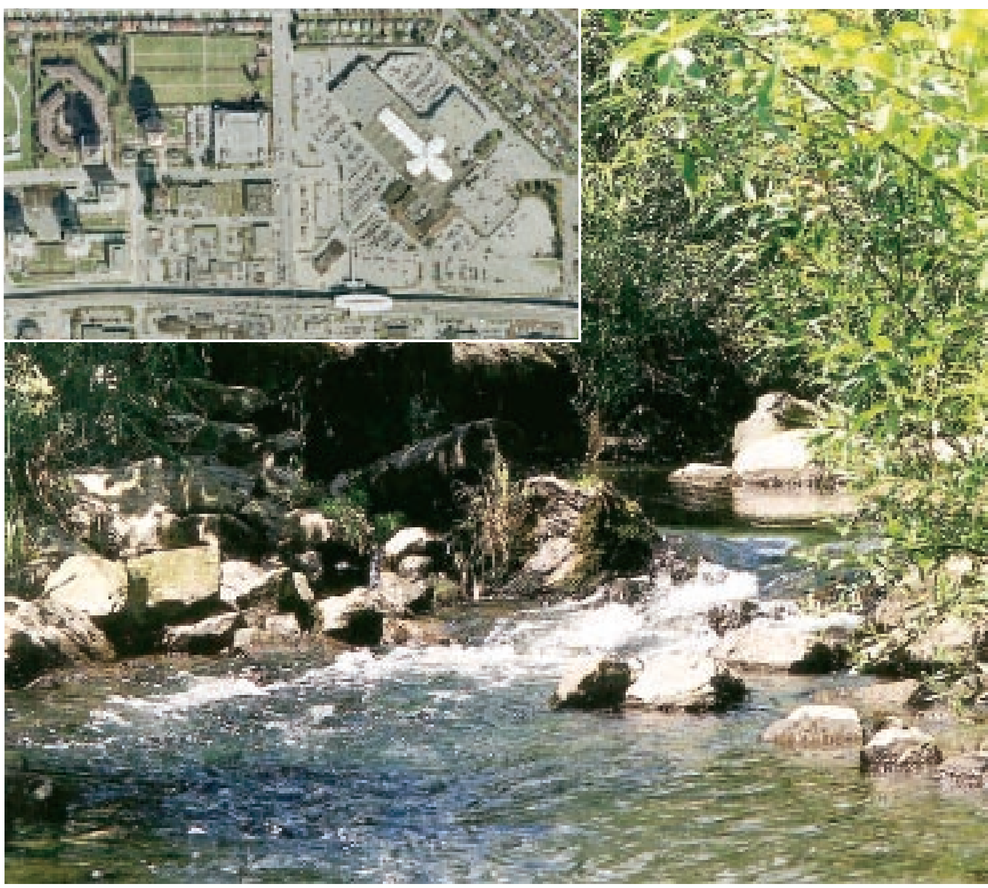
Introduced in 2002, the *Stormwater Guidebook* offers direction and guidance on stormwater management planning, design principles and objectives. Portions of the *Guidebook* have been adopted by regulatory agencies; some municipalities have gone so far as to implement elements of the *Guidebook* into their bylaws governing the design of infrastructure within their borders.

Discussions with *Guidebook* author Kim Stephens PEng suggest that its concepts were presented to stimulate discussion rather than establish a set of firm rules. His intent was to create a framework under which the engineering design of drainage works would be aimed at minimizing future impacts on streams and even mitigating problems of the past.

Is it now time to go "beyond the Guidebook?" Do we have the knowledge to allow us to do this? The answer to both questions should be yes.

A large body of published information is now available regarding a wide range of interrelated topics pertinent to stormwater management. The information lies in fields as diverse and wide-ranging as hydrology and hydraulics through to hydrogeology, geomorphology, soil physics, agronomy and onto biology.

While the information is available, there are seldom obvious and direct linkages between the various special-



ized fields. Could it be that specialists in one field give only cursory acknowledgement to other areas of learning? As professionals, engineers must be willing and able to engage in the integration of knowledge, and to seek the best results for society and the environment. This must be an ongoing process.

Engineers are at a crossroads in the path defining the methodologies and applications used in stormwater management. Whether one realizes it or not, there are two paths to follow. The fundamental difference between the two approaches lies in how rainfall data is used.

Path 1: Runoff Based Approach

One path, the runoff based approach, leads to the analysis of runoff and its interaction with the physical aspects considered important to the aquatic environment. A primary benefit of this approach is the use of continuous simulation using long-term rainfall records to calculate runoff, so that the frequencies and durations of various conditions can be easily estimated.

For example, performance of stormwater best management practices depends not only on rainfall volume and temporal distribution, but also antecedent conditions such as soil moisture and the volumes of existing water retained in ponds from previous storms. All of these factors overlie the physical characteristics of a site or watershed in terms of vegetative cover, imperviousness, connectivity, slope and the many defining parameters that describe the condition of the soils.

The use of continuous simulation allows direct observation of the frequency of the condition of interest (eg flood frequency, flow duration) from the results of the calibrated models, and therefore accounts for the effect of joint probabilities of occurrence of the large number of variables (rainfall volume and temporal distribution, antecedent conditions and volumes of retained water).

These results can be used to determine the durations of depth and velocity in streams along with the amount of aquatic habitat available over time. The results can also be extended into an assessment of the energy available to cause erosion and transform the physical characteristics of a stream.

We now have the basic components to begin integrating the engineering with the environmental aspects relating to aquatic environments. This will allow us to create an understanding of how we affect the environment and how to mitigate those impacts. We will be able to clearly define relationships between rainfall, runoff, habitat availability, erosion forces and geomorphology of streams. On this path there is an opportunity to integrate the wisdom gleaned from many areas of knowledge.

Path 2: Rainfall Based Approach

Without realizing it, many have already taken the other path, the rainfall based approach. This approach uses the same weather records to create a range of artificial design storm events, which are then used to analytically test drainage systems.

The rainfall based approach grew out of the drainage system design methodologies that address the reduction of flood risk. The operation of these systems can only be assessed for specific design events, and any extrapolation of system operation beyond these events cannot be easily verified. These methodologies are simple to use and many practitioners may be reluctant to move away from such tried and trusted approaches.

The rainfall based approach has been extended in an attempt to address environmental impacts. Based on the *Guidebook,* there is an assumption that the onsite retention of a given amount of rainfall — say, one-half the mean annual daily precipitation amount — will translate into a benefit for stream health. The assumption is that runoff does not occur for small events, and that retention of this volume will mimic the natural hydrology of a site.

Unfortunately, the physical systems being assessed are much more complex, and this simplistic approach does not adequately describe the rainfall and runoff processes and their impacts on the environment. There is some circumstantial evidence linking impermeable surfaces in a watershed to adverse stream impacts, but the linkages are not clearly definable and therefore not well understood.

There are no valid sets of equations or functions to support the simplistic rainfall based approach. The basic requirement for valid equations and functional relationships is the maintenance of dimensional continuity of units; to date, this criterion has not been met.

Going Forward

Hydrological engineers see the need for both runoff and rainfall based approaches; they can be complementary.

The runoff based approach is best suited to the analysis needed to assess environmental impacts and effectiveness of mitigation techniques. Within this is an underlying need to focus on the small runoff events that can overwhelm fragile environmental systems. Flood protection measures, on the other hand, can and should be designed with reference to extreme events using established rainfall based approaches.

Subsequent to the introduction of the *Stormwater Guidebook,* an Intergovernmental Partnership (IGP), comprising members from three levels of government and supported in part by industry, began to advance the science of reducing and mitigating the environmental impacts of urban development. The IGP developed a planning and decision support tool, the Water Balance Model (WBM), to demonstrate the benefits of applying the *Guidebook* principles. In so doing, they began along the path of using the runoff based approach to assessing linkages between stormwater management and the environment.

The IGP has decided to upgrade the WBM and to include enhancements to the runoff based approach. Over the next several months, the WBM will provide users with more advanced design tools. This is good engineering practice and takes us "beyond the Guidebook."

Jim Dumont PEng is a Senior Hydrotechnical Engineer with McElhanney Consulting Services Ltd in Surrey. Mr Dumont will present a session on "Modern Urban Stormwater Management" on Friday, October 13 as part of the professional development program at APEGBC's Annual Conference and AGM in Victoria.