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Managing Urban Wet-Weather Flows: On the Road to Sustainability (Editorial)

By:

J. Marsalek, S. Kok, H. Colas

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Managing Urban Wet-Weather Flows: On the Road to Sustainability (Editorial)

Marsalek, J., S. Kok and H. Colas

ABSTRACT

This editorial article introduces a collection of 14 papers on stormwater management and combined sewer overflow (CSO) control and treatment in a theme issue of the Water Quality Research Journal of Canada. The main thoughts discussed include continuing interest in the management of urban wet-weather flows, stormwater impacts on receiving waters and their ecosystems, and stormwater management within the context of sustainable communities. Innovative approaches to CSO treatment and control include optimization of existing facilities using computational fluid dynamics (CFD) modeling and implementing high-rate treatment in storage facilities, and optimal utilization of sewer system/CSO facility capacities by operation in real time. In this process, existing and future environmental stressors need to be accounted for, including growing urban population, releases of chemicals, ageing infrastructure and climate change.

NWRI RESEARCH SUMMARY

Plain language title

Managing urban stormwater and combined sewer overflows (CSOs) in support of achieving sustainability

What is the problem and what do scientists already know about it?

Stormwater discharges and combined sewer overflows impair water quality and beneficial uses of receiving waters, and need to be addressed in water pollution control planning. Older approaches relied too much on storage of such flows with controlled flow releases.

Why did NWRI do this study?

Stormwater and CSO discharges are recognized as major contributors to the water pollution encountered in the Great Lakes Areas of Concern. The delisting of such areas requires the abatement of stormwater and CSO pollution by innovative measures.

What were the results?

An improved assessment of stormwater impacts on receiving waters and their ecosystems is needed and should lead to a better design of best management practices, including source controls. Innovative approaches to CSO treatment and control include optimization of existing facilities using computational fluid dynamics (CFD) modelling and implementing high-rate treatment in storage facilities, and optimal utilization of sewer system/CSO facility capacities by operation in real time.

How will these results be used?

The results will be used by municipalities for planning and implementing stormwater control and CSO treatment and control.

Who were our main partners in the study?

The main partners were the Great Lakes Sustainability Fund (Burlington, Ontario), and BPR-CSO (Montreal, PQ).

Débits pluviaux en milieu urbain : en voie vers la durabilité (article de fond)

Marsalek, J., S. Kok et H. Colas

RÉSUMÉ

Cet article de fond présente une série de 14 communications sur la gestion des eaux pluviales ainsi que sur la régulation et le traitement par trop-pleins d'égouts unitaires (TPEU) dans le cadre d'une question-thème du Water Quality Research Journal of Canada. Les principales idées examinées comprennent l'intérêt soutenu pour la gestion des débits pluviaux en milieu urbain, les impacts des eaux pluviales sur les eaux en aval et leurs écosystèmes, et la gestion des eaux pluviales dans le contexte des communautés durables. Des approches innovatrices en matière de traitement et de régulation par TPEU comprennent l'optimisation des installations existantes grâce à la modélisation *computational fluid dynamics* (CFD), à la mise en oeuvre du traitement à haut débit dans les installations de stockage, et enfin à l'utilisation optimale d'une capacité d'installation réseau d'égouts/TPEU avec exploitation en temps réel. Dans ce processus, il faut tenir compte des stresseurs environnementaux existants et futurs, y compris la population urbaine croissante, les rejets de produits chimiques, l'infrastructure vieillissante et le changement climatique.

Sommaire des recherches de l'INRE

Titre en langage clair

Gestion des eaux pluviales urbaines et des trop-pleins d'égouts unitaires (TPEU) en soutien à la réalisation de la durabilité.

Quel est le problème et que savent les chercheurs à ce sujet?

Les rejets d'eaux pluviales et les trop-pleins d'égouts unitaires, qui altèrent la qualité de l'eau et les utilisations bénéfiques des eaux en aval, doivent être examinés dans le cadre d'une planification des mesures antipollution de l'eau. Les approches antérieures étaient basées de façon excessive sur le stockage de ces eaux avec des rejets à débit régulé.

Pourquoi l'INRE a-t-il effectué cette étude?

Les rejets d'eaux pluviales et de TPEU contribuent de façon majeure à la pollution de l'eau observée dans les Secteurs préoccupants des Grands Lacs. La radiation de ces secteurs suppose la dépollution des eaux pluviales et des TPEU grâce à des mesures innovatrices.

Quels sont les résultats?

Il faut améliorer l'évaluation des impacts des eaux pluviales sur les eaux en aval et leurs écosystèmes, ce qui devrait conduire à une conception plus efficace des meilleures pratiques de gestion, y compris les mesures de contrôle à la source. Des approches innovatrices en matière de traitement et de régulation par TPEU comprennent l'optimisation des installations existantes grâce à la modélisation *computational fluid dynamics* (CFD), à la mise en oeuvre du traitement à haut débit dans les installations de stockage, et enfin à l'utilisation optimale d'une capacité d'installation réseau d'égouts/TPEU avec exploitation en temps réel.

Comment ces résultats seront-ils utilisés?

Les résultats seront utilisés par les municipalités pour la planification et la mise en oeuvre des mesures de contrôle des eaux pluviales ainsi que du traitement et de la régulation par TPEU.

Quels étaient nos principaux partenaires dans cette étude?

Les principaux partenaires étaient le Fonds de durabilité des Grands Lacs (Burlington, Ontario), et BPR-CSO (Montréal, Québec).

Managing Urban Wet Weather Flows: On the Road to Sustainability

The management of urban wet weather flows, and particularly of combined sewer overflows (CSOs) and stormwater discharges, continues to attract attention worldwide. Obvious examples of this interest include the recent U.S. EPA report to Congress on the impact and control of CSOs and sanitary sewer overflows (SSOs) (U.S. EPA 2004) and the European Union Water Framework Directive emphasizing the need to attain the "good" status for surface waters in terms of chemistry and ecology (Mohaupt 2004). The situation in Canada is no different, with many ongoing or recently completed projects on sustainable infrastructure for stormwater management (National Guide to Sustainable Municipal Infrastructure 2003), guidance documents for stormwater management planning (British Columbia Ministry of Water, Land and Air Protection 2002; Ministry of the Environment 2003), CSO treatment (XCG Consultants Ltd. 2004), and many other reports on planning and engineering studies.

In response to this Canada-wide interest, the Guest Editors enthusiastically accepted the invitation from Dr. R. Gehr, Editor of the *Water Quality Research Journal of Canada*, to prepare a theme issue on wet-weather flows, and secured funding from the Government of Canada's Great Lakes Sustainability Fund. This issue builds on the success of the two earlier ones on similar topics, which were published in 1997 and 2000, under the titles "Great Lakes 2000 Cleanup Fund Program: Stormwater Management and Control of Combined Sewer Overflows" (Water Qual. Res. J. Canada, Vol. 32, No. 1, 1997) and "Urban Stormwater Management for Ecosystem Protection" (Water Qual. Res. J. Canada, Vol. 35, No. 3, 2000), respectively. While the earlier issues focused only on studies in the Great Lakes Basin conducted with co-sponsorship of the Great Lakes Sustainability Fund (GLSF), no such restrictions apply to the current issue. The Guest Editors approached potential contributors in all regions of Canada, and finally, the only limiting factor was a demanding time schedule, as the entire project had to be accomplished in about nine months. Many authors accepted this constraint and the result is the following collection of 14 papers. These papers provide a good balance between the two major topics, with about a half of the papers dealing with stormwater and the other half with CSOs.

The management of urban stormwater is of concern in many Canadian jurisdictions, particularly in connection with the principles of sustainable development. There have already been many success stories on the road to sustainability. Such a goal is, however, difficult to achieve without addressing the issue of sustainable communities, or the sustainability of the entire watershed, because some of the required management measures extend beyond the municipal authority and require a concerted action of all stakeholders. One example of such an over-arching action is building product (material) substitution, which may prevent the use and release of chemicals of potential concern into stormwater (Clark et al. 2002).

Increased interest in source controls (as a form of prevention) has been noted in the literature and has led to a new term "rainwater management". This approach emphasizes maintaining a pre-development water balance on site (e.g., by infiltration and reduced

catchment imperviousness), control measures targeting smaller rain events conveying a large proportion of the annual rainfall, etc. This new expression confirms a continuing search for "the best fitting" terminology in this field, which often reflects a particular practice, or contemporary terminology in other fields related to stormwater management. Historically, various aspects of stormwater management have been called urban runoff controls, alternative techniques, best management practices (BMPs), sustainable urban drainage systems (SUDS), low impact development (LID), and water sensitive urban design (an Australian expression). One can argue that rainwater management represents a type of source control applied in stormwater management, which was defined by Marsalek (2001) as "the measure designed to control the generation of, and entry of pollutants into, stormwater runoff, with emphasis on non-structural and semi-structural measures applied at or near source." It is the Editors' opinion that the rainwater management term describes the concepts included in advanced stormwater management. To illustrate this point, one can cite from older (seminal) literature; e.g., the ASCE Guide (ASCE, 1977), which referred to many common source controls that would reduce or prevent runoff (stormwater) generation; an application of LID in the Woodlands Planned Community in Texas (this development started in 1974); the hydrology of urban runoff quality control (i.e., focus on smaller rather than extreme storms) that was described in the early 1990s (as referenced in Roesner and Urbonas 1993), etc.

The papers on stormwater in this theme issue address a broad range of topics including an overview of the GLSF program in the municipal pollution control sector, water balance modelling in support of low impact development, examination of a guidance document on stormwater management planning, various means of detecting stormwater discharge impacts on receiving waters with respect to hydrology, erosion, water quality and ecology, on-line treatment of stormwater, and experience with the master planning for a large-scale stormwater (and CSO) control project. This mix of papers indicates a certain maturity of the field, and at the same time, the need for further refinement of our understanding and the means of detection of stormwater impacts on receiving waters and their ecosystems. The field's maturity is documented by a large number of projects co-sponsored by GLSF, the availability of guidance documents for stormwater management, and a large-scale planning application in the City of Toronto. These three papers indicate a broad range of techniques, including computer models which are available for stormwater management and these are further enhanced by addition of a water balance model applied in British Columbia and elsewhere.

Over the years, a fair understanding of the performance of individual BMPs has been developed, though with some limitations. Such limitations include the list of parameters studied, focus on removal rates (often removals of suspended solids) rather than the significance of effluent quality, and measurement of readily quantifiable parameters (e.g., flows, chemical concentrations) rather than measurements/observations of broader indicators of receiving water quality and its ecosystem health, as required by the EU Water Framework Directive, for example (Mohaupt 2004). Some contributions towards expanding our understanding of stormwater impacts are presented in this issue (e.g., with respect to erosion, operational performance and benthic communities), but obviously more work is needed, and in some cases, the future findings may lead to re-examination

of some older facilities and their adaptation to meet new objectives. It is the Editors' opinion that in stormwater management applied in both new and older areas, all options need to be considered ranging from source controls (including rainwater management) to end-of-pipe facilities, or even in-stream facilities. Only such an integrated approach will be successful, particularly in the existing urban areas, where opportunities for source controls may be limited not just by physical constraints, but also by the need to secure support and cooperation of property owners.

CSOs cause environmental concerns in all urban areas with combined sewers. Even though the CSO problem assessment in Canada is almost 40 years old (Waller 1968), progress has been relatively slow. The main reasons for this are high costs generally associated with CSO control, slow development of abatement technologies, and limited experience with operation of CSO control and treatment measures. The last point can be illustrated by noting that currently, in the USA and Canada, there are around 20,000 stormwater storage facilities, but the total number of CSO facilities is probably two orders of magnitude smaller. Recognizing the high costs of CSO measures, one needs to be strategic in making such investments. Such strategies start with a comprehensive problem assessment, including characterizing CSO flows, frequencies, composition, and treatability. Some guidance in this regard is provided in this theme issue, including the description of a guidance document for planning CSO control and a novel method of treatability assessment. In the examination of control/treatment options, it is recognized that cost-effective solutions can be obtained by combining storage with treatment, and whenever feasible, volumetric CSO controls should be considered for quality improvements as well. This may require a more accurate knowledge of flows and their distribution in CSO facilities, because the facilities serving for storage and treatment require better flow control (particularly flow velocity distribution) than those serving purely for storage. Computational Fluid Dynamics (CFD) modelling offers a promising technique for this purpose.

A wide range of CSO treatment options is now available and requires careful consideration for specific applications. Indeed, the treatment effectiveness can be greatly increased by moving from conventional settling to lamellar settling, clarification with chemical addition, filtration, ballasted clarification, and adding disinfection. Each of these steps has cost implications, as well as maintenance and operational demands, which need to be carefully considered for specific local conditions. Additional benefits can be obtained by using dual-purpose wet-flow and dry-flow facilities. The number of installations with chemical addition is increasing and others are planned; much of the literature on ballasted clarification refers to pilot studies of limited scope. However, great progress can be expected in the field of CSO treatment in the near future, as also indicated in this theme issue.

Finally, great savings on investments in CSO abatement can be achieved by real-time control (RTC) of CSOs. RTC represents a strategy which allows an optimal utilization of the capacities (flow, storage), which are available, or could be inexpensively created, in the existing sewer systems. This concept has existed for several decades, but it has not gained wide acceptance for various reasons, including inertia, concerns about costs,

manpower requirements, etc. By now, significant favourable experience with RTC for CSOs has been gained in several places in France (St. Dennis County in the suburbs of Paris) and in Quebec City, Canada. It is hoped that this theme issue will contribute to further promotion of RTC in CSO abatement.

The theme issue indicates progress in managing wet weather flows in most advanced jurisdictions in Canada. It highlights innovative approaches to solving older problems and preventing new ones by adopting principles of sustainable development in new urban areas. Such approaches need to be extended across the entire spectrum of communities, and implemented recognizing the existing environmental stressors in urban areas, including growing urban populations, use of chemicals of concern, ageing municipal infrastructure, and climate change.

In closing, the Guest Editors would like to thank all who contributed to this issue. Thanks are due, first, to the authors of papers, who worked with the Editors and met all deadlines. Second, we could not have produced this issue without assistance of many reviewers. They responded to our call for help and generously donated their time to make this project a success. Finally, we would like to thank the Journal Editor, Ron Gehr, for giving us this opportunity to work on the theme issue, to Kristin May, the Managing Editor, for her enthusiastic support and patience throughout the whole project, and to the Government of Canada's Great Lakes Sustainability Fund for financial support. We hope that the readers will enjoy reading this issue as much as we did preparing it.

Jiri Marsalek, Sandra Kok and Hubert Colas
Guest Editors

References

ASCE. 1977. Guide for collection., analysis, and use of urban stormwater data. Proceedings of Eng. Foundation Conference, Easton, MD.

British Columbia Ministry of Water, Land and Air Protection. 2002. Stormwater planning: a guidebook for British Columbia. Ministry of Water, Land and Air Protection, Victoria, BC.

Clark S, Field R, and Pitt R. 2002. Wet-weather pollution prevention by product substitution, p. 266-283. *In* Urbonas BR (ed.), Linking stormwater BMP designs and performance to receiving water impacts mitigation. Proc. Eng. Foundation Conf., Snowmass, Colorado, ASCE, New York.

Marsalek J. 2001. Review of stormwater source controls in urban drainage, p. 1-15. *In* Marsalek J, Watt E, Zeman E, Seiker H (ed), Advances in urban stormwater and agricultural runoff source controls. NATO Science Series, Earth and Environmental Sciences, Vol. 6. Kluwer Academic Publishers, Dordrecht/Boston/London.

Ministry of the Environment. 2003. Stormwater management planning and design manual. MOE, Toronto, Ontario.

Mohaupt V. 2004. On research and measures in European countries for basin management, p. 17-24. *In* Proc. Workshop on Measures against Diffuse Pollution and Water Environment, Kutsatsu, Japan.

National Guide to Sustainable Infrastructure. 2003. Source and on-site controls for municipal drainage systems. National Research Council, Ottawa, Ontario.

Roesner L and Urbonas B. 1993. Hydrologic design for urban drainage and flood control, chapter 28, p. 28.1-28.52. *In* Maidment DR (ed.), Handbook of Hydrology.

U.S. EPA (United States Environmental Protection Agency). 2004. Report to congress: impact and control of CSOs and SSOs. EPA 833-R-04-001.

Waller DH. 1969. Combined sewers in Canada. Engineering Journal, Vol. 52, No. 6, 22-30.

XCG Consultants Ltd. 2004. Guidance manual for the treatment of combined sewer overflows. A draft report prepared for the Great Lakes Sustainability Fund, Environment Canada (National Water Research Institute), Regional Municipality of Niagara and the City of Welland.

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