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MODÉLISATION D'UN BASSIN D'ORAGE EN VUE DE L'AMÉLIORATION DE LA QUALITÉ DES RIVIÈRES PAR LA GESTION EN TEMPS RÉEL

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Abstract

The development of real-time control rules of sluice gates located at a stormwater basin outlet requires testing various options, taking in account weather forecasts, water quality of the upstream river, river flow and water quality in the stormwater basin, by using long-term simulations to allow improved ecohydraulics of rivers. To do so, these rules have to be tested by using an integrated "watershed - storm basin – river" system. In order to perform long-term simulations, a stormwater basin model with small computation time is needed, which simulates the water quality in the basin accurately in function of imposed operating conditions. The purpose of this thesis was to develop such stormwater basin model.

The developed model is based on superimposed homogeneous layers creating a concentration gradient to represent local phenomena such as light penetration affecting the mortality of pathogens. It is also based on the definition of several particle classes characterized by their settling velocities; the latter being determined experimentally using ViCAs tests. It also includes pollutants associated with particles. The basic unit, called cell, is defined by a surface and a maximum height above which water overflows. Each cell has a time-variable water volume, divided into several layers and a constant volume sediment layer. To reproduce spatial heterogeneity of an experimental stormwater basin, it is necessary to connect several cells. Connections are then done layer by layer with the condition that the water levels of all cells are at the same water height. A theoretical model describing the concentrations of pathogens, including complex processes such as growth, adsorption on particles and light disinfection has also been developed

The calibration of the model required experimental data which were collected by sampling in the summers of 2008, 2009 and 2010 on the basin Chauveau in the "des Rivières" district of Quebec City. First, the efficiency of the basin in its current operation was determined. An average removal efficiency of 39% for total suspended solids (TSS), 10% for ammonia and 20% for zinc was revealed. In a second step, the stormwater basin outlet was closed with a wooden structure equipped with a guillotine door to retain the water for varying periods of time. The second configuration of the basin significantly improved the efficiency of the basin for TSS (90%), ammonia (84%) and zinc (42%). Samples were also collected within the basin, revealing heterogeneity in TSS measurements between the area near the inlet and the area near the outlet for the first 20 hours of storage.

The model showed its ability to adequately reproduce the behavior of the TSS concentrations using three particle classes defined by settling velocities of 80, 2 and 0.1 m/d. For the hydraulics, five cells were required to recreate the spatial heterogeneity revealed by the sampling campaigns. Finally, the addition of a resuspension flowrate was needed to model the increased outlet TSS concentrations at the end of emptying.

The validation confirmed the good performance of the model for the hydraulics and the prediction of outlet TSS concentration. It has also revealed several points that require further research: the definition of the sediment resuspension flowrate, determination of the initial mass of sediments in the stormwater basin, the possibility of using more cells to better represent the hydraulics and the interest of running ViCAs tests associated with each phase of the runoff (the beginning, the flow peak and the end).

With this model, real-time control strategies for the outlet valve can now be tested.