Geophysical Research Abstracts, Vol. 9, 11567, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-11567

Optimisation of operational responses to non-deliberate contamination events in water distribution networks

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Two types of operational actions for managing non-deliberate contamination in water distribution networks can be distinguished: preventive and corrective. The first are focused on attacking the causes of potential problems such as infiltration and back-siphonage. The second are focused on solving the problem that already exists, through recommended actions stated in plans that previously have been developed.

When a water distribution network becomes contaminated is necessary to know where the source of the contamination is, where the contaminated water is flowing to and who is going to be affected from it. After this, is necessary to start actions to mitigate the water quality problem, which may include, among other activities, operational actions to be executed directly on the system in order to reduce the damaging concentrations of the contaminant.

The reaction in this case must be quick (to avoid contamination propagation) and accurate (to avoid operational mistakes). However, under emergency conditions, the process to make decisions is very difficult and stressing, even if a hydraulic and quality model of the system are available. Such decisions must be taken in a restricted period, so trial-and-error experiments with these models becomes forbidden, as a huge number of evaluations may be needed to come up with an optimal solution.

This research addresses the problem of generating this set of corrective (operational) actions when the contamination is detected in the system. The methodology aims to find an optimal set of operational actions to flush the contaminant out the system (by switching pumps, hydrants and valves) such that minimize the risk of contamination exposition over the population, with the less possible operational effort, provided the limited resources to carry them out.

The situation is posed as an optimization problem with two different solution approaches. The first one takes into account a single objective to optimise, which is solved by using genetic algorithms (GA); the second one consider a multiobjective problem, and it is solved by using non-sorted genetic algorithms (NSGA-II). Both approaches use the EPANET solver engine to perform the hydraulic and water quality calculations.

The methodology is tested on a simple network and on a real case study. The results confirm that the methodology can be used in a decision-support tool for advising operators and decision makers about the operational activities to carry out. It is also found that the complexity of the problem is such that even intuitive solutions from experimented operators may worsen the situation as the pollutant can be spread out in the network.