New Ground-breaking Water System Pumping Optimisation Software for Systems with Alternative Water Sources

On Thursday 23rd of June 2016, researchers from the University of Adelaide acting within the CRC for Water Sensitive Cities hosted Samantha McGufficke from Orange City Council (NSW) and Martin Haege from Geolyse to transfer a newly developed sophisticated genetic algorithm-based multi-objective optimisation tool for water system management. The Pumping Operation for Alternative Water Sources (POAWS) software was developed over a two year period by Dr Angela Marchi, Professor Angus Simpson, Professor Martin Lambert and Lisa Blinco in the Intelligent Water Decisions Research Group of the School of Civil, Environmental and Mining Engineering. The connection between the Adelaide researchers and Orange City Council was forged through the Cooperative Research Centre for Water Sensitive Cities (CRCWSC, subproject C5.1).

From left to right: Martin Haege, Samantha McGufficke, Lisa Blinco, Dr Angela Marchi, Professor Angus Simpson and Professor Martin Lambert.

“In recent years, Orange City Council has developed a range of new water sources (including two stormwater harvesting schemes, a 37 km pipeline from the Macquarie River and three groundwater bores) to supplement the natural catchment supply that had come close to running out of water due to drought in 2000 to 2010. In managing this system, Orange City Council has to decide how much and when to use the various water sources, and what water levels in the main storage (Suma Park Dam) will trigger pumping.” Prof Simpson explains. “Minimising the cost of pumping is their main concern, however, they would also like to minimise spill (to avoid pumping before rainfall provides natural inflow) and maximise the benefit to downstream waters by maximising the river and creek flows for environmental benefit.”

“As there are many different choices for the operating rules for the system, the problem becomes very complex and multi-objective optimisation provides an efficient way to determine good operating rules. A multi-objective optimisation tool called NSGA-II (based on a non-dominated sorting genetic algorithm) is used as the basis for the very powerful optimisation tool.” Prof Simpson says. “However, this is not the only challenge of the project” he adds.

“In fact, the water delivery system needs to comply with several complex constraints, including limits on the water withdrawals from certain sources and minimum environmental flows. In addition, evaporation, losses during the transfer of water in creeks and water restrictions need to be modelled.” Dr Marchi said. “These constraints and additional processes are not simulated by the hydraulic solver EPANET, which is commonly used to carefully calculate the pump operating energy including various electricity tariffs, and hence the electricity costs, during the optimisation of conventional water distribution systems”.

“In addition to integrating the EPANET simulation with the above processes, we also improved the EPANET toolkit so that rule-based controls can be optimised. Rule-based controls are pumping controls that are based

on more than one condition", Dr Marchi explains. "These could be the different times of the day and the tank levels to switch a pump on or off, as explained in this blog, or they could be the level of different water storages."

"We have tested the improved toolkit for the optimisation of rule-based controls (called ETTAR) in a paper recently published by the Journal of Water Resources Planning and Management" Prof Simpson adds "We tested it on a typical water distribution system, but we already anticipated that optimising rule-based controls would have been necessary in systems that use alternative water sources."

"These systems are more complicated to model and optimise", Lisa Blinco says "and require additional expertise as I explain in this blog. Being part of the CRC for Water Sensitive Cities has allowed us to broaden our knowledge and to better understand the problems of the Industry Partners."

"We have developed the POAWS toolkit taking into account the Orange system's requirements and its ease-of-use. The interface of the POAWS toolkit has four comprehensive Excel spreadsheets for the users to control input to the optimisation process as well as to visualise the results. Year-long flow sequences from a 110 year sequence of streamflows and evaporations are able to be chosen in the optimisation process. Thus the user can optimise the system performance in dry, average and wet years. The software allows for built in triggering of water restrictions based on the dropping of the water level in critical reservoirs below threshold values." Prof Simpson says. "Martin Haege and Samantha McGufficke were then able to test out the POAWS software and learn how to use it themselves after the morning presentation."

"The presentation of the optimisation model was extremely useful and it is our opinion that it will be a useful planning tool for Orange City Council to help inform decisions about the mix of water sources" Martin Haege wrote in an email to the Adelaide team after their visit.

Communication between the Adelaide researchers and Orange City Council will continue over the next few months, as the software is further tested, updates will be made to ensure it has all the required functionality and the settings are suited to the Orange system.

"We are really pleased to know that our Industry Partners Martin Haege and Samantha McGufficke are satisfied." Prof Lambert says. "We hope that the POAWS software can be useful to other Councils in the future."

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