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INTEGRATED REAL TIME CONTROL OF INFLUENT PUMPING STATION AND PRIMARY SETTLING TANKS AT WWTP EINDHOVEN

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Abstract
This research deals with the design and implementation of an integrated control for the WWTP of Eindhoven. The control influences the operation of the primary settling tanks and influent pumping station to reduce reduce ammonia peaks in the WWTP effluent. The control takes into account the treatment capacity of the biological tanks, the influent flows and the available storage capacity in the individual catchments. It was implemented in winter 2016 and has been operational since April 2016. Model results and preliminary measurements show that the WWTP can be operated with a reduced number of PCs for over 90% of the time.

Keywords
combined sewer, implementation, RTC, storm water settling tank, impact based control

INTRODUCTION

Integrated real time control in wastewater management has been a research topic for several decades, see e.g. (Schilling, Andersson, et al., 1996; Harremoës, 2002; Schütze, Campisano, et al., 2004; Olsson, 2012). In the past years it has become increasingly accepted for optimising the functioning of wastewater systems (Schütze and Muschalla, 2013). The majority of studies that have been published are theoretical, either being based on fictional systems or on modelling exercises only (Frehmann, Niemann, et al., 2002; Erbe and Schütze, 2005; Lacour, Joannis, et al., 2011). Recently, a few studies emerge that discuss the practical details of applying RTC (see e.g. Campisano, Cabot Ple, et al., 2013; Beeneken, Erbe, et al., 2013) or are based on real cases such as (Seggelke, Löwe, et al., 2013; Hoppe, Messmann, et al., 2011).

This study deals with the wastewater system of Eindhoven in the Netherlands. It is intensively monitored and studied over an extended period of time, see (Langeveld et al., 2013) for details. Based on an analysis of the available measurements and expert knowledge on the system functioning, an alternative control for the operation of the primary clarifiers (PCs) at the wastewater treatment plant (WWTP) of Eindhoven has been designed and is implemented. The alternative control aims at reducing peak loading of the activated sludge stage of the WWTP to enhance the treatment process and reduce ammonia (NH_4) peaks in the effluent.

MATERIALS AND METHOD

Description wastewater system and measurements

The WWTP of Eindhoven, the Netherlands, treats the wastewater from 3 catchment areas: Nuenen-Son (NS), Eindhoven Stad (ES) and Riool Zuid (RZ). The WWTP generally consists of 3 identical treatment lines containing a PC, an activated sludge tank and 4 secondary clarifiers (SCs). At high inflows a storm water settling tank (SST) can be operated to first store and later discharge partly settled wastewater to the river directly, see figure 1. Continuous water level measurements are performed in the influent chambers and in the SST. Continuous flow measurements are performed for the influent from the catchments and the flows towards the biological tanks.

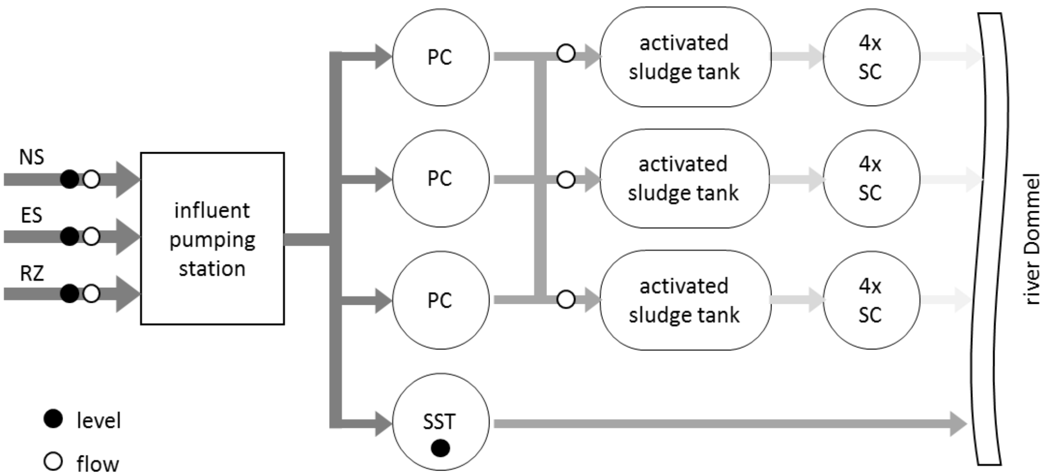

Figure 1. Schematic overview of the WWTP of Eindhoven.

Original PC control

All PCs were operated equally and continuously, independent of the wastewater constituents or influent flows. During dry weather flow (DWF) conditions the PCs were filled with raw sewage and have a hydraulic retention time (HRT) of 4 hours. At the onset of a rain event this volume is transported at wet weather flow (WWF) rate to the activated sludge tanks, which reduces the HRT to 1 hour and leads to a deterioration of the treatment efficiency during this peak load and while recovering, resulting in NH_4 peaks in the WWTP effluent.

Alternative PC control

The alternative control operates the influent pumping stations and PCs based on the treatment capacity of the biological tanks, the influent flows and the available storage capacity in the individual catchments. It consists of different phases depending on the inflow conditions: 0 - DWF, 1 - start WWF, 2 - high WWF and 3 - low WWF. The capacity at which the WWTP is operated is different for each phase and can only (but not necessarily) reach its maximum in phase 2. An example for a strong, spatially uniform rain event is given in figure 2.

Key elements in the alternative control are: i) the number of operational PCs depends on the phase; during DWF only 1 PC is operated to reduce the storage of raw sewerage, ii) whenever possible, the influent of ES is prioritised over RZ; The functioning of ES and the WWTP influent correlate strongly as opposed to RZ and more idle storage is available in RZ, iii) the SST may only be filled in phases 1 and 2 and is only allowed to discharge in phase 2 when the combined sewer overflows in ES are prone to spill, and iv) the operation of the influent pumps is only influenced by introducing a maximum on the total influent from a catchment.

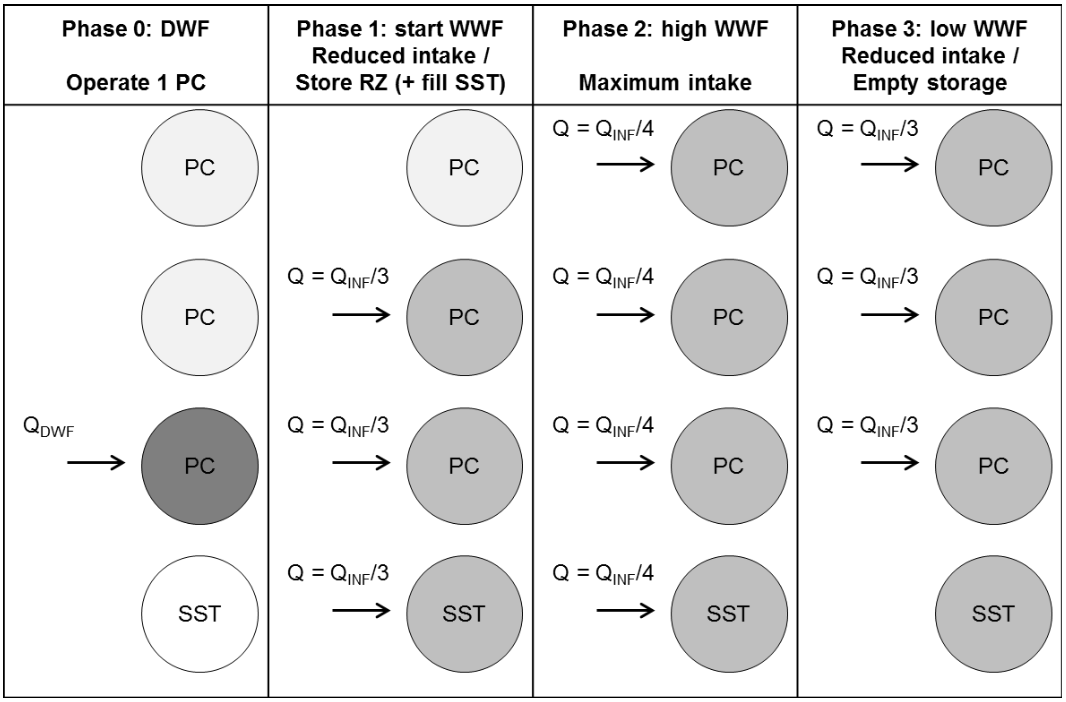

Figure 2. Operation of PCs and SST in the alternative PC control in case of a spatially uniform and strong rain event.

RESULTS

A Matlab model that uses historic measurements was built to determine the impact of the alternative control on the water levels in the influent chambers, the influent flows and the flows at the WWTP. Based on one year of measurements the control will reside in phases 0, 1, 2 and 3 for 75, 3, 6 and 17% of the time respectfully. Three quarters of the time the WWTP should be able to operate with only 1 PC. Practical tests have shown this will lead to an overall improvement in the WWTP operation from any perspective (treatment efficiency, energy consumption, maintenance effort, sludge removal, ...).

The alternative control was implemented in the WWTP SCADA system and tested from December 2015 until March 2016. During the test period several small and larger issues were encountered and dealt with. After the designed control was found to be unstable at high influent flows, it was simplified from 9 (sub)phases to the current 4 to reduce switching between phases. At the same time, better use is made of the original stable operation of the influent pumping station. Also the proposed control was found to at times contradict the influent pumps control to prevent blockage of the grates. As a side effect, several issues not related to the new control were found and reconsidered during the test period as the WWTP functioning has been scrutinised.

From halfway March 2016 onwards it has been operational. In the 1.5 months since, the control has resided in phases 0, 1, 2 and 3 for 88, 1, 2 and 9% of the time respectfully.

CONCLUSIONS AND FUTURE RESEARCH

A alternative control for the influent pumping station and primary settling tanks was successfully designed and implemented at the WWTP of Eindhoven. It aims at reducing NH_4 peaks in the

WWTP effluent by looking at the WWTP functioning including the contributing catchments. Model results and preliminary measurements show that the WWTP can be operated based on a reduced number of PCs for over 75% of the time, thereby reducing the amount of stored raw sewerage at the WWTP and reducing the loading of the activated sludge tanks.

Future research will focus the application of continuous quantity and quality monitoring data of the WWTP influent and effluent to quantify the effect of the alternative control on the WWTP functioning. This will include data analysis and modelling exercises.

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