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A STOCHASTIC SEWER MODEL TO PREDICT PIPE FLOWS AND POLLUTANT LOADS IN AN URBAN DRAINAGE SYSTEM

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Abstract

This work implemented a stochastic sewer model (SIMDEUM-WW) to forecast dry weather sewer flows and pollutant loading, from probabilistic household demand patterns based on information about inhabitants and appliance usage. The probabilistic outputs were fed into MIKE URBAN (DHI) for hydrodynamic and water quality simulations. The MIKE URBAN model consists of a 1D sewer network model. The model was validated against field measurement data and the results show that the SIMDEUM-WW can adequately calculate wastewater and pollutant loading. However, the SIMDEUM-WW was originally calibrated on households in the Netherlands such that errors were observed in the UK application. The uncertainties in actual flow and pollutant loading also contributed to the inaccuracy of modelling results.

Keywords
Flood model, stochastic modelling, urban drainage.

1 INTRODUCTION

Climate change and population growth has been responsible for placing a burden on water resource management, particularly in recent decades (1–3). Changes in urbanisation and land use has complicated this problem, as the natural hydrological cycle is disrupted by non-permeable surfaces. This leads to increased run off, and an upsurge in flood risk. Urban flood models play a crucial role in flood risk management, as they aid in the geospatial analysis of flood hazards. Contemporary flood management requires reliable numerical models to better understand the performance of drainage systems. Stochastic methods are important in urban drainage modelling as they introduce probability distributions, rather than unique values to modelling outcomes (4). Therefore, the stochastic modelling results could better reflect the possible scenarios than single deterministic modelling result. This could a more realistic modelling approach, as some have argued that drainage models should always have some element of probability due to their complexity (5).

This paper intends to validate a stochastic sewer model (SIMDEUM-WW) against a new data set (*E. coli,* suspended solids, total nitrogen, and total phosphorus) collected in a U.K catchment. Further validation of the model will include the comparison of spill volumes at a combined sewer overflow (CSO) in the downstream part of the catchment.

2 METHODS

2.1 Study location and data sets

The case study is situated in a small town called Sandford, the Poole Harbour region of the U.K. A small section of Sandford Town was chosen for the analysis, which included 500 households. Data were provided by the water utility company Wessex Water. Data included a sewer map and CSO monitoring data. The data contained pollutant loads of *E. coli,* suspended solids, total nitrogen, and total phosphorus. Hydraulic data included spill volumes and durations at the outflow. Figures 1 and Figure *2* shows the concentration measurements.

2.2 Hydraulic discharge

SIMDEUM was originally developed in the Netherlands as a water demand tool (6), though has since been developed and calibrated to simulate wastewater discharge based on household and appliance usage data, using Monte Carlo Simulations (7,8) Calibration took place in a Dutch case study (Prinseneiland). Input variables (household occupancy, home–presence, individual details of household water consumption and average household occupancy) were adjusted in the calibration procedure. Validation included reviewing model performance over an average week using the Nash–Sutcliffe efficiency (NSE), the root mean squared error (RMSE) and correlation coefficient (R2). Dry weather flow data was chosen at several points of the year (2 weeks from each season) to produce mean water use patterns of the catchment.

2.3 Wastewater

SIMDEUM-WW links water quality from the stochastic flow patterns. A variety of pollutants and water quality indicators can be modelled, including *E. coli*, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrogen (N), phosphorous (P) and suspended solids (SS). Appropriate inputs for nutrient values in SIMDEUM-WW were conducted in previous research (8).

2.4 Sewer model

MIKE URBAN (DHI) will simulate 1D sewer flow. Here, outputs from SIMDEUM-WW will be integrated into the 1D MIKE model. The sewer model is used to analyse the water movement within sewer systems that flow is confined by the drainage network and can only move along the pipes such that it is regarded as a 1D modelling practice. The storm event period was set for simulation period.

2.5 Water quality model

MIKE ECO Lab is an integrated module in the DHI software. The module is coupled to the Advection-Dispersion Modules of the hydrodynamic flow model, so that transport mechanisms based on advection-dispersion can be integrated in the MIKE ECO Lab simulation. *E. coli*, N, P and SS were simulated over the storm duration period.

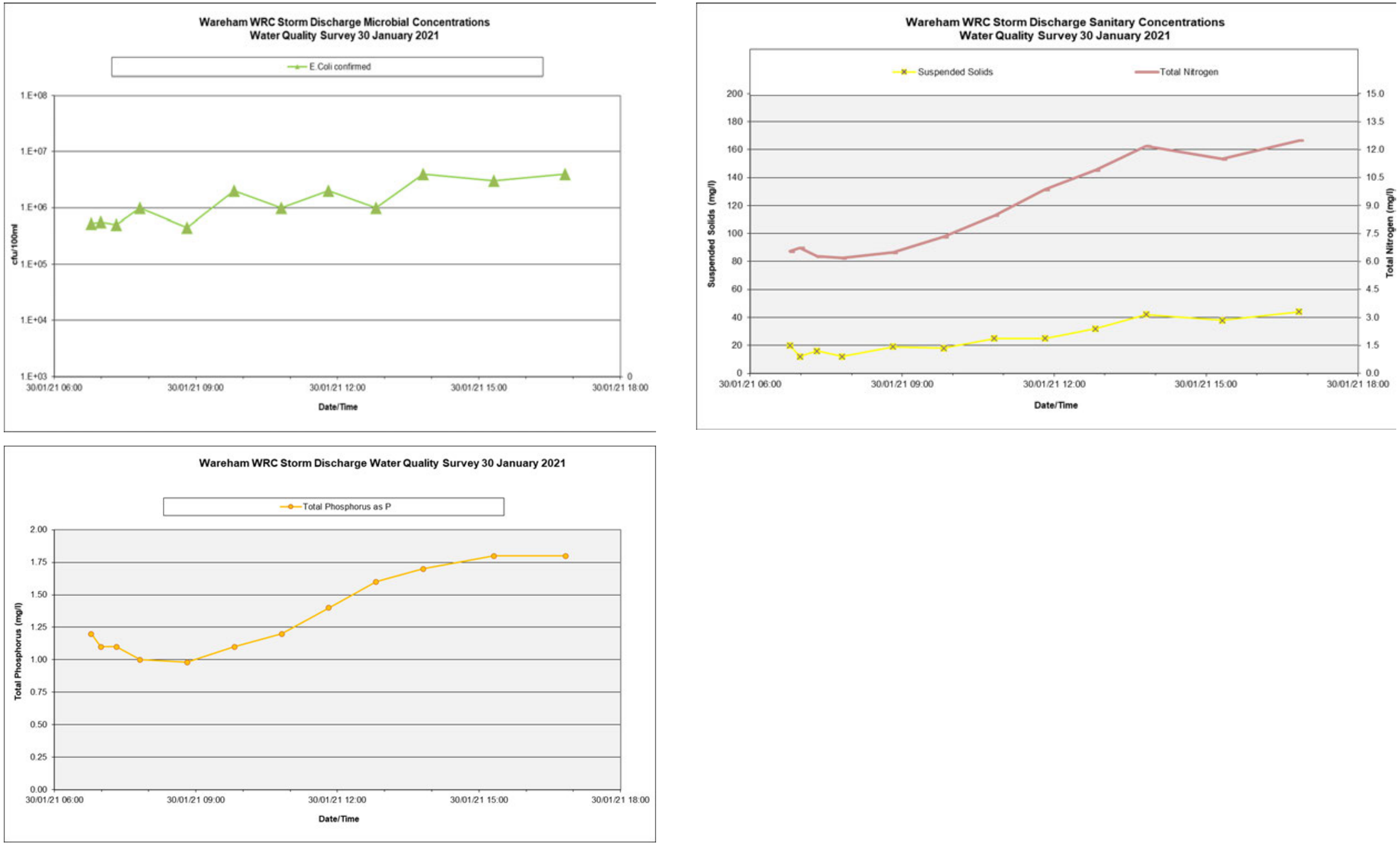

Figure 1: E. coli, suspended solids, total nitrogen, and total phosphorus data

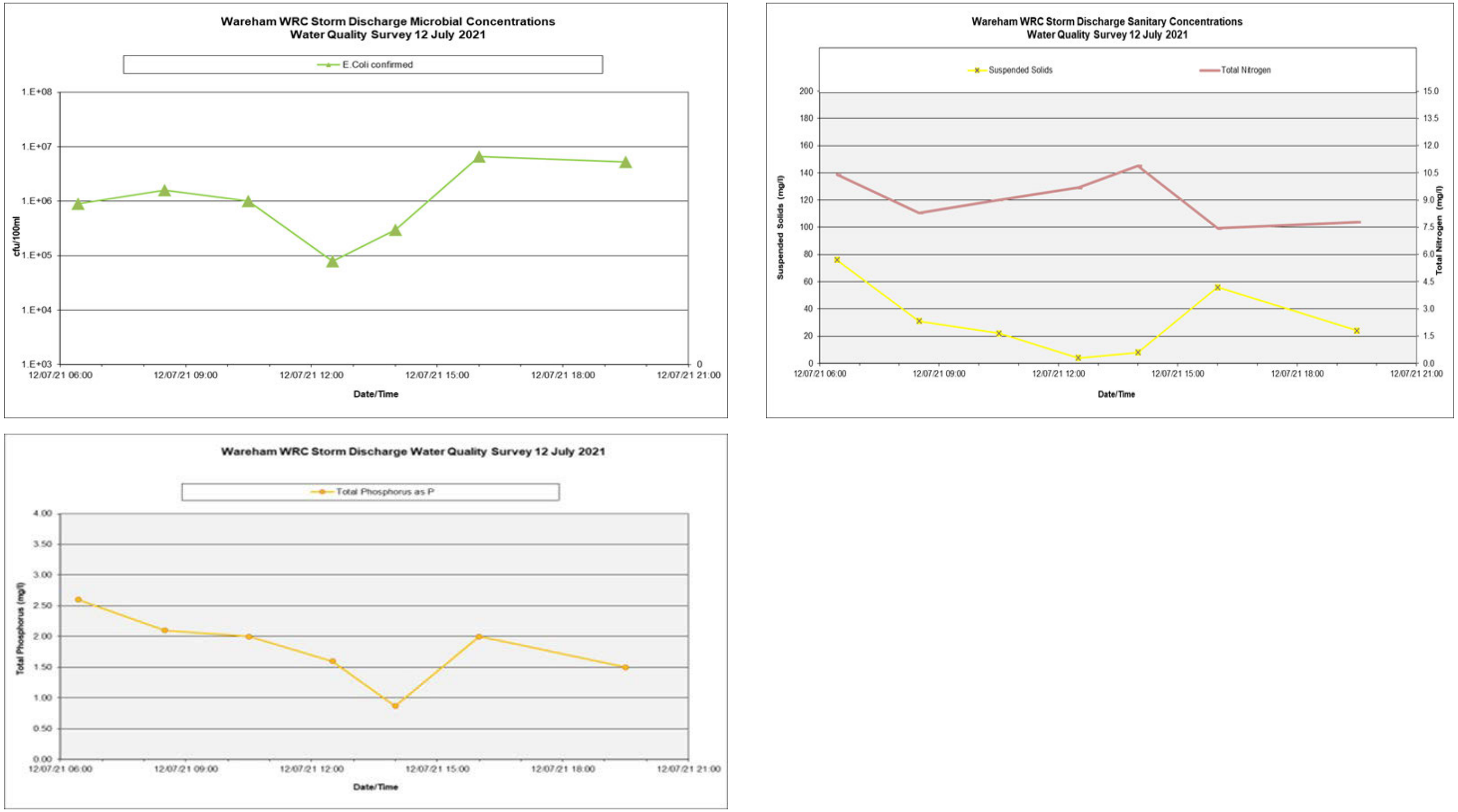

Figure 2: E. coli, suspended solids, total nitrogen, and total phosphorus data

3 RESULTS AND DISCUSSION

As this is ongoing work preliminary results will be discussed. It is predicted that the stochastic sewer model can properly calculate wastewater flows and pollutant loading. However, small errors exist due to SIMDEUM-WW being calibrated on households in the Netherlands. The water consumption patterns in the UK household are not the same as the Netherlands households, though water demands in both countries are similar. As drainage systems are complicated other errors may include flow and pollutant loading at the pipe outflow. Combined sewer systems are very complicated, so flows and pollutants from other parts of the system is likely.

4 CONCLUSIONS

It was predicted that the numerical model was able to replicate accurate hydraulic and wastewater discharges, validated against CSO monitoring data. Though small error was present due to the complexity of dual drainage systems and the fact SIMDEUM was calibrated in The Netherlands.

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