SEWEX MODELLING TOOL FOR CORROSION & ODOUR MANAGEMENT

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ABSTRACT

Sewer corrosion and odour problems are common worldwide costing water utilities hundreds of millions of dollars annually in sewer rehabilitation and odour mitigation actions.

In 2013, the University of Queensland's Advanced Water Management Centre (AWMC) completed a 5 year $20M Sewer Corrosion & Odour Research (SCORe) project. This project was supported by the Australian Research Council Industry Linkage Grant, nine Australia water utilities, six universities and one consulting company. The SCORe project generated innovative tools, including the SeweX modeling tool, for optimal management of corrosion and odour problems in sewers. Since then, the AWMC used the SeweX modeling tool to assist many water utilities to improve their corrosion and odour management effort.

This paper provides a description of the SeweX model and results of many real-life applications as case studies. These case studies include optimization of existing chemical dosing facility for corrosion and odour control, online process control of chemical dosing facility and integrated corrosion and odour management plan for a large wastewater system.

KEYWORDS

Sewer corrosion odour management, sulfide modeling, optimization

PRESENTER PROFILE

Prof. Zhiguo Yuan is the Director of AWMC, University of Queensland. He has published over 300 refereed journal papers and were recognized through national and international awards including the 2015 ATSE Clunies Award and 2017 ARC Australian Laureate Fellowship. He is a Fellow of the Australian Academy of Technological Sciences and Engineering.

1 SEWEX MODEL OVERVIEW

The SeweX model is a leading-edge simulation tool for predicting hydrogen sulfide and methane production in sewers as well as other water quality parameters related to various biotransformation processes occurring in the sewers.

The SeweX model has been developed from available literature and the results of over 10 years of extensive research led by the University of Queensland's Advanced Water

Management Centre (UQ AWMC) in collaboration many Australian water utilities including the SCORe project. The SeweX model incorporates the following in-sewer processes:

1. Convective transport of wastewater and air as applicable
2. Biological carbon transformations under aerobic, anoxic and anaerobic conditions
3. Biological sulfur transformations consisting of sulfate reduction, microbial oxidation of sulfide with oxygen and nitrate and also sulfur release from hydrolysis of organic sulfur compounds
4. Chemical oxidation of sulfide with oxygen
5. Chemical precipitation of sulfide and several other competing anions by metal ions
6. Gaseous transfer between the liquid and the gas phases (in gravity sewers)
7. Uptake of hydrogen sulfide in the headspace
8. Weak acid-base equilibrium chemistry for pH prediction

The effect of sewer flow velocity and wastewater temperature and pH on above in-sewer process are also incorporated in the model.

The SeweX model predicts the spatial and temporal changes of the following parameters in the sewer:

1. Hydrogen sulfide and methane concentrations both in liquid and gas phases
2. General wastewater composition including pH as a result of the biological, chemical and physical processes
3. Wastewater composition due to the implementation of a mitigation strategy (chemical dosing, ventilation etc.) for odour and/or corrosion problem
4. Estimate of concrete sewer corrosion rate

The input data required for the SeweX model are:

1. Layout of the sewer system showing connection of branches and trunk sewers, and locations of manholes, pump stations and other sewer structures
2. Sewer pipe length, diameter and slope as appropriate
3. Hydraulic data of the sewer system: The model in its current form does not have the capability of modeling the hydraulics, and hence the required hydraulic data needs to be imported from other hydraulic models. The model requires dynamic data in terms of flow rate, water depth and flow velocity, and the SeweX model calculates other hydraulic parameters required by the model based on the input data
4. Wastewater characteristics: Time series of the concentrations of a number of water quality parameters
5. Temperature and humidity data
6. Chemical dosing rates where chemicals are added for sulfide control
7. Ventilation data

A conceptual SeweX modelling framework is presented in Figure 1. The model is currently built on the MATLAB®/SIMULINK® platform.

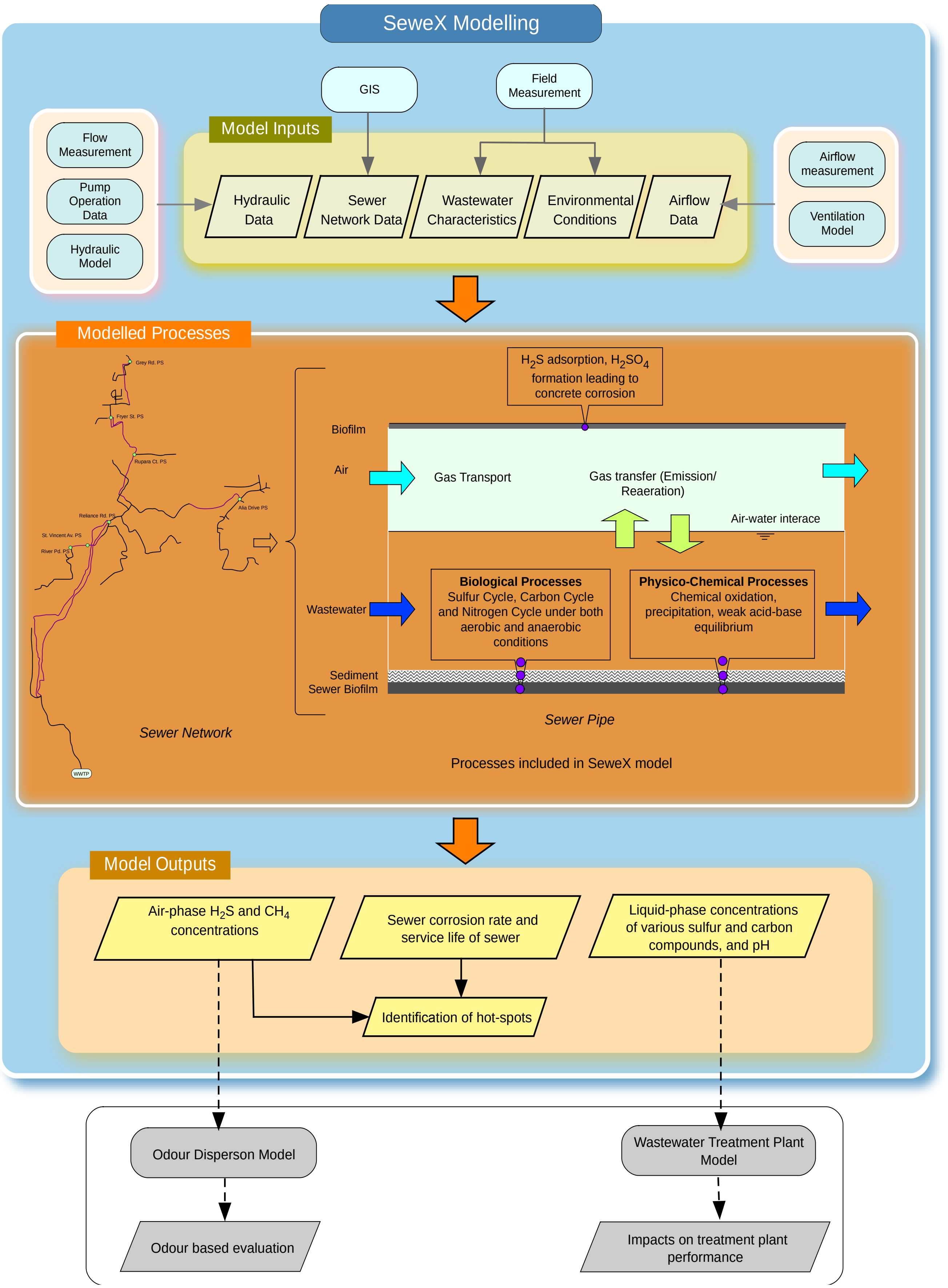

Figure 1: Conceptual SeweX Modelling Framework including Its Possible Integration with Other Models

2 SEWEX MODEL APPLICATIONS

The SeweX model has been used by many water utilities to:

- develop strategy for management of sewer odour and corrosion
- develop and evaluate options for sewer odour and corrosion control
- select optimal chemical, dosing location and doing rate for odour and corrosion control
- optimize the existing chemical dosing facility

Sydney Water, a partner of the SCORe project, used the SeweX model as a planning tool to develop a Corrosion & Odour Management Strategy for all of its sewerage systems. Sydney Water's staff presented case studies of this work at various conferences and symposium in the last few years (Vorreiter et al., 2015; Wang et al., 2013a, 2013b, Nguyen et al., 2010). One of the case studies presented by Sydney Water (Vorreiter et al., 2015) showed an estimated saving of more than $ 80M in 30-year net present cost (NPC) of corrosion and odour management between the preferred option and the existing mitigation action for its North Head sewerage system.

SA Water engaged CH2M Hill and UQ AWMC (all are partners of the SCORe project) to develop and evaluate options for the management of odour and corrosion of its various wastewater systems. This case study presented by Cesca et al., 2015, showed how the SeweX model was used to evaluate the options including determining optimal chemical dosing rate and select the preferred option for the SA Water Ethelton system.

One of the tools developed by the SCORe project is the Auto Regressive Moving Average (ARMA) algorithm that predicts the future dynamic wastewater flow rate using current flow data from online instrument. This can be used with SeweX model to develop a feed forward control of chemical dosing system to achieve optimal hydrogen sulphide control. Sydney Water used this combined model to develop and implement a SCADA chemical dosing control to achieve 25% chemical cost saving for it Bellambi wastewater system (Gonzalez et al., 2015).

3 LATEST CASE STUDY

The SeweX model has been applied to a number of sewer systems in South East Queensland for developing odour and corrosion management plan for a new development, developing appropriate chemical dosing strategies for existing sewer system, optimizing the existing chemical dosing, and developing odour and corrosion management plan for a large catchment. Details of a typical study carried out for the chemical dosing optimization is presented in this section.

Water utilities are investing large sum of money in chemical dosing to manage odour and corrosion issues.The dosing regime is normally decided based on the local experience. In many cases, either the intended results are not achieved or, are achieved at the expense of chemical over-dosing. The SeweX model has been employed to test various dosing strategies and develop an optimized strategy taking into consideration the intended sulfide control at key locations of the sewer, and minimizing wastage of the dosed chemical. One of such study was recently conducted for Elanora sewer network in Gold Coast, Australia. The sewer network consists of 75 pump stations, 53 km rising mains serving an equivalent population of 83,000 as of 2016. A layout map of the sewer system is shown in Figure 2. The system has experienced odour issues at a number of locations including sewage treatment plant (STP) inlet, and chemical dosing at two locations along the sewer main and odour control unit at the STP inlet have been employed for mitigation of the problem.

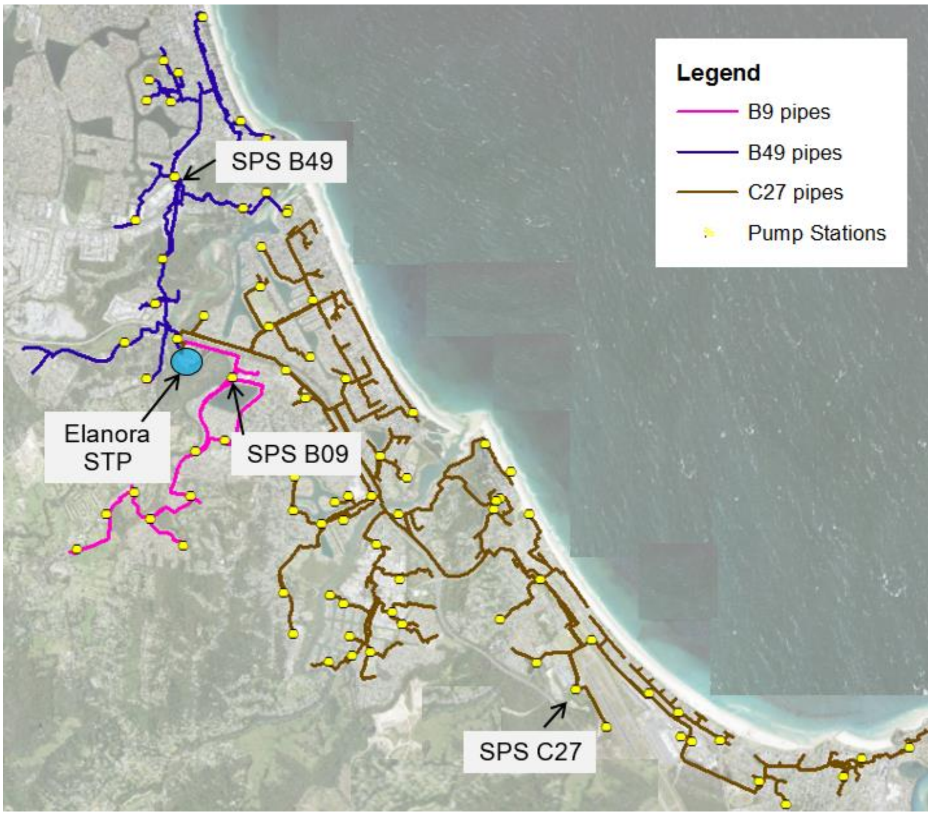

Figure 2: Elanora Network Map showing the pump stations entering the Elanora STP

The sewer system posed significant challenges in terms of chemical dosing mainly because of the split of trunk sewer into two branches downstream of a dosing location and the presence of a large number of injector pump stations along the parallel trunk mains with significant flows. The intermittent nature of the sewer flow due to intermittent pump operation further added to these challenges.

The system is currently receiving magnesium hydroxide liquid (MHL) dosed at two locations. The dosing is intermittent but at a constant rate at both the locations. The model based study identified shortcomings of the current dosing strategy and investigated a number of other options for dosing optimization. The options included continuous dosing at a reduced rate and automated pH based dosing control. Different pH set points for pH based control and different dosing rates for constant dosing were investigated.

Among all the investigated dosing scenarios, 24 hour continuous dosing at the upstream dosing location and pH based controlled dosing at the downstream location showed the most effective pH control with lowest amount of chemical use. Figure 3 presents a comparison of pH at three locations along the network for current dosing case with the continuous dosing at a reduced at the first dosing location and pH based control option for the second location.

The downstream section of pump station C27 is a complex rising main with eight pump stations injecting into the common rising main. This presents challenges to chemical dosing as it would be difficult to maintain high pH in the sewage throughout the day. By having an automated online dosing control based on pH and flow measurements, the impacts of flow as well as the pH variation are minimized thereby preventing the both possible over-dosing and under-dosing of the chemical. The simulation results show 20% saving of chemicals without compromising the pH levels in sewer pipes along the network while eliminating the high peaks of H_2S concentration resulting from the current dosing at the STP inlet works.

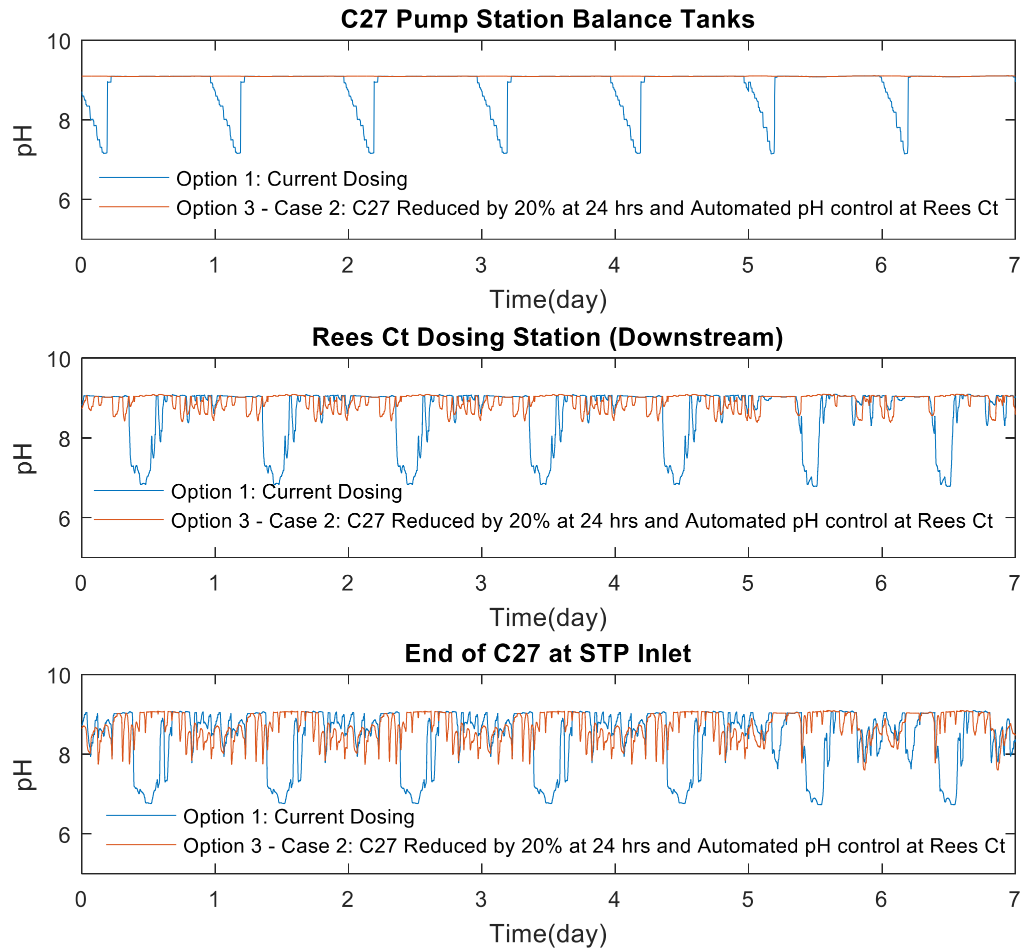

Figure 3: Comparison of pH for two simulation cases (1) current dosing; and (2) continuous MHL dosing with 20% reduction in dosage and automated pH control at the second location

4 CONCLUSIONS

The SeweX model has been demonstrated to provide valuable support to planning as well optimization of the strategies for odour and corrosion control in sewers. The modelling tool helps identification of potential hotspots, quantitative assessment of the likely extent of the odour and corrosion problems for the current flow as well as the future flow scenarios, and development of appropriate strategies for their control. The model can be effectively used to evaluate the existing chemical dosing scenario for a complex sewer system, and make quantitative assessments of a number of different options guiding the utilities in making selection of an effective and economical option as demonstrated in this paper.

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