

Intermittent Discharges and the Water Framework Directive – A UPM based approach for River Reach Assessment and Establishing the Significance of CSOs to WFD Compliance

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1. Introduction

The Water Framework Directive (WFD) requires waterbodies to achieve ‘Good’ ecological status by 2027, through the delivery of a number of objectives regarding flow and water quality (EU, 2016). Intermittent discharges have the potential to influence compliance with the WFD, as they are a source of polluting materials. The significance of Combined Sewer Overflows (CSOs) to overall waterbody quality will be dependent on a number of factors, but in essence by the relative importance of the CSO (or CSOs) in comparison with other sources, and with the quality of the upstream water entering the river reach. Assuming that a CSO is significant to quality on the basis of its position, frequency, or magnitude of operation may not, necessarily deliver a solution that improves water quality, or WFD status. This is especially true in AMP6, where CSOs have potentially received a great deal of attention and improvement in previous investment periods. Assuming CSOs have a significant role to play, without confirming this, runs the risk of investment with little benefit, and missing the opportunity to target sources which will have a material impact on water quality and WFD status.

WFD status is generally driven by the interaction of a number of sources, and so a robust understanding of sources of impact, and therefore of solutions for improvement, requires an understanding of these sources and their interactions. Approaches involving focusing on one type, or location, of source are not necessarily going to deliver the best understanding, and therefore provide the information to deliver the most effective management strategy to improve WFD status.

This paper describes an applied method which has resulted in a robust, targeted assessment strategy, using a tiered-complexity approach to modelling tools and analysis, whilst delivering the over-arching principles of Urban Pollution Management (UPM), and accounting for new developments such as ‘21st century drainage’ or Drain and Wastewater Management Planning (DWMP). Assessments are designed to deliver validated, detailed understanding of water quality impacts which are delivered at a level of complexity fit for the individual river reach. In summary:

- Delivering an understanding of impacts to WFD compliance and meeting ‘Good’ ecological status
- Delivering an understanding of the significance and proportional impact of all identified sources, intermittent, continuous, diffuse, etc.

- Level of complexity suitable for the given river reach
- Modelling programme supported by comprehensive data collection
- Methodology and approach agreed with EA
- Effective integration of network and environmental modelling to maximize benefits of studies

The WFD standards are applied according to the various guidance and policy which provides performance criteria for determinands under a variety of river types, altitudes, etc. Although not covered by this paper, in short for intermittent discharges, the UPM identifies two types of standard to which the receiving water quality should be assessed. These are outlined in the UKTAG document 'River Basins Management (2015-21)'.

The two types of standards are percentile standards and Fundamental Intermittent Standards (FIS) (UKTag, 2013). The percentile standards for WFD assessments are a combination of 99%ile and 90%ile values. Although the 99%ile thresholds are generally more important when reviewing intermittent discharges the 90%ile threshold should still be assessed to give further understanding to the impact of all assets to the river reach. Our modelling approach provides output for all of the standards, including FIS. This is particularly important as all sources are being assessed, and so the potential for sources to impact 90 percentile (as well as 99 percentile) standards can be appraised, thus increasing the value and breadth of the study. It means that potentially the outputs can be compared to the high level SAGIS or SIMCAT outputs used to generate investment plans for continuous sources.

2. Approach

As we move towards 2027 the EU WFD directive for all rivers to reach a 'good' status becomes more prevalent. Severn Trent Water have outlined in AMP6 that a number of river reach assessments could be undertaken to help understand the impact of Severn Trent assets on the wider river reach complying with at least a 'good' status. A total of 32 river reaches across the region are being investigated, with approximately 400 CSOs being assessed, as well as continuous and diffuse sources being appraised in order to understand overall impact. An initial Scoping Phase was undertaken, both to confirm that the Reaches would benefit from investigation, but also to assess existing data and characterise water quality issues, and to establish the most beneficial / most valuable modelling approach. The Scoping Phase was critical to the overall approach in that it defined objectives and served to establish an agreed method of assessment.

A three level approach to undertaking water quality assessments was defined from the Scoping Phase. The three levels are Simple, Detailed and Complex.

Simple approach

- UPM approach in accordance with current industry practice
- Monte-Carlo approach to mixing statistically derived river flows / loadings with sewer / surface water model predicted flows (with fixed WQ loading on the spill flows)
- Results will be reported against FIS and percentile standards (99%ile and 90%ile)

Detailed approach

- An integrated hydrological modelling system, which uses an approach based on the reFEH method
- A diffusive wave approach to simulate the movement of water
- Includes dispersion and simulation of conservative and first order decay parameters and interactions between water quality parameters
- Results will be reported against FIS and percentile standards (99%ile and 90%ile)

Complex approach

- These models provide an array of computational methods for steady and unsteady flow in branched and looped channel networks, and flood plains.
- These models provide sophisticated water quality approaches. The process functions can consist of mathematical functions, built-in functions, numbers, forcings, constants, and state variables.
- Results will be reported against FIS and percentile standards (99%ile and 90%ile)
- MIKE11 has been used

It is important to note that these assessments are undertaken on a river reach level therefore all overflows, surface water outfalls and STW storm and final effluent flows within the river reach should be taken into consideration. Boundary Conditions for the modelled section of river are therefore key factors as these consider any impact from upstream ancillaries. To this end the approach requires the use of:

- Network models for accurate representation of water company asset performance
- Environmental (river and river catchment) models for the accurate representation of river flows and water quality processes
- Effective analysis of model data to deliver robust predictions of performance under the various WFD performance criteria (water quality)
- Field data for both model input values, and datasets for validation/verification processes

3. SMP Interaction

These Severn Trents WFD assessments are being undertaken within the Sewerage Management Planning (SMP) framework meaning that the network models have the potential to be built for WFD and SMP assessments at the same time. This also means that the WFD outputs are defined at the outset ready to link into the SMP process and catchment strategy. During the scoping stage stakeholder engagement was undertaken with internal Severn Trent Service Delivery and Asset Creation teams to understand not just the CSO risks but to understand the wider catchment risks and what schemes are under investigation within the network. Due to this stakeholder engagement, where a promoted flooding scheme aligns geographically with the WFD area the survey investigations and network model enhancement has been undertaken together. In some cases, the Asset Creation team taking the lead on the model upgrades and in some the WFD team taking the lead.

Within the 32 river reaches a total of 33 SMP models have been reviewed and are in the process of survey and model upgrades being undertaken to increase confidence in the model outputs. This includes over 1,000 flow monitors in the sewer and surface water system along with manhole,

ancillary, CAS, river cross sections. Additionally nearing 100 long term river sites are being monitored to enhance understanding on the determinands (Ammonia, BOD, etc.) and to calibrate the river models.

This joint approach of investigations, model upgrades and scheme development has meant Severn Trent have the tools in place to understand the catchment strategies development over AMP6 and AMP7 and giving efficiencies between the SMP, WFD and Asset Creation investigations occurring in the same catchment.

4. Outputs and Benefits

The modelling approach undertaken delivers a high resolution study which differentiates between the impact of intermittent discharges, continuous treated discharges and other sources, such as diffuse. In providing detailed outputs against a number of thresholds, the key sources are identified and their impact understood, which allows the prioritisation of targets which will yield the most beneficial, cost-effective interventions to improve water quality status in the river reaches. As a result, Severn Trent have a much greater understanding of their impact on WFD (across all tested thresholds and standards), which allows them to work more effectively with the Environment Agency in delivering asset investments which will improve river quality. In summary:

- The initial requirement of determining the significance of intermittent discharges will be achieved
- The associated impacts of other sources, both in absolute terms and relative to the intermittent discharges, will be determined
- A more complete understanding of water quality, and the delivery of WFD aspirations will be achieved
- A better understanding of beneficial investments or interventions
- A means to test potential interventions within the rivers and SMP models
- A source of valuable information regarding impact (consequence) of asset operation will be delivered, improving future operational asset management, and investment planning

A set of tools and data have been generated which have ongoing and developmental benefit. The data generated by the study can be used for a number of operational or investment planning approaches:

- At an early stage, the modelling method (and early data generated) was used to develop a PR19 prioritisation tool, which delivered a short list of investments (based on the probability of a number of assets requiring investment)
- The final output of the study can be used for various risk assessment and contingency tools, including CSO risk assessment approaches, using methods similar to Severn Trent Waters flood risk tool (see paper, UDG Autumn conference, 2017). Severn Trent gain an approach which is consistent across both flooding and water quality planning and management.

The datasets, and the fact that the tools will remain embedded in the SMP data, means they can be used for re-assessments if new data is available (for example should sewer network operations change, or to assess climate change), meaning that the WFD assessment for intermittent discharges will remain a highly valuable assessment for the foreseeable future.

5. Next Steps

The study as it stands is due to be delivered in Spring 2019 in its entirety. The models and assessment are in various stages across the 32 reaches, as we are in the midst of the data collection period at present.

Next phases will be to update and verify sewerage network models and to calibrate and validate water quality model performance. Data can then be generated to undertake full water quality analysis for each run, outputting predicted compliance, and delivering source apportionment breakdowns to determine critical sources.

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