

Environment Agency Review of Sewer Modelling

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Introduction

The Agency must ensure the AMP3 intermittents program delivers the expected environmental outcomes. The reliability of sewer models used in scheme design will be a key factor in this delivery. The Agency must therefore ensure the uncertainties inherent in models are within acceptable limits.

Agency strategy to achieve this includes:

- Encouraging improvements in model build/verification QA procedures which many companies and consultants are already developing.
- Undertaking fitness for purpose audits.
- Issuing appropriate consents

Subsequently the Agency intends to use various post scheme appraisal techniques to review the reliability of sewer models, UPM modelling tools/techniques, and aesthetic solutions, and to assess whether the expected environmental outcomes are being delivered.

This paper is to update and report on the above and will concentrate on the sewer model audits.

Background

On the 24 November 1999, the Secretary of State for the Environment announced the extent of the environmental investment programme (AMP3) to be completed by the water companies by March 2005. Overall, in England and Wales, almost 3500 unsatisfactory combined sewer overflows (CSOs) will be improved and approximately 1,000 other intermittent discharges including overflows at pumping stations, storm tanks and at the sewage treatment works.

The intermittent programmes for each Company vary in scale and complexity. The percentage of total outputs in each region as follows:

- North East 31%
- North West 19%
- Wales 17%
- South West 17%
- Midlands 7%
- Southern 4%
- Anglian 3%
- Thames 2%

Delivery of schemes accelerates throughout the 5 year period with an average of nearly 18 per week.

The Agency has been instructed by DEFRA to implement a consent review programme in line with the requirements and completion dates set out in the AMP3 programme. Over 4000 intermittent discharge consents are included in that review.

The completion dates are in line with the following priorities identified by the Government and the Agency:

- Achievement of EC mandatory standards related to
- Urban Wastewater Treatment Directive
- Bathing Waters Directive
- Shellfish Waters Directive
- Freshwater Fish Directive
- Achievement of Guideline standards related to Bathing Waters Directive and Shellfish Waters Directive
- Achievement of river water quality improvement
- Address aesthetic problems and minimise release of persistent substances and thereby minimise public complaints

In delivering the AMP3 the Agency aims to review scheme proposals to ensure the scheme meets Agency policy, issue appropriate consents on time, and then to monitor achievement of environmental outcomes.

Reason for Agency Audits

In consenting intermittent discharges (IDs) the Agency generally consents pass forward flow storage and screening, ie process, rather than the required discharge regime or emission standard. Where modelling predicts an acceptable discharge regime the consent would reflect the minimum pass forward flow during spillage and the proposed/modelled storage volume. Inaccurate modelling therefore implies a possible risk that the CSO might not meet its design objective ie the required discharge regime, whilst still complying with its consent.

The Agency would be culpable if it did not ensure the uncertainty inherent in the modelling was within acceptable limits of tolerance. An alternative to this might be to somehow transfer that risk to the discharger. Even if the risk was transferred to the discharger it is clearly in the interest of both parties to get it right first time. The Agency therefore aims to promote a balanced approach to, where possible, minimise risks by agreeing modelling methods and outputs, and to transfer any outstanding significant risk back on to the discharger by agreements and by issuing appropriate consents.

Model Purpose

In general for the AMP3 unsatisfactory ID programme the models purpose/s are simply the IDs that need to be predicted. Other purposes may exist such as to predict flows at a point in the system where storage, or a pumping station, is to be constructed, or to predict the flow in a surface water system which requires verification in order to consider its diluting effect on spills. The clearer the understanding of the sewer models purpose/s the more efficiently its fitness for purpose can be assessed. This is important to avoid unnecessary delay in the delivery of AMP3, and maximise the value of the audit resource. For example if we could say; a purpose of the model is to predict spills from the existing CSO x, and then if necessary improve its spill frequency to 10 spills/annum on average using off-line storage adjacent to the CSO, - then we could limit the scope of the audit to those features which affect the models suitability for that purpose. Similarly if in an adjacent sub-catchment a CSO is only identified for aesthetic improvements this

would allow a reduced level of audit in that location. Both the discharger and the Agency input into defining the purposes of the model. In some cases it may be possible to take a view on the type and location of likely improvements soon after the needs are identified from the predictions of the existing sewer system model.

Agency Fitness for Purpose Assessments (Audits)

The need to assess fitness for purpose raised the question as to how the Agency could most effectively determine this. The reliability of a sewer model depends on many aspects of its construction. These include; the accuracy of the data, the sensitivity of the outputs to any inaccuracies in the data, the suitability and reliability of the algorithms in the software, the effects of any model simplification, and whether or not the boundaries, boundary conditions, and processes have been correctly represented. To check all the above would involve repeating the modelling process and is not a practical or desirable option.

Verification and/or calibration of sewer models is carried out using various data including data from flow surveys, flow and quality surveys, historic flow data, and from flooding records. In addition the WaPUG Code of Practice (WaPUG CoP) sets out criteria for the acceptable degree of verification at individual monitor locations. One way to assess the models fitness for purpose eg its ability to reliably predict the performance of various ID`s, might be to simply check whether flows in the region of those IDs are accurately verified in accordance with the WaPUG CoP criteria. This would mean treating the model itself as a `black box`. Unfortunately strict achievement of the WaPUG criteria is difficult to obtain and a strict audit comparison against those criteria would run the risk of rejecting many suitable models. Also if the characteristics of the rainfall used to verify the model differ significantly from the rainfall used when designing the improvements, then the `black box` may not give reliable predictions outside the range of events used for the calibration/verification.

The Agency has therefore produced an audit scope which involves taking an overview of the model data, construction, and verification, but which also looks in detail at the accuracy and verification of the model in the vicinity of the ID`s and other locations where it is important that the model predictions are reliable. The WaPUG CoP as well as the WaPUG user notes set out the appropriate levels of data collection, model detail, and standards of good modelling practice, against which the suitability of the models overall construction and verification are to be judged. With respect to each specific individual purpose of the model the audit considers whether the results of the assessment of model data, modelling methodologies, model accuracy, and the model verification, are sufficient in combination to confirm the model is fit for that purpose with or without caveats.

Where the flow verification data alone is inadequate to confirm the models fitness for purpose/s at these key locations checks on the models construction may add confidence to the model predictions. For example; if inflows to a CSO are verified but continuation flows were poorly recorded, then the accuracy with which the CSO structure is represented in the model may add to confidence in the reliability of predicted spills.

Where significant uncertainty remains the audit may indicate confidence limits, or where necessary recommend sensitivity analysis in order to determine confidence limits.

Where the audit does not conclude the model is unconditionally fit for a specific individual purpose it wherever possible recommend ways it can be readily improved on so as to be fit for purpose and/or ways the model can be used to produce a safe design.

The audit would only concludes a model is unfit for a specific individual purpose where the above can not be done, and major survey work or modelling work would be necessary before it could be used for that specific purpose.

The Agency has obtained regional agreements with the companies on the level of data necessary to meet the above audit scope. Typically this includes:

- Model build and verification reports.
- Verified model and associated files
- Plans showing the sewer network, the model network and the exact location in the sewer system of the flow monitors and the raingauge locations.
- Flow survey reports including full time series of data,
- Ancillary data
- Contributing area data.

The audits involve a lot of information being transferred between the companies the Agency and our consultants. Agreements with the companies to transfer data and reports in electronic format, on CDs, has helped this process.

Audit scopes vary depending on the purposes of the model taking account of the various investment drivers. A generic audit scope document has been produced which Agency staff complete to include the model purpose before passing the reports to the selected auditor.

The generic audit scope document details a 2 stage audit:

Stage 1 involves checking that the documentation provided is sufficient to carry out the audit. Where the documentation is insufficient this may result in a further information request.

Stage 2 involves carrying out the audit as to the defined level and producing recommendations on the use of the model for the proposed purpose.

A 3rd stage will only be necessary if the auditor and the Agency can not draw sufficient conclusions from the initial 2nd stage audit. This may include a request for further data.

Agency strategy for sewer model audits

Having designed an audit there remained the question of how much sewer model auditing does the Agency intend to carry out in AMP3 given finite funding and limited resource. The options included either:

- Audit all models used in support of consent applications.
- Audit a random sample of models
- Prioritise audits based on risk and availability of funds.
- Carry out a very basic audit on all models.

A strategy for sewer model audits was therefore developed as follows:

Short term:

- Ensure schemes proposed are designed using models that are either reliable, conservative, or used in a manner so as to provide an environmentally safe design. Audits have generally not been targeted at aesthetic schemes but to schemes where significant storage may be necessary.
- Avoid delaying AMP3 delivery by collaborative programming of the audits and their timely completion using the Agency framework contracts. The use of consultant on Agency framework contracts has helped streamline the audit process but capacity restrictions in sewer modelling are evident in the industry.
- Require auditors to provide a way forward where possible rather than reporting simply a pass or fail result.

Medium term:

- Summarise findings from first batch of fitness for purpose assessments and assess any risks to the effectiveness of AMP3 UID programme.
- Report the findings so that the Agency and can make a reasoned assessment of the resource allocation appropriate for this work for the remainder of the AMP3 period.

Long Term:

- Promote as best practice that models used in support of consent applications have undergone fitness for purpose assessments prior to their submission to the Agency, and agree the specification of such assessments.
- Agency to audit the findings.
- Where the conclusions of the fitness for purpose assessment are adverse the Agency would look to transfer risk of failing to meet the design objective on to the Company
- Develop a risk based approach to assessing and consenting discharges.

Company QA Procedures

Some companies already commission their own audits on sewer models before using them to identify needs and develop solutions whilst others carry out a level of quality control. The Agency strongly supports this trend. Company commissioned audits are generally carried out by modellers that are independent from the original modelling team. The audit scope will probably differ from the Agency audit scope but there may be large areas of overlap. Where this is the case and the audit finds the modelled feature to be satisfactory the Agency gives full credit to that finding and curtails the Agency audit accordingly. In the interest of efficiency the Agency would hope such audits move rapidly towards a situation where the Company conducted audits overlap entirely with the Agency's. This would reduce delays and re-work associated with adverse audit findings to an absolute minimum. The Agency intends to promote as best practice the need for models to be subjected to an independent fitness for purpose

assessments before they are submitted in support of a consent application. The role of the Agency would be to audit that process and ensure that the specification of the audits was appropriate for the model purpose.

Audit Findings

The first batch of audits have been reviewed in order to assess the risk to AMP 3 delivery and to inform future resource allocation to such work, and to hopefully feed back into future modelling practice. The findings presented are based on 20 of the audits carried out for the Agency on sewer model from across England and Wales. They are summarised below in terms of their general issues highlighted regularly, and in terms of their overall outcomes.

General Issues

Model Construction:

- Confusion over model purpose and the scope of the study.
- Use of free outfalls where inlet works interacts with upstream overflows
- Poor modelling/understanding of inlet works
- Impermeable areas surveys are often omitted for catchments partially separately
- Poor or absence of modelling of dual manholes or failure to model interaction of surface water system

Model Verification

- Use of inappropriate run off equation
- Poor coverage of flow monitors in vicinity of CSOs, particularly those requiring improvement.
- Questionable use of silt and roughness to achieve a fit.
- Too few rain gauges and no calibration checks where data suspect.
- Failing to make use of all information from flow survey where monitor failures occur for selected events.
- Historic verification poorly carried out, often considering only DG5 property flooding.
- Poor accounting for boundary conditions with water courses.
- Surface water systems poorly verified where reliable predictions required to assess dilution of CSO spills in receiving water.
- Varying parameters beyond what is considered reasonable without evidence to justify.

Provision of Data for audit

- Poor quality of plans of sewer system
- Confusion over appropriate model
- Documentation of model build and verification often poor and too basic.
- Provision of ancillary survey data inadequate
- On the positive side the use of more than 3 storms for verification is a welcome trend and supported by the WaPUG Code of Practice

Summary of Audit Outcomes

For the purpose of this summary the reliability of the model predictions for each UID reviewed has been categorised into one of the following:

- **Reliable:** Model predictions are within acceptable limits or conservative.
- **Uncertain:** Reliability of model predictions could not be confirmed from available data.
- **Unreliable:** Model predictions are outside acceptable limits ie under predicting impact

The 20 audits included a total of 166 UIDs and the outcome was as follows:

- **Reliable:** 34%
- **Uncertain:** 34%
- **Unreliable:** 32%

Options following audit outcomes

Where the audit concludes the predictions are reliable the model can be used to design scheme and a consent can be issued as normal.

Where the model predictions are unreliable but the inaccuracy can be quantified then the options include:

- Require a precautionary design.
- Calibrate the model to the data where reliable data is obtained.
- Limit the use of the model to those purposes it is fit for. Give instructions for using the model so as to design a safe scheme.
- Request reworking of the data, the model build or the verification as appropriate.

Where there is uncertainty in the model predictions that can not be quantified then the options might be to:

- Carry out sensitivity analysis on the uncertain parameters and design a scheme which provides an acceptable level of confidence of meeting its objectives.
- Allow the model to be used for design, require monitoring of spills, and transfer the risk of failure to the company.
- Reject the model.

Future Audits

Meanwhile the Agency will decide the scale and scope of its ongoing audit in the light of the above findings.

The assessment of the validity of the sewer model verification is only one factor in assessing the suitability of a scheme proposal. Errors can also result from the way the model is used to develop a solution and future audit work will aim to cover this element of the process. The Agency also has established a partnership approach with the companies for the remainder of the UPM modelling procedures and this will be continued and strengthened as AMP 3 progresses.

Post Scheme Appraisal:

In addition to the Agency is to carry out post scheme appraisal to assess the overall benefit of the AMP 3 programme in terms of the environmental outcomes. This will be carried out within the next 2 years. It is intended to assess the success of the full range of AMP3 quality investment drivers.