MOSQITO - The Royton Experience

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Introduction

MOSQITO is the water quality model, linked to WALLRUS, for modelling the behaviour of sediments and pollutants in separate and combined sewer systems. It produces storm event loadings and discharge pollutographs for suspended solids, BOD, COD, and ammonia.

MOSQITO has been tested under a joint programme devised by HR and WRc, to determine its performance in terms of numerical stability, conservation of mass, and goodness of fit with recorded data. Its sensitivity to variation in the input data was also investigated.

The testing programme was successful: MOSQITO conserves mass, is generally stable, and produces sensible reactions to changes in input data. The next stage in the development of the model is its use in field trials, and this work is being carried out under the Sewerage Management Planning club contract set up by WRc in 1989. The SMP club also includes the use of river and STW models, but this paper is concerned only with MOSQITO. Five water companies put forward projects for the SMP club, and work has begun in several areas including Royton, in North West Water's area; where data have been collected for using MOSQITO.

The first half of this paper describes data requirements and the procedure for construction and verification of a MOSQITO model. The second half describes how this has been put into practice in Royton, with emphasis on the data collection programme.

MOSQITO data requirements

MOSQITO requires data for input and for verification. Input data describe flows into the system and the initial state of the system. Input data include dry weather flows and quality at the top of the system, industrial flows and quality, characteristics of sediments on the catchment surface and in pipes, and the depths of consolidated sediment in the pipes.

Verification data are made up of data on flows and quality for dry weather periods and storm events, collected at strategic points in the system in much the same way as flow data for WALLRUS verification.

Because of the high cost of data collection, particularly laboratory analysis, a set of standard input values have been suggested for use with MOSQITO. The standard values are averages derived from a limited data set, and should be used with caution. As more data are collected by users the standard values will be improved.

Construction of a MOSQITO model

A MOSQITO model is built on top of a verified WALLRUS model. The best way to construct the MOSQITO model is to start with standard values in all the input files, and replace them with measured data during verification. This avoids the situation where all the input data are used at once and the model predictions do not agree with the verification data. It also helps the user to understand the model, as the effects of changing parameters one at a time are apparent during verification.

Verification

The verification procedure is structured so that standard values used in the initial construction are replaced in stages. Once a standard value is replaced with a data value, it becomes fixed and the situation where several parameters are being adjusted simultaneously is thus avoided.

It is assumed that the underlying WALLRUS model is verified and that all the MOSQITO verification storms give good fits with modelled flows.

The first stage in verification is to ensure that dry weather flows are accurately represented. Flows at the top of the system will be of different quality to those at the bottom because of additional inputs, such as industrial discharges, and because of sedimentation in the pipes. Dry weather flow verification involves checking domestic and industrial inputs so that flows entering the system are modelled correctly, then checking sediment characteristics so that sediment erosion and deposition in the pipes are modelled correctly.

Dry weather flow inputs should be checked first. If these have been generated using standard values and they do not agree with the measured data, then the standard values are not applicable to the catchment and should be replaced with data values. Dry weather flows predicted at the bottom of the system should then be compared with measured data. Disagreements should be resolved by checking industrial discharge data and replacing standard sediment characteristics with measured values.

Once the dry weather flow model has been verified, rainfall event verification can be started. This introduces two new processes - sediment washoff from the catchment surface, and scouring of pipe deposits. Disagreements should be resolved by checking antecedent conditions, which govern the amount of fine sediment in the system; and consolidated sediment depths in individual pipes. The standard characteristics of the coarse sediment and the surface sediment can be replaced with data values.

A MOSQITO model is more difficult to verify than a WALLRUS model, partly because of difficulties in collecting data and partly because of the large number of parameters which directly affect the output. It is important to try and understand the cause of any difficulties encountered during verification so that collection of additional data is only used as a last resort.

The Royton catchment

Royton is situated 3km north of Oldham and has a population of 27,600. The sewerage system is principally combined and the flow is treated at Royton STW which, because of the discharge from three abattoirs, has a population equivalent of 33,700. There are two main outfall sewers: the Southern Outfall, which follows the course of Luzley Brook, and the Northern Outfall, which follows the River Irk.

The Southern Outfall Sewer was constructed in the early 1980s, closing unsatisfactory CSOs and improving Luzley Brook to a satisfactory NWC Class 2. There are now two main CSOs: Holden Fold Lane, which rarely operates, and the controlling CSO upstream of the STW, which operates according to Formula A for the subcatchment.

The Northern catchment has two main CSOs: Cedar Grove and Spaw, both set at slightly more than Formula A. Because of the small flow in the R.Irk, they create Class 3 conditions in the watercourse. Adjacent to the STW is a separate subcatchment discharging direct to the works with a CSO controlling the flow.

Royton STW has a dry weather flow of 70l/s, produces a good quality effluent but, because of the lack of dilution, contributes to the Class 3 quality in the R.Irk below the works.

Data collection at Royton

Flow monitoring, rainfall data capture and sewage sampling was undertaken by the Scan Group. Three raingauges were installed on the catchment. Standard flow monitoring techniques were used at the three CSO sites (Cedar Grove, Spaw, and the Southern Outfall). At each site, flow monitors were installed upstream and downstream of the CSO, and in the pipes discharging to the streams.

An automatic sampler (Epic 1011) capable of taking 24 discrete samples at a pre-set frequency was installed at each CSO. For storm sampling, the samplers were activated by ARX level sensors; set to trigger the sampler when the level reached halfway between invert and weir level. The first 12 samples were taken at 5 minute intervals and the remainder at 15 minute intervals, giving a total sampling time of 4 hours. Samples were also taken at the STW inlet.

Sewage samples were taken under storm and dry weather flow conditions. These were analysed for COD, BOD, ammonia and suspended solids. Sediment samples were taken by Oldham B.C. from catchment surfaces and sewers, and analysed for moisture content and bulk density in addition to the determinands measured on sewage samples.

Difficulties of data collection at Royton

Problems were experienced with both flow monitoring and sampling. Flow balances at each overflow were difficult to achieve because of backwater effects, and dry weather flows were difficult to measure accurately because they were small.

Sampling in such a hostile environment was difficult and the first attempts had a number of missed samples. The two main causes were blood from the abattoirs perishing the samplers' rubber seals, and ragging at the inlet. After overcoming these problems a good fingerprint of quality in dry weather was obtained. During the storm surveys the samplers achieved a high rate of success except for one storm where only four samples were taken at one site.

Results

Four 24 hour dry weather flow surveys were completed. There were marked variations in flow and quality at all sites but particularly at Cedar Grove and Spaw, which were most affected by abattoir discharges. The early morning pollutant concentrations were low, coincident with the minimum diurnal flow. Typically BOD values were less than 50mg/l, compared with an average of about 300mg/l. High BOD and COD values were found during the afternoon with sharp rises to about 1500mg/l. Suspended solids were more typical of domestic sewage, most of the pollutants from the abattoirs being soluble or colloidal.

There were three strom events for which samples were collected: 19th June, 30th June and 4th July. The first event was small and did not cause Cedar Grove or Spaw to operate. The rainfall on the 30th June was intense, and caused all three overflows to operate. There was a pronounced first flush at all the sites. The event of the 4th July lasted for 3 hours 45 minutes and had a total depth of 12.4mm. The effects of the abattoir discharges can be seen in the pollutant levels during this event.

Summary

Sewer flow and quality data have been collected in Royton by NW Water to construct and verify a MOSQITO model. The next step is to use the data with the model. The full version of this paper, available from the authors, contains more information on MOSQITO, data collection in Royton, and preliminary results from the MOSQITO modelling.