PAPER 2

Comparing MOSQITO and Hydroworks QSIM with the measured performance of an actual CSO

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Comparing *MOSQITO* and *HydroWorks QSIM* with the measured performance of an actual CSO

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Scope of Work

The Boldon Colliery catchment is located in the north east of England and is in the River Don drainage catchment. The Boldon Colliery catchment is substantially residential with a total catchment area of approximately 26 ha comprising both combined and surface water sewers. There are a series of six CSOs on the combined sewers spilling to the surface water sewers during storm flows. Foul flows continue to Howden STW via the Don Valley Interceptor Sewer and storm flows discharge to the River Don.

The Environment Agency (EA), had cited the River Don as a priority watercourse as having unsatisfactory CSOs which required rectifying under the Urban Waste Water Treatment Directive (UWWTD).

The nature of the catchment led to the belief that the CSOs could be rationalised and storage used to both improve the quantity and quality of storm sewage discharged as well as meeting the aesthetic requirements. This approach was sanctioned by the EA at an early stage, as it was thought that if successful it could be applied to other problems of a similar nature.

Since the time of the study the WALLRUS and HydroWorks software are being replaced by HydroWorks and QSIM. Hence it was necessary to check the predictions using both models to ensure that a degree of confidence can be placed in the future use of the software. Simulations using HydroWorks and QSIM have been carried out for the Boldon Colliery catchment in an attempt to discover some of the differences in input data, simulation control data and output data required by the different modelling software.

WALLRUS and MOSQITO Modelling

A WALLRUS model of the Boldon Colliery catchment was constructed and validated using data from a six week flow survey carried out in the summer of 1993 comprising ten flow monitors and three rain gauge sites. Time Series Rainfall runs with the validated model indicated that a single CSO out of the seven was responsible for the majority of storm spills to the River Don. Analysis of the flow and water quality survey data revealed that a first foul flush phenomenon occurred within the Boldon Colliery catchment.

The validated WALLRUS model was used as a base for the MOSQITO model for use in assessing the polluting effect of the unsatisfactory CSO and in assessing the effectiveness of on-line storage to capture the first foul flush.. Initial MOSQITO calibration was attempted using the default water quality parameters recommended in the Wallingford Procedure Water Quality Supplement.

The methodology adopted in calibrating the MOSQITO model was to first calibrate the suspended solids loads and concentrations. This was achieved by altering the amount of pipe sediment in the model available for erosion and altering the sediment characteristics. Once a reasonable agreement was achieved calibration of the BOD loads and concentrations was attempted. This was achieved by altering the pollutant potencies and proportions of each sediment fraction. Checks were made to ensure that BOD calibration did not have adverse effects on the calibration of the suspended solids.

Use of MOSQITO default values lead to under prediction of peak and total modelled pollutant loads and concentrations compared with observed data, thus demonstrating that the default values inadequately descried the water quality mechanisms in the Boldon Colliery catchment. In an attempt to increase the peak and total pollutant loads the amount of sediment entering the sewerage system was increased. It is understood that the MOSQITO model derives pollutant input into the system from the pipe sediments. The calibration of the pollutants was achieved by adding sediment in pipes where it will not accumulate under the ambient hydraulic conditions and thus contribute to the pollutant quantities in the system.

This method did not produce a satisfactory increase in the peak and total pollutant loads, resulting in a sewer sediment survey being instigated. The sewer sediment survey indicated that large deposits of sediment were unlikely to occur but certain sediment depositions were located and the model revised. Calibration procedures resulted in a reduction of the sediment shear strength as confirmed during the sediment survey by observing that most sediment was unconsolidated. The proportion of coarse and fine sediment fractions was also increased to increase the peakiness of the simulated load. The size and density of both sediment fractions were not altered. This lead to reasonable agreement between the observed and simulated suspended solids concentrations and loads.

Initial calibration runs for BOD indicated that modelled BOD was considerably lower than observed values. The BOD potency for coarse sediment was increased to attain a suitable agreement between observed and modelled BOD.

HydroWorks and QSIM Modelling

The validated WALLRUS model has been converted to HydroWorks format using the conversion facility in HydroWorks. The QSIM runs have been carried out in accordance with the guidelines in the on-line help.

The data for the calibrated MOSQITO model has been transferred to the relevant HydroWorks files for water quality simulations.

Comparison of the hydraulic output from the HydroWorks runs show good agreement with the observed data. It is noted that there is an improved fit on the depths for the HydroWorks simulations compared to the WALLRUS simulations. Comparisons of the water quality show that QSIM considerably underestimates all water quality determinands compared to the observed data.

Design Runs

Design runs using the validated MOSQITO and corresponding QSIM model were carried out to using Time Series Rainfall as model input to investigate the effects of providing on-line storage to capture the first foul flush during storm flows.

Figure 1 shows the results from Time Series Rainfall runs at the incoming pipe to the unsatisfactory CSO structure. The first foul flush phenomenon can be clearly identified.

It can be seen that for a relatively small storage volume of 50 m^3 that 70% of the pollutants can be stored in the system. It was therefore recommended that an on-line storage volume of 50m^3 located downstream of the unsatisfactory CSO be provided to capture the first foul flush.

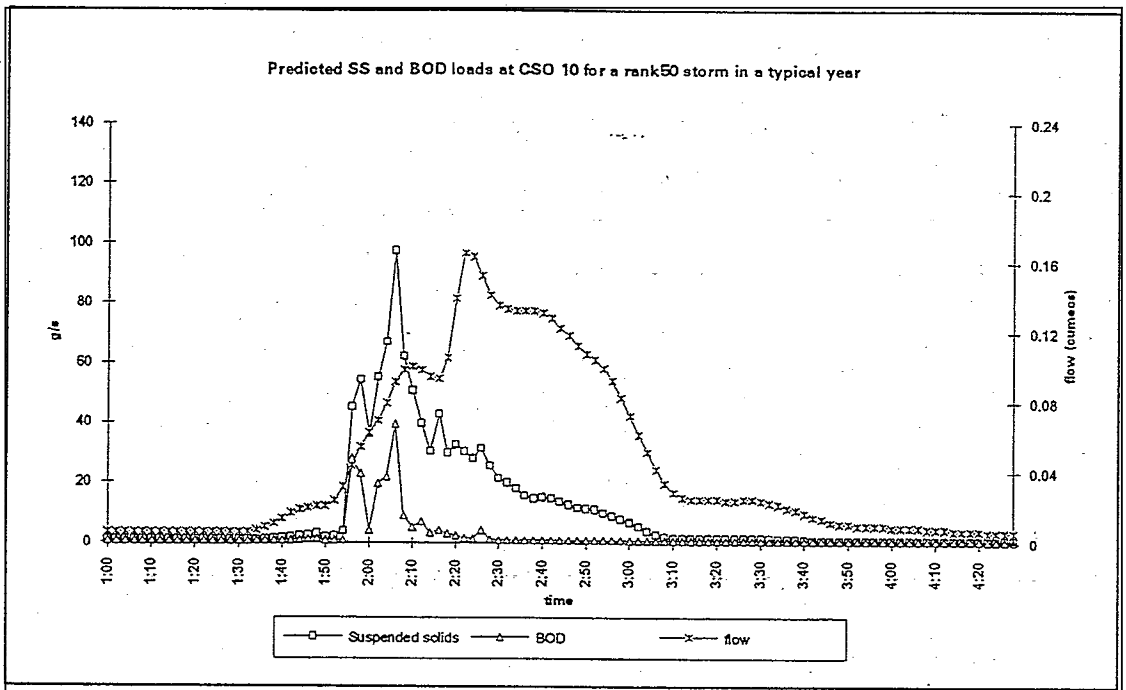

Figure 1 First foul flush phenomenon at the unsatisfactory CSO. Boldon Colliery.

Figure 2 presents the results from Time Series Rainfall using different storage volumes on-line located downstream of the unsatisfactory CSO structure.

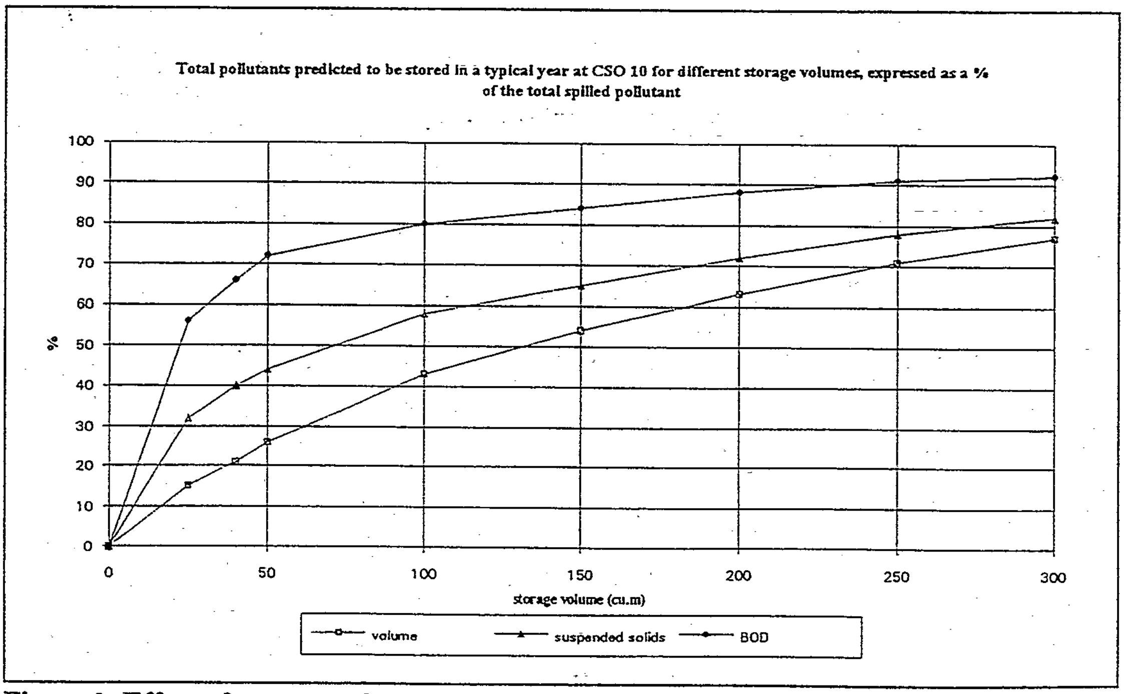

Figure 2 Effect of storage volume on total pollutant retention at the unsatisfactory CSO.

Discussion of Model Comparison

The WALLRUS modelling software calculates the sewer flows and depths using Muskingham-Cunge flow routing. It is well accepted that this leads to miss-representations of flow depths, backwater and reverse flow effects. Although these deficiencies were observed during the WALLRUS validation a good degree of correlation was achieved between the simulated and observed flows.

The HydroWorks software provides a numerical solution to the St. Vennant equations describing one dimensional free surface flows. Pressurised flows are modelled using the Priessman slot methodology. It was expected that the HydroWorks model would lead to a much better agreement between observed and simulated flows and depths. This was indeed confirmed by the HydroWorks output.

The MOSQITO model input parameters required considerable adjustment during model calibration. However, following calibration of the MOSQITO model a good degree of agreement was found between the observed and simulated data. The QSIM model, run with the calibrated data from the MOSQITO model, suggests that the water quality determinands are considerably underestimated relative to the observed values. It is thought that this underestimation is due to the QSIM model deriving pollutants into the system from the surface of the contributing area as opposed MOSQITO which was calibrated by adjusting the pipe sediments. The QSIM model is currently being recalibrated using the HydroWorks defaults as a base.

Post construction flow and water quality monitoring is currently underway and it is anticipated that data from this survey will assist in better assessing the operation of the QSIM model for the Boldon Colliery catchment.

It should be noted that the hydraulic calculations carried out in HydroWorks utilise the Wallingford surface runoff model, as in WALLRUS. However, QSIM uses the French Desbordes surface runoff model for generating the pollutants used as input to the sewer system.

Generally it is felt that there is lack of guidance and clarity on the specification of relevant files for use in QSIM modelling and the sensitivity of the parameters used.

Conclusions

From the study to date, the following conclusions can be drawn.

1. The WALLRUS Model of the Boldon Colliery system adequately represents the hydraulics of the sewerage system.

2. The MOSQITO model shows a good degree of agreement with observed water quality data but during calibration considerable changes were made to the MOSQITO model parameters.

3. The flow survey and water quality data clearly show that a first foul flush phenomenon occurs at the Boldon Colliery catchment.

4. Design runs using Time Series Rainfall as model input show that for a small on-line storage volume of $50m^3$ 70% of the total pollutants are retained in the system, greatly improving the water quality of the spills from the CSO.

5. Simulations with HydroWorks show that there is a much improved representation of depths compared with WALLRUS.

6. QSIM simulations using the calibrated MOSQITO parameters as model input tend to considerably underestimate the water quality parameters predicted by the model. It is anticipated that this is due to the calibration of MOSQITO being carried out by adjustment of in sewer sediments whereas QSIM requires calibration of the surface and gully pot parameters.

7 QSIM utilises the French Desbordes surface runoff model to derive the pollutants used as inputs into the sewer system. WALLRUS and therefore MOSQITO utilises the Wallingford UK surface runoff model for deriving flows into the sewer system.

8. Calibration of the QSIM model using the default input values suggested in the software on line help as a base in now underway.

9. The recommended design has now been implemented and constructed on site. Post construction monitoring is now in progress. It is expected that the data from this monitoring exercise will aid in the understanding of the operation of the QSIM model for the Boldon Colliery catchment.

10. Further modelling is to be carried out using the HydroWorks and QSIM software utilising the comprehensive flow and water quality data for both pre and post construction phases at Boldon Colliery catchment.