THE MODELLING OF BECKTON SEWAGE TREATMENT WORKS CATCHMENT

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Introduction

The catchment of the Beckton Sewage Treatment works includes the whole of central London on the north side of the River Thames. It covers an area of approximately 325 km^2 and serves a population equivalent of 3 million people. The older central area of the catchment is served by combined sewers whilst the newer outer areas have separate foul sewers.

With over 400 points where flow can spill from one sewer into one or two other sewers, this complex system had become increasingly difficult to understand without the aid of a sophisticated computer model. To add to the complexity of the system, there are a number of points where the flow can be subject to Real Time Control (RTC). This usually involves the diversion of flow from one route to another under storm conditions by the operation of sluice gates. Longer-term diversions are also undertaken to allow maintenance of the system.

Because of the large size of the catchment, it had been decided that it would be unrealistic to assess the performance of the system by applying uniform design storms across the whole area. To allow for correct spatial variation of rainfall the model was to be run using historic rainfall data collected over the catchment by radar.

The work was carried out as part of a major project undertaken by the client, Thames Water Utilities Limited (TWUL), which is described in the paper by Martin (1995). A methodology for carrying out the work was agreed with TWUL before starting. This was amended and upgraded as different problems were encountered and resolved. One of the requirements was for the modelling of the Beckton catchment to be carried out using both the Hydroworks and RUNSTDY computer models which are both fully dynamic hydraulic models capable of simulating RTC. Both of these models had to accept surface runoff inputs generated by either the SWMM RUNOFF block or the UK Wallingford runoff model. All the modelling results presented in this paper are based on work carried out using the Hydroworks package.

Data Collection and Handling

It was realised at the start that the project was going to involve the handling, interpretation and graphical representation of large amounts of data and results. Computer programmes were therefore developed for the storage of data and its transfer between applications. These routines helped to speed up the work and ensured a reasonable degree of Quality Assurance as data was only manually entered once.

The details of approximately 12,400 manholes, out of an estimated total population in excess of 100,000, were digitised into a computer database. This database was used to further simplify the sewer system into a number of nodes which could be reasonably handled by the modelling software. The final model contains approximately 2500 pipes with a total length of 621 km. 650 ancillaries, including weirs, sluice gates, orifices and pumps, have also been modelled. Because of the degree of simplification involved, this type of model is sometimes referred to as a 'macro' model.

Large Contributing Areas

The model currently contains 649 contributing areas with an average size of 37 ha. The large size of the areas led to some concern that the runoff model in HydroWorks, which was derived from areas of 1 ha or less, would produce incorrect runoff patterns. TWUL commissioned Hydraulics Research to carry out an investigation into this aspect. The result of the investigations was the Large Catchment Runoff Model which is incorporated into HydroWorks V2.0.

A detailed hydraulic model existed of part of the catchment with average contributing areas of about 2 ha. Figure 1 shows a comparison of the predicted flows from the detailed model using the standard runoff model and the macro model using the new Large Catchment Runoff Model. The predictions are for the storm flow from an area of 57 ha which was subdivided into 28 contributing areas in the detailed model but only 3 in the macro model. From the figure it can be seen that there is very little difference between the two model predictions.

Comparison of Detailed and Macro Model Results
North London Upstream Monitor 9 Storm of 16 March 1991

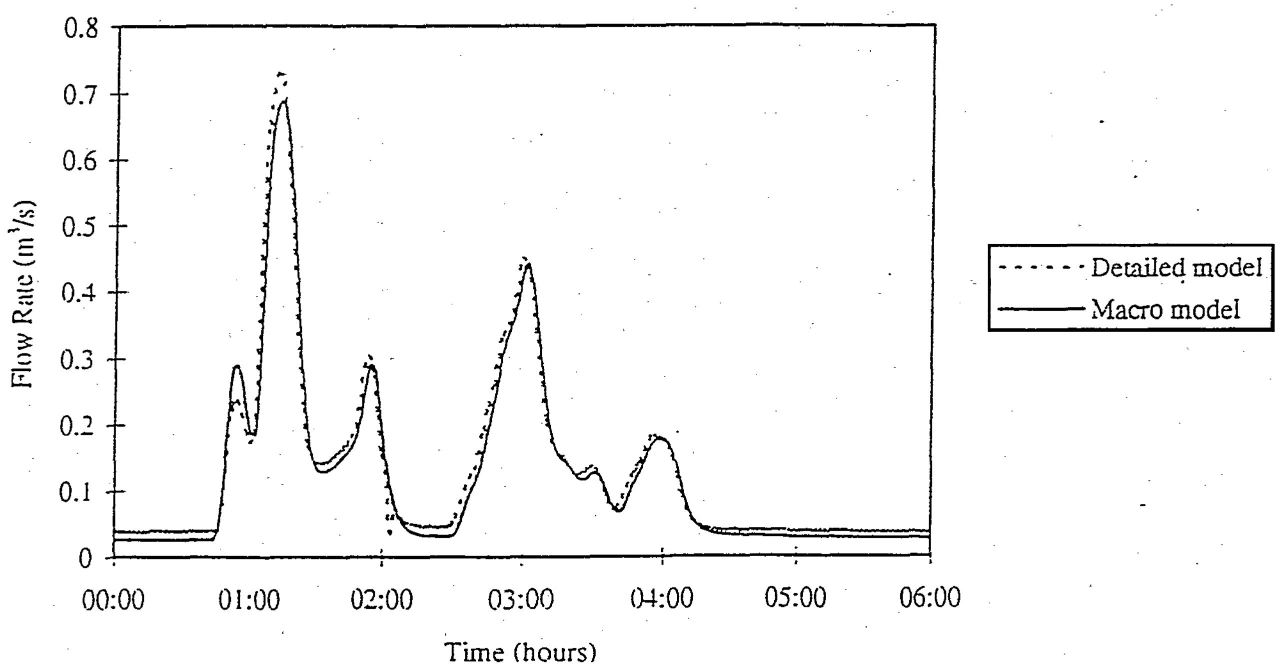

Figure 1 Comparison of Detailed and Macro Model

Dry Weather Flow

Details of the methodology used for modelling dry weather flow (DWF) were presented in the paper on "Infiltration and Dry Weather Flow Verification" presented at WaPUG in November 1994. DWF was input as a population-generated component plus an infiltration component. The populations for the contributing areas were obtained by overlaying the area boundaries on Thames Water's GIS system. The appropriate diurnal variation was applied to the population-generated component of flow and infiltration was input as a 'constant' value. Major industrial flows were treated separately.

Rainfall

The basic radar rainfall data was supplied from a weather radar operated by the Meteorological Office. This was then recalibrated using a special technique developed by Moore et al (1991) for the London Weather Radar Local Calibration Study. The radar data provides rainfall information in terms of intensities at five minute intervals over a grid of 2 km x 2 km squares. At this resolution the entire Beckton catchment is covered by 99 grid squares. Originally data covering the 5 years from 1988 to 1992 was obtained with further data being acquired as it became available. An example of the spatial variation in rainfall which can occur across the Beckton catchment is shown in Figure 2.

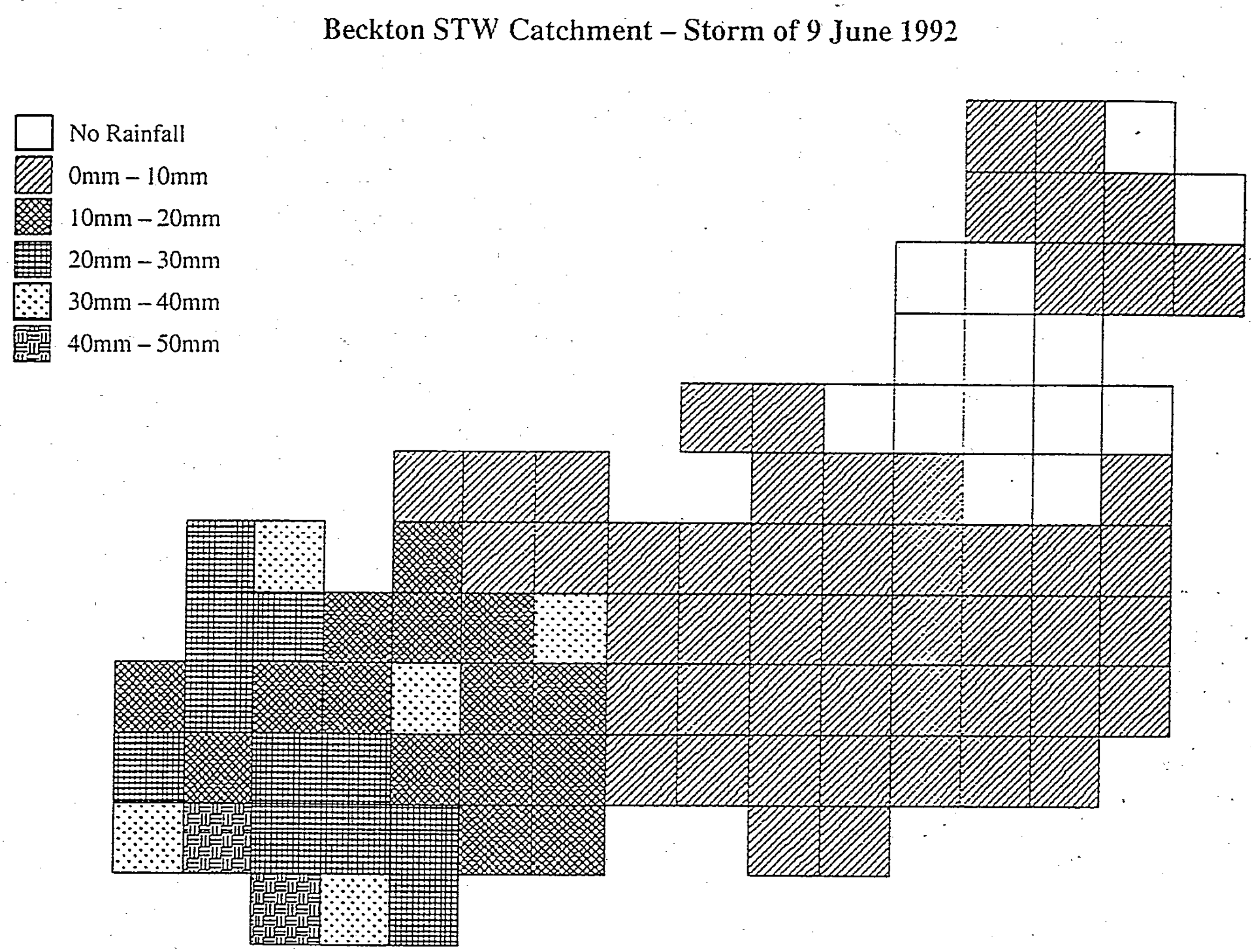

Figure 2 Radar Rainfall – Example of Spatial Variation

With the data available to the project it was possible to assess the quality of the radar rainfall data by carrying out a three-way comparison of radar rainfall data, rain gauge data and sewer flow data. This showed that the radar calibration method produced reasonable information for some storms but not for others. Possible problems with the calibration are believed to arise from factors such as bright band, ground clutter and range effects. It is understood that meteorologists are aware that there may be some shortcomings in current radar calibration techniques and development of better techniques is well advanced.

Real Time Control

From time to time long term diversions are installed in the Beckton system to allow maintenance. Rather than have separate DSD files to represent these diversions it was decided to use time based RTC rules to reconfigure the system appropriately.

More complex situations exist to control the filling and emptying of storm tanks such as those at Auckland Road. These tanks are operated if the flow immediately downstream exceeds 0.675 m^3/s or if the water level at a point 2 km downstream exceeds 1 m. When one of these limits is exceeded flow is first diverted to the storm tanks by closing a penstock on the high level incoming sewer and opening penstocks to the storm tanks. If the set points are still exceeded then a penstock on the low level incoming sewer is closed and flow is pumped into the storm tanks.

Figure 3 shows a comparison of the measured flow in the pipe downstream of the storm tanks and the predicted flow from the model for the storm of 10 August 1994. The reduction in flow at the peak of the storm is caused by the storm tank penstocks being operated. One factor, which sometimes became apparent when setting up the real time control rules, was the difference between the operators' explanation of how they believed the rules operated and the actual operation based on flow measurements. This factor may explain some of the differences between measured and predicted flows as the rules used for emptying the tanks after the storm had passed were not well-defined.

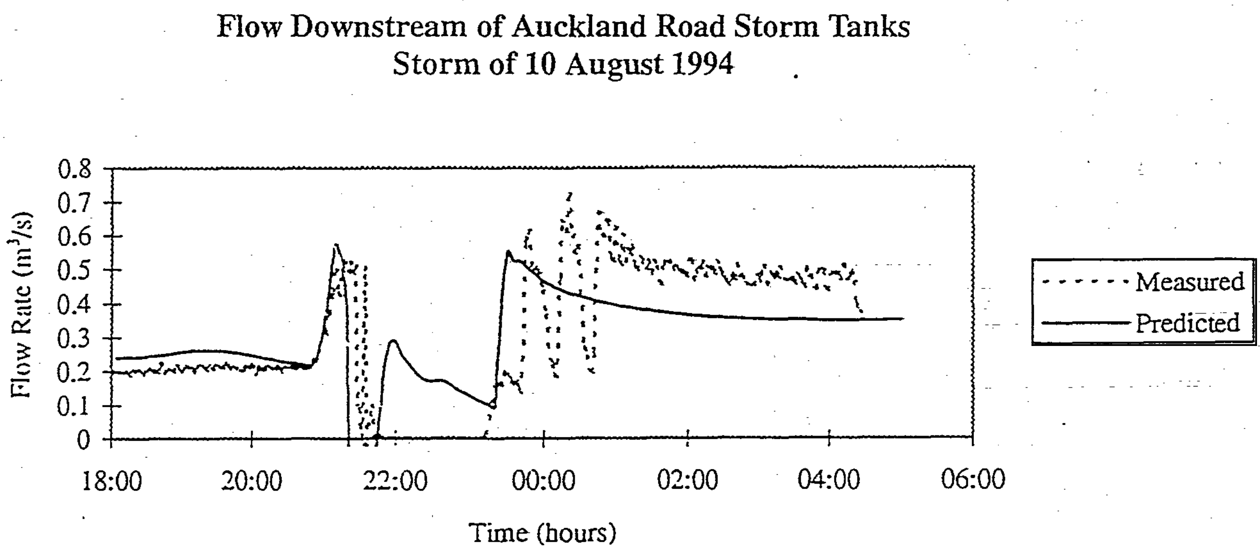

Figure 3 Example of Real Control

The Future

The project demonstrated that with appropriate software it is possible to successfully develop computer models of large complex catchments which incorporate real time control features. However the completion of the model is not an end in itself; it is intended to be the start of the study of the catchment.

References

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Moore, R.J., Watson, B.C., Jones, D.A. and Black, K.B. (1991). "Local Calibration of Weather Radar." In: Hydrological Applications of Weather Radar, Cluckie, I.D. and Collier, C.G. (Eds), Ellis Horwood Limited, Chichester, 65-73.

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Chairman's Comment
Paper clearly shows that UPM is not about a book or a procedure but about understanding and operating your catchment in an effective manner.