MOSQITO TRIALS

BUXTON SMP PILOT STUDY

James R Allen, Sewerage, Severn Trent Water Limited

1. SMP - Sewerage Management Planning

The Sewerage Management Planning (SMP) Research Contract is a three year programme of work undertaken by WRc in collaboration with, and funded by five regional Water Companies. These are:- Severn Trent, North West, Anglian, Yorkshire and Thames. The objectives of the SMP research programme are to implement and evaluate computer simulation tools and methodologies developed for the rational and cost-effective management of sewer water quality and urban river pollution control.

The SMP approach is based on pilot study applications of the appropriate tools used in real situations to:-

(i) develop and enhance individual quality models and management techniques through "hands on" experience.

(ii) develop a methodology for the integrated use of sewerage, sewage treatment and urban river models for quality management. The modelling tools being used are:-
MOSQITO - Sewer Flow Quality Model
STOAT - Dynamic Sewage Treatment Works Model
MIKE 11 - Dynamic River Impact Model

The research forms part of the Urban Pollution Management (UPM) Programme.

2. Introduction to MOSQITO

MOSQITO is an extension to the WALLRUS simulation package of the Wallingford Procedure.

The WALLRUS simulation program models the quantity of water discharged from a drainage system. MOSQITO is an urban drainage water quality simulation tool. It simulates the movement of sediments and pollutants through a drainage system.

MOSQITO, like all simulation models, requires data to describe the system which it is to represent. This will include details of the drainage system and the catchments which drain to it, but it will also include pollutant data which are present in the drainage system and on the catchment surface.

It is particularly important that a WALLRUS model intended for use with MOSQITO is properly constructed and verified. Discharges should be predicted with reasonable accuracy.

Engineering features

MOSQITO consists of four sub-models which represent:-

(i) Surface washoff model

(ii) Foul water inflow model

(iii) Pollutant behaviour model (a) pipes and channels

(iv) Pollutant behaviour model (b) ancillary structures

These sub-models are linked to the flow simulation model from WALLRUS, which performs all of the hydraulic calculations used by MOSQITO.

The models attempt to represent the transport of dissolved and particulate pollutants through a sewerage system. The determinands modelled are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), ammonia and suspended solids.

MOSQITO can be used to simulate sediment transport in sewerage systems; to predict levels of pollutant discharge from CSOs; to assist in Drainage Area Planning and, linked with sewage treatment works and river model to check whether water quality objectives are achieved. It can also be used to compare designs to see which offer the greatest benefit in terms of pollutant discharge.

3. Pilot Study Catchment - Buxton

Buxton is situated in a valley in the centre of the Derbyshire Pennines midway between Manchester and Chesterfield. Much of the town centre dates back to Victorian times, including the theatre and a number of large hotels. The remainder of the town is mainly residential with both post and pre-war estates. Industrial development is extremely limited.

The spa town of Buxton was selected as Severn Trent's Pilot Study site for numerous reasons. The main being:-

(i) a verified WASSP model had already been developed for this catchment.

(ii) the catchment is relatively small, compact and predominantly residential, with it's own Sewage Treatment Works.

(iii) there were three significant CSOs on the sewer system.

(iv) the catchment contained the River Wye which flows through the town and by the Sewage Treatment Works. The river quality of the Wye falls from 1B to 3 across the town.

The total population for Buxton is approximately 20,000.

4. Buxton Flow and Sampling Survey

The Buxton MOSQITO model, as with all MOSQITO models, required a considerable amount of data collection both for input data and for dry weather and storm flow verification. Input data was needed to describe inflows to the sewerage system and the initial state of the system. DWF and storm verification data were used for comparison with MOSQITO predictions to demonstrate that the model was producing sensible results.

The additional qualitative features of the MOSQITO program required that site data was needed for effluent loading during "dry weather" and around the significant CSOs during storm spills. The Buxton quality survey required the positioning of flow monitors in a number of locations:-

(i) In upstream and downstream catchments to enable the quantities of DWF loading to be applied to the MOSQITO model ("dry weather sites").

(ii) At significant CSOs to enable spill quantities to be accurately recorded ("storm sites").

Several sampling sites were also used to provide both pollutant input data and observed data for the verification exercise. Some of these sites were adjacent to flow monitor locations whilst others were completely separate. Two sewer sediment sampling sites were also used to provide some indication of the chemical composition and size of existing sewer sediment in the Buxton drainage system.

Most of the flow monitoring and sampling equipment was installed at the beginning of April 1991 and the intention was to complete the full survey after five full weeks of monitoring. However, insufficient rainfall during that period resulted in the inevitable extension to the field survey work. The flow and sampling survey was eventually completed in early August, some seventeen weeks after the original installations and still without sufficient MOSQITO "storm run" data. **(A MOSQITO storm run can be described as the deployment of pollutant samplers to measure overflow spillage in times of expected heavy rainfall.)**

Because of the extremely high cost of the flow and sampling data collection exercise, the MOSQITO program contains a set of standard input values. These include dry weather flow quantity and quality and sediment characteristics. The two sets of values are held in MOSQITO files. The standard dry weather flow values are in the file FOUL.PRM and the sediment values in SED.PRM. Both files can be edited outside of MOSQITO by the user to include actual catchment data.

5. Producing the Buxton MOSQITO Model

A verified WASSP model of the Buxton catchment had already been produced as part of a drainage area study. Therefore it was only necessary to convert this model to the new international WALLRUS format.

Detailed checking of the model was undertaken and this identified several input errors and omissions from the original verified model. Therefore, it was necessary to correct these errors and incorporate into the model significant changes to the sewerage network. The main differences were:-

(i) a substantial increase in the dry weather flows for the catchment.

(ii) an attempt to model suspected siltation.

(iii) the modelling of the dual system through the old Gas Works site, directly upstream of the sewage treatment works.

(iv) an attempt to model the 6DWF overflow at the STW which is controlled by an automatic penstock.

(v) general corrections of errors in the initial WASSP model.

The data to describe the Buxton sewerage system is the same as any WALLRUS model with some special requirements for MOSQITO. Using WALLRUS record type 18 it was possible to define actual sediment depths for individual pipes, therefore providing a default value in MOSQITO for sediment erosion in the pipes. Each pipe record was also given a land use index to define characteristics of the dry weather flows and of the pollutants on the catchment surface.

Most of the site sampling data used are given in the data files prepared in advance of a simulation run using the MOSQITO EDITOR program. Some additional items of data are input from the keyboard at run-time. Dry weather flow quantity and quality data files were prepared using the DRY WEATHER FLOW GENERATOR program in MOSQITO.

It was then necessary to verify the new WALLRUS model at the top and bottom of the system and particularly at actual CSO locations. The verification was successfully completed but unfortunately the rainfall events used did not coincide with "MOSQITO storm runs".

Four "storm runs" were attempted during the period of the flow and sampling survey. One was during a low intensity, long duration event which was insufficient to trigger overflow operation and unsuitable for verification purposes. Two others were during even smaller rainfall events. The 8 June "storm run", although far from ideal (this event also failed to trigger overflow operation) was the only event where verification was possible. Sample data had been taken when flows were "contained in the sewer" and the verification of the MOSQITO model relied solely on this information.

6. Verification of the Buxton MOSQITO Model

Dry weather flow verification

The basis of the verification procedure in MOSQITO is the same as the verification process in WASSP/WALLRUS, where comparisons are made between measured and predicted data. The difference is that MOSQITO compares measured quality data with predicted quality data for Suspended Solids, COD, BOD and ammonia.

The first stage in verifying the Buxton MOSQITO model was to examine the DWF predictions near the top and at the bottom of the system, both for flow quality and flow quantity. A number of test runs were attempted and initially the SIMPART 2 program "crashed" 80 minutes into the DWF event. A new MOSQITO SIMPART 2 model was installed and a number of test runs were undertaken to test the stability of the Buxton MOSQITO model. A DWF 24 hour verification test run was successfully completed, however pollutant hydrograph outputs could not be viewed in the MOSQITO GRAPH module. It was subsequently identified that when running long events the model time step should be set so that no more than 480 outputs are produced. The Buxton model time step was reset to an interval of 5 minutes and the model was re-run.

With the MOSQITO model using the standard values, comparisons were made of dry weather flow quantity and quality observed against predicted data. Disagreements were noted and it was necessary to adjust the standard parameters of the model to represent actual recorded conditions and provide a better fit on dwf data. Changes were made to the settling velocity for SL1; the standard value for per capita water consumption; adjustments were made to the pollutant concentrations based on measured data and their potency factors were also altered.

After a considerable amount of time spent adjusting and fine tuning the DWF Buxton model, a good verification fit was acheived for sites both at the top and bottom of the system.

Storm event verification

With the Buxton DWF model now successfully verified the next stage was to verify a MOSQITO "storm run". The only event avaliable to verify the model against was the 8 June "storm run" and this event, failed to trigger the CSOs. Therefore, the verification relied solely on data gathered when flows were "contained in the sewer".

Now confident that the model would run, several SIMPART 2 runs were commenced using the MOSQITO standard values; slight variations on the standard values and using the actual recorded catchment values used in the DWF model. Comparisons were then made of measured rainfall event data with the MOSQITO storm predictions. Again, disagreements were noted and it was necessary to adjust the model parameters to reflect the recorded conditions. Changes were made to the settling velocity for SL1; adjustments were made to the standard average pollutant concentrations and their potency factors were altered.

The standard values in the SED.PRM file were compared against actual measured data and were found to be quite close. In some cases the same as the standard surface sediment MOSQITO values. Although, minor adjustments were made to reflect actual surface sediment characteristics for SL1 and SL2, minor changes were made to sediment size, settling velocity, moisture content, wet bulk density and the concentrations of soluble pollutant in sediment.

With the minor adjustments in place, further storm event verification runs were commenced and predicted against observed quality data was compared for the five "storm" sites. One site located towards the top end of the catchment had very little recorded data and the quality "fit" was very poor. This has been attributed to errors in the recorded data for this site and has therefore been discounted from the verification. The remaining four "storm" sites with good quality data, showed what can be considered as a reasonable "fit" for suspended solids in three of the sample sites. The quality verification "fits" for COD, BOD and ammonia for the event are not as impressive as the DWF results but they do install some confidence in the way MOSQITO models pollutants in times of rainfall.

Further changes were made to the standard and recorded values and the model was re-run several times with no significant improvement achieved in the overall verification.

It should be borne in mind, however, that there was no other event available to verify against and that the event used was not suitable for verifying in MOSQITO. It had a peak intensity of less than 4mm/hr and was intermittent. Guidance provided at the outset of the pilot study recommended that events with an intensity below 12mm/hr should not be used for verification.

7. Conclusion

In conclusion, the pilot studies have provided valuable experience in the use of MOSQITO, and have proved that it is possible to simulate reasonably accurately the movement of sediments and pollutants through a drainage system. It has been shown that in conjunction with the sewage treatment works and river impact models, MOSQITO can be used to assess the effects of sewer discharges on river water quality. It is without doubt an important first step in providing an integrated approach for the management of pollution in our rivers, streams and watercourses.

References

MOSQITO User Manual (August 91)	HR Wallingford
Buxton Sewer Flow Survey Report	WRc Commercial Report UC1435
WaPUG User Note 26	HR Wallingford
Mosqito Training Course Notes	HR Wallingford

BUXTON MOSQUITO TRIALS - DWF VERIFICATION

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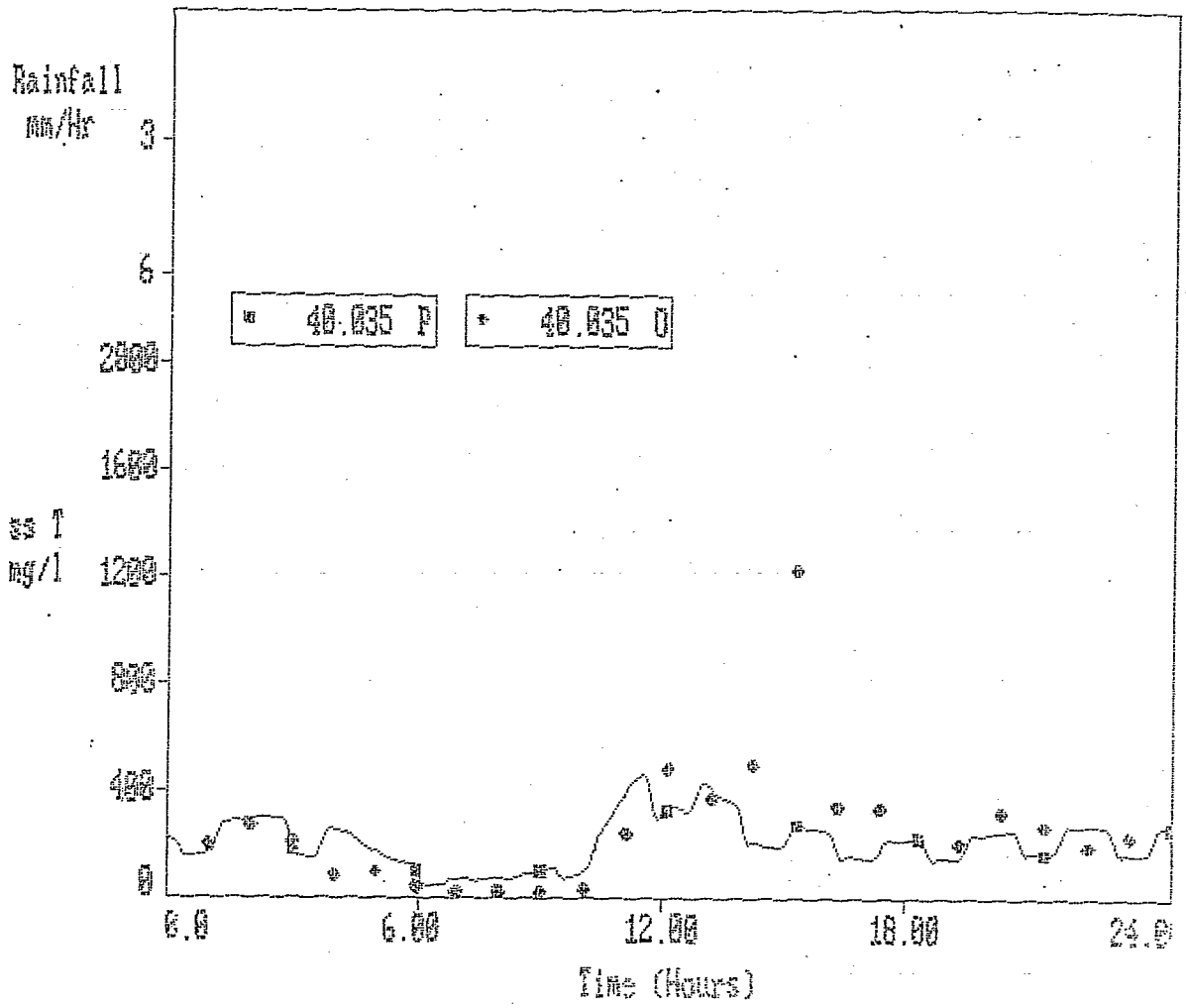

BUXTON MOSQUITO TRIALS - DWF VERIFICATION

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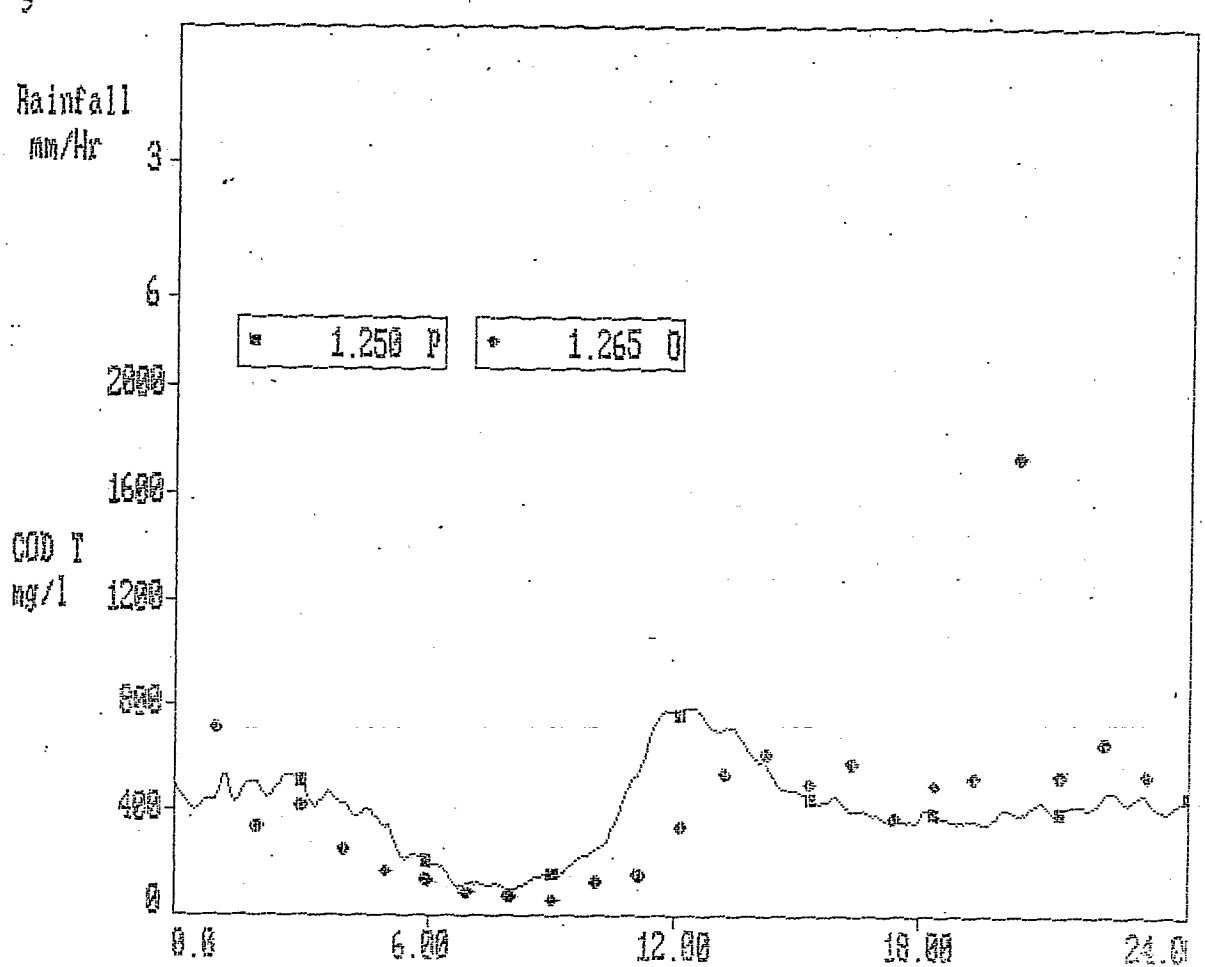

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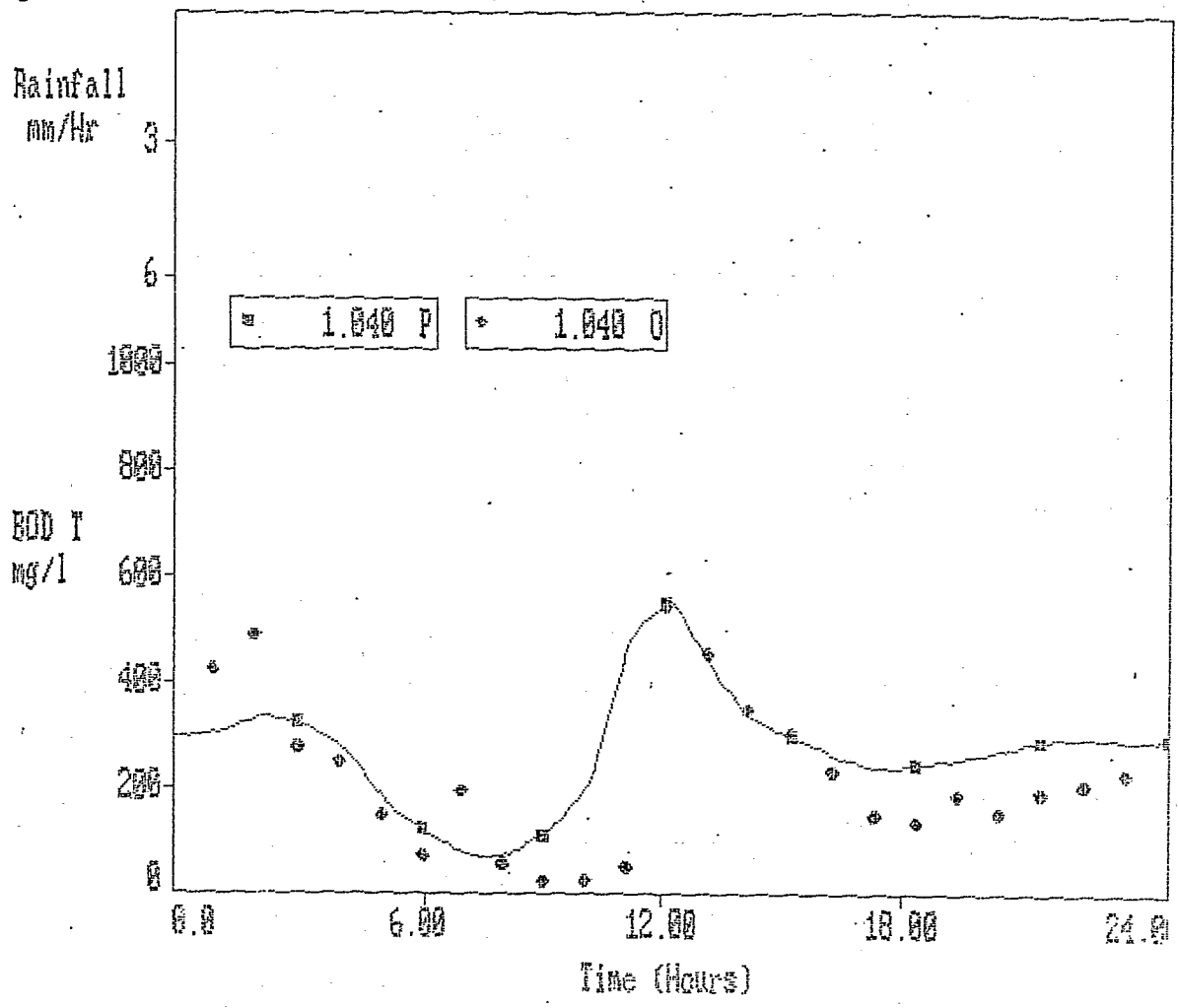

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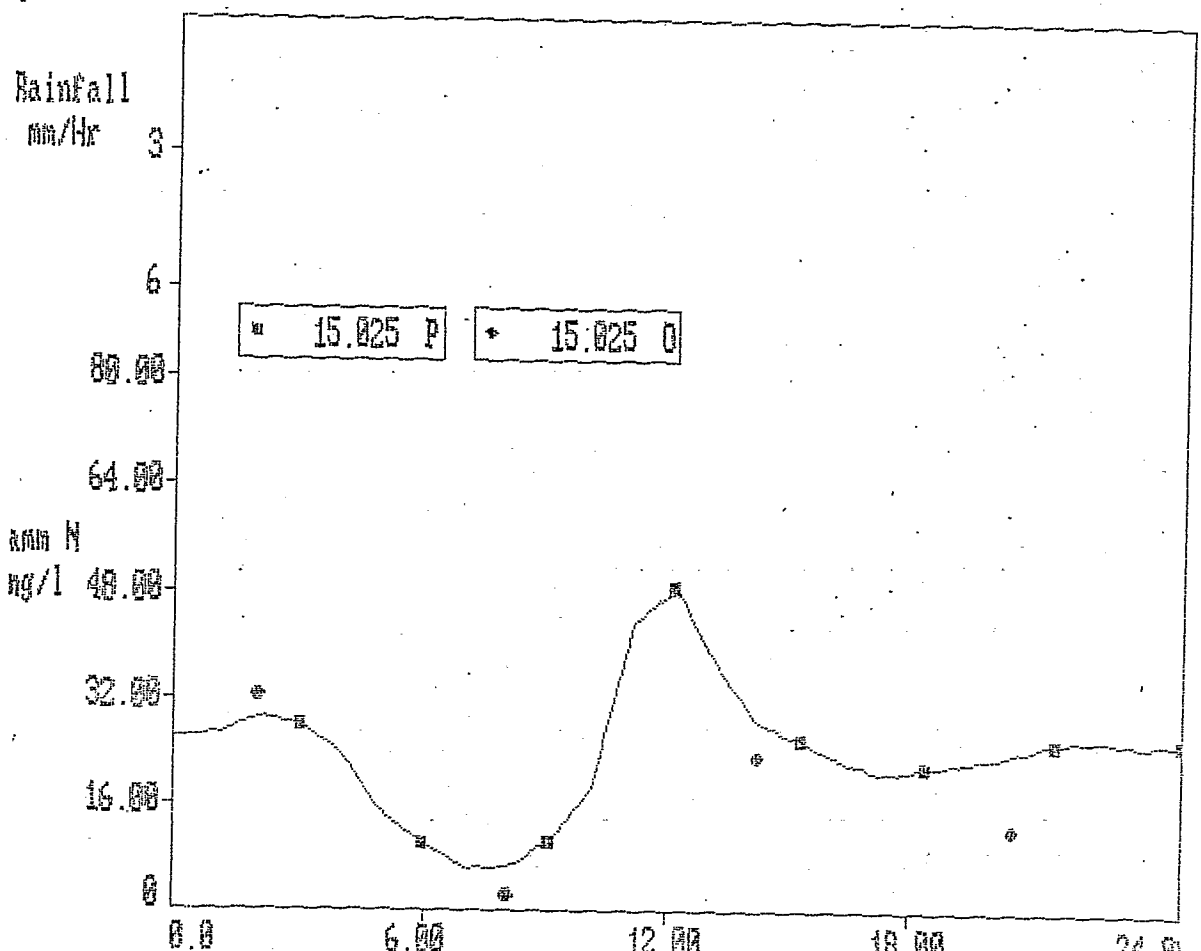
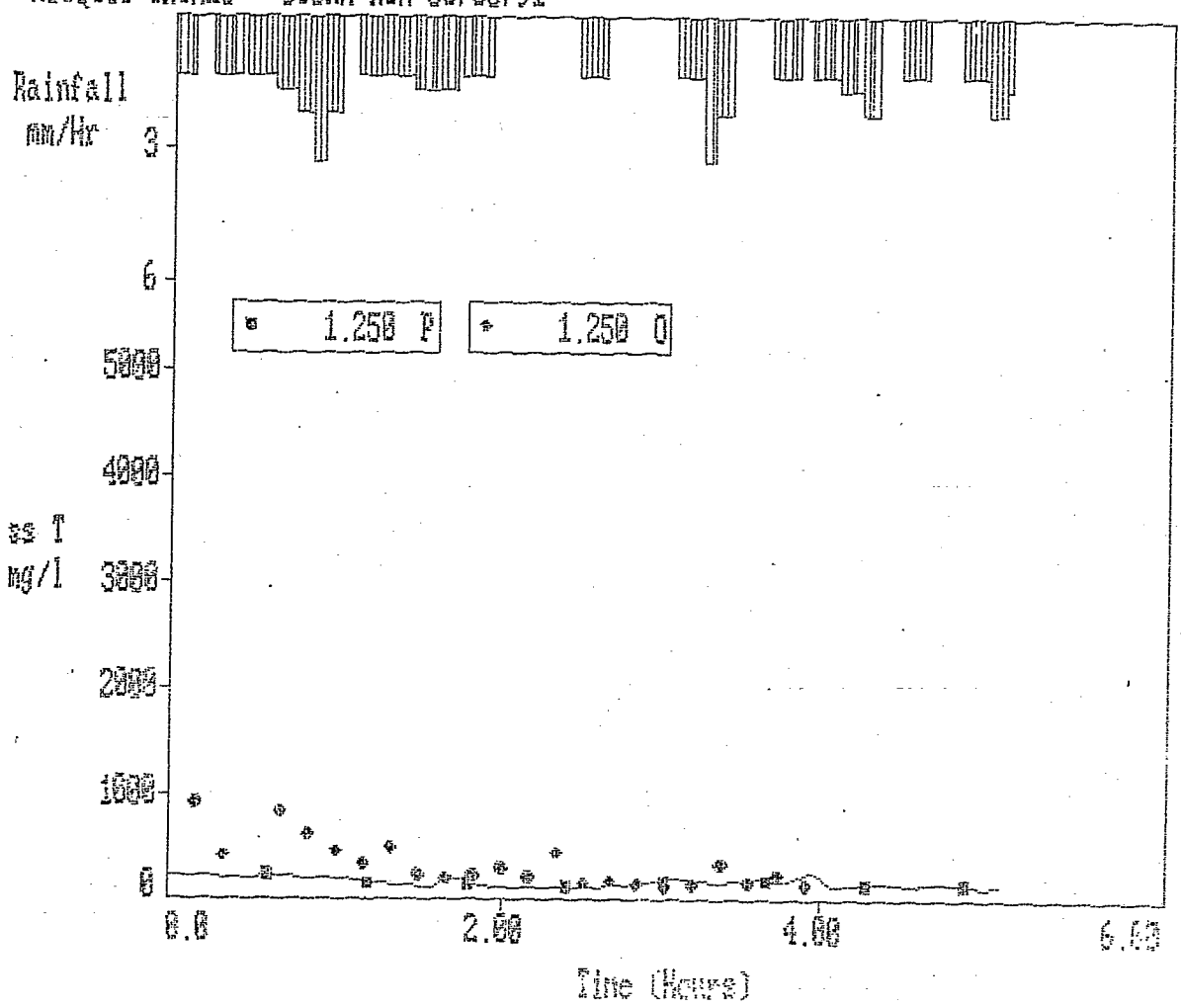


BUXTON MOSQITO TRIALS _ STORM EVENT VERIFICATION



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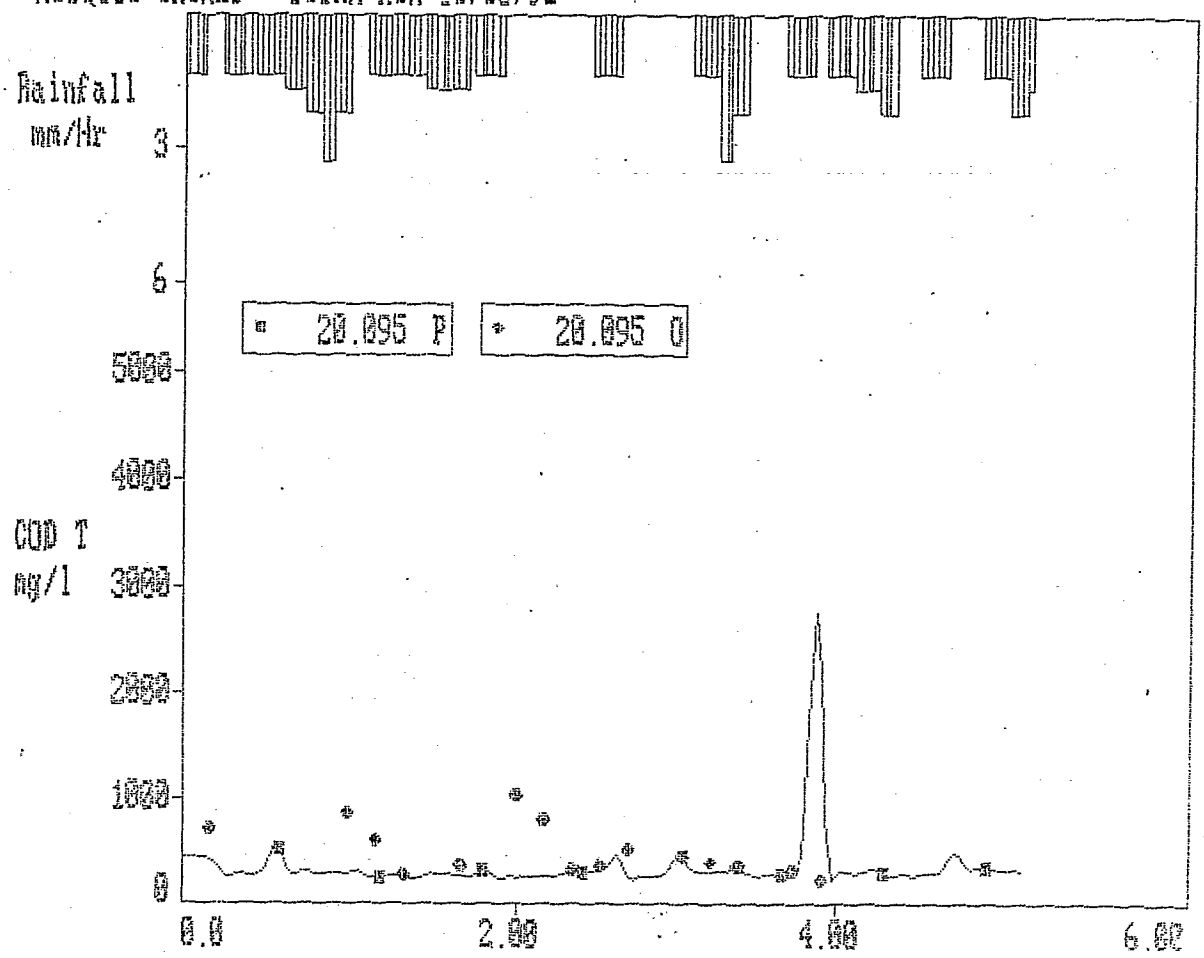
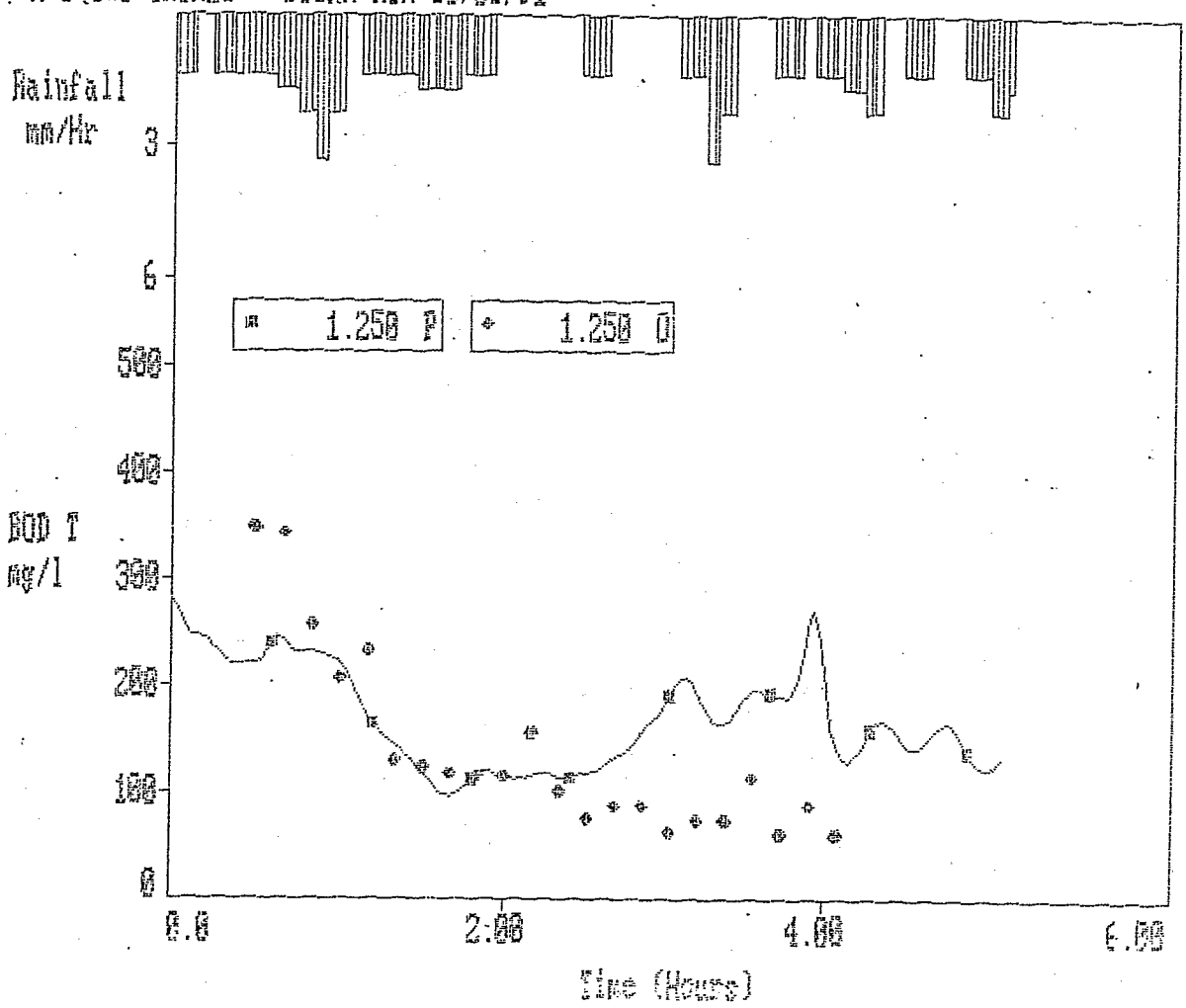


BUXTON MOSQUITO TRIALS _ STORM EVENT VERIFICATION

MOSQUITO TRIALS - STORM RUN 08/06/91



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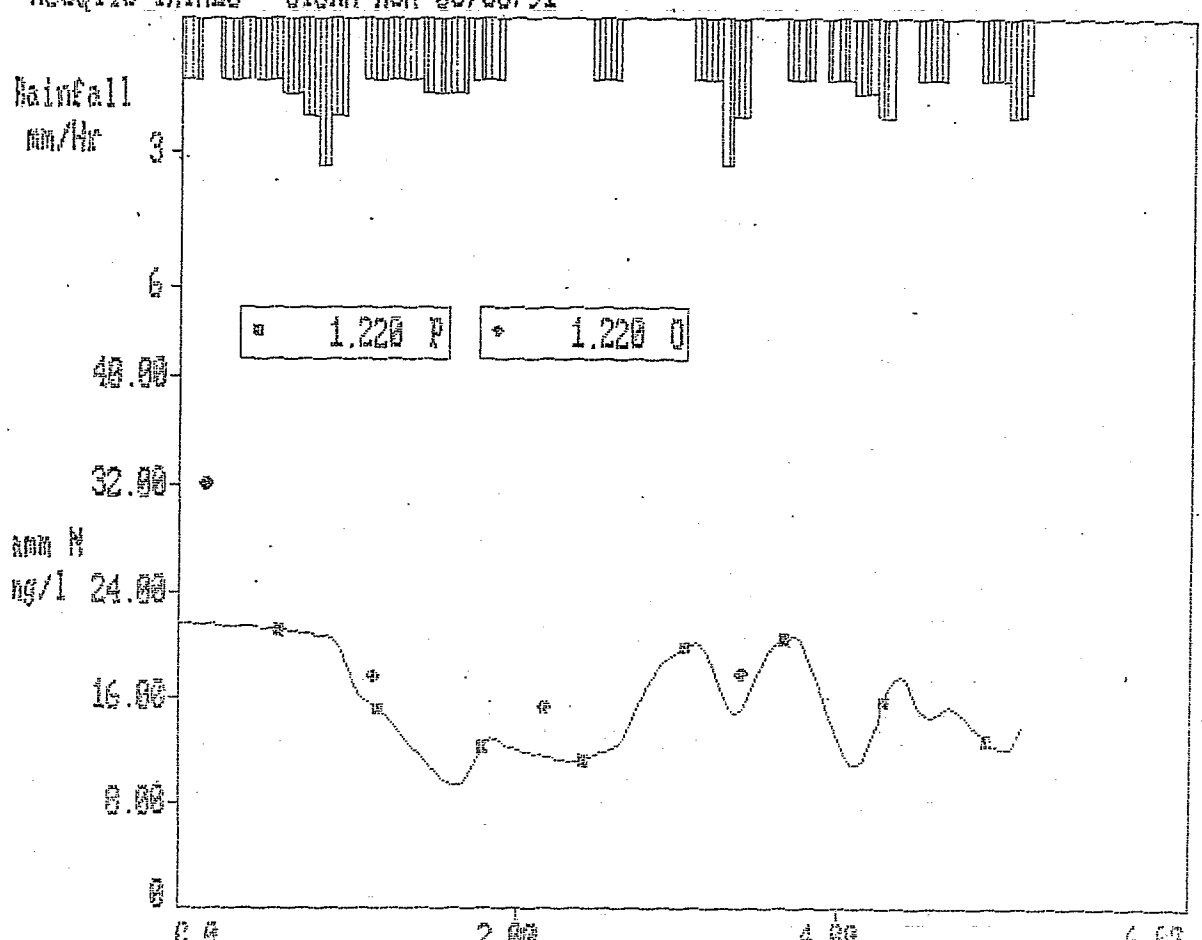

Paul Ambrose Bournmouth Borough Council

Question

How much did the flow and sample survey cost ?

Answer

The exercise was expensive £60,000-£70,000, it was waiting for the storm events that made it expensive. Manual sampling was carried out and it was difficult to get to the sites and do the sampling with the only warning of the event being provided by the Met office. Several good events were missed and only the tail end was caught.

David Balmforth Sheffield Hallam University

Question

Nobody should underestimate the problems with getting all samplers working simultaneously and collect information for the right type of event, it is an extremely difficult task. What had been done in looking at the integration of the MOSQITO results into the integrated sewage treatment and river basin management.

Answer

The results had been fed into the STOAT model for the treatment works and DHI's Mike 11 for the river.

There had been some problems with the Mike 11 but STOAT was working well albeit that it is still at an early stage.

Graham Wells North West Water

Comments

NWW's work on the Royten system had produced some good fits on the storm verification following good rainfall.

The model has been successfully linked to STOAT and is being linked to Mike 11.

The MOSQITO package has been used in anger on other projects and the results have been used in detailed discussions with the NRA.

NWW see real potential in the package for further development and use.