WaPUG
Spring 1995
Birmingham

THE DERBY UPM DEMONSTRATION PROJECT: CONCLUSIONS

R Crabtree - WRc Swindon; W Earp - Severn Trent Water Ltd. Birmingham; and P Whalley - Severn Trent Region NRA, Solihull

1. INTRODUCTION

The Urban Pollution Management (UPM) Research Programme[1] has been the UK water industry's response to the need to limit the risk of transient and potentially serious pollution of receiving waters resulting from intermittent discharges, such as combined sewer overflows (CSOs). The UPM Procedure described in the UPM Manual[2] will play a major role in developing cost effective integrated wastewater system solutions to meet the requirements of the Urban Wastewater Treatment Directive for the control of wet weather discharges. The major benefit of the UPM Procedure will be the ability to identify solutions with a high degree of confidence that environmental criteria will be met and which will be cost-effective by avoiding the over-provision of storage or treatment capacity.

The need to demonstrate to the industry the environmental and financial benefits to be realised from the practical application of the UPM Procedure was considered to be a major step in promoting its uptake. To fulfil these requirements, the UPM Demonstration Project commenced in 1993 with the aim of applying the UPM Procedure to a catchment with recognised wastewater system performance deficiencies. This 2 year project was jointly funded by UKWIR, the NRA and SNIFFER through FWR.

Specific objectives of the UPM Demonstration Project were:

(i) to carry out a comprehensive application of the UPM Procedure in a selected study catchment;

(ii) to identify a notional UPM strategy solution to the specific problems of the selected study catchment; and

(iii) to contrast the above solution with alternatives derived by applying traditional planning procedures.

Derby was selected as the demonstration catchment. There are longstanding concerns about flooding and CSO pollution problems caused by the sewer system in Derby. Both the complexity of the sewer system and the critical nature of the multiple uses of the River Derwent complicate the identification of an effective solution. The designation of 23 unsatisfactory CSOs in the catchment and the river quality response to rainfall indicate the need for a planning study to resolve these problems. NRA policy identified in the AMP2 Guidelines[3] requires that wastewater upgrading strategies ensure that legitimate receiving water uses are protected from intermittent wet weather discharges. In relation to the River Derwent, which is a designated

fishery and also of high amenity use value, appropriate water quality standards for protecting river aquatic life and emission standards for protecting amenity use are to be complied with.

Previous papers have considered the application of the "Initial Planning" and "Assembling Data and Tools" phases (Phases A and B) of the UPM Procedure at Derby[4]. This paper considers the third phase, "Developing Solutions" (Phase C) in detail and reviews the outcome of the project.

2. DATA COLLECTION PROGRAMME

The data collection programme to support the development of the modelling tools was constrained by a paucity of suitable rainfall. Only one storm event was captured out of the three events originally proposed. However, this allowed calibration of MOSQITO and verification of the STOAT and MIKE 11 models.

The following key conclusions can be drawn about river water quality from the results of the data collection programme:

(i) there are extreme diurnal variations in DO in Cut D during the summer which would cause it to fail the intermittent discharge DO thresholds on a regular basis under dry weather flow conditions; and

(ii) the main impact of both continuous and intermittent discharges occurs around Borrowash.

3. DEVELOPMENT OF QUALITY MODELLING TOOLS

The size of the Derby catchment necessitated the simplification of existing WALLRUS models for the main interceptor sewers to produce viable MOSQITO models. Two simplified WALLRUS models gave an acceptable simulation of sewer system hydraulic performance and were converted to MOSQITO models. A strategic approach to MOSQITO modelling for a large catchment was successful and MOSQITO models for the western and eastern catchments were calibrated under DWF conditions. A single storm event enabled wet weather calibration to be achieved. This work highlighted the significance of site specific sewer sediment data for sewer flow quality modelling.

The STOAT model was able to represent all treatment process components adequately and was calibrated and verified. The model tended to overpredict final effluent concentrations. Verification may have been improved by specific data to characterise the major industrial influent had this been available.

The MIKE 11 model concentrated on the representation of the main River Derwent and major continuous and intermittent inputs. The model was calibrated and verified under low flow summer conditions. The major diurnal variations in DO were well represented as were wet weather ammonia concentrations.

These detailed models were used to calibrate a SIMPOL[2] model for the sewerage system and STW and to identify appropriate river quality criteria for impact assessment. SIMPOL is a spreadsheet model which combines many of the key processes involved in wet weather pollution modelling in a simplified way, so that many events can be rapidly simulated. It incorporates both stochastic and deterministic elements and is specifically designed to assist in the implementation of the UPM Procedure. The Derby catchment was divided into 10 SIMPOL subcatchments, based on internal flow transfers and CSO spills.

4. EVALUATION OF UPGRADING OPTIONS

Severn Trent Water Ltd specified a "base" option for sewerage upgrading to be assessed by the UPM Demonstration Project in terms of environmental impact. In addition, certain variations on the "base" option were identified, to demonstrate the benefit of the UPM Procedure compared to alternative approaches. The "base" option represented a potential solution based on work carried out by Severn Trent Water Ltd up to late 1994, and excludes any changes to treatment or storage capacity at the STW. The estimated cost of the pollution improvement elements within the "base" option is £16 million.

The major features of the "base" option, which maximises the use of existing infrastructure, include:

(a) increased inlet pumping rates at the sewage treatment works to 4.4 m^3/s;

(b) provision of a new CSO on the Eastern Interceptor (EI);

(c) conversion of the Southern Surface Water Sewer (SSWS) to a combined sewer (Southern Combined Sewer (SCS), with a new CSO at the crossing point of the Chellaston Trunk Foul Sewer (CTFS) at Green Lane to combine the two sewers;

(d) catchment transfer from the Northern Interceptor (NI) to the SCS, plus a local storage solution in the upper catchment; and

(e) catchment transfer from the Southern Interceptor (SI) to the CTFS.

Evaluation of the "base" option using the models described previously, showed that this option is compliant with the standards (Table 1). The most critical pollutant is un-ionised ammonia from Cut C to below Borrowash where only marginal compliance is shown.

Table 1 - SIMPOL results for "base" option

Criteria	Standard Applied (mg/l)	SIMPOL Result (1) (mg/l)
In-river 6 hr BOD concentration with 1 year return period	15.0	10.7
In-river 6 hr Un-ionised ammonia concentration		
(a) 1 year return period	0.15	0.13
(b) 1 month return period	0.075	0.070

The major impact on the river during dry weather flow was from the discharge of final effluent from Derby STW. While this is currently within its consent, the interaction with an industrial discharge during summer conditions of low flow, high temperature and pH is complex and, as a result, there are high levels of un-ionised ammonia downstream. This is exacerbated under wet weather conditions by further inputs of ammonia from CSOs and the STW storm tanks. To illustrate this, results from SIMPOL showed the following proportional inputs for a 1 year return period event:

STW Final Effluent	56%
STW Storm Tanks	27%
All CSOs	17%

On this basis, further improvement to the sewer system to improve the performance of CSOs above that of the "base" option, would give little improvement in terms of in-river un-ionised ammonia which is the critical pollutant as river impact is more sensitive to the performance of the STW.

5. BENEFITS OF UPM PROCEDURE APPLICATION

The greater understanding of the wastewater system and its environmental impact gained in the course of the study will increase confidence that the environmental criteria can be met cost-effectively. To illustrate this, the "base" option can be contrasted with alternatives derived by applying more traditional planning criteria. A modification of the "base" option from 4.4 m^3/s to 6.6 m^3/s inlet pumping capacity based on a QUALSOC[3] analysis, is considered to be cost-neutral by Severn Trent Water Ltd. However, it has been shown to have a slightly worse environmental impact. Increased storm tank capacity would be more cost-effective in increasing confidence in the overall scheme than increased in-sewer storage. A modification to the "base" option using the SDD[3] method would require the point of discharge from the Green Lane CSO to be moved from Cut D to the main river at Borrowash. While the overall significance of this variation is debatable, the cost of extending the outfall is estimated at £1.35m by Severn Trent Water Ltd. This represents a potential saving of 8.5% on the total notional cost of the pollution improvement elements within the "base" option. Also, the interaction of the continuous and intermittent discharges, which results in the high levels of un-ionised ammonia below Spondon, would not have become apparent using traditional design methods.

Notional screening capacity requirements have been identified which will reduce the risk of gross solids pollution to levels considered to be acceptable by the NRA, thereby alleviating current problems specific to the Markeaton Brook and the Cut D flood relief channel.

The results from the UPM Demonstration Project will be taken forward for consideration in the final development and approval of the Derby improvement strategy. It is anticipated that the UPM Procedure and tools will be used further to refine the upgrading options being considered.

REFERENCES

1. Clifforde I and Murrell K (1993). Urban Pollution Management: Review of Products and Implementation. *Foundation for Water Research.* Report No. FR0405.

2. Foundation for Water Research (1994). Urban Pollution Management Manual. *Foundation for Water Research.* FR/CL0002.

3. National Rivers Authority (1993). Guidelines for AMP2 Periodic Review (Version 2). *NRA.*

4. Crabtree R, Earp W and Whalley P (1994). The Derby UPM Demonstration Project. *WaPUG Autumn Meeting* Blackpool.

5. Crabtree R, Dempsey P and Gent R (1995). UPM Demonstration Project: Final Report. *Foundation for Water Research.* Report No. FR0494.

Session 3 - Chairman Brain Sharman North West Water

The Derby UPM Project: Conclusions

R. Crabtree **WRc Swindon**
W. Earp **Severn Trent Water Ltd**
P. Whalley **NRA Severn Trent Region**

Question Graham Squibbs North West Water

I am not sure where the river Derwent fits on the slope/ width /depth curve , but what were the benefits of a detailed river model rather than simple mass balance models. Was it all worth it ?

Answer

The River Derwent is a highly regulated river system with a number of large continuous discharges and abstractions below Derby. Historic data indicate significant diurnal variation in dissolved oxygen levels during the summer. These factors and the basic river physical characteristics indicate the need for detailed water quality modelling (see Table 3.3 of the UPM Manual) to produce site specific BOD standards to ensure compliance with the Fundamental Intermittent Standards for dissolved oxygen. Similarly, simple mass balance models would not have adequately represented the spatial and temporal interactions between the continuous and intermittent discharges, particularly with respect to in-river un-ionised ammonia concentrations. Hence, detailed river modelling using MIKE 11, formed a key component of the study.

Question Dave Walters M W Barber

In my experience the critical slope is not at STW or the CSO but some distance downstream. Flows tend to hug the banks of the river. Is the impact occurring where the mixing takes place?

Is there a table of mixing zone position based on width/ slope/ depth etc. ?

Answer

Data collection and subsequent environmental impact assessment should be carried out below the mixing zone of the discharge, where the effluent is fully mixed with the river. Typically, for example, this could be assumed to be a downstream distance of around twenty times the river width for discharges to large rivers. In practice this will be based on the characteristics of the river and the nature of the discharge, on an individual basis.

Average river gradient will influence self-purification and the interaction between discharges.

Question Andy Eadon Charles Haswell & Partners

It is important that the model builders and regulators get together using technical tools, did this happen ? and was it worth it ?

Answer

Yes, this did happen once the initial nervousness was overcome and it was very helpful with a positive impact on the outcome. The approach enabled the Plc to confirm that the money was being spent effectively and that the NRA got the right environmental improvements.

Written Question Ian Garside Montgomery Watson

Were the capital cost savings of using the UPM procedure as against "Traditional" methods quantified and if so did these cost savings justify the costs of model building and data collection?

Answer

The cost of applying the UPM Procedure to Derby was approximately £300k. Initially, potential capital savings of £1.35m have been identified compared to "traditional" methods. This is equivalent to 8.5% of the estimated cost of the pollution control elements originally envisaged. It is anticipated that this level of saving will increase as options are refined further using the UPM Procedure and tools.