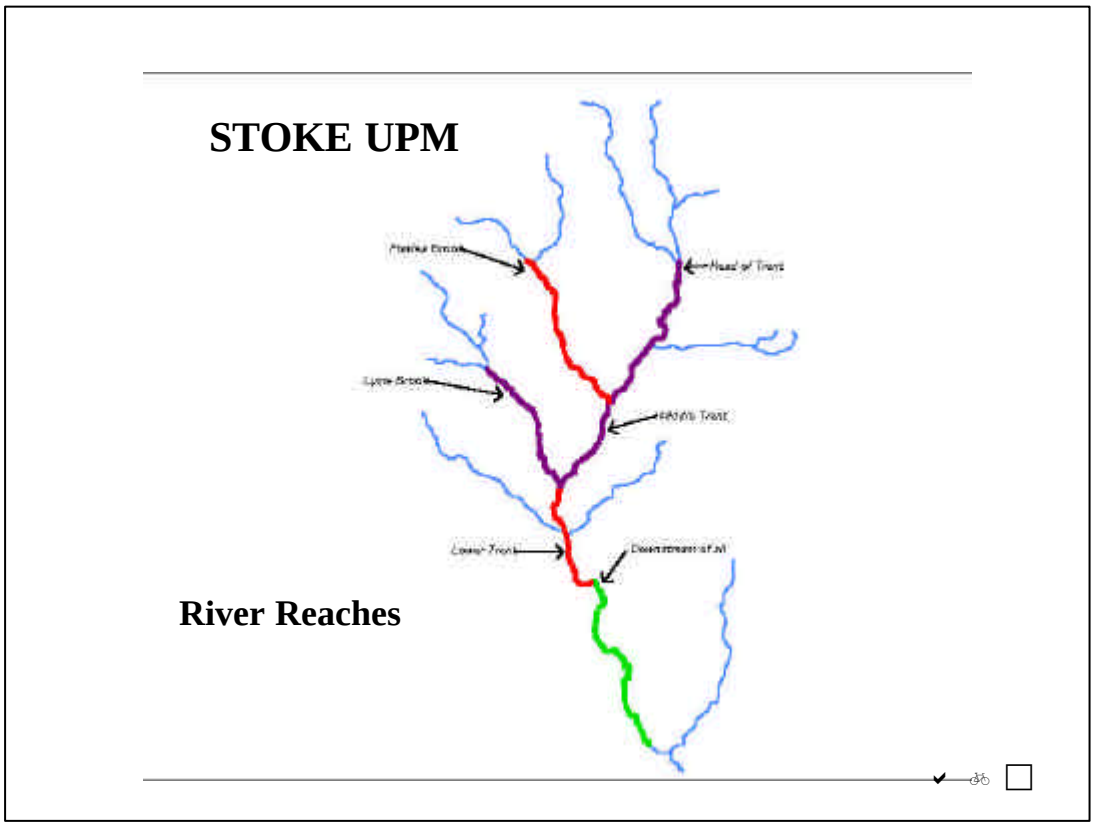
UPM - MOVING FROM MODELLING TO OPTIONS

Andy Eadon and Malcolm Horne – Haswell Consulting Engineers
David Gordon – Severn Trent Engineering

Introduction

This short paper outlines the approaches which have been adopted to develop options to improve the performance of 54 unsatisfactory intermittent discharges in Stoke on Trent. The discharges are from a sewer system serving the City which is mainly combined and the discharges are to the headwaters and tributaries of the River Trent. The dilutions available are limited and there is evidence that both water quality and aesthetics in the receiving waters are below standard. For these reasons the city wide catchment was chosen by Severn Trent Water for a UPM study. This was endorsed by the Environment Agency and the work included in the AMP3 investment programme. Progress to date includes the construction and verification of the required models for the sewer, sewage treatment and river systems. These have since been used to develop improvement options which will be refined as engineering feasibility and design progresses. This is being done within the envelope provided by the UPM models so that any possible interactions are accounted for. This in turn permits the construction and issuing of consents for some of the UID improvements early in the AMP period. An illustration of the river system is given in the figure below.



Summary of Model Development and Use

The development of the various models used in the study and their interrelations are described below. The process of development necessarily follows a sequence of enhanced knowledge of the sewer and river systems, and the incorporation of field measurements which have been used to verify and calibrate the models. The major models were InfoWorks for the sewer system, GPSX for the sewage works and Mike 11 for the receiving waters. These are event models and are too cumbersome to develop the FIS and 99%ile standards to test river impact on a city wide catchment. The more versatile SIMPOL has therefore been employed. SIMPOL has been constructed and verified in accordance with the UPM Manual.

The InfoWorks model covers the entire sewer system and was compiled from verified HydroWorks models developed by Severn Trent's Drainage Area Study programme. There was no further verification thought to be necessary except for one area previously not included in the model coverage. This was added and together with terminal pumping stations and storm tank arrangements. The combined model was bolted together and verified by further field measurements. The Infoworks model was then updated as necessary to include the changes made by recent investment. After careful examination of the InfoWorks model, its hydraulic performance was confirmed and the quality element built. The quality element was calibrated from field samples and confirmed at the outfall and at intermediate points. Flow, volume and quality outputs from the Infoworks model were then used to interface with the GPSX (sewage works) model and the Mike11 (river system) model.

The GPSX model was constructed by Severn Trent Processes using standard modelling techniques. The full treatment process stream is represented. The model was calibrated using samples and works compliance data. The flow to the model was provided by InfoWorks and the flow, volume and quality outputs fed into the Mike11 model.

The Mike 11 model was constructed from the geometry of reaches and cross sections provided by the Environment Agency. The model represents the main tributaries of the River Trent system which drain the urban catchment. The model was verified and calibrated from field measurements and samples. The model includes representation of background polluting sources and receives cumulated discharges via CSOs and storm tanks from the InfoWorks model, and the final effluent from the GPSX model.

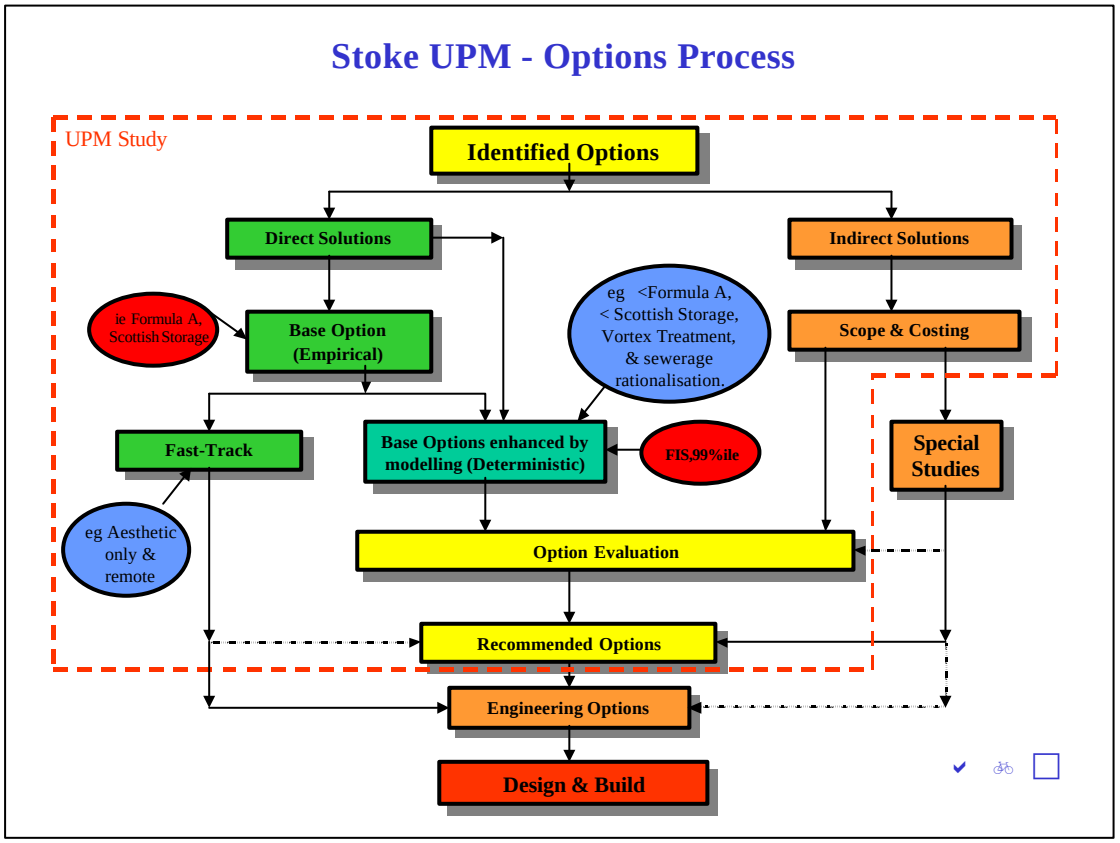
The three major models above permitted any storm event to be effectively modelled and hydraulic and pollution profiles to be produced. A selection of events for the existing reticulations were tested but due to the size of the models and the computing time required, a full series of storms to examine the threshold of the fundamental intermittent standards (FIS) was not possible (nor required by the UPM procedures). The production of a skeletal InfoWorks model was a considered alternative, because it is the detail of this model which consumes computer power. However due to uncertainty about the resulting accuracy, this option was discarded in favour of the alternative provided by the standard application of SIMPOL.

The SIMPOL model was constructed in accordance with standard procedures. It is a simplified representation of the whole integrated drainage system on which rainfall series can be applied to generate statistical data. It was therefore possible to check the impact of rainfall induced discharges against FIS and to design improvements in a deterministic manner rather than revert to empirical approaches. The representation of the sewer system was constructed with eleven elements, one for each sewer sub-catchment. Each element uses actual connected area and the actual aggregated storage volume of CSOs and other sewer ancillaries. The element was calibrated by adjusting the carry forward throttle (attenuation factors) for selected events to match the CSO discharge generated by the InfoWorks model. SIMPOL also incorporated an output from the sewage works which was verified against the GPSX model and a model of the river system. The representation of the sewer and river systems permitted impacts to be assessed on each tributary and reach. The outputs of the selected storms applied

to the main models were compared with outputs from SIMPOL for the same storms to check the calibre of SIMPOL.

The development of notional schemes for improving the sewer system and elevating the performance of the 54 UIDs in the system was an intuitive process as is normal practice with simulation models. The first stage was the adjustment of storage volumes in the sewer elements of SIMPOL to achieve FIS in all reaches which receive discharges from UIDs. This gave the first indication that improving storage at UIDs would produce satisfactory results. The second stage was to assign this storage to individuals UIDs in the InfoWorks model and to make a physical assessment of the buildability of the proposals. The final stage will be to compare both the SIMPOL and InfoWorks model with the improvements incorporated for the selected storms, as the notional schemes develop through feasibility and design. The tools to check final designs and to continuously assess progress of the investment strategy are therefore in place.

Option Management



The above diagram illustrates the process which is being used to provide initial estimates and to refine options as feasibility and design progresses. It is considered that there are broadly two types of solution for improving the quality of the receiving waters. Direct solutions are on-site improvements to the 54 UIDs to reduce the polluting load. Indirect solutions are any other feasible alternatives such as augmenting river flows, introducing more treatment or improving other CSOs. The advantage this gives is that direct solutions can readily be

estimated using the empirical design parameters of Formula A and Scottish Paper Storage. This has also been selected as the base option against which all other options are compared.

Almost all of the indirect options identified do not have an empirical design approach and are dependent upon the UPM procedures. On the other hand the base option can either be designed empirically or refined deterministically using the fundamental intermittent standards (FIS). This provides a second general comparator which has become known as the 'storage' option.

The feasible indirect solutions have a number of limitations and some have already been eliminated as impractical. The remainder are alternatives for only some of the UIDs and cost comparisons with the base and storage options show if these are worth pursuing. Some require further study.

A small number of the UIDs are 'aesthetic' only and remote from others. With the early knowledge that the base option in which they are included will provide satisfactory results in the river, these UIDs have been selected for fast track so that some early investment can be made. It is argued that there are unlikely to be any better options available.

The final solutions will of course have to be 'engineered' and sub-options will arise. These will be evaluated in due course.

The most significant results so far are:

- Improving UIDs empirically (base option) gives satisfactory results in the receiving waters.
- Refining the base option to just meet the FIS produces potential savings of almost £10M.
- Most indirect solutions have been eliminated on cost grounds.

The examination of engineering options is now firmly underway.

Andy Eadon - Divisional Director, Haswell Consulting Engineers
Malcolm Horne – Section Leader Engineer, Haswell Consulting Engineers
David Gordon – Principal Engineer, Severn Trent Engineering