YORK MACRO MODEL

Ray Chaplin: York City Council

C/O Yorkshire Water, 32/34 Monkgate, York

ABSTRACT

Naburn WWTW serves York and a number of surrounding villages. Its drainage system has developed since the turn of the century. There is currently no co-ordinated system of easily analysing the flows to the Works and this study is aimed at producing a verified hydraulic model to address this.

Previous studies on parts of the system have identified that significant volumes of infiltration water enter the system from the River Ouse resulting in excessive pumping and treatment costs. This study will investigate the potential locations for the points of entry of the infiltration water and the rate at which it occurs. The data will then be available to demonstrate the effects of this problem and the benefits accrued from its removal.

1.0 THE SEWERAGE SYSTEM

The basis of the sewerage system in York was laid out in the 1890's by James Mansergh, a Consulting Engineer from London. He designed a system of trunk sewer to pick up the combined sewage from those sewers which already existed and so new trunk sewers were laid through all major conurbations. These sewers outfalled to a terminal pumping station at Fulford from where flows were pumped to Naburn WWTW. The sewerage system has been extended as developments have proceeded and this included the construction of Castle Mills Pumping Station, a joint project with the NRA to alleviate flooding to 25% of York. To the west of the City, a large residential area has developed since the 1950's. This is largely on a separate system whose flows discharge to a terminal pumping station at Middlethorpe. This pumping station also receives flows from several villages adjacent to York and discharges its flow to Naburn WWTW.

Naburn WWTW also receives flows direct from York University, a local Hospital and from Naburn village ejector station. The final discharge conveyed to this Works comes from the recently constructed East York Ring Main which picks up flows from 6 villages and the MAFF field station currently under construction.

The sewerage system discharging to Naburn WWTW serves an approximate population of 135,000 spread over an area of 40 km^2 and has 3 terminal pumping stations, 16 on-line pumping stations and 70 CSO's. The urban area of York is divided into 11 drainage area zones.

2.0 PREVIOUS STUDIES

2.1 TRRL Model

The Greater York Sewerage Study of 1982 involved analysis of flows in the system using the TRRL method. The size of the network did not lend itself for an individual model, therefore discrete catchment areas were analysed and an output hydrograph was produced for each. These hydrographs were then imposed onto the trunk sewer leading to Fulford Pumping Station. The station could not cope with the flows being delivered to it, resulting in surcharge of the trunk sewer and hence the output hydrographs from the discrete catchments were invalid as they were prepared assuming a free outfall from the discrete catchments.

Site surveys as part of this study also confirmed that the sewerage system suffered from significant ingress of river water upto 12 times per year. An attempt was made to calibrate the volume of infiltration to the system and this showed that the inlet sewer to Fulford Pumping Station was carrying 214 l/s of infiltration in a base flow of approximately 500 l/s.

2.2 Wallingford Model

The Wallingford procedure was being developed in the early 1980's and the York system was one of the first projects to utilise the software. This then became one of the case studies in the Sewerage Rehabilitation Manual.

This study also concluded that the main trunk sewers were universally overloaded to a moderate degree in times of storm and surcharging throughout the system arose from the operation of Fulford Pumping Station.

2.3 WASSP/WALLRUS Models

In the mid 1980's York City Council as Agents for Yorkshire Water Authority embarked on a programme of Drainage Area Planning as a pre-requisite for some major capital work to be undertaken as part of a project to alleviate the effects of flooding from the River Ouse.

An attempt was made using WASSP to model the system upstream of Fulford Pumping Station and a short term flow survey was carried out for verification. However, the model was not satisfactorily verified because:-

- The storm pumps at Fulford Pumping Station were operated by hand and the simulation of this proved impossible.

- Ingress of river water was significant in times when the River Ouse was above normal summer level and no method of ascertaining the rate of this inflow was available. WASSP was not able to deal with such a variable inflow to the system.

- The surcharging which manifested itself up the system from Fulford Pumping Station could not be accurately simulated using WASSP.

All the above served to make verification impossible and hence the WASSP model would only be good for low intensity storms, when the river was low and the normal duty pumps at Fulford were working on auto. However, this was rarely the case.

2.4 Future Model

The control system at Fulford Pumping Station has now been uprated so all foul and storm pumps work automatically at pre-defined levels, thus lending themselves to modelling. Also, software is now available to simulate looped flow.

Both these developments now make it possible to create a hydraulic model to simulate the flow regime which exists in York.

3.0 RIVER IMPACT ON SEWERAGE SYSTEM

In a recent study carried out by Howard Humphreys on the River Ouse, the impact from the sewerage system in York showed that the principal discharge to the River Ouse was from the storm tanks at Fulford Pumping Station. This was confirmed by an actual flow/water quality survey and simulated Time Series Rainfall results.

Fulford Pumping Station has been fitted with a "Supervision Control and Data Acquisition" (SCADA) system which records River, wet well and storm channel levels. Examination of results from this equipment over a period of time clearly shows that when the River Ouse is running above its normal summer level flows in the sewerage system increase. The Howard Humphreys' study predicted that of the total of 16.4 million m^3/year of flow to Naburn WWTW, 5.5 million m^3/year could be attributed to river infiltration.

This infiltration is known to enter the system through structural dereliction in the sewers and manholes and through leaking flap valves on CSO's.

Castle Mills Pumping Station is activated by a rising level in the sewer immediately downstream of itself. Hence, one major detrimental effect of the surcharge in the trunk sewers due to the ingress of river water and the surcharge created by Fulford Pumping Station is that Castle Mills Pumping Station is brought into operation much more frequently than is necessary, with the obvious revenue implications.

4.0 CREATION OF A MACRO MODEL

Over the past 7 years studies have been carried out on 8 drainage areas within York. These studies have produced hydraulic models of the sewerage systems in each but the confidence in their verification varies depending on their proximity to

either the River Ouse or Fulford Pumping Station. It is proposed to merge all these models and create simple models of the surrounding villages to merge into one Macro Model of all the sewerage systems delivering to Naburn WWTW. This model will be run on a 2000 node version of Hydroworks.

5.0 FLOW SURVEY

In order to verify the hydraulic model a short term flow survey has been commissioned from Integrated Hydro Systems in association with ADS Environmental Services.

The flow survey involves 100 standard flow, 34 bi-directional flow, 3 depth, 7 pumping main and 58 pump run time monitors, along with 36 raingauges and 4 river level monitors.

Flow monitor sites have been selected at salient points around the catchment to show the development of flows in the system. Also, bi-directional flow monitors have been installed in the CSO's and trunk sewers adjacent to the River Ouse to monitor the growth in infiltration at varying river levels. The bi-directional monitors are capable of detecting and quantifying reverse flow, early results of this are looking promising.

6.0 THE FUTURE

6.1 The aim of the study is to produce a verified hydraulic model which is relevant to both high and low River Ouse levels.

6.2 Use the results of the flow survey to verify the hydraulic model and predict the locations of significant infiltration.

6.3 Provide a tool which can be used to assist in decision making processes for future strategies to comply with ECUWWTD and EIFAC Directives.

6.4 Utilise the hydraulic model to allow the interaction of Fulford and Castle Mills Pumping Stations to be studied to minimise the operational revenue costs.

ACKNOWLEDGEMENTS

Integrated Hydro Systems Ltd
ADS Environmental Services Ltd
Howard Humphreys and Partners Ltd

York Macro Model
Ray Chaplin **York City Council**

Question Cello Vitasovic Reid Crowther Consulting Inc.
What was the cost of the flow survey ?
Answer
The survey is not complete and I cannot discuss the final cost.
Written Question Bruce Leatherbarrow Bechtel Water Technology Ltd
From the photographs shown and the results of the investigations undertaken, it is obvious that water ingress from the river is a serious problem. Since the locations of some serious inflows are known (i.e. the CSO river discharge pipes), what steps, if any, are being taken to make the one-way valves more water tight ? No mention was made of any such works which is surprising, given that the costs of undertaking this work would be offset to some degree by savings in pumping and treating less river water.
Answer
Consideration was given to carrying out early remedial works to the flap valves but this was discounted because:

1. There was a need to establish the current rates of inflow on the system, at it exists, so as to demonstrate the magnitude of the problems and how these effect other parts in the sewerage system and treatment process.
2. The actual locations and rates of inflow were not known prior to the survey and hence no cost/benefit relationship could be established to justify works being carried out.
3. The cost of any remedial works was perceived to be significant given the nature of the problem and these works may then not fit in with the final solution.