Botley Back to Basics

Andrew Hagger; Thames Water, Reading
Danielle Hibbert & Neil Marples; Optimise, MWH High Wycombe.

28 Flooding Properties

The Optimise joint venture comprising of MWH, Murphy's, Clancy Docwra and Barhale has been tasked by Thames Water to resolve a long standing problem of foul sewer flooding in Botley, Oxfordshire. Work began to understand and resolve the problem in July 2010.

Botley is a low lying community 2km to the west of Oxford, lying within the Oxfordshire flood plain. Between the two Botley and Oxford, there are five watercourses including the River Thames.

Be wary of 'perception' - the problem

When living on or adjacent to a flood plain, actual and anticipated flooding becomes a regular topic for discussion and publicity which leads to a demand for solutions to be developed. The Oxfordshire Flood Alliance summarises the problem;

> "*Oxford's major floods are a result not of water falling on the immediate area, but of water which has fallen as far away as the Cotswolds coming down the valley of the River Thames*"

It was widely believed by the Stakeholders that the flooding was caused by runoff from the rural catchment. The perception was that the foul flooding in Botley, resulting in 28 properties being on the DG5 flooding register, was due to the lack of capacity in the foul system which became inundated with the rural run off.

In Botley there is significant demand for new development in the town. Whilst various bodies are responsible for elements that contribute to the flooding the public see it in a more simplistic way. They certainly cannot see how additional properties can be built and connected to a sewerage system that regularly fails. Accordingly the Local Authority are under pressure to grant planning permission for new developments but need the public sewerage system to be upgraded and therefore pressurised Thames Water to invest in new capital works.

The culmination of this was that "Grampian" conditions were imposed on the catchment. This means that no new development can be connected to the public system before the 30th December 2012, it also means that Thames Water have to upgrade their system by this date.

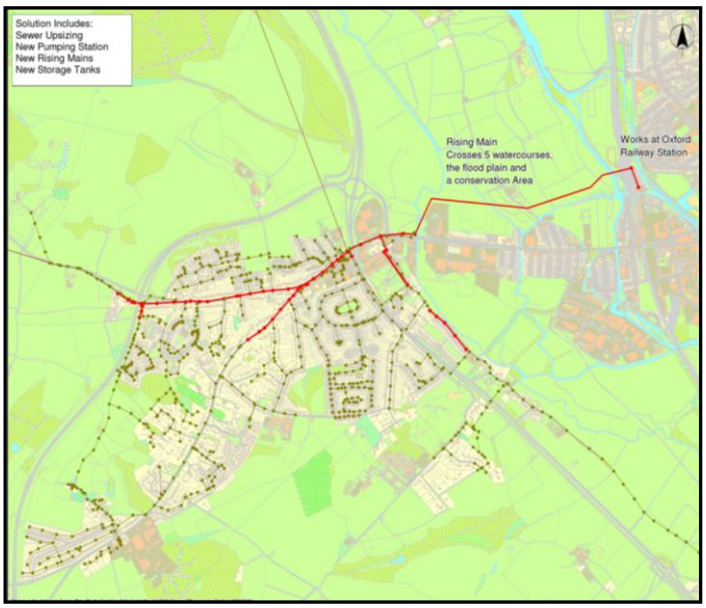

Figure 1 Transfer from Botley to Oxford

Perception generates the Solution

Based upon the widely held view of the flooding mechanism it was deduced that flows needed to be transferred to a point where there was available spare capacity. Based upon a calibrated model, a solution

to pump flows from the centre of Botley, across the flood plain to the trunk sewer in Oxford was developed, see Fig 1.

The Back to Basics approach - understand the problem

From the outset, Optimise appreciated that problems in Botley were complex and possibly that no single body understood all the issues. If the problems were to be resolved they needed to be replicated, so a detailed hydraulic model was commissioned. Whilst the timescale was tight the decision was taken that not until the full connectivity, performance of key assets and operational problems were understood would any "optioneering" be undertaken. This was subsequently referred to as a "Back to Basics" approach, ultimately proving to be invaluable. It entailed:

Delivery Team: Understanding previous investigations and current issues was fundamental and would not be achieved within the timescale if the traditional client / contractor relationship was employed. A single delivery team was created that included Thames contracting, operational and modelling staff working with Optimise design, modelling, construction and third party staff. An excellent working relationship developed with good transfer of information. This was probably typified with the relationship with Mark Taylor, who leads the operational team, where it started with designers asking questions yet culminated in the operational teams passing information and questioning the designers on its relevance and impact

Stakeholders: In addition to Thames Water, information was obtained from other stakeholders, notably; the residents of Botley, the Environment Agency, Vale of White Horse District Council, Oxford City Council, Oxfordshire County Council, Oxford Area Flood Partnership and the Oxford Flood Alliance.

Flow Survey: Working with IETG, a comprehensive flow survey was undertaken which was in the ground for 33 weeks. From a financial perspective there was certainly pressure to limit the duration of the survey, however being if we were to understand the issues and not carry out calibration it was imperative that critical information was obtained Monitors were located at key points within the sewer network to confirm the flow rates, volumes and flow routes. The survey confirmed;

- The primary route for flow was for it to turn right off West Way, under the trunk A34 to join the sewer at North Hinksey lane adjacent to the cemetery.
- A secondary route for flow was to spill over the weir at the West Way / Westminster Way junction, through a hydrobrake and along West way to North Hinksey PS from where it was pumped into North Hinksey Lane.
- A tertiary route was for the flow to pass over the weir, continue along West Way and to spill at the unscreened CSO

Asset Surveys: For Optimise, Dene Tech undertook a 400ha Impermeability area survey, 80 manhole and 2 CSO surveys. A further 4.7km of CCTV surveys were completed

Rural Run Off Assessment: MWH undertook a hydrological assessment and calculated the rural run off volumes to the north and west of Botley, determining the interaction with the foul sewer network. It was initially envisaged that this would confirm the perception of what the flooding mechanism was.

Determining the System Performance & Key Findings

The findings of the investigations were incorporated into the hydraulic model and verified against monitored flows. As a result of the information that had been gathered across the whole catchment, modelling assumptions of how the network operated did not have to be made.

A key finding of the survey was the confirmation of sewer connectivity at the junction of West Way and Westminster Way. As a result the hydraulic model replicates the primary, secondary and tertiary flow routes previously identified.

The perceived problem was that there was a large storm response entering the foul system that appeared to be confirmed by the high flow depths evident in the flow monitoring, as shown in fig 2. However the impermeable area survey identified that there were only relatively minor areas that would induce a storm response and it was also proven that the rural run off and infiltration does not have a significant impact on the flows within the foul system, as originally interpreted. Further investigation into the network identified that in general the high depths observed during the flow monitoring were in fact due to operational constraints. These included an inverted siphon, hydrobrake, partial blockages and high levels of silt.

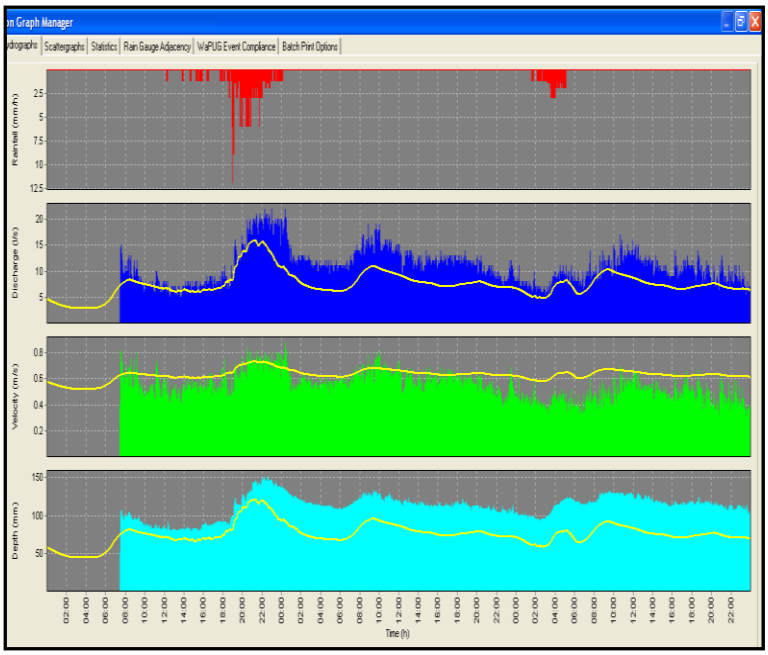

Figure 2 Hydrograph prior to silt removal

Using the flow monitor data a further restriction was eventually identified in the fields south of the rugby club. This turned out to be a letterbox shaped pipe 600 x 200mm, though initially it was thought to be a siphon. A subsequent ground radar survey showed that the "letter box" was probably installed to allow the sewer to pass below a large gas main.

Another key finding were two substantial root ball blockages by the primary school in North Hinksey Lane. These blockages occupied approximately 50% of the pipe section. The CCTV allowed Thames operational teams to remove these restrictions.

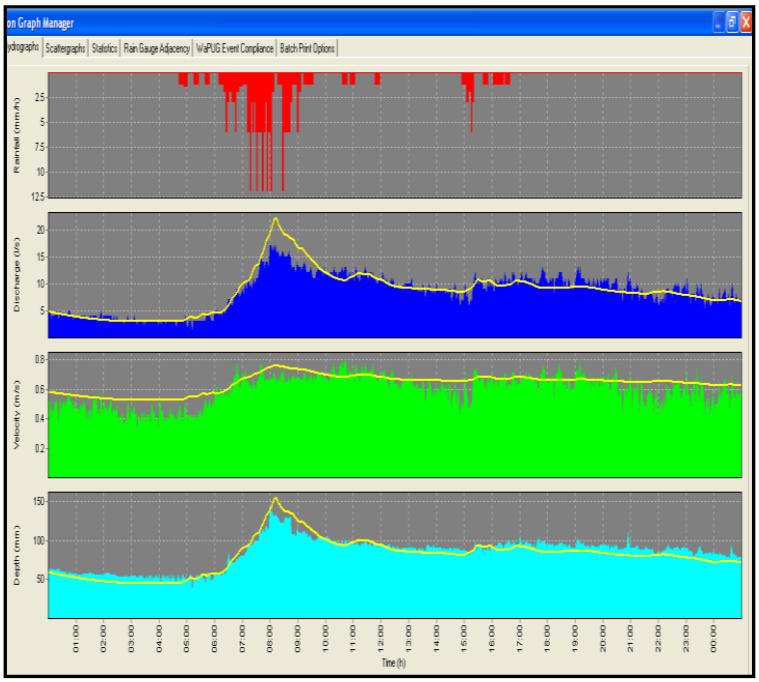

Figure 3 Hydrograph after silt removal

Surveys showed high silt levels which was measured and jetted clear in the early part of the flow survey. It was also monitored throughout the survey. The effect of removing the silt can be seen in Fig 3The silt covered the main sewers through the west of Botley and two kilometres along North Hinksey Lane from its junction with West Way through to

the rugby club. 28 tonnes of silt were removed from this part of the network along with a further 11 tonnes downstream of the rugby club.

The investigations downstream of the rugby club also located a concrete plug that had once been positioned within a lateral connection. The plug has moved from its original location into the main sewer line causing a reduction of about 40% of the cross sectional area. This obstruction has yet to be removed. The network operatives also located a large piece of timber that was obstructing a manhole in Manor Road in South Hinksey, where some of the driver properties are located.

Some small areas of misconnections were identified, including surface water gullies and property misconnections to the foul system. The surface water gullies have subsequently been reconnected to the correct system and Thames will be looking to resolve the misconnection problems via the Environmental Health department of the Local Authority.

Understanding the Flooding Mechanism through detailed investigation and analysis

North Hinksey Lane: The 200mm high by 600mm wide "Letterbox" shaped sewer in North Hinksey Lane, acts as a sharp edge orifice, which restricts the pass forward flow as the flows hit the wall above it. This arrangement results in the flows in the upstream network slowing down causing sedimentation.

This orifice also causes flows to back up along North Hinksey Lane, which cause flooding at the low spots, including the most vulnerable low spot by the primary school. The flooding at this location is exacerbated by the two nearby areas where roots have broken through the top of the sewer and are blocking up to fifty percent of the sewer diameter.

The foul sewer system along North Hinksey Lane generally has a very gentle gradient, adding to the issues with slow velocities and sedimentation. There are some locations where the sewers have very flat gradients resulting in a restricted pass forward capacity of approximately 40l/s. These capacities are inadequate for the flows generated in the upstream catchment and result in further backing up during storm events.

The combination of all of these hydraulic restrictions and operational issues has a wide ranging impact on the upstream network. The Botley area is hydraulically sensitive and any one of these flow constraints creates a risk of flooding in the town centre, some 2.5 kilometres upstream of the letter box orifice.

West Way: The short term flow survey and investigation has shown that there are components of the sewer system, such as the inverted siphon on West Way, that are susceptible to blockages.

This inverted siphon restricts the pass forward flow despite it being larger in diameter than both the upstream and downstream sewers that it connects to. The slow velocities through the inverted siphon result in silt building up leading to slowing of the velocities and backing up of flows upstream or spilling at the CSO.

The survey showed that the more the inverted siphon became blocked, the more flows were being forced to spill at the CSO, potentially even during dry weather. Permanent monitoring of these vulnerable sites could help to maintain the network in the future and alert the Thames Water operatives immediately to problems within the network.

Central Botley: Small diameter sewers cause hydraulic pinch points in the network, along Eynsham Road, in Old Botley, at Deanfield Road and at the bottom of Cumnor Hill. The sewer flows are constrained and back up in the network causing flooding at the lowest spots.

Grampian Conditions:The Grampian Condition is a consequence of all the constraints detailed above. There is only one exit route for the flows from Botley to reach the terminal pumping station at Littlemore and that is along North Hinksey Lane. The numerous restrictions here result in a network that cannot cope with any additional flows. The addition of the four new developments in the Botley catchment, without any upgrading work would only result in increased flooding incidents.

Developing the Solution based on sound evidence

Understanding the network, its interactions and performance characteristics allowed the optioneering to be carried out with a high degree of confidence. It allowed a proper evaluation both in terms of whole life cost, environmental impact and operability of conveyance, transfer and overflow solutions to be considered.

Common Element: Regardless of any main option selected there needs to be localised upsizing at Cumnor Hill, Eynesham Road and within Old Botley where local incapacities and hydraulic pinch points in the sewer network have been shown to be the cause of the flooding. 400m of upsizing from 225mm dia to 300mm dia along Eynsham Road

Preferred Option: A conveyance solution with online storage. The option entails upsizing 1700m along North Hinksey Lane and the construction of a 400m online storage tank in the fields to the south of North Hinksey Lane.

Rejected Option - Transfer: The perceived solution which consistd of 3.5km of gravity pipeline upsizing, 170m rising main from North Hinksey SPS, provision of a foul sewage pumping station, off West Way pumping at a rate of 360l/s with 630m³ of storage, together with a 1.7km rising main across the flood plain (including 5 watercourses) discharging to the Oxford Trunk adjacent to the railway station. Rejected due to cost and environmental impact.

Rejected Option – CSO: New or reconstructed CSO structure together with 800m of upsizing of the sewers along North Hinksey Lane. Negotiations took place with the Environment Agency and it was envisaged that this could be consented and delivered within the required time frame, however it was rejected on cost grounds and environmental impact.

Future Maintenance: Understanding the network enabled the weaknesses to be identified. A maintenance programme is currently being developed. The primary areas where future maintenance will be required are:

- The siphon and surrounding network in West Way. Lack of maintenance will result in premature spilling from the CSO. The installation of telemetry within the overflow will allow the frequency of maintenance to be properly understood
- Identified low spots in West Way and North Hinksey Lane
- The On line storage tank where dry weather channel and grit collection chamber is provided.

Conclusion

The "*Back to Basic"* approach has allowed Optimise to identify and replicate the flooding mechanisms, the recorded flooding and the CSO performance. This resulted in confidence that any promoted solution will resolve the flooding issues and provide capacity for growth. The approach also identified weaknesses in the network where operational maintenance needs to be routinely undertaken together with the implications if it is not. A maintenance schedule is currently being developed with the operations team along with ways of providing early alarms to prevent failure.

The perceived problem of rural run off inundating the foul system was shown to be false and any solution based on this flooding mechanism would not have given Thames value for money and critically would not have resolved the flooding and growth problems. A calibrated model here could have led to the incorrect solution. The publicity from this would have been significant as the new developments in the catchment came on line.

Not identifying the operational problems in the catchment at this stage would require further investigation to understand the cause flooding in Botley.

Fundamental to this process was understanding how the network performed and verification of a hydraulic model based on good quality survey data, that was provided by IETG and Dene Tech. This allowed the verification to be based on the actual catchment performance and not modelling assumptions.

The process has identified Thames Water's responsibilities within the Botley catchment and the information will help others understand the flows emanating from the highways and land drainage systems.

Having the verified model to carry out the optioneering meant that options could be developed with a confidence that they would be viable and this significantly reduced the amount of re and potentially abortive work.

The preferred solution will be delivered well before the deadline date for removal of the Grampian conditions. This can only enhance Thames Water's reputation, particularly with the relevant Local Authorities. The solution will also give a saving of many millions of pounds when compared against the original perceived solution.

Acknowledgements

It should be noted that this paper represents the views of the authors and not necessarily the Companies they represent.

Thanks are given to the numerous staff in Thames Water who were equally keen that the problem was understood and replicated. In addition the many stakeholders who were consulted and importantly the residents of Botley, who despite their problems were very helpful in providing information that allowed critical issues to be understood.