Botley Sewer Renewal

be wary of 'perception' - back to basics

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Botley is a low lying community 2km to the west of Oxford, situated within the Oxfordshire flood plain. Between Botley and Oxford there are five watercourses including the River Thames. There is significant demand for new development in the town. Accordingly the Local Authority are under pressure to grant permission for new developments, but need the public sewerage system to be upgraded, therefore pressurising Thames Water to invest in new capital works. The culmination of this was that 'Grampian Conditions' were imposed on the catchment, meaning no new development can be connected to the public system before the 30th December 2012, and Thames Water have to upgrade their system by this date.

Figure 1 Transfer from Botley to Oxford - Courtesy of Optimise

The problem

When living on or adjacent to a flood plain, actual and anticipated flooding becomes a regular topic for discussion and publicity. It was widely believed that the foul flooding in Botley, resulting in 28 properties on the flooding register, was due to the lack of capacity in the foul system which became inundated with the rural run-off.

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. Using 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 Figure 1 (above).

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. Despite tight timeframes, 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 Water's contracting, operational and modelling staff, working with Optimise's design, modelling, construction and third party staff. An excellent working relationship developed with a good transfer of information. Key stakeholders, such as the residents, local councils and local flooding groups, were also consulted.
- ***Flow survey:*** IETG undertook a comprehensive flow survey which confirmed flow rates, volumes and flow routes in critical location of the catchment. Most notably,

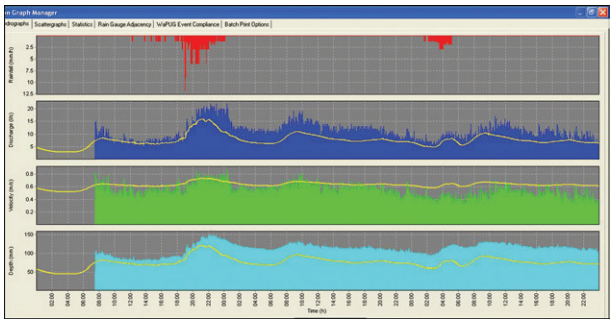
the complex West Way/Westminster Way junction where there are separate flow routes involving a weir, siphon hydrobrake and CSO structure.

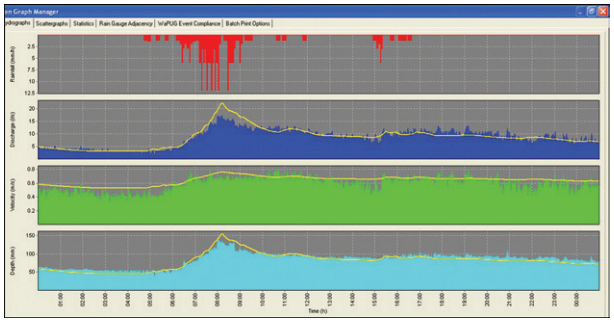
- ***Asset surveys:*** A 400ha impermeable area survey, 80 (No.) manholes, 2 (No.) CSOs and a further 4.7km of CCTV surveys were carried out.
- ***Rural run-off assessment:*** A hydrological assessment was undertaken which quantified the rural run-off volumes to the north and west of Botley, determining the interaction with the foul sewer network. It was initially envisaged that this would align with the perception of the flooding mechanism.

Determining the system performance & key findings

The findings of the investigations were incorporated into the hydraulic model and verified against monitored flows. A key finding of the survey was the confirmation of sewer connectivity at the junction of West Way and Westminster Way. This allowed the hydraulic model to replicate the previously ill-defined primary, secondary and tertiary flow routes.

The perceived problem was a large storm response entering the foul system that appeared to be confirmed by the high flow depths in the flow monitoring, see Figure 2 (below).





ABOVE: Figure 2 Hydrograph prior to silt removal - BELOW: Figure 3 Hydrograph after silt removal - Courtesy of Optimise

However the impermeable area survey identified there were relatively minor areas that would induce a storm response. 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.

Using the flow monitor data, a further restriction was eventually identified in the network downstream of North Hinksey Lane. This was confirmed to be a letterbox shaped pipe 600 x 200mm, installed to allow the sewer to pass below a large gas main.

Surveys showed high silt levels which were measured and jetted clear in the early part of the flow survey. The effect of removing the silt can be seen in Figure 3 (above). The silt covered the main sewers through the west of Botley and 2km along North Hinksey Lane.

28 tonnes of silt was removed from this part of the network along with a further 11 tonnes directly downstream.

Understanding the flooding mechanism through detailed investigation and analysis

North Hinksey Lane: The 600 x 200mm 'letterbox' shaped sewer in North Hinksey Lane, acts as a sharp edge orifice, which restricts the pass forward flow as it hit the wall above it. This arrangement results in flows backing up along North Hinksey Lane, causing 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 50% of the sewer diameter.

The foul sewer system along North Hinksey Lane generally has a very gentle gradient, and in some locations the very flat gradients restricting pass forward capacity to 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 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 2.5km upstream of the letterbox orifice.

West Way: The flow survey and associated investigations have 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 to which it connects. The slow velocities through the inverted siphon result in build-up of silt leading to backing up of flows upstream, or spilling at the CSO, potentially even during dry weather.

Central Botley: Small diameter sewers cause hydraulic pinch points in the network, along Eynsham Road, Cumnor Hill, and in Old Botley. 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; namely North Hinksey Lane. The numerous restrictions here result in a network that cannot cope with any additional flows.

The construction of 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.

Preferred option: A conveyance solution with on-line storage. The option entails upsizing 1,700m along North Hinksey Lane as well as the construction of a 400m on-line storage tank in the fields to the south of North Hinksey Lane.

Rejected option - transfer: The perceived solution which consisted of 3.5km of gravity pipeline upsizing, 170m rising main from North Hinksey SPS, provision of a foul sewage pumping station off West Way at 360l/s with 630m≥ 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. This option was rejected due to cost and environmental impact.

Construction of box culvert online storage tank - Courtesy of Optimise

Rejected option - CSO: A 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 timeframe. However this option was rejected on grounds of cost 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.
- The on-line storage tank where dry weather channel and grit collection chamber is provided.
- Identified low spots in West Way and North Hinksey Lane.

Conclusion

The *'Back to Basics'* 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 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 Water value for money and critically, would not have resolved the flooding and growth problems.

Fundamental to this process was understanding how the network performed and verification of a hydraulic model based on good quality survey data. This allowed the verification to be based on the actual catchment performance and not modelling assumptions. The approach also identified weaknesses in the network where operational maintenance needs to be routinely undertaken together with the implications if it is not.

The preferred solution has been delivered well before the deadline date for removal of the Grampian Conditions, and at a saving of many millions when compared against the perceived solution. This can only enhance Thames Water's reputation, particularly with the relevant local authorities.

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Construction of pipeline in North Hinksey Lane - Courtesy of Optimise