Cardiff East Control Strategy

to low lying flood areas

by
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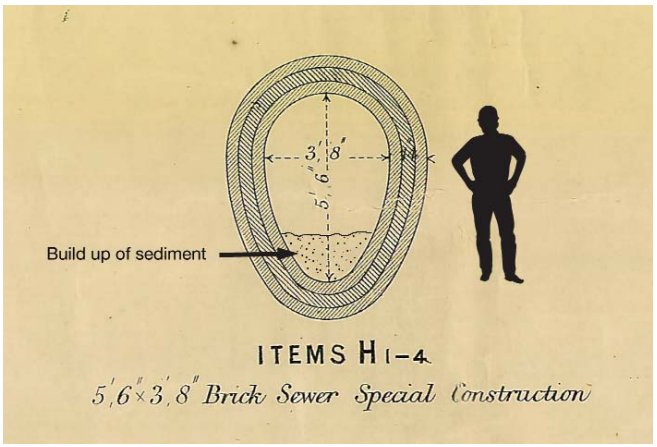
To meet the combined effects of climate change, population growth, rainwater infiltration and an ageing Victorian infrastructure, the sewers in Cardiff, a city of 320,000, required work to address the frequent flooding at a number of low lying areas. An innovative solution was implemented that augmented the network with new sewerage and storage, as well as interconnections to redistribute and redirect sewage flows. This helps to increase the capacity and also attempts to use any spare capacity in the sewerage network.

Flooding caused by overflowing sewer network in Cardiff East *Courtesy of Dwr Cymru Welsh Water*



Extent of Sediment Build Up in Sewers *Courtesy of Dwr Cymru Welsh Water*

The goal was to create a solution that would make the network more robust and deter frequent flooding rather than design a capital intensive scheme. Traditional solution systems as implemented during the early years of the environmental clean-up following the privatisation of the water industry, create additional capacity to store flood waters. Earlier studies had indicated that 100,000m^3 of new storage would be required, at a cost of approximately £100m.

By contrast, The Control Strategy maximised the usability and lifespan of the existing sewer network, resulting in a significantly reduced flood risk and reduced operating costs. The project was delivered at an overall cost of only £3m.

Solution Development

In order to design a functional control strategy, significant time was spent understanding the sewerage catchment. This entailed conducting large scale mapping to identify the critical sewers for conveying flows from the Ystradyfodwg and Pontypridd (Y&P) catchment through Cardiff East catchment and onwards to the terminal pumping station and then to Cardiff Bay WwTW or, in times of heavy rainfall, for spilling into the Severn Estuary.

It was first necessary to confirm the storage capacity of the larger sewers in the lower reaches of the Cardiff East catchment. Although this can be done by interrogating a catchment model, the model is only as good as the data that has been collected. To achieve the most cost-effective solution for this catchment, we devised a backwater test. This test was a full scale prototype test and involved shutting the penstock at the downstream end and allowing the sewers to gradually fill. As the sewers filled, measurements were taken at strategic manholes over a wide area to determine the rate of fill and thus the storage in the system. This backwater test was, and still is, as far as we are aware, the only example of its kind in the UK.

We also carried out a 12 month project to monitor flow within the catchments; giving us an opportunity to carry an out in-depth analysis of events over an annual cycle. Flow monitoring is typically carried out over a period of 6-10 weeks (covering 3 significant rainfall events), so our extended monitoring was also somewhat unique.

Over time we gained an understanding of the Cardiff East catchment. Within a year, we had created and verified a robust overall hydraulic sewer model. Our next task was to design and implement quality improvements. We rationalised the location of a number of Combined Sewer Overflows (CSOs) to discharge storm water above agreed pass forward flows (typically Formula A although in some cases relaxed to 3DWF where this could be shown not to cause detriment to the receiving watercourse). Screening was improved to remove gross solids.

In order to solve the flooding issue it was necessary to recognise that the catchment is particularly complex in operation.

- The Cardiff East catchment used to discharge directly into the Severn Estuary up until 1999. At this date the discharges were intercepted by the newly constructed Cardiff interceptor sewer and the 'dry weather flows' diverted to Cardiff Bay WwTW for treatment;
- At the same time, flows from the Y&P catchment were diverted to the Cardiff East catchment for conveying to Cardiff Bay WwTW;
- In conjunction with modifications to the Cardiff East sewers, some sewers were interconnected to facilitate these operational changes;
- As a result of the operational changes, some sewers now flowed bi-directionally depending on which flows dominated either the flows from the Y&P or from Cardiff East.

The merging of flows from the Y&P trunk sewer and the Cardiff East catchment area brought together two very different sewer flow hydrographs. Simplistically, flows within the Cardiff East catchment are quite 'peaky' in that they rise quickly and then reduce quickly, whereas flows from the Y&P build up more slowly but, once they are high, they tend to stay high for longer periods of time and have long-drawn-out curves or tails.

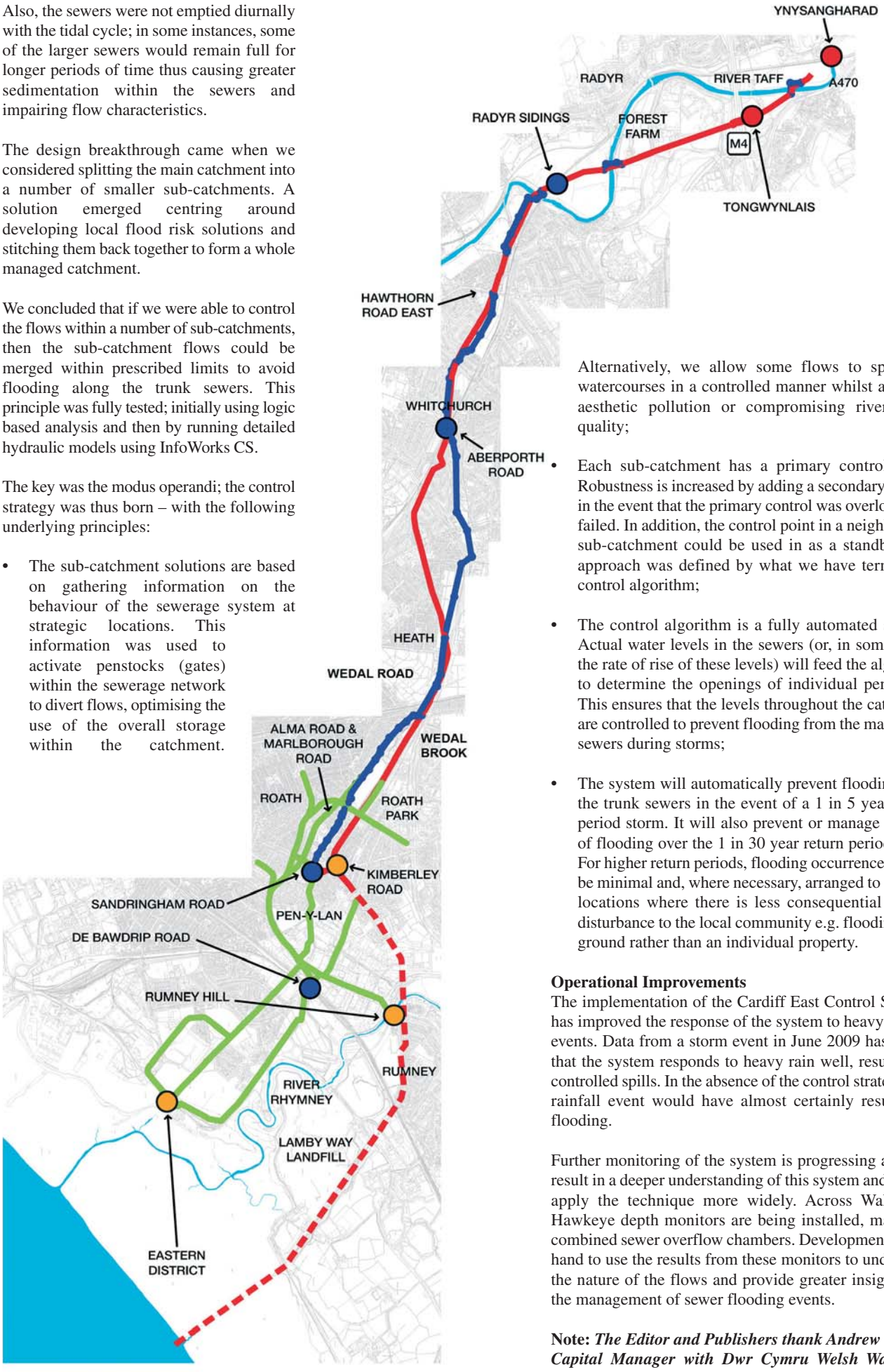
Also, the sewers were not emptied diurnally with the tidal cycle; in some instances, some of the larger sewers would remain full for longer periods of time thus causing greater sedimentation within the sewers and impairing flow characteristics.

The design breakthrough came when we considered splitting the main catchment into a number of smaller sub-catchments. A solution emerged centring around developing local flood risk solutions and stitching them back together to form a whole managed catchment.

We concluded that if we were able to control the flows within a number of sub-catchments, then the sub-catchment flows could be merged within prescribed limits to avoid flooding along the trunk sewers. This principle was fully tested; initially using logic based analysis and then by running detailed hydraulic models using InfoWorks CS.

The key was the modus operandi; the control strategy was thus born – with the following underlying principles:

- The sub-catchment solutions are based on gathering information on the behaviour of the sewerage system at strategic locations. This information was used to activate penstocks (gates) within the sewerage network to divert flows, optimising the use of the overall storage within the catchment.



Schematic Overview of Cardiff East Control Strategy Courtesy of Dwr Cymru Welsh Water

Alternatively, we allow some flows to spill into watercourses in a controlled manner whilst avoiding aesthetic pollution or compromising river water quality;

- Each sub-catchment has a primary control point. Robustness is increased by adding a secondary control in the event that the primary control was overloaded or failed. In addition, the control point in a neighbouring sub-catchment could be used in as a standby. This approach was defined by what we have termed the control algorithm;

- The control algorithm is a fully automated system. Actual water levels in the sewers (or, in some cases, the rate of rise of these levels) will feed the algorithm to determine the openings of individual penstocks. This ensures that the levels throughout the catchment are controlled to prevent flooding from the main trunk sewers during storms;

- The system will automatically prevent flooding from the trunk sewers in the event of a 1 in 5 year return period storm. It will also prevent or manage the risk of flooding over the 1 in 30 year return period event. For higher return periods, flooding occurrences would be minimal and, where necessary, arranged to flood in locations where there is less consequential loss or disturbance to the local community e.g. flooding open ground rather than an individual property.

Operational Improvements

The implementation of the Cardiff East Control Strategy has improved the response of the system to heavy rainfall events. Data from a storm event in June 2009 has shown that the system responds to heavy rain well, resulting in controlled spills. In the absence of the control strategy, this rainfall event would have almost certainly resulted in flooding.

Further monitoring of the system is progressing and will result in a deeper understanding of this system and how to apply the technique more widely. Across Wales 600 Hawkeye depth monitors are being installed, mainly in combined sewer overflow chambers. Developments are in hand to use the results from these monitors to understand the nature of the flows and provide greater insights into the management of sewer flooding events.

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