Introduction

Urban sewer flooding occurs when flows entering the sewer network are in excess of those leaving the network at the associated treatment works or outfall. These events manifest due to a number of possible causes such as: general incapacity in the sewerage system, ground water infiltration, blockages and pipe failure, pumping station failures or incapacity, excess surface water connectivity, and overwhelming rainfall events. The problem has been exacerbated over the last decade, as a result of the EU Directive to reduce the number of consented overflows to watercourses and the increasing popularity to pave grassed areas.

During an incapacity flooding scenario, the volume of flow entering the sewerage network is in excess of the volume of sewage that is able to be conveyed through the pipe under gravity. The pipes and associated manholes then surcharge and flooding may be witnessed at manholes or property connections depending on the systems hydraulic grade line and local topography.

Blockages and pipe failures such as collapsed sewers prevent the egress of flows, which will then build upstream of the problem before surcharging from the system in the manner above.

Infiltration of groundwater into a sewer system will reduce the capacity of the system and can thus cause surcharging during periods of increased flows. Infiltration may occur at poorly sealed joints and cracked or broken pipes to both the public sewer and private drainage systems. Areas with a high ground water level where pipes are continuously submerged are at most risk and result in a consistent base flow rather than periodic rainfall induced infiltration.

Pumping stations are utilised to transport flows to higher elevations, usually outside of local sub-catchments. Pumping stations comprise varying well configurations with which to store incoming water from a catchment, pumps to overcome the required head, and one or more rising mains to transport the flows. Problems can occur if there is a failure in any of the above and/or if either has insufficient storage capacity to deal with the incoming flows.

Older networks often consist of combined sewers, where surface water and foul flows utilise the same pipe work. During heavy rainfall events the excess surface water entering the system may overwhelm it causing foul flooding. Some surface water connectivity is expected in most systems and currently solutions are designed for 1 in 15 year rainfall events at a minimum with consideration made for 1 in 30 year events.

In order to relieve foul flooding within an area, investigations are undertaken to determine the extent of the flooding, identify the causes and develop possible solutions. Where required, any engineering detailed design is then progressed to provide information for the utility company and its contractors to enable the flooding to be alleviated. The investigation often requires a complete urban catchment review to ensure that flooding associated with fluvial and highway drainage discharges are mitigated appropriately.

Flooding Investigations

Urban investigations are driven by the Sewer Flooding History Database which lists areas and properties affected. Questionnaires are then issued in a strategic spread targeting known and

possible areas affected, to discern more in-depth information such as flooding dates, flooding extents and useful information residents may have which is not already held.

Site visits are undertaken to investigate the flooding areas, to determine local topography and note features such as nearby rivers, highway drainage, manholes and general lay of the area. At this time interviews may be held with residents to gain further information of discuss returned questionnaires.

Look and lift surveys may be used to give a general overview of network condition, previous surcharge evidence, flow rates, and the cover and invert levels of the sewers which can be utilised during hydraulic modelling. CCTV surveys will also be undertaken on known or suspect sections of sewer to establish condition and connectivity. This may be aided by dye testing to ascertain surface water connections to the foul system.

To create an accurate picture of the sewerage network in the area a hydraulic model will be used or built if required. The model may be either calibrated or fully verified utilising data obtained from rain gauges and flow monitors placed in strategic locations around the catchment; together with current clamps and depth monitors placed at any pumping stations. The flow surveys are often supported by draw down tests undertaken at the pumping station to determine actual pumping rates and identify any deficiencies in either the pumping station and/or associated pumping main.

The information gathered from the above surveys is analysed and with the help of the calibrated or verified hydraulic model possible solutions are developed, if required. A number of different solutions will be developed where possible. Any solution must take into account known future developments in the area. These flows will be added into the hydraulic model and used to ensure an effective design which incorporates increased flows due to future development.

General Engineering Solutions

Where engineering solutions are required they invariably relate to the problems listed above. Common solutions are as listed below:

Upsizing of sewer pipes to increase capacity. If not upsizing down to sewer termination, an analysis must be undertaken to ensure flooding is not pushed further downstream.

Transfer of flows from the system under capacity to a system with ample capacity or new dedicated system. This may be achieved by severing flows and creating a full diversion or commonly by using a weir chamber design. The weir is set at an appropriated level at which increased flows previously causing flooding are diverted once this level is reached.

Storage may be used to create a buffer for high flows during storm conditions. Excess flows which cannot be held within the existing system are stored on or off-line and throttled back into the system. The buffer storage may be in the form of gravity culverts and tanks capable of holding excess flows for the event required. Pumped storage may be used where gravity storage is not practical and involves the discharge of excess flows into a shaft or chamber which are then pumped back into the system once full or the design event is over.

Blockages and pipe failures must be cleared or replaced when found, to ensure flow continuity. Infiltration found depending on severity may be mediated using lining or patching techniques to stem the ingress of ground water. In severe cases pipe replacement may be required. Manholes and chamber covers can be sealed to prevent the ingress of surface water or fluvial water into the foul network during flood conditions. Unfortunately, infiltration also is known to emanate from private drainage system and although CCTV survey can be undertaken from the public sewer using bespoke satellite cameras difficulties arise in satisfactorily retrying the problem. This issue may be improved once the ownership of such drains is transferred to the utility company in a similar manner that Section 24 Sewers were transferred in 1936 to the Sewerage Agency.

Possible remediation of pumping stations may consist of replacing or adding pumps to increase flow rates to cope with incoming flows, increasing the volume of the wet well to cope with flow spikes and replacing or upsizing fittings and outgoing rising mains to allow greater throughput. These options all aim to increase flows able to be stored or passed at the pumping station, which should reduce surcharging in the upstream network. As previously mentioned impact analysis on the receiving catchment must be undertaken to ensure that flooding isn't just pushed downstream. Other civil, mechanical and electrical works may be required at pumping stations depending upon individual cases. It is unlikely that the Environment Agency will consent to a CSO in either the short or long term.