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Crayford Integrated Drainage Study (Paper 10)

Francesca Hurt

AMEC Environment & Infrastructure UK Limited
17/18 Angel Gate, City Road, London, EC1V 2SH, UK
Tel ++44 (0)207 843 1488, mobile +44 (0)7971 324667
francesca.hurt@amec.com

Crayford, a town within the London Borough of Bexley (LBB), has a long history of flooding. A number of studies have previously been undertaken which looked at flood risks from various sources in isolation. They were undertaken to help advance the understanding of the flood risk mechanisms through Crayford, to better inform potential mitigation measures.

- *Crayford Flood Mitigation Study (2006)*
- *River Cray Dredging Impact Assessment (2008)*
- *London Borough of Bexley Strategic Flood Risk Assessment (SFRA) (2010)*
- *London Borough of Bexley Preliminary Flood Risk Assessment (PFRA) (2011)*
- *London Borough of Bexley Surface Water Management Plan (SWMP) (2011)*

The London Borough of Bexley Surface Water Management Plan (SWMP) (2011) identified Crayford as a Critical Drainage Area, which required further investigation. Notably, Crayford High Street was identified as having experienced flooding in recent years as a consequence of rainfall, with both domestic and commercial properties affected. In addition to surface water flood risk, Crayford has a history of fluvial flooding from the River Cray, notably the 1968 event. The effects of a combined fluvial and surface water event were not fully understood. To better understand the flooding mechanisms, and the links between pluvial and fluvial sources, the Council commissioned AMEC to investigate these through a project involving integrated modelling. The overall objective was to undertake a detailed integrated modelling exercise, justified by the requirement to better determine the flood mechanisms in Crayford, and to better understand how surface water and fluvial events interact. In addition the study aimed to: a) engage key stakeholders and build on the existing partnerships established; and b) identify potential flood risk reduction options and assess at high level their potential flood risk reduction benefits. The study also aligned with the actions outlined for the area in the North Kent Rivers Catchment Flood Management Plan.

An integrated modelling approach was undertaken, modelling the surface water sewer system, rainfall and the rivers Cray and Wansunt in a single model. Foul and combined drainage, highway drainage and private sewers were not included. Integrated modelling allowed for enhanced understanding of how the different sources of flooding (pluvial, fluvial) interact and influence each other. InfoWorks ICM version 3.5.0 modelling software was utilised for this purpose as it has the ability to model river networks, sewer networks and surface water flow routes in one model. Also the 2D model within ICM is based on a variable triangular mesh, which enables greater detailing only where it is required, thus avoiding excessive detail in the areas of the model where it is not required.

The 2D Surface model was constructed to represent the local topography and features which could have an impact on the flow of surface water, and hence on flood risk. The ground topography was based on 50cm LIDAR data. The 2D variable mesh was defined through the incorporation of a series of breaklines, porous walls and mesh zones. Breaklines were used to define the mesh along roads and railways, where kerb lines, embankments and cuttings would influence the flow of shallow surface water. Porous Walls were used in places to allow a more detailed representation of buildings. These walls were set to have a height of 6m and a porosity of 0.1 (10%) - this was assumed based on the likely percentage of the building where water could enter (e.g. doors, airbricks). In the places where watercourses were not represented by a 1D River model they were defined using a mesh zone. The mesh zone creates an area of more detailed mesh, allowing the detail of the channel, as defined by the LiDAR, to be better represented in the 2D Mesh. Mesh zones were also used ensure critical floodplain flow routes were represented in the 2D mesh. Finally, a series of polygons were digitised, using OS Mastermap, to differentiate between areas of different surface types to allow for the spatial variation in roughness and infiltration across the 2D surface model. Four roughness zones, each assigned an individual Manning's n value, and two Infiltration zones were specified (impermeable, permeable) and assigned a fixed percentage runoff value.

Underlying the 2D surface model was a 1D surface water sewer network model. Thames Water network data was used for model construction, supplemented where necessary with additional data from the London Borough of Bexley manhole records and Wansunt Culvert CCTV data. Only those sections of the network that had a direct impact on Crayford Town Centre were included in the model. Those parts of the network that discharged outside of the study area were omitted. The sewer network was modelled as surveyed, *i.e.* "clean" and free from debris or obstructions. The sewer network model was formed by a network of pipes, manholes and subcatchments. The pipe and manhole network was imported directly into InfoWorks. Subcatchments were digitised to enable the determination of contributing catchments to each section of the sewer network. Generally, a detailed approach was taken, with a single subcatchment digitised for each manhole. The area of each subcatchment was then split between three runoff surfaces. A 'roof' runoff surface represented buildings only, a 'permeable' surface represented 50% of the garden areas, and 'paved' represented roads, paths and hardstanding, as well as the remaining 50% of the garden areas.

The River Cray and River Wansunt are an integral part of the drainage network through Crayford, often with a direct connection to the surface water sewer system in places. They were explicitly represented using a 1D River model. The existing Environment Agency approved 1D ISIS model of the River Cray and the River Wansunt was imported into InfoWorks to form the 1D River model. A new section of river reach was created for this model for the River Wansunt from Hall Place to the upstream of the Wansunt Culvert. The structures along the River Cray and Wansunt were represented, as far as possible, as they were in the ISIS model, but some structure representations were altered. Minor structures were represented as Bernoulli losses in the ISIS model, as there is no similar unit in InfoWorks, the structures were represented as per the original survey drawings. Similarly, as there are no crump weirs in Infoworks, the crump weirs at Crayford Gauging Station were represented using standard weir units instead. Amendments were also made to some structures in order to achieve a realistic initial water level in the river network, as per gauge records the levels of the Hall Place Weirs were raised to 9.03m and 9.05m; the sluice gate at Vitbe was modelled as closed; and the weir under Vitbe Mill was included.

To connect the 1D river model to the 2D surface model, a series of bank lines were digitised along the length of the river reaches. The 1D surface water sewer network model was connected to the 2D surface model by 2D manholes. Those sewer outfalls which discharge directly into the River Cray and River Wansunt were explicitly linked with the 1D river model using 'culvert outlet' links. The two outfalls which discharge to the River Stanham were set to 2D outfalls.

The hydrological inputs from the existing Environment Agency ISIS-TUFLOW model were used within the 1D River Model. No new assessment of the fluvial inflows into the River Cray was carried out. The design rainfall events used were generated using the Direct Rainfall FEH methodology. The 1 km^2 Flood Estimation Handbook (FEH) rainfall depth-duration-frequency (DDF) model parameters were input into the InfoWorks FEH rainfall generator, along with urban catchment wetness index

(UCWI) values (based on local conditions) to generate the design hyetographs. A suite of pluvial only runs were completed, looking at a wide range of durations, seasons, and return periods, to determine the critical duration and the appropriate season. From this matrix of runs it was determined that the 30 minute summer storm is the critical storm for the study area.

Following this a matrix of design modelling scenarios (which included pluvial only, fluvial only and combined events) were developed, in consultation with stakeholders, to identify the receptors at risk from the various sources of flooding, and what, if any, relationships there are between the drainage network and the fluvial watercourses. Due to the discrepancy in event durations between fluvial (45 hours) and pluvial events (30 minutes), for the combined events, the peak of the pluvial event was set to coincide with the peak of the fluvial event.

The suite of results enabled the study area to be split into discreet zones, dependant on the source of flood risk. Pluvial flood risk through Crayford is extensive, but is largely shallow (e.g. less than 0.5m deep). Pluvial flooding was shown to have the potential to affect over 1800 properties in the 1 in 100 year 30 minute summer rainfall event with an allowance for climate change. During any given event, over 80% of properties affected were residential. Fluvial risk is limited to the corridor along the River Cray through the centre of town. The town centre suffers from deep flooding, up to 1m in a 1 in 100 year plus climate change event. However, as the town centre is largely in commercial use, those receptors highlighted at risk are generally commercial or industrial properties. Along the north bank of the River Cray through the town centre, there are some areas where the fluvial flooding was shown to result from fluvial water in the River Cray surcharging the surface water sewer network, along with some overtopping of the banks. Information on whether the sewer outfalls are flapped was not available at the time of the study and therefore no flaps were included in the model. It was a recommendation of this study that a survey be commissioned to ascertain whether any of the outfalls are flapped.

The inclusion of a detailed subsurface network model altered the propagation of the fluvial flood through the town centre, with areas flooding earlier than indicated in previous modelling due to the movement of water through the subsurface network. The combined pluvial-fluvial flood risk showed connectivity between the two occurred in those areas immediately adjacent to the River Cray and through the town centre. The integrated model indicated that a combined pluvial-fluvial event would also result in an increase in depth of flooding due to the increase in volume of water. The change in extent was greater during lower return period events.

This study increased the understanding of the flood mechanisms through Crayford and how the fluvial and pluvial systems interact. The integrated model was used to test a number of high level options, but there was no single ‘stand-out’ option. However, it did provide an insight into the scale of scheme which is likely to be required to reduce the flood risk through Crayford. This study forms a firm basis for future development and refinement. There remain data gaps in some locations, including detailed bank heights and sewer outfall information, the subsequent inclusion of which would help to refine the model. Further work is also suggested to refine the hydrological inputs into the model - there are ongoing discussions over the length of the fluvial hydrograph, which the council consider is too long based on anecdotal evidence. The installation of a suitable gauge network through Crayford would enable refinement of the hydrological inputs to be carried out and calibration of the model.