Title:
Cambridgeshire's approach to local floods risk management and the key lessons learnt to date

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Introduction
Cambridgeshire County Council (CCC), as a Lead Local Flood Authority (LLFA) under Flood and Water Management Act, has new duties to assess and manage local flood risk in Cambridgeshire. The county is predominantly rural, and spans an area of approximately 304,400 ha. The county has five second tier local Authorities and includes the main settlements of Cambridge, Ely, Huntingdon and Wisbech. Cambridgeshire also incorporates the Fens, a unique area of low lying land. This low lying area is not only the lowest point in the County but also the lowest point in the UK, with Holme Fen being approximately 2.75m below sea level. The complex drainage mechanisms, significant development pressures, increasing risk from climate change and sinking ground levels will require holistic and integrated approaches to flood risk management in the County.

Building on vital experience gained by undertaking a number of strategic and detailed studies that focus on partnership working, managing flood risk at a local level, and the lessons learned, the paper will focus on:

- How wetspot areas were prioritised for detailed assessment and options development (including the development of a bespoke web GIS multi criteria analysis tool) based on locally derived priorities and resource constraints - both at a strategic and local level.
- 1D/ 2D surface water modelling approaches – innovative use of TUFLOW/ Estry to identify surface water risk and incorporate suitable SUDS measures and options development.
- How the findings and outputs from the SWMP will contribute to the development of a Local Flood risk Management Strategy.
- Lessons learnt from the Defra early action funded Surface Water Management Plan (SWMP). What Lead Local Flood Authorities should do next and how Cambridgeshire County Council intends to improve local flood risk management and data sharing?

Project description
Cambridge City Council obtained a grant from Defra to undertake a detailed SWMP for Cambridge and Milton. At the same time CCC was planning a SWMP for the whole county, initially starting with a Countywide Strategic Assessment. A partnership approach was considered the most effective way of bringing these potentially disparate studies into a cohesive piece of work. The Cambridgeshire Flood Risk Management Partnership (CFRMP) was used as the delivery body of these studies. A joint procurement exercise was undertaken to ensure best value for the Local Authorities.

Hyder Consulting was appointed in August 2010 to produce the strategic SWMP for the entire county, and individual detailed SWMPs (Figure 1). The overall work is due to be completed by April 2015 as part of a framework. The first phase of work was the Countywide Strategic SWMP report and was completed in April 2011. Hyder were also appointed to undertake the detailed surface water management assessment of Cambridge and Milton (Figure 2). The Cambridge and Milton Detailed SWMP was completed in April 2011 with the input from Edenvale Young. The detailed SWMP demonstrated of all the stages of a SWMP, from a strategic assessment of the overall study area through to optioneering of the prioritised wetspots. As part of this work, a Preliminary Flood Risk Assessment (PFRA) was also produced to satisfy the requirements of Flood Risk Regulations 2009.

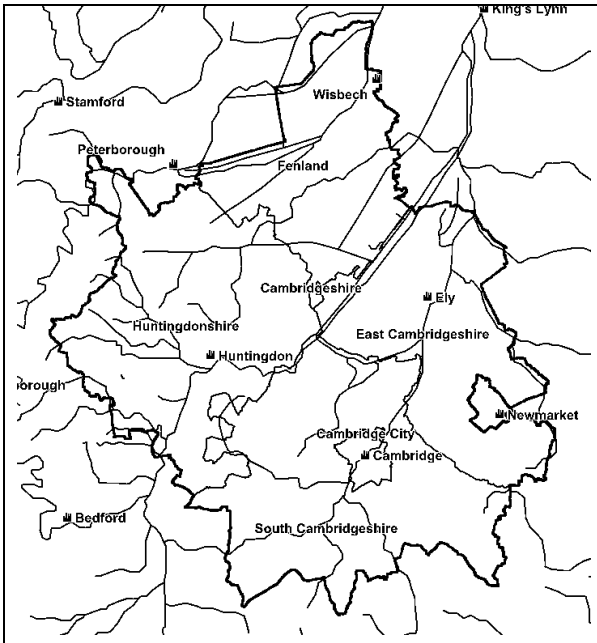

Figure 1 Study Area for Countywide Strategic SWMP

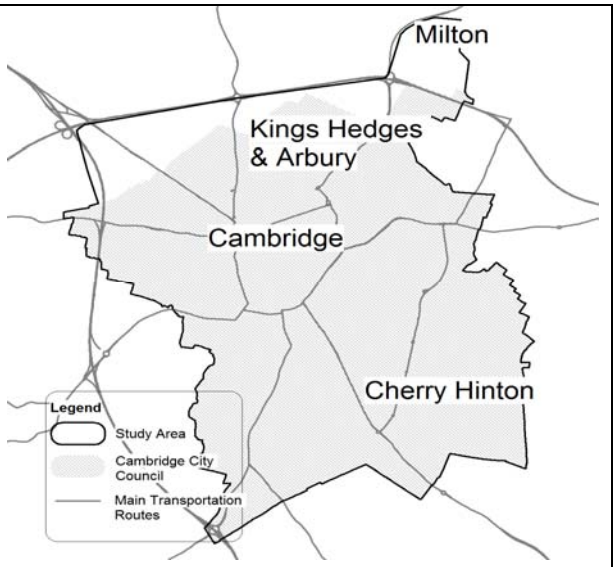

Figure 2 Study Area for Cambridge and Milton detailed SWMP

Results

Countywide Strategic SWMP

A key aspect of the study was to identify and then prioritise the wetspots (areas estimated to be at significant risk of flooding) for further detailed investigation and intervention for flood mitigation. Following the methodology outlined in Figure 3, wetspots that are deemed to be at risk of surface water flooding were identified using either historical flooding reports and / or the Environment Agency's Surface Water Flood Maps along with local modelling and knowledge. A Multi Criteria Analysis (MCA) framework, which is a scoring and weighting methodology by which the impact of flooding on a wide range of receptors can be compared and evaluated, was used as a high level and transparent decision making tool. It allows for comparison of severity of flooding between areas based upon the perceived value of domestic and non-domestic buildings, critical infrastructure, transportation, land and public open space and cultural assets.

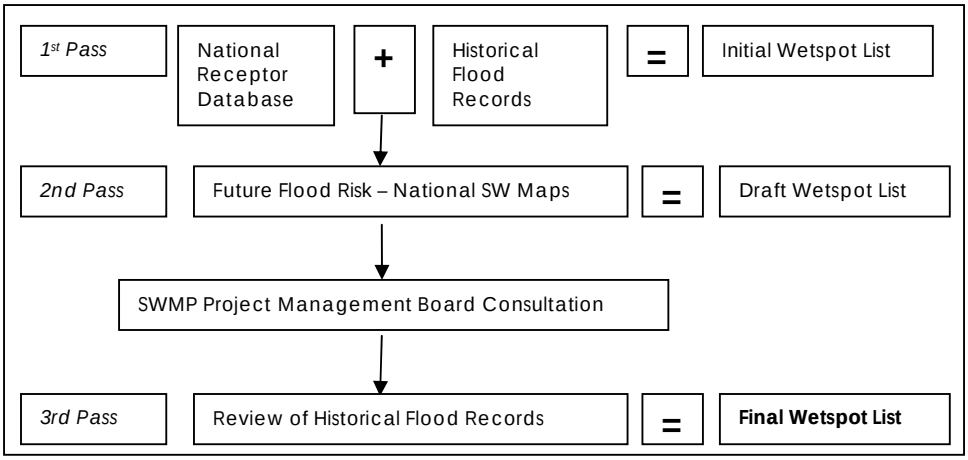

Figure 3 Methodology for identification of wetspots

A flood incident register was created to summarise the key data of all reported incidents (which contained in excess of 13,000 records) along with type of flood source and perceived confidence levels. This will inform the future stages of SWMP and also provide a useful starting point for the CFRMP members to record future flood incidents in the County. To promote public engagement,

CFRMP carried out a public consultation exercise to collect flood risk data focusing predominantly on small to medium localised flooding events. Members of the public were asked to complete a questionnaire on their memories of flooding incidents, either via a paper questionnaire, online, or via road shows held across the county. The exercise collated over 250 responses.

In addition, a bespoke web-based GIS database was developed to store and assess information on historic and future flooding across the county. This enabled the efficient prioritisation of wetspots. The surface water MCA calculations were carried out within the web-based GIS database and were based on a flood depth susceptibility weighting multiplied by a Property/ Land Use Multi Criteria weighting for each receptor type. Multi Criteria Analysis weightings could be easily manipulated within the WebGIS to test a range of scenarios.

Cambridge and Milton detailed SWMP

The surface water MCA calculations were used in the assessment of the Cambridge and Milton detailed SWMP. The weightings for all receptors were discussed with the Project Board during a workshop in December 2010 and then agreed following further consultation with CCC's emergency management team and Natural England.

In order to address the specific issues relating to the Cambridge and Milton detailed SWMP, a three stage modelling strategy was developed and implemented:

- Stage 1 - Hydrological Analysis and development of broad scale, bare earth, models of North and South Cambridge and sensitivity testing to determine the hydrological / infiltration response of the catchment.

- Stage 2 – Identification and evaluation of wetspots using the bare earth model developed in Stage 1 and Prioritisation using Multi Criteria Analysis (MCA).

- Stage 3 - Detailed modelling assessment of specific wetspots including the sub-surface network within Cambridge and Milton. This included the development and testing of engineering options and economic analysis.

Stage 1 direct rainfall analysis and review of historical data has improved the understanding of future surface water flood risk within Cambridge and Milton at a strategic level. Hydrological analysis was undertaken as part of Stage 1:

- To estimate the scale of infiltration losses within the extent of the study area to be incorporated within the direct rainfall model.
- To ensure the direct rainfall model output is consistent with FEH estimates of fluvial peak flows.

Hydrological analysis informed the scale of infiltration losses to be incorporated in to the hydraulic model, improving confidence in results. To do this, the 2D model was run iteratively for a number of estimated infiltration losses before comparing the model output with fluvial flow estimates determined by Flood Estimation Handbook (FEH) techniques on specific sub-catchments. The FEH techniques account for infiltration losses either implicitly (in the case of the statistical method) or explicitly (using ReFH) and were considered to provide an indicative estimate of the infiltration losses to be included within the 2D model.

Stage 2 Multi-criteria analysis confirmed Cherry Hinton and the Kings Hedges & Arbury estate as two key priority wetspots (see Figure 2 for location) where the risk of surface water flooding required more detailed modelling, including the development of potential engineering options to reduce flood risk in the wetspots.

Following the identification of the Cherry Hinton and King's Hedges / Arbury Estate as 'Priority Wetspots', further detailed modelling was undertaken to refine the existing Stage 1 model to a geographically smaller region. Accordingly, enhanced direct rainfall models were developed for the Cherry Hinton and King's Hedges / Arbury wetspots. These models were developed to enable a greater level of detail to be incorporated into the TUFLOW domain (e.g. storm sewer network, existing SuDS schemes and proposed engineering options) whilst at the same time reducing the grid size to give better resolution to the output and maintaining reasonable model run-times. The objective of Stage 3 modelling was to better understand and quantify the effects of surface water

flooding and to model the effectiveness of any proposed engineering option elements to mitigate for the effects of surface water flooding for "do nothing", "do minimum" and "do something" options.

Conclusions

The Countywide Strategic Assessment outlined nine distinct 'Next Steps' including indicative timescales (ranging from 6 months to 6 years) and lead responsibility for their implementation. Next steps included detailed modelling of the top ten priority wetspots in the County; review of stakeholder asset management and capital spending plans; identification of quick wins; review of asset vulnerability and emergency plans; and preparation of a supplementary planning guidance document to assist planners and developers on how to use SWMP outputs in the development control and planning process.

TUFLOW Direct rainfall analysis produced an improved assessment of surface water runoff, infiltration, depression storage and rainfall distribution and its effects on flooding within Cambridge and Milton. The modelling results, assessments and maps created during this detailed SWMP (with emphasis on the eleven identified wetspots) can be used in flood risk management. The modelling results can be used as evidence to indicate potential development constraints and opportunities to reduce the predicted flood risk and show why developers should undertake further investigation and develop appropriate mitigation measures. Highways and asset planning teams can use the results to see where highways and surface water flooding has occurred in the past enabling them to focus maintenance and emergency response efforts in these areas. The Emergency Planning teams can also use historical flooding data, updated flood receptors, MCA findings and broad wetspot areas to identify vulnerability and prepare suitable emergency planning measures. The results will inform the development of future planning policies (ideally in the form of a Supplementary Planning Document) and the Council's 'Local Flood Risk Management Strategy'.

A range of potential engineering measures and options were identified, modelled and costed for Cherry Hinton and Kings Hedges and Arbury (i.e. up to eight option combinations for each wetspot). The options clearly highlighted the need and benefit of reducing the future flood risk. These engineering options should be considered along with non engineering policy measures in order to maximise benefits. The options assessed at this stage provide a strategic assessment of how best to mitigate against flood risk in the wetspot. This provides an analysis of where investment could be directed in the future. However, funding constraints and stakeholder buy-in are likely to be a key obstacle to implement catchment wide solutions at both wetspots, highlighting the need for further stakeholder consultation and the prioritisation of the viable measures. Despite the relatively high benefit-cost ratio of the 'Do Minimum' option, this option may not be viable in light of the new duties imposed on LLFA, under the Flood and Water Management Act, along with social and environmental acceptance. The 'Do Minimum' option does not deliver any reduction in the number of properties vulnerable to flooding and will not address increasing flood risk associated with climate change. This clearly highlights the need for further consideration and implementation of a broad strategy, including the refinement of engineering measures associated with 'Option Combinations' (to further optimise the benefit cost ratios), Quick Wins and Policy Initiatives.

Examples of other key learning points include:

- The active engagement of CFRMP members has helped smooth data provision and consideration of local needs in future flood risk management and planning. This was particularly important for meeting the challenging timescale specified for the early phases of SWMP and PFRA.
- The need to address the limitations of the 'National Receptor Database' and the need to supplement with local data such as critical infrastructure, residential and care homes.
- Limitations in available surface water sewer and local watercourses data along with local historical flooding records to clearly identify surface water incidents and associated flooding consequences – more effort and coordination is required to address this key limitation when undertaking future phases of SWMP and PFRA.
- The MCA tends to provide high scores for main urban centres and priority due to relatively high surface risk from the EA's national surface water maps and likely consequences to flood receptors – however it is equally important to identify potential 'quick wins' to remediate flood risk in smaller locations in a rural county such as Cambridgeshire.