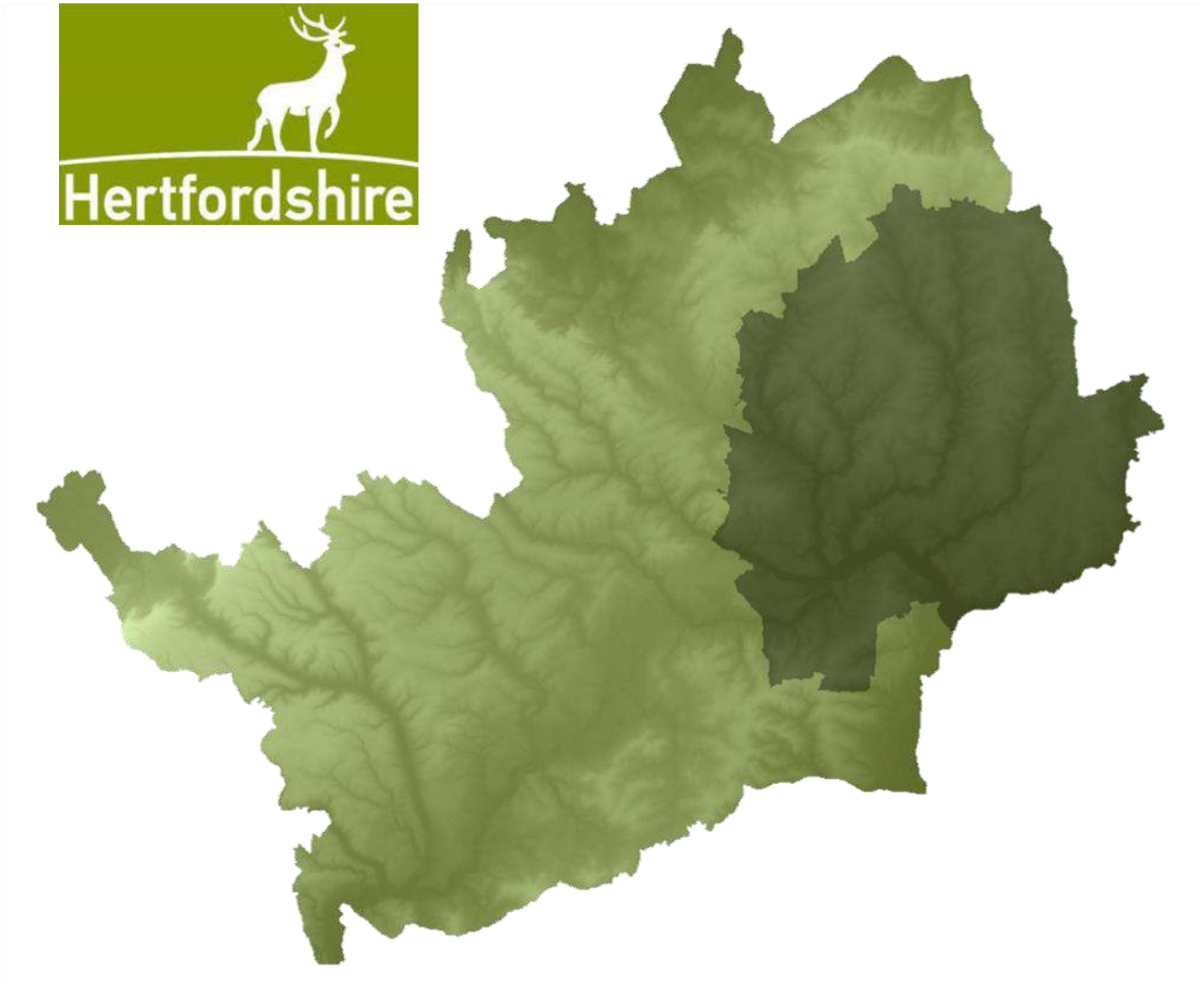

EAST HERTFORDSHIRE DISTRICT SURFACE WATER MANAGEMENT PLAN.

FINAL REPORT

REPORT N^{O} 70009115 - EH_SWMP_01 2017-03-15

WSP | PARSONS BRINCKERHOFF

EAST HERTFORDSHIRE DISTRICT SURFACE WATER MANAGEMENT PLAN

FINAL REPORT

Hertfordshire County Council

Final

Project no: 70009115
Date: March 2017

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KEY DEFINITIONS

Surface water flooding (Pluvial Flooding)	**In the context of a Surface Water Management Plan, Defra's SWMP Technical Guidance[1] defines surface water flooding as flooding from sewers, drains, groundwater, and runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall.**
Groundwater flooding	**Surface water flooding due to groundwater occurs when the water held underground rises to a level where it breaks the surface in areas away from usual above ground channels and drainage pathways, though it can occur when subterranean (underground) rivers rise to above the surface. It is generally a result of exceptional extended periods of heavy rain, but can also occur as a result of reduced abstraction, underground leaks or the displacement of underground flows.**
Overland Flow / Surface Water Runoff	**Water flowing over the ground surface that has not reached a natural or artificial drainage channel.**
Fluvial flooding	**Fluvial flooding occurs when rivers overflow and burst their banks, due to high or intense rainfall which flows into them. In the SWMP only fluvial flooding from Ordinary watercourses is assessed.**
Main River	**Main Rivers are usually larger streams and rivers which have been designated as such by Defra and the Environment Agency. The Environment Agency has powers to undertake works on any stretch of Main River and is responsible for flood risk management activities.**
Ordinary watercourse	**Ordinary watercourses are deemed to be all rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices, sewers (other than public sewers vested with utilities) and passages, through which water flows that are not classified as Main River by the Environment Agency.[2]**

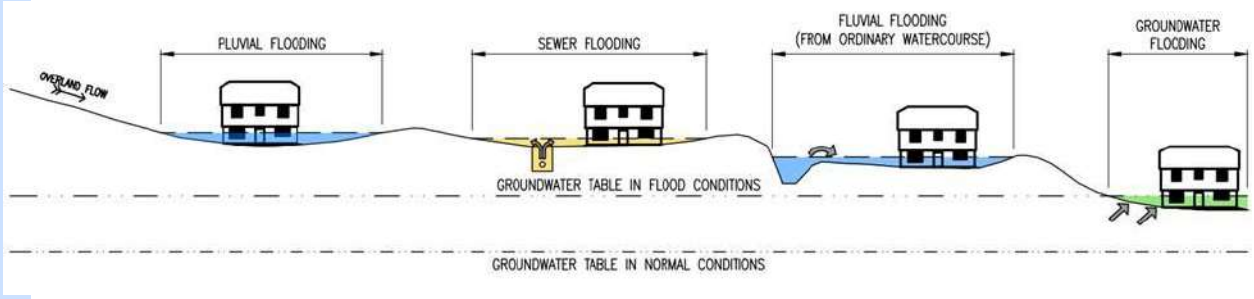


Figure 1: A diagrammatic summary of the key definitions

[1] Surface Water Management Plan Technical Guidance, Defra (March 2010) (Source: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69342/pb13546-swmp-guidance-100319.pdf)

[2] Hertfordshire County Council's definition of Ordinary watercourses (Source: https://www.hertfordshire.gov.uk/services/recycling-waste-and-environment/water/ordinary-watercourses/ordinary-watercourses.aspx)

1 EXECUTIVE SUMMARY

1.1 BACKGROUND

WSP | Parsons Brinckerhoff has completed a Surface Water Management Plan (SWMP) for East Hertfordshire District on behalf of Hertfordshire County Council, as Lead Local Flood Authority. The study has been undertaken in consultation with key stakeholders. The stakeholders worked together to understand the causes and effects of surface water flooding and agree the most cost effective processes of managing surface water flood risk for the long term. The process of working together is designed to encourage the development of innovative solutions and practices as well as identifying funding streams to assist in the delivery of the outcomes of the SWMP.

The Defra SWMP Technical Guidance (2010) suggests that a SWMP study will not be required in all locations but rather where areas are "considered to be at greatest risk of surface water flooding or where partnership working is considered essential to both understand and address surface water flooding concerns". The need for a SWMP for East Hertfordshire District was identified within the Local Flood Risk Management Strategy (LFRMS) for Hertfordshire.

The Surface Water Management Plan is to be a living document that should be reviewed approximately every five years, to ensure the implementation of the agreed actions is correct and that any new issues are addressed. A review may be required following any new flood event, when new flood data becomes available, or new modelling techniques are developed, and when there is a change of policy in the catchment.

1.2 IDENTIFICATION OF HOTSPOTS

The first part of the risk assessment phase of the East Hertfordshire District SWMP was the strategic and intermediate assessments. The principle purpose of these assessments was to identify broad locations which were considered to be vulnerable to surface water flooding. This was undertaken using the best information available, including some GIS analytical techniques, and historical information.

The Risk of Flooding from Surface Water Maps (RoFfSW) (previously referred to as the updated Flood Map for Surface Water, uFMfSW) are considered to be the best available Hertfordshire-wide representation of potential surface water flood risk. Historical flooding incidents were then used as supporting evidence when looking at the Risk of Flooding from Surface Water Maps, in order to determine areas to focus on in this SWMP. This included the Section 19 Flood Investigation Reports produced under the Flood and Water Management Act 2010.

Local knowledge was used to pinpoint instances of surface water flooding. However, only broad areas were identified (by the Local Planning Authorities and the Environment Agency) as having experienced known incidents of surface water flooding. These included areas identified as being potential development sites and areas which have had Section 19 Investigations already undertaken for Acorn Street, Hunsdon.

A Desk-Based analysis was conducted to assess the flood risk to receptors within the East Hertfordshire District. From this, 45 hotspots (areas perceived and identified locally as being at greatest risk of surface water flooding) were analysed using GIS Multi-Criteria Analysis (MCA) to prioritise the hotspots most at risk of flooding within the East Hertfordshire District. A stakeholder meeting was then held in February 2015, followed by site visits to confirm the findings.

As a result, five of the hotspots were then assessed for suitability of modelling, which resulted in the final six SWMP Modelled Hotspots:

- Hotspot 1 Buntingford;
- Hotspot 40 Bengeo, Hertford;
- Hotspot 43 Hadham Road, Bishop's Stortford;
- Hotspot 44 Benhooks Avenue, Bishop's Stortford;
- Hotspot 47 Raynham Road, Bishop's Stortford;
- Hotspot 60 Potter Street/South Street, Bishop's Stortford.

1.3 DETAILED PHASE OF SWMP

The detailed phase of the SWMP focussed on the six SWMP Modelled Hotspots identified above. The detailed modelling involved the construction of individual hotspot models to assess the baseline flood mechanisms, pathways and extents. This included:

- Collection and review of available digital terrain models (DTM) (e.g. LiDAR) for the area;
- Topographic surveys to supplement the DTM where necessary;
- Collation and review of below ground infrastructure;
- Consideration of land use; and
- Specific items where further consideration was required. This included for example an additional site investigation of sewer capacity for a specific area within a hotspot.

The models were 1D-2D linked ESTRY-TUFLOW models to represent the below ground infrastructure (1D) and above ground flowpaths (2D), with direct rainfall applied across the model domain. This produced flood extents, depths, velocities and hazard ratings for events ranging from the 1 in 5 year (20% annual exceedance probability) event up to the 1 in 1,000 year (0.1% annual exceedance probability) event.

Following the hydraulic modelling, a review of the modelled flood extents was undertaken. From this review the types of mitigation measures which could be implemented for each hotspot were identified with the aim to reduce the impacts and damage associated with flooding.

The table below summarises the findings for each hotspot, including details on the mitigation and proposed recommendations to be taken forward.

LOCATION	SUMMARY OF FLOOD RISK	PROPOSED MITIGATION MEASURES	RECOMMENDATIONS
Hotspot 1 – Buntingford	Some highly localised flooding is predicted on the estate roads that are off Vicarage Road. Flooding is predicted along Monks Walk and from runoff draining from Station Road into the area north of Rib Way. Flooding is predicted in the area south of the Business Park.	→ Property Level Protection (PLP) for those at risk: ■ South of Business Park; ■ Monks Walk; ■ High Street; ■ Rib Way; ■ Vicarage Road.	→ Investigation of keeping the preferential flowpath along Station Road; → Modify drainage along roads to the north and introduce permeable paving if financially viable; → Investigate feasibility of upsizing pipes draining into the river, and; → Modify drainage upstream of Snells Mead – investigate adoption of small drain.

LOCATION	SUMMARY OF FLOOD RISK	PROPOSED MITIGATION MEASURES	RECOMMENDATIONS
	For flood hazard, danger for most is shown around the Business Park and along Monks Walk as well as Rib Way and Vicarage Road.		
Hotspot 40 – Bengeo, Hertford	Some highly localised flooding on the south-east corner of Cowper Crescent, Peel Crescent (a cul-de-sac off The Avenue), Westfield Road, and an extensive area along Sacombe Road as well as Glebe Road and along Rib Vale in the east. For flood hazard, danger for most is shown in the south-west corner of Cowper Crescent, a cul-de-sac just off The Avenue, Sacombe Road, Glebe Road, the northern side of Watermill Lane and Ware Park, Rib Vale, Palmer Road, Bengeo Street and Revel Road.	→ Redirect flowpath from The Avenue across playing fields in the north using a speedbump, and; → Property Level Protection (PLP) measures in Globe Court and downstream properties as well as those around Watermill Lane and Rib Vale.	→ Investigation into the need for PLP in Globe Court after flowpath redirection; → Investigate measures to keep preferential flowpath along Watermill Lane; → Preferential flowpath through the footpath at Duncombe Close, and permeable paving; → Increase infiltration in the upstream area; → Maintain flowpaths between properties, and; → Investigate garden boundary lines – ensuring no impermeable fences.
Hotspot 43 – Hadham Road, , Bishop's Stortford	Flooding is predicted along Matching Lane and surface water runoff is predicted to drain north-easterly towards Hadham Road. For flood hazard, danger for all is shown at the eastern end of Hadham Road.	→ Maintain bund to attenuate water in the field/open areas in the north-west and south-west; → Increase capacity/improving re-profiling the ditch east of Matching Lane; → Improve conveyance of adjacent ditches to stop water draining into Matching Lane; → Upstream attenuation and maintain a bund to minimise flow across the school, retain water in the car park, and; → Property Level Protection (PLP) if required.	→ Ensure all Draincare recommendations have been implemented; → Repair collapsed pipes and remove root ingress; → Desilting key sections of pipe network; → Restore blocked open watercourses; → Ensure suitable maintenance regime and pre-storm action plan is in place; → Encourage de-culverting with riparian owners, and; → Consider increasing attenuation capacity of balancing pond in recreation grounds.
Hotspot 44 – Benhooks Avenue, Bishop's	Flooding is predicted along Scott Road which may drain along Waytemore Road and towards Benhooks Avenue and the	→ Property Level Protection (PLP); → Maintain a bund to attenuate	→ Modify highway drainage along Badgers, install permeable pavements if

LOCATION	SUMMARY OF FLOOD RISK	PROPOSED MITIGATION MEASURES	RECOMMENDATIONS
Stortford	northern end of Badgers. Surface water runoff also drains along Cemetery Road to Benhooks Avenue where it then impacts Beechlands. Flow from Benhooks Avenue also affects South Street, Stort Road, Wharf Road and Braziers Quay. For flood hazard, danger for all is predicted at the intersection west of Benhooks Avenue and danger for most along Scott Road, Waytemore Road, Badgers and South Street.	water off of Great Hadham Road; → Maintain a bund on the eastern boundary to attenuate water in allotment area, and; → Property Level Protection (PLP): ■ South of Waytemore Road; ■ South Street.	financially viable, and; → Modify highway drainage along South Street.
Hotspot 47 – Raynham Road, Bishop's Stortford	Flooding is predicted around Plaw Hatch Close, Raynham Road, Parsonage Lane, Friars Wood and the schools. For flood hazard, danger for most is shown in the industrial estate, Plaw Hatch Close, Raynham Road and near to Summercroft Primary School. For flood hazard, danger for some is shown near Birchwood High School and along Friars Wood.	→ Property Level Protection (PLP): ■ Plaw Hatch Close; ■ Raynham Road, and; ■ Commercial properties in the industrial estates.	→ Investigate upstream attenuation/storage and widen the drain in the golf course; → Investigate potential storage in the recreation ground; → Potential attenuation within school grounds or a wall to retain water in fields; → Potential pipe upsizing along the car park, and; → Investigate speedbumps to keep water in Parsonage Lane.
Hotspot 60 – Potter Street / South Street, Bishop's Stortford	Surface water drains from Apton Road into Potter Street / South Street and partly towards Hotspot 44. For flood hazard, danger for some is shown along Potter Street / South Street.	→ Property Level Protection (PLP).	→ Investigate Potter Street and South Street shop thresholds.

An economic viability assessment of the potential benefits of each option compared to an indicative cost estimate was undertaken. This assessment was undertaken to ensure that HCC could prioritise future work to focus on measures which not only would reduce flood risk but also would have the potential to secure funding to facilitate their construction. A summary of the economic assessment for each site is provided in the table below.

HOTSPOT	MITIGATION OPTION	PRESENT VALUE DAMAGES [£]	PRESENT VALUE BENEFITS [£]	PRESENT VALUE COSTS [£]	BC RATIO
1 - Buntingford	Baseline	18,500,000	/	/	/
	100yr SOP	9,200,000	9,300,000	1,410,000	6.6
40 - Bengeo, Hertford	Baseline	13,570,000	/	/	/
	75yr SOP	9,850,000	3,720,000	1,725,000	2.2
43 - Hadham Road, Bishop's Stortford	Baseline	28,600,000	/	/	/
	30yr SOP	18,600,000	10,000,000	3,750,000	2.7
44 - Benhooks Avenue, Bishop's Stortford	Baseline	23,300,000	/	/	/
	30yr SOP	11,850,000	11,450,000	3,010,000	3.8
47 - Raynham Road, Bishop's Stortford	Baseline	38,100,000	/	/	/
	100yr SOP	18,500,000	19,600,000	1,850,000	10.6
60 - Potter Street, Bishop's Stortford	Baseline	25,600,000	/	/	/
	100yr SOP	14,400,000	11,200,000	1,680,000	6.7

The economic assessment finds that the schemes across the hotspots are considered to be submitted to the Environment Agency for inclusion on their MTP and further assessments undertaken to refine the schemes to a level suitable for a formal funding application (Outline Business Cases). For these schemes, it is advised that HCC work with key stakeholders to secure additional third party funds to ensure the schemes have sufficient funding for delivery. Alternatively, smaller more localised schemes could be considered as part of HCC and their partners' operational and capital workstreams.

In addition to the six SWMP Modelled Hotspots, 21 of the SWMP Non-Modelled hotspots were allocated recommendations and actions, as shown in the table below.

HOTSPOT NUMBER	LOCATION	RECOMMENDATIONS AND ACTIONS
→ Hotspot 3	Puckeridge / Standon	Work with the Environment Agency as they assess potential options.
→ Hotspot 5	Watton at Stone	Increased maintenance of the ditch to the rear of properties on Great Innings North may alleviate some flood risk to nearby properties.
→ Hotspot 8	St Margarets / Stanstead Abbotts	Work with the Environment Agency as they finalise their hydraulic model and potentially develop options.
→ Hotspot 18	Hormead	Property Level Protection (PLP) surveys could be

HOTSPOT NUMBER	LOCATION	RECOMMENDATIONS AND ACTIONS
		conducted to make recommendations for home improvements to reduce flood risk.
→ Hotspot 25	Dane End	HCC to explore the possibility of a cut-off drain and channel diverting flows around residential properties.
→ Hotspot 27	Thundridge / High Cross	Work with EHDC and HCC Highways to gain a better understanding of the causes of historical flooding and if there are any small improvements that could reduce flood risk, before considering recommending PLP.
→ Hotspot 28	Hadham Cross / Much Hadham	An Excel based analysis of the culvert underneath the Bull Inn could determine if there is adequate capacity in the culvert.
→ Hotspot 30	Hunsdon	Work with landowners to ensure maintenance is undertaken; consider enlarging the pond and/or improving outfall connectivity. Assess options for utilising the highway as a preferential flowpath, prior to considering PLP.
→ Hotspot 39	Ware (east)	PLP surveys are to be considered for houses in the southern part of the hotspot in the areas surrounding Garlands Road.
→ Hotspot 41	Sele, Hertford	Ensure maintenance is prioritised to the highest risk areas to facilitate rapid drainage.
→ Hotspot 42	Central Hertford	No recommendations and actions for this hotspot at this stage. HCC, in conjunction with the Environment Agency, has undertaken an Initial Assessment into the combined fluvial/pluvial flooding in Hertford. This study has encompassed this central Hertford area.
→ Hotspot 46	Stansted Road, Bishop's Stortford	No recommendations and actions for this hotspot at this stage. Part of this hotspot will be included as part of the Raynham Road, Bishop's Stortford model, as part of the downstream flowpath that flows through Parsonage Lane and Stansted Road towards the River Stort.
→ Hotspot 58	Green Street, near Little Hadham	Assess options for utilising the highway as a preferential flowpath prior to considering PLP.
→ Hotspot 61	Rhodes Avenue, Bishop's Stortford	Work with the Environment Agency to ensure that this section of Main River is considered for hydraulic modelling, potentially with a view for developing attenuation options on public open space between Lower Park Crescent, Thorley Hill and Thornbera Road.
→ Hotspot 75	Little Hadham	No recommendations and actions for this hotspot at this stage. This is due to the proposed A120 bypass and associated flood alleviation scheme, which is due to reduce flood risk at Little Hadham.
→ Hotspot EH01	Grange Paddocks / Stane Close	Consider the preferential flowpaths and work with residents to ensure that these are not obstructed, ensure flap valves are present on the surface water drainage network if deemed appropriate.
→ Hotspot EH02	Jackson Square / The Causeway, Bishop's Stortford	Consider the preferential flowpaths, gully maintenance regimes and work with property owners to consider PLP as appropriate, ensure flap valves are present on the surface water drainage network if deemed appropriate.

HOTSPOT NUMBER	LOCATION	RECOMMENDATIONS AND ACTIONS
→ Hotspot EH03	Thorn Grove, Bishop's Stortford	Work with landowners to ensure maintenance is undertaken and the gully maintenance regime is appropriate.
→ Hotspot EH04	Ford End, Hadham Ford (near Little Hadham)	No recommendations and actions for this hotspot at this stage. This is due to the proposed A120 bypass and associated flood alleviation scheme, which is due to reduce flood risk at Ford End, Hadham Ford (downstream of Little Hadham).
→ Hotspot EH05	Marsh Lane Industrial Estate	Work with landowners to consider PLP as appropriate, ensure riparian maintenance is undertaken and the gully maintenance regime is appropriate.
→ Hotspot EH06	Ware (south)	Consider the preferential flowpaths, gully maintenance regimes and work with property owners to consider PLP, if required.

1.4 HABITATS REGULATION ASSESSMENT (HRA)

There are important designated sites (Sites of Special Scientific Interest (SSSI) and Special Areas of Conservation (SAC)) along the River Lea/Lee corridor within and in close proximity to East Hertfordshire District. To ensure that the implementation phases of the SWMP will not lead to adverse impacts within these sites, a Habitats Regulation Assessment (HRA) has been undertaken in conjunction with this study. This demonstrates that the SWMP will not lead to adverse impacts on the designated sites.

1.5 ACTION PLAN

An Action Plan (provided in Appendix G) has been developed to cover the measures identified and recommended as part of the SWMP. The Action Plan identifies the process that would need to be undertaken for each element that would require capital funds to facilitate its implementation.

2 INTRODUCTION

2.1 BACKGROUND

East Hertfordshire District has suffered flooding in February 2014. Historically, flooding has been associated with fluvial sources, however more recent events have seen both fluvial, pluvial and combined causes.

The overall SWMP process is set out in Section 2.4.

This document specifically deals with surface water flooding. However, where there is potential interaction between fluvial flows and surface water flooding, it outlines the potential impacts.

This report has been developed using the 'Surface Water Management Plan Technical Guidance' published by the Department for Environment, Food and Rural Affairs (Defra) in March 2010. Since the publication of this document the Environment Agency has published the Risk of Flooding from Surface Water (RoFfSW) map. The information contained within this dataset means that the full Strategic and Intermediate Phases as detailed in the guidance are no longer necessary.

2.2 STUDY AREA

East Hertfordshire District is a non-metropolitan local authority in Hertfordshire, England. The district includes the towns of Hertford, Bishop's Stortford, Ware, Buntingford and Sawbridgeworth. Figure 2 illustrates the location of East Hertfordshire District within Hertfordshire; area of the district is 476km^2.

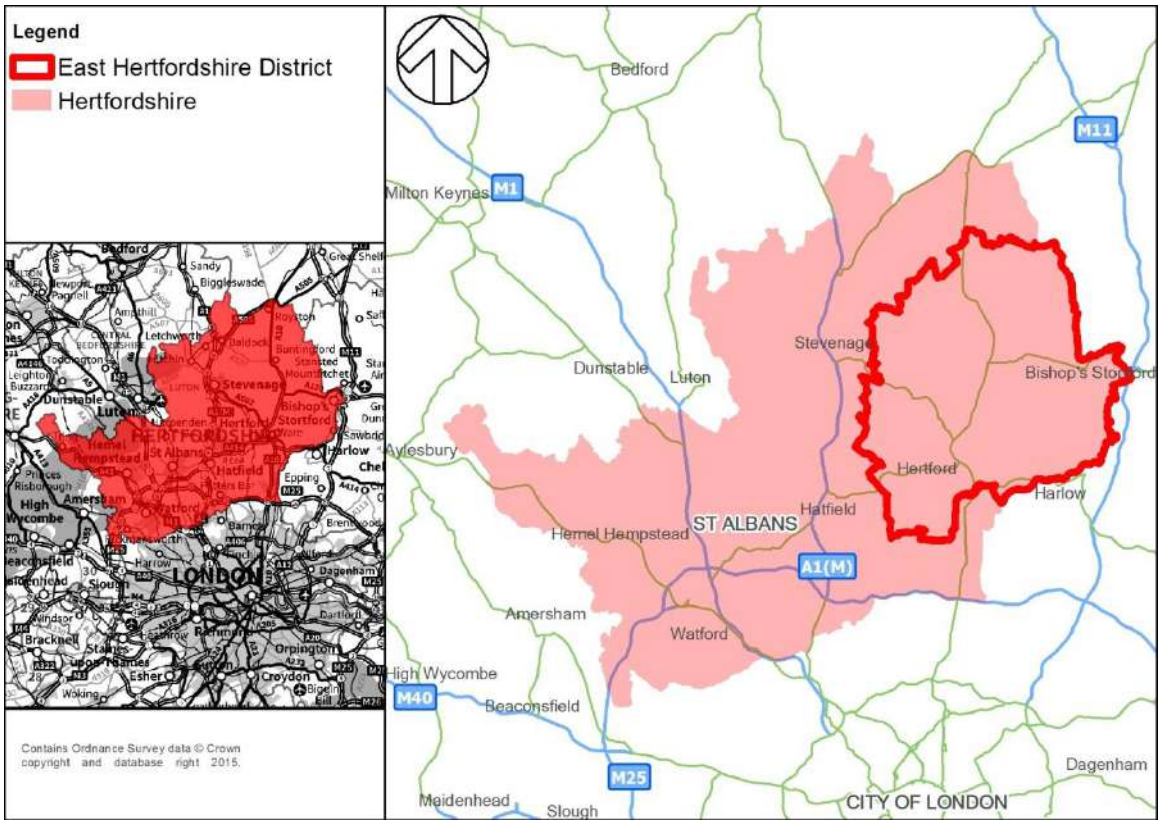


Figure 2: East Hertfordshire District Location Plan

There are multiple river catchments within East Hertfordshire District. These all drain towards the River Lea / Lee (Lea is the natural river channel; Lee is the man-made canalised channel). The River Lea rises near Luton in Bedfordshire and flows across Hertfordshire towards East Hertfordshire District. Within East Hertfordshire, the river passes through the towns of Hertford, Ware and St Margarets / Stanstead Abbotts before continuing south, out of the district.

Within the River Lea catchment, there are a number of other Main Rivers and associated catchments that are tributaries of the River Lea. These tributaries include:

- River Mimram – Flows in an easterly direction through North Hertfordshire, to the north of Welwyn Garden City before joining the River Lea to the west of Hertford town centre.
- River Beane – Flows southerly through the villages of Walkern and Watton-at-Stone before passing to the west and south of Bengeo, Hertford and joining the River Lea near Dicker Mill, Hertford.
- River Rib – Flows in a southerly direction through the Villages of Buntingford, Puckeridge and Standon before passing to the east of Bengeo, Hertford and joining with the River Lea to the northeast of Hertford.
- River Ash – Rises near the village of Meesden and flows southerly through Little Hadham, Much Hadham and Hadham cross before joining the River Lea near Great Amwell.
- River Stort – Flows through the towns of Bishop's Stortford and Sawbridgeworth and flowing to the north of Harlow before joining with the River Lea to the south of St Margarets / Stanstead Abbotts. The river forms the south eastern boundary of East Hertfordshire.

Figure 3 shows the Main Rivers within East Hertfordshire District along with the river catchments.

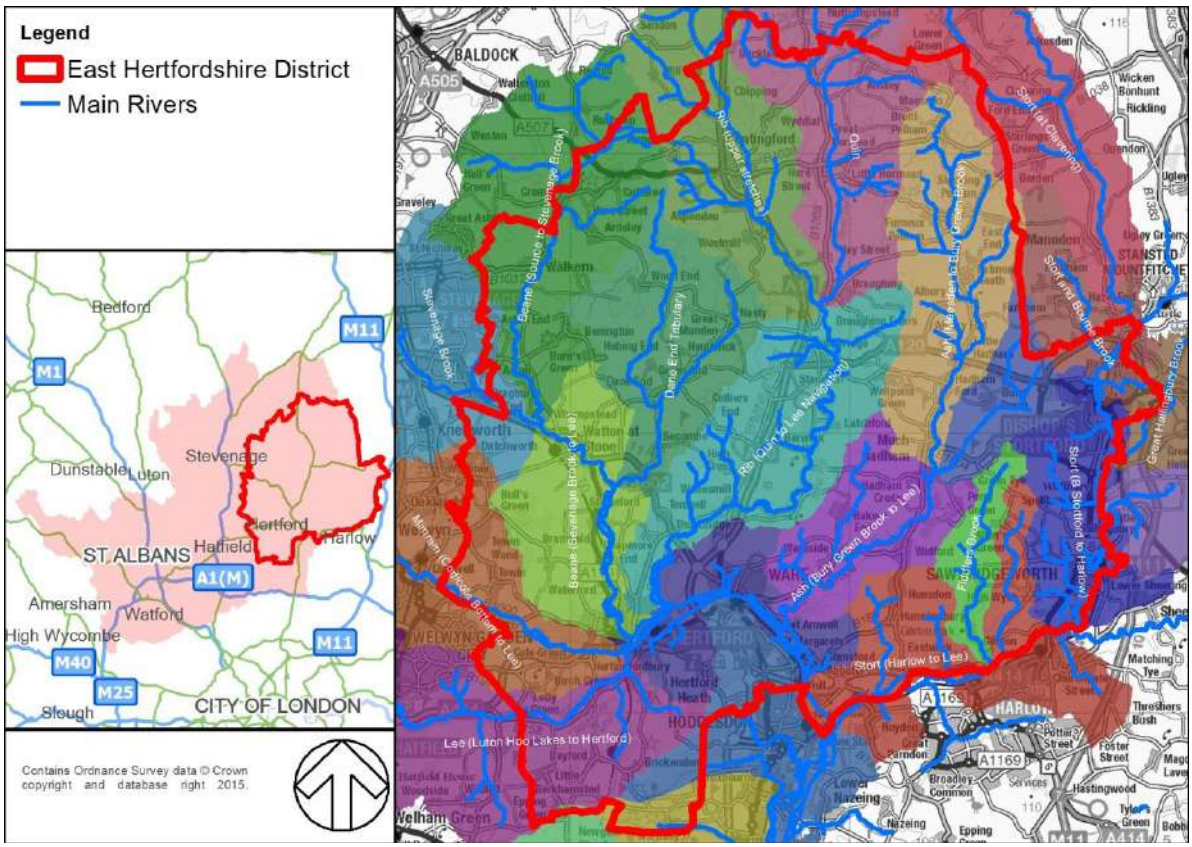


Figure 3: River catchments within East Hertfordshire District

The British Geological Survey (BGS) mapping indicates that East Hertfordshire is underlain by a number of chalk and sand formations with areas of London Clay deposits towards the south and south east of the District; shown in Figure 4.

In general, chalk catchments are considered to be permeable with large proportions of the rain falling on the ground able to infiltrate to provide baseflow to the surface water features, often delaying the flood peak. Certain types of storms, particularly heavy summer storms, can however lead to flooding, where the intensities exceed the infiltration capacity.

The majority of the underlying chalk formations are classed as Principal Aquifers. These are rock layers that have high intergranular and/or fracture permeability. As a result, the aquifers can provide a high level of water storage. They may support water supply and/or river baseflow on a strategic scale.

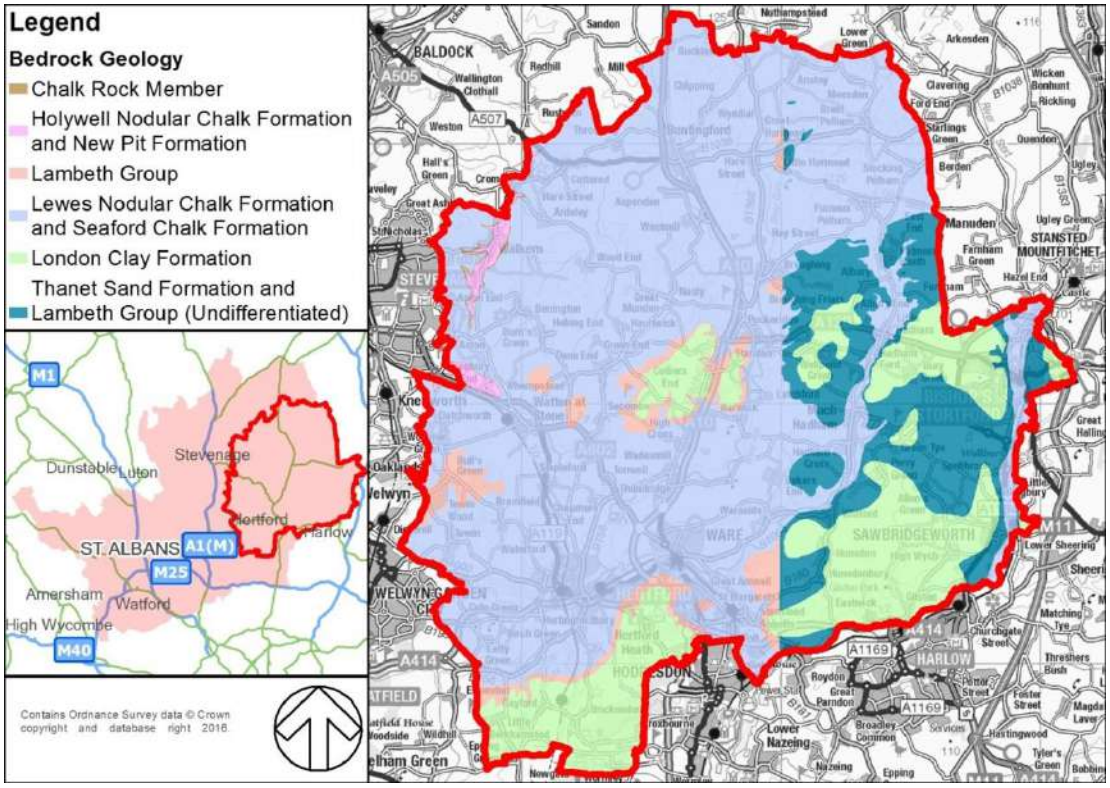


Figure 4: British Geological Survey Map of East Hertfordshire District - Bedrock Deposits

Figure 5 shows the superficial deposits overlying the bedrock. Most of the superficial deposits are a result of glacial deposits during the Pleistocene Epoch. Infiltration rates will be localised depending on deposit type and depth.

The majority of the superficial deposits are classified as Secondary Undifferentiated aquifers due to the variable characteristics of the rock type. In locations close to river channels where the deposits are classed as sand and gravel, these are classed as Secondary A aquifers, capable of supporting water supplies at a local rather than a strategic scale, and in some cases forming an important source of baseflow to rivers. These are generally aquifers formerly classified as minor

aquifers. During times of heavy rainfall, water may saturate the underlying soils and as a result cause groundwater to seep out of the ground[3].

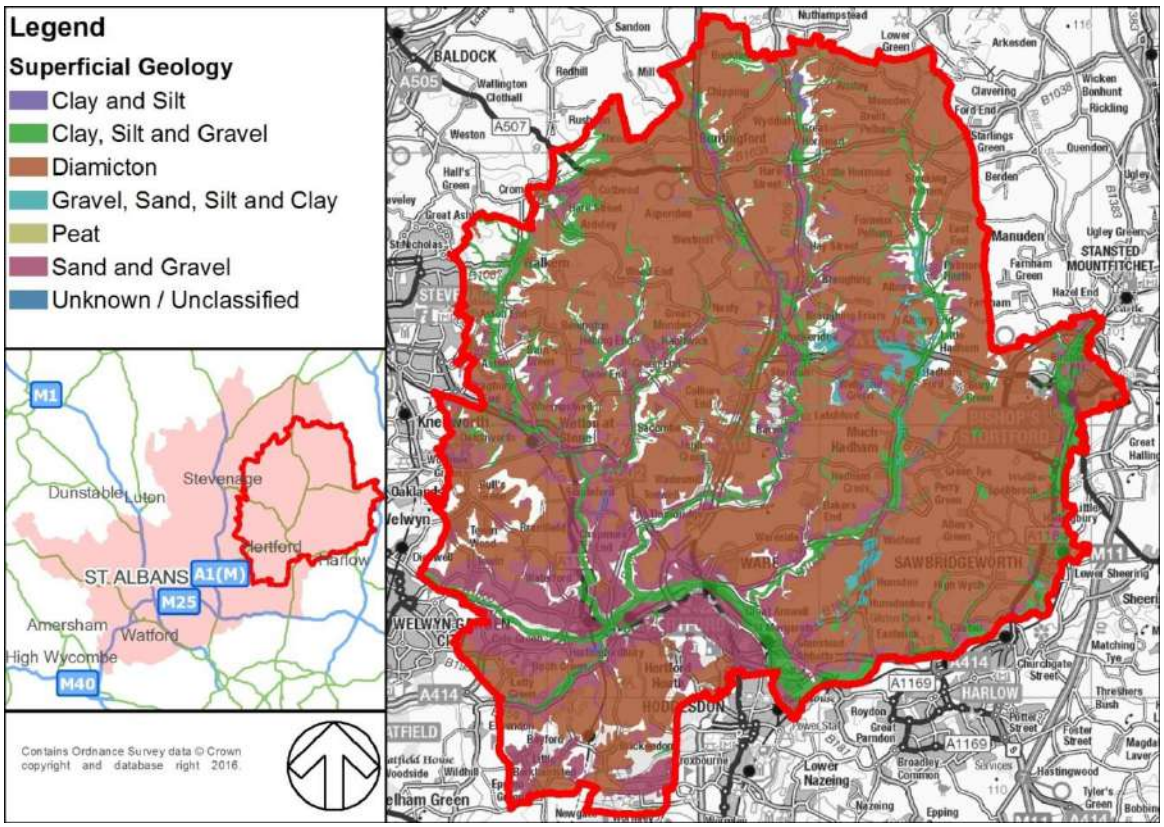


Figure 5: British Geological Survey Map of East Hertfordshire District - Superficial Deposits

2.3 SURFACE WATER MANAGEMENT PLANS (SWMP)

A Surface Water Management Plan (SWMP) is a plan which outlines the preferred surface water management strategy in a given location. In this context, surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small watercourses and ditches that occur as a result of heavy rainfall. It does not include river (fluvial) flooding except to the extent that river levels impact on surface water flooding.

The study is undertaken in consultation with key stakeholders who are responsible for surface water management and drainage in their area. All parties should work together to understand the causes and effects of surface water flooding and agree the most cost effective processes of managing surface water flood risk for the long term. The process of working together is designed to encourage the development of innovative solutions and practices as well as identifying funding streams to assist in the delivery of the outcomes of the SWMP.

[3] Definitions adapted from Environment Agency What's in Your Back Yard website http://apps.environment-agency.gov.uk/wiyby/117020.aspx

2.4 STAGES OF A SWMP

There are four phases to be completed in order to undertake a SWMP study as illustrated in Figure 6.

The Defra Surface Water Management Plan Technical Guidance (March 2010) sets out a description of the four stages as follows[4]:

- **Preparation** – The first phase of a SWMP study focuses on preparing and scoping the requirements of the study. Once the need for a SWMP study has been identified the LLFA and the key stakeholders should identify how they will work together to deliver the SWMP study. The aims and objectives of the study should be established, as well as details of how all parties should be engaged throughout the SWMP study. An assessment should subsequently be undertaken to identify the availability of information. Based on the defined objectives, current knowledge of surface water flooding, and the availability of information, an agreement is made regarding the level of assessment at which the SWMP study should start.
- **Risk assessment** – The outputs from the preparation phase will identify which level of risk assessment will form the first stage of the SWMP study. The first stage is likely to be the strategic assessment where little is known about the local flood risks. The strategic assessment focuses on identifying areas more vulnerable to surface water flooding for further study. The intermediate assessment, where required, will identify flood hotspots in the chosen study area, and identify quick win mitigation measures, and scope out any requirements for a detailed assessment. A detailed assessment of surface water flood risk may be required to enhance the understanding of the probability and consequences of surface water flooding and to test potential mitigation measures in high risk locations. Guidance is provided on undertaking modelling to support a detailed assessment of surface water flood risk and mitigation measures. The outputs from the strategic, intermediate and/or detailed assessment should be mapped and communicated to all stakeholders including spatial planners, local resilience forums, and the public.
- **Options** – In this phase a range of options are identified, through stakeholder engagement, which seeks to alleviate the risk from surface water flooding in the study area. The options identified should go through a short-listing process to eliminate those that are unfeasible. The remaining options should be developed and tested using a consideration of their relative effectiveness, benefits and costs. The purpose of this assessment is to identify the most appropriate mitigation measures which can be agreed and taken forward to the implementation phase.
- **Implementation and Review** – Phase 4 is about preparing an implementation strategy (i.e. an Action Plan), delivering the agreed actions and monitoring implementation of these actions. The first step is to develop a coordinated delivery programme. Once the options have been implemented they should be monitored to assess the outcomes and benefits, and the SWMP should be periodically reviewed and updated, where required.

[4] Page xvi, Paragraphs i29 to i32.

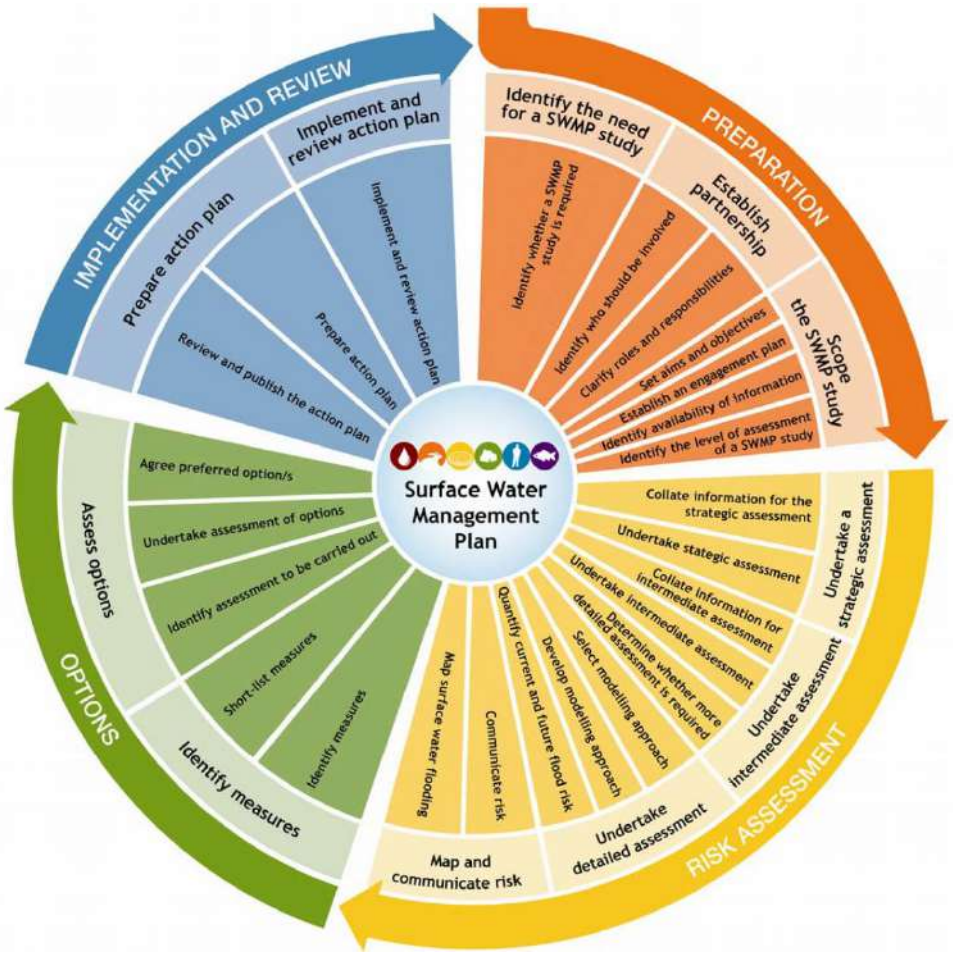


Figure 6: Different Stages of a SWMP study

The Local Flood Risk Management Strategy (LFRMS) for Hertfordshire 2013 – 2016 (published February 2013) identified the need for district scale SWMPs. A strong partnership has already been developed to implement aspects of the Flood and Water Management Act 2010, as well as deliver the St Albans and Watford SWMP update (February 2015), undertaken by WSP | Parsons Brinckerhoff. Given the work undertaken across Hertfordshire to date, it was deemed suitable to combine the Strategic and Intermediate Assessments of the Risk Assessment Phase.

3 WIDER POLICY AND LEGISLATIVE CONTEXT

3.1 POLICY AND LEGISLATIVE HISTORY

There has been a sequence of legislative and policy frameworks which cover flood risk developed by central government over the course of the last 15 years. The following information details a chronology of when this policy was developed, published and the main changes it brought about.

- Land Drainage Act (1991)

  The Land Drainage Act brought together legislation relating to IDB's and local authorities previously in the Land Drainage Act 1976 concerning inland and sea defence matters. This was amended by the Land Drainage Act 1994 and the key elements are duties on the enhancement of the environment, restoration and improvement of ditches, provision of funding and compulsory purchase of land.

- Planning Policy Guidance Note 25 (PPG25): Development and Flood Risk (2001)

  PPG25 set out the government's guidance to local authorities and others on planning policy associated with flood risk. This document was replaced in 2006 by the introduction of PPS25.

- Planning Policy Statement 25 (PPS25): Development and Flood Risk (2006)

  PPS25 set out the government's policy on development and flood risk following a review of the PPG25 document. Its aim was to ensure that flood risk was taken into account at all stages in the planning process to avoid inappropriate development. Key methodologies promoted within the document were as follows:

  - Defining four Flood Zones for fluvial or coastal flooding based on the Annual Exceedance Probability (AEP) of an event occurring;
  - Requiring the preparation of Regional Flood Risk Appraisals (RFRAs) or Strategic Flood Risk Assessments (SFRAs);
  - Development of the Sequential and Exception Tests which guides development away from areas most at risk of flooding; only permitting development in flood risk areas where it is appropriate;

  A Practice Guide was issued in 2008 and offers guidance on how to implement the policies within PPS25.

  In PPS25 SWMPs were referred to as tools to manage surface water flood risk on a local basis by improving and optimising coordination between relevant stakeholders. The guidance issued alongside PPS25 advised that planners at the strategic and development control levels should use SWMPs to inform their Core Strategy documents, such as the SFRA. The core strategy policies would have the SWMP as evidence to support any policies on flooding and surface water drainage. This document was superseded in 2012 when it was incorporated into the National Planning Policy Framework (NPPF).

- The Pitt Review: Learning Lessons from the 2007 Floods (2008)

  The Pitt Review was undertaken following the summer 2007 flooding and looked at the causes and response to the flood events across the UK. The review found inadequacies in terms of who was responsible for different types of flood risk and how that flood risk was communicated to emergency services and the wider community when required.

The review made 92 recommendations, particularly aimed at driving closer collaboration between government agencies and improved information on where there is risk of flooding.

Recommendation 18 of the Pitt Review states that Surface Water Management Plans (SWMPs) "should provide the basis for managing all local flood risk. SWMPs will build on or inform Strategic Flood Risk Assessments (SFRAs) and provide the vehicle for local organisations to develop a shared understanding of local flood risk, including setting out priorities for action, maintenance needs and links into local development frameworks and emergency plans."

- Flood Risk Regulations (FRR) (2009)

  The Flood Risk Regulations (FRR) transposed the EU Floods Directive into law in England and Wales. Under the FRR the Environment Agency (EA) and Lead Local Flood Authorities (LLFAs) had to prepare preliminary flood risk assessments (PFRAs). Completed by LLFAs, these PFRAs are published by the Environment Agency. There is also a duty on LLFAs with an agreed Flood Risk Area to publish flood hazard and flood risk maps for all sources of flooding and flood risk management plans. These flood risk management plans should set objectives for flood risk management and outline measures for achieving these objectives.

- Flood and Water Management Act (FWMA) (2010)

  The FWMA (2010) was first proposed as the legislative vehicle to implement the European Floods Directive, however due to delays in the bill, it was not implemented within the timeframe set out by the Floods Directive, hence the FRRs implemented the Floods Directive and the FWMA was delayed until 2010.

  The FWMA provided the legislative basis for a number of recommendations in the Pitt Review. In October 2010, Section 9 of the FWMA came into force requiring all LLFAs in England to develop, maintain, review, update as well as apply and monitor the application of a strategy for local flood risk in their area. This is known as a Local Flood Risk Management Strategy (LFRMS).

- National Planning Policy Framework (NPPF) (2012)

  The NPPF was published in 2012 and simplified all the disparate Planning Policy Statements into one coherent framework to underpin the planning system. PPS25 was updated and included in the NPPF in *Section 10: Meeting the challenge of climate change, flooding and coastal change.*

  Planning Practice Guidance was published alongside the NPPF and the section of the Guidance for flood risk provides additional details on the approach for strategic level studies. The NPPF does reiterate the importance of the Strategic Flood Risk Assessment (SFRA) in setting local planning policy.

  NPPF does not explicitly mention SWMPs but highlights the importance of assessing flood risk from all sources including surface water. A SWMP can be undertaken either proactively to inform future SFRAs or reactively as a result of an SFRA study.

  On 24th March 2015, the Government laid a statutory instrument making the Lead Local Flood Authority a statutory consultee in planning for all major development in relation to the management of surface water drainage from 15th April 2015. The NPPF and associated Planning Practice Guidance were updated to reflect these changes.

3.2 LEAD LOCAL FLOOD AUTHORITY (LLFA)

Hertfordshire County Council, as the Lead Local Flood Authority for Hertfordshire, has the role of managing flood risk from surface water and groundwater and is a statutory consultee in planning for all major development in relation to the management of surface water drainage.

As LLFA the county council has a range of duties which includes:

- Preparing reports and plans to meet the requirements of the Flood Risk Regulations 2009 (FRR);
- Carrying out investigations of flooding where appropriate and publishing reports;
- Keeping a public register and associated record of structures and features which have a significant effect on local flood risk;
- Designation of structures and features where appropriate;
- Regulation of Ordinary watercourses outside of areas covered by Internal Drainage Boards (IDBs).

In accordance with the Flood and Water Management Act (2010), LLFAs are required to co-ordinate and lead local flood risk management activities by preparing and implementing a Local Flood Risk Management Strategy (LFRMS). HCC has already prepared a Local Flood Risk Management Strategy, and is currently progressing through 10 district / borough based Surface Water Management Plans (SWMPs) throughout Hertfordshire, to gain a better understanding of local flood risk and the priorities for management.

3.3 OTHER PLANNING POLICIES

This section details the different sources of information available to help inform the production of the SWMP and a summary on the content of each planning policy document is detailed further in this section. An overview of the interaction of the documents is provided in Figure 7.

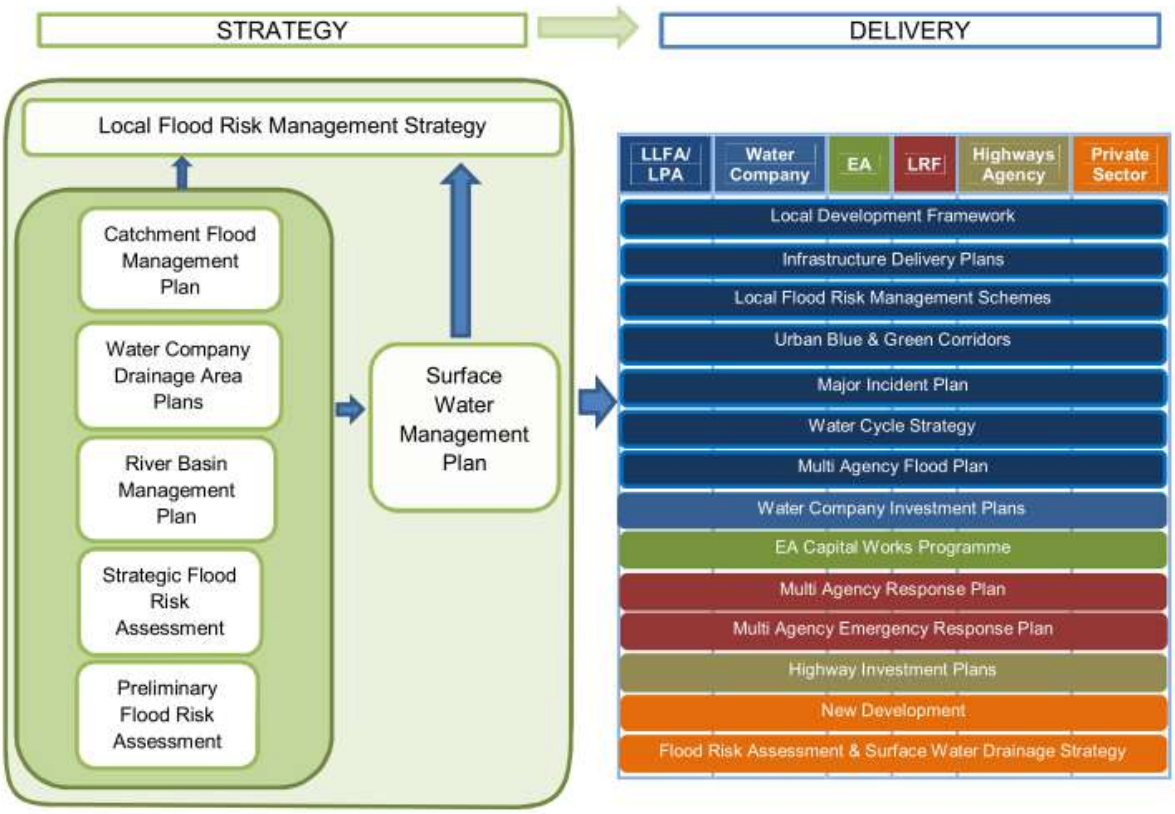


Figure 7: Link between Surface Water Management Plans and other Strategies, Plans and Policies

STRATEGIC FLOOD RISK ASSESSMENTS (SFRA)

The Planning Practice Guidance states the following with regards to Strategic Flood Risk Assessments[5]:

"A Strategic Flood Risk Assessment (SFRA) is a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future, taking account of the impacts of climate change, and to assess the impact that land use changes and development in the area will have on flood risk.

The Strategic Flood Risk Assessment will be used to refine information on river and sea flooding risk shown on the Environment Agency's Flood Map for Planning (Rivers and Seas). Local planning authorities should use the Assessment to:

- Determine the variations in risk from all sources of flooding across their areas, and also the risks to and from surrounding areas in the same flood catchment;
- Inform the sustainability appraisal of the Local Plan, so that flood risk is fully taken into account when considering allocation options and in the preparation of plan policies, including policies for flood risk management to ensure that flood risk is not increased;
- Apply the Sequential Test and, where necessary, the Exception Test when determining land use allocations;
- Identify the requirements for site-specific flood risk assessments in particular locations, including those at risk from sources other than river and sea flooding;
- Determine the acceptability of flood risk in relation to emergency planning capability;
- Consider opportunities to reduce flood risk to existing communities and developments through better management of surface water, provision for conveyance and of storage for flood water."

Each Local Planning Authority (LPA) area in Hertfordshire is covered by an SFRA which was produced in 2007-2008. A number have been supplemented with further assessment.

CATCHMENT FLOOD MANAGEMENT PLANS (CFMP)

Catchment Flood Management Plans (CFMPs) are key strategic documents that outline future flood risk management policies on a catchment by catchment basis. The East Hertfordshire District lies almost entirely within the River Thames CFMP.

CFMPs give an overview of the flood risk across each river catchment. They recommend options for managing those risks at present and over the future 50 – 100 years. CFMPs have been prepared in partnership with regional and local planning authorities, community environmental groups and other stakeholders.

CFMPs consider all types of inland flooding, from rivers, groundwater, surface water and tidal flooding, but not coastal flooding, which is covered in Shoreline Management Plans. They also take into account the likely impacts of climate change, the effects of how we use and manage the land, and how areas could be developed to meet our present day needs without compromising the ability of future generations to meet their own needs.

[5] http://planningguidance.communities.gov.uk/blog/guidance/flood-risk-and-coastal-change/strategic-flood-risk-assessment/

Figure 8 illustrates the extent of the River Thames CFMP and Thames RBMP within East Hertfordshire District.

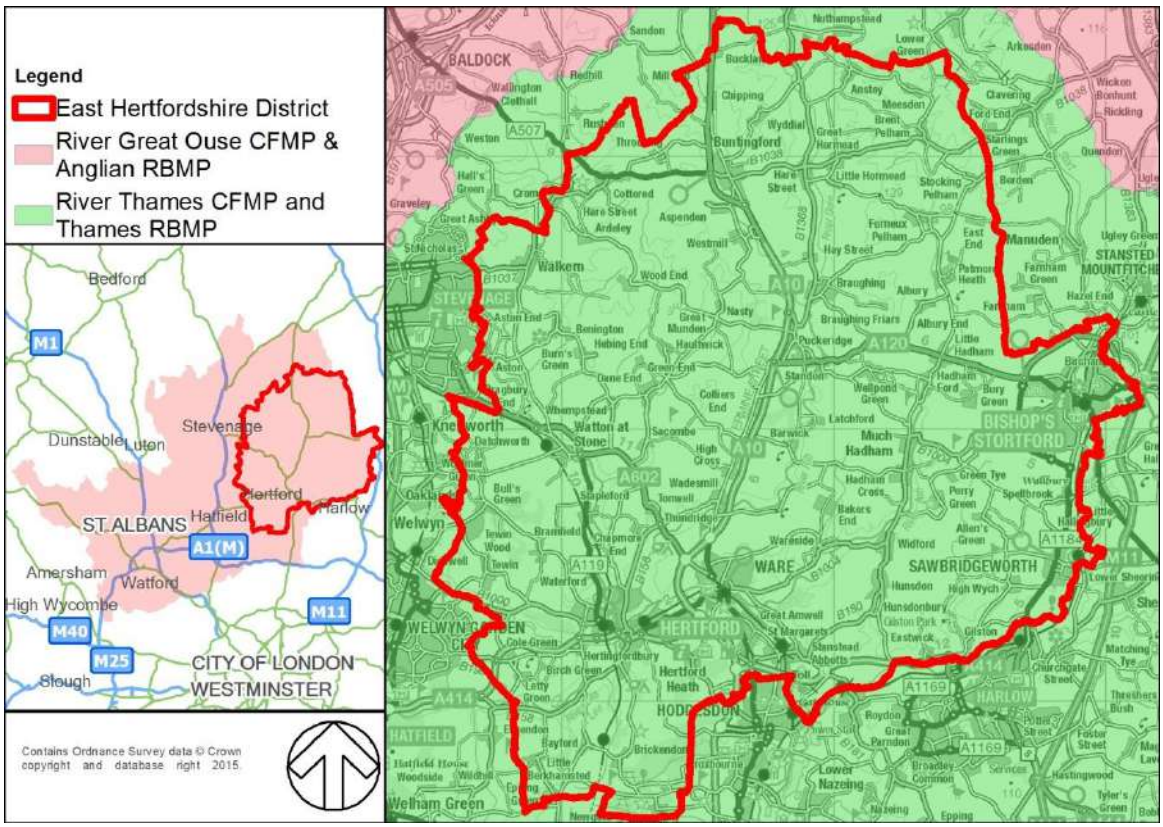


Figure 8: Environment Agency CFMP Areas and RBMP Areas covered within East Hertfordshire District

WATER FRAMEWORK DIRECTIVE (WFD)

The Water Framework Directive was introduced in December 2000 and became UK law in December 2003. The directive focuses on improving the ecology of our water ecosystems and aims to protect and enhance the quality of surface water, groundwater, estuaries and coastal waters. The Environment Agency is the lead authority responsible for the delivery of these targets, but must work closely with Lead Local Flood Authorities (LLFAs), in this instance Hertfordshire County Council, to ensure that targets are achieved.

RIVER BASIN MANAGEMENT PLANS (RBMP)

East Hertfordshire District lies wholly within the Thames River Basin Management Plan area. Figure 8 shows the RBMP and CFMP areas within East Hertfordshire District. The following is quoted from the plan covering 2009-2015[6].

"This plan focuses on the protection, improvement and sustainable use of the water environment. Many organisations and individuals help to protect and improve the water environment for the benefit of people and wildlife. River Basin Management is the approach the Environment Agency

[6] https://www.gov.uk/government/publications/thames-river-basin-management-plan

is using to ensure our combined efforts achieve the improvement needed in the Thames River Basin District.

This plan has been prepared under the Water Framework Directive, which requires all countries throughout the European Union to manage the water environment to consistent standards. Each country has to:

- Prevent deterioration in the status of aquatic ecosystems, protect them and improve the ecological condition of waters;
- Aim to achieve at least good status for all water bodies by 2015. Where this is not possible and subject to the criteria set out in the Directive, aim to achieve good status by 2021 or 2027;
- Meet the requirements of the WFD protected areas;
- Promote sustainable use of water as a natural resource;
- Conserve habitats and species that depend directly on water;
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants;
- Contribute to mitigating the effects of floods and droughts."

WATER CYCLE STUDY / STRATEGY (WCS)

A Water Cycle Study identifies the potential conflict between growth proposals and environmental requirements and identifies feasible solutions to addressing them. Effective planning and close cooperation between all parties involved is essential to the success of a water cycle study.

The WCS provides the evidence base for setting out allocations, phasing of development, potential developer contributions and further guidance. Since all organisations work in partnership to carry out the WCS, each partner is more likely to be committed to delivering the resulting WCS.

The effect of development on the water environment forms a key part of the Sustainability Appraisal (SA) and Strategic Environmental Assessment (SEA), required under the Local Plan process. As part of the Local Plan a WCS will give planning authorities a robust evidence base to assess this. It identifies and assesses risk, investigates all the options and issues and helps decide which option(s) will best support the Local Plan and related policies.

The WCS helps to plan for water more sustainably by:

- Bringing together all partners and stakeholders existing knowledge, understanding and skills;
- Bringing together all water and planning evidence under a single framework;
- Understanding the environmental and physical constraints to development;
- Working alongside green infrastructure planning to identify opportunities for more sustainable planning, and;
- Identifying water cycle planning policies and a water cycle strategy to help all parties plan for a sustainable future water environment.

The Rye Meads Water Cycle Strategy covers the majority of East Hertfordshire District and was produced by Hyder Consulting (UK) Limited in October 2009. Please refer to Figure 9 for a map showing the Districts covered by this Water Cycle Strategy. This WCS is intended to form part of the Local Authorities' evidence base for their Local Plans, and sets out the water and wastewater

infrastructure, amongst other measures, that will need to be in place to achieve their growth targets.

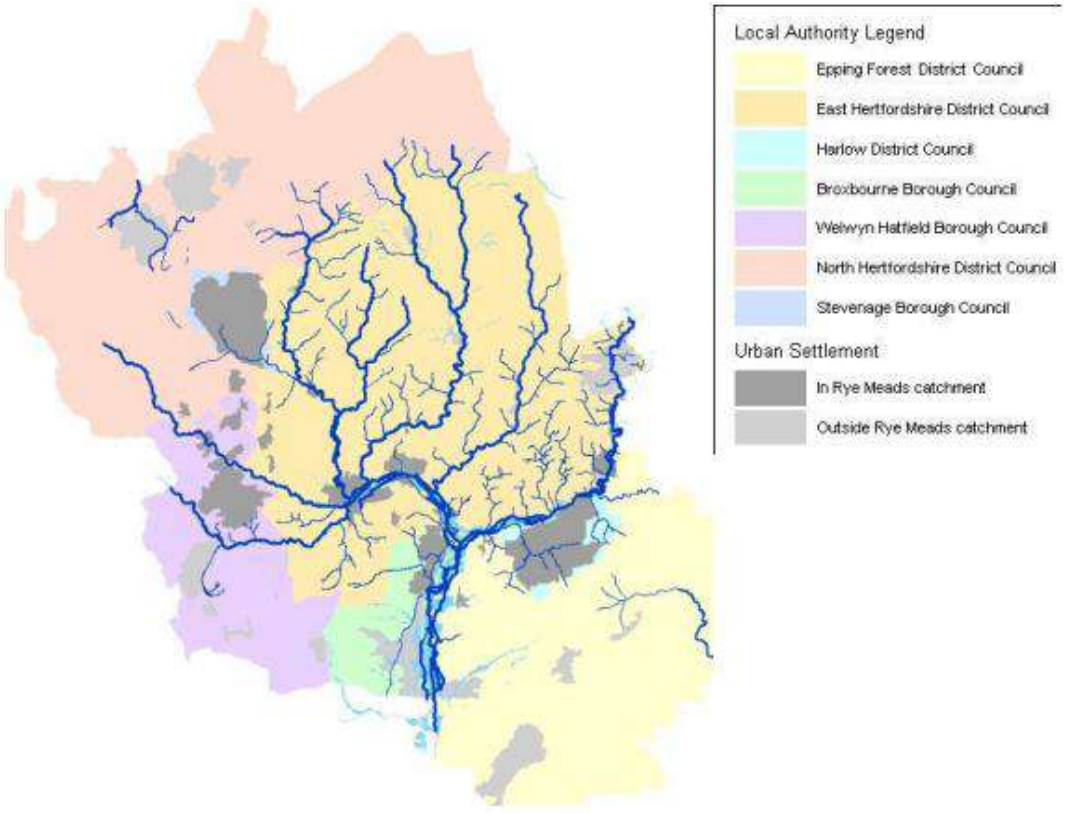


Figure 9: Rye Meads Water Cycle Strategy Study Area[7]

LOCAL FLOOD RISK MANAGEMENT STRATEGY (LFRMS)

In October 2010 Section 9 of the Flood and Water Management Act (FWMA) 2010 came into force. This element of the FWMA required all Lead Local Flood Authorities (LLFAs) in England to develop, maintain, review, update as well as apply, and monitor the application of a strategy for local flood risk in their area. The overarching aim of the Local Flood Risk Management Strategy is to provide a robust local framework that employs a full range of complementary approaches towards managing and communicating the risks and consequences of flooding arising from surface runoff, groundwater and Ordinary watercourses in Hertfordshire and the surrounding areas.

The objectives by which the county council will achieve this vision are set out below and actions and measures that have been developed to achieve these objectives are set out in Section E7 of the Hertfordshire LFRMS.

7 Rye Meads Water Cycle Strategy, Detailed Study Report, October 2009, page 11

- **Studies, assessments and plans** – Developing a greater understanding of local flood risk in Hertfordshire will be critical to deploying the most effective measures for managing the risk and making the best use of limited resources.
- **Information-sharing protocols** – This function will be developed to understand what data is needed for, what information is available, what information is missing and how information will be shared. The data will help define 'locally significant' flood risk and set criteria for when the LLFA will investigate a flooding incident.
- **Development control –** (The policy context for this area of the LFRMS has recently changed. National Planning Practice Guidance has superseded previous guidance. The Lead Local Flood Authority is identified as a statutory consultee on surface water drainage arrangements for all major development). An improving information base about local sources of flooding will help inform the determination of development proposals and support the Strategic Flood Risk Assessments produced by the local planning authorities.
- **Sustainable Drainage Systems (SuDS) –** The CIRIA SuDS Manual (C753) set out how "Sustainable drainage systems (SuDS) are designed to maximise the opportunities and benefits we obtain from surface water management. SuDS can deliver four main benefits by improving the way we manage water quantity, water quality, amenity and biodiversity"[1] It was anticipated that Hertfordshire County Council would become the SuDS Approving Body (SAB) after enactment of Schedule 3 of the Flood and Water Management Act. Following Defra consultation, Schedule 3 will not be enacted and instead HCC in their role as LLFA will become the statutory consultee on planning applications for major developments with surface water drainage (DMPO 2015)[8].
- **Raising awareness –** Individuals and communities should understand that there will always be a degree of flood risk and the role that they can play in the local management of that risk. Raising awareness will be a critical aspect of the Strategy.
- **Resilience** – The Strategy will explore ways in which flood risk can be reduced through individuals and communities increasing their own resilience.
- **Investment and funding** – The Strategy will look at the development of priorities for investment and at the same time explore opportunities for funding.

Hertfordshire County Council (HCC) has prepared their Local Flood Risk Management Strategy (LFRMS), which is consistent with the national strategy. The Local Flood Risk Management Strategy for Hertfordshire 2013-2016 was published in February 2013; this has identified the following objectives:

- The risk management authorities in the LLFA area and what flood risk management functions they may exercise in relation to the area;
- The objectives for managing local flood risk. These are relevant to the circumstances of the local area;
- The measures proposed to achieve objectives;
- How and when the measures are expected to be implemented. In some instances this could be linked to the Flood Risk Regulations outputs – The Preliminary Flood Risk Assessment;
- The costs and benefits of those measures and how they are to be paid for;
- The assessment of local risk for the purpose of the strategy. HCC as the LLFA have

[1] The SUDS Manual –C753 (2015) CIRIA
8 http://www.legislation.gov.uk/uksi/2015/595/made

used the information from previous studies to identify the risk and identify gaps in understanding the local flood risk and specify what actions need to be taken to close these gaps (i.e. completion of this SWMP);

- How and when the strategy is to be reviewed;
- How the strategy contributes to the achievement of wider environmental objectives.

4 PREPARATION

4.1 IDENTIFY THE NEED FOR A SWMP

Action 8.2.4 of the LFRMS 2013 – 2016 is "Develop Surface Water Management Plans based on the boundaries of the 10 district authorities." This SWMP for East Hertfordshire District is a realisation of Action 8.2.4.

4.2 ESTABLISH PARTNERSHIP

A SWMP is a framework through which key stakeholders with responsibility for surface water and drainage in their area, work together to understand the causes of surface water flooding and agree the most cost effective way of managing surface water flood risk.

Under the legislative framework, involvement in a SWMP by all stakeholders is voluntary. The Flood and Water Management Act 2010 requires Lead Local Flood Authorities (LLFA) to take the lead role for flood risk management and have a coordination role amongst the other stakeholders, in the development of SWMPs.

The East Hertfordshire District SWMP was produced in consultation with:

- Hertfordshire County Council;
- East Hertfordshire District Council (EHDC);
- Thames Water;
- The Environment Agency.

As part of the Strategic Assessment, consultation has been undertaken with a number of stakeholders to obtain historical flooding information. As the SWMP progresses, other stakeholders will be invited to provide additional information.

In addition, parish councils were contacted to inform stakeholders on any flooding issues which they wish to be taken into consideration as part of the hotspot selection.

The project aims to build upon the successful working platform between all bodies responsible for drainage and emergency response and ensure that this will continue after the SWMP is complete. Project meetings (at appropriate times) with the key stakeholders will ensure agreed actions are executed and that any new issues are discussed and reviewed. This is subject to an agreement between all stakeholders and availability of resources.

4.3 SCOPING THE SWMP STUDY

The key objectives of the SWMP are:

- To continue and enhance the successful working relationship between all stakeholders and to provide a future framework for this forum;
- Enhance the understanding of local flood risk across East Hertfordshire District;

- Establish the areas at significant risk9 of flooding and the potential impacts;
- Aid in understanding the mechanism of flooding. It may be that while local knowledge suggests one singular cause, there may be multiple factors with interconnectivity between sources;
- Identify various mitigation options (taking into account both the current and future situations, including the impacts of climate change) and prioritise the options;
- Develop an Action Plan to reduce the flood risk within the East Hertfordshire District.

4.4 POLICY DOCUMENTS REVIEWED

As part of the review of the available information, an assessment was undertaken of the link between the SWMP and other flood related plans and policy.

During the preparation of this Surface Water Management Plan, the following national and local policy documents were referred to:

- The Pitt Review, 2008;
- Water Framework Directive (WFD), 2003;
- Flood Risk Regulations, 2009;
- Flood and Water Management Act (FWMA), 2010;
- National Planning Policy Framework (NPPF), 2012;
- East Hertfordshire Strategic Flood Risk Assessment (SFRA), July 2008;
- Rye Meads Water Cycle Study, Outline Study Phase 1 (WCS), 2009;
- Thames River Basin Management Plan (RBMP), 2009;
- River Thames Catchment Flood Management Plan (CFMP), December 2009;
- Hertfordshire Preliminary Flood Risk Assessment (PFRA), August 2011;
- Local Flood Risk Management Strategy (LFRMS) for Hertfordshire, February 2013.

The Surface Water Management Plan (SWMP) will be a living document that needs to be reviewed as part of the LFRMS update cycle. This will ensure the implications of the agreed actions and new issues are addressed. However, a review may be required following any future surface water flood events, new data becoming available, new modelling data techniques becoming available or any changes in policy within the catchment.

4.5 COLLATING AVAILABLE INFORMATION

During the preparation stage of the SWMP, consideration was also given to the availability of information and the appropriate sources of this information. This included an assessment of which data could be provided by each partner or stakeholder and the format in which the information can be provided.

A review of all the data received from the different stakeholders and partners was undertaken as part of the Strategic Assessment.

[9] In accordance with the NPPF, all areas at risk of flooding are considered. However, weightings are applied to the analysis based on the mechanism of flooding and the annual probability of occurrence. This is done to guide the SWMP to areas most at risk of surface water flooding. Further information can be found within the Hotspot Selection Technical Note.

In addition to an assessment of the historical flooding experienced within the East Hertfordshire District SWMP study area, analysis was also undertaken utilising the following datasets from the Environment Agency (EA):

- Risk of Surface Water Flooding Maps (RoFfSW) (the third generation of surface water flood maps);
- Flood Map for Planning;
- Locations of Main Rivers and defences;
- National Receptor Database (information on properties at risk of flooding);
- Areas Susceptible to Groundwater Flooding (AStGWF) Map.

Consideration has also been given to the following data, as well as the reports detailed in earlier sections:

- East Hertfordshire, Strategic Flood Risk Assessment (SFRA), November 2008;
  - East Herts also completed Level 1 and Level 2 SFRAs in 2016.
- Ordnance Survey Data, MasterMap Topography and Integrated Transport Layers.

A Geographic Information System (GIS) was used to collate the available information, including the extents/locations of historical flooding.

4.6 QUALITY, LIMITATIONS AND RESTRICTIONS

Hertfordshire County Council have mechanisms in place to record reported incidents of flooding, this information has been used to inform the study along with the information detailed within other studies, such as the PFRA to provide an assessment of all recorded historical flooding within the study area.

Some of the data collated as part of the SWMP is subject to licensing restrictions. These restrictions include the level of detail that the SWMP is able to make publically available. For instance, the findings of the SWMP are based upon detailed site specific flooding information which cannot always be shown in publically available maps. In some instances assumptions were required and the resulting SWMP should be treated as a 'living document' with regular updates in line with improvements in collated data.

The data that has been collated as part of the Strategic Assessment, has come from a number of sources and in some cases is licensed to Hertfordshire County Council for the purposes of preparing this SWMP for East Hertfordshire District.

The level of assessment for the Strategic and Intermediate Assessments that was agreed with Hertfordshire County Council was an over-arching assessment, based upon the LFRMS and other recent studies, to cover the flood risk across the whole district. This identifies the hotspot areas for detailed assessment, which may include hydraulic modelling.

5 STRATEGIC AND INTERMEDIATE RISK ASSESSMENT

5.1 INTRODUCTION

The principle purpose of the Strategic Assessment is to identify broad locations, which are considered vulnerable to surface water flooding. This is undertaken on a coarse spatial scale and therefore provides a simplified assessment using the best information available, starting with a review of the historical events.

The purpose of the Intermediate Assessment is to identify the nature and sources of the flooding, and the frequency and severity of flooding. This improved understanding is then used to identify flood hotspots and begin to identify mitigation measures to reduce surface water flooding.

As there have been several completed assessments that cover the district (e.g. the Hertfordshire LFRMS and the Hertfordshire PFRA), it was determined that the Strategic and Intermediate Assessments should be combined.

This phase of the assessment considers flooding from surface water runoff, ordinary watercourses, sewers, canals and groundwater. This assessment also takes into consideration the interaction of these sources with Main Rivers and their associated tributaries in order to identify areas most at risk of surface water flooding.

In the context of this report, surface water flooding includes the following (as defined in the Key Definitions section):

- Surface water runoff; runoff before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity;
- Flooding from groundwater;
- Sewer flooding; flooding which occurs when the capacity of underground systems is exceeded due to heavy rainfall;
- Flooding from open-channel and culverted watercourses;
- Overland flows from the urban/rural fringe entering the built-up area, and;
- Overland flows resulting from groundwater sources.

The following information has been used for this phase of the assessment:

- Historic flooding records;
- Environment Agency's Risk of Flooding from Surface Water maps (sometimes referred to as the updated Flood Map for Surface Water, uFMfSW);
- Environment Agency's Areas Susceptible to Groundwater Flooding (AStGWF);
- East Hertfordshire Level 1 Strategic Flood Risk Assessment, Nov 2008;
- Local Flood Risk Management Strategy (LFRMS) for Hertfordshire (2013);
- Environment Agency's Flood Maps for Planning.

5.2 FLOODING HISTORY

HISTORIC FLOOD RECORDS

A review of the reported and recorded historical events experienced within East Hertfordshire District was undertaken however, it does not constitute a comprehensive assessment of all flood risk. Historical data cannot identify all locations at risk of flooding; it is possible that areas that have experienced flooding are not represented in this assessment as all occurrences may not be reported or recorded.

The East Hertfordshire District Level 1 SFRA provides a starting point for recorded historic flood events. Map 9 of the SFRA shows the locations of historic flood events and the numbers of events are tabulated and included in Appendix C of the SFRA; this table is reproduced as Table 1.

Table 1: East Hertfordshire District SFRA Appendix C – EHDC Flood Incidents Database

CATEGORY	ASH	BEANE	LEE	MIMRAM	RIB	STORT	TOTAL
Foul Water		2	1			1	**4**
Ground Water	1		2	1		3	**7**
Highway	3	2	6	2	4	15	**32**
Highway & Surface Water		1					**1**
Highway & Main River		1					**1**
Highway & Ordinary Watercourse	1					1	**2**
HW			1				**1**
Main River	15	14	7		10	7	**53**
Pond					3		**3**
Ordinary Watercourse	13	11	20	3	26	20	**93**
Ordinary Watercourse & Foul Water						1	**1**
Ordinary Watercourse & Highway						2	**2**
Ordinary Watercourse & HW						1	**1**
Ordinary Watercourse & Pond	1						**1**
Principal Watercourse*	1		9			16	**26**
Principal Watercourse* & Foul Water			1				**1**
Principal Watercourse* & Surface Water						1	**1**
Surface Water	5	7	7	1	9	13	**42**
Surface Water & Foul Water		1	14	1		2	**18**
Surface Water & Highway			1				**1**
Surface Water & Highway & Foul Water						1	**1**
TOTAL	**40**	**39**	**69**	**8**	**52**	**84**	**292**

*A Principal Watercourse is an Ordinary Watercourse that has been identified by EHDC's Land Drainage Team as part of the SFRA process. 150 principal watercourses have been identified with East Hertfordshire District and the land drainage team intends to survey and maintain them regularly to reduce flood risk.

FLUVIAL FLOODING

Due to the number of Main Rivers within East Hertfordshire District, there have been large numbers of fluvial flooding incidents within the District. Table 2 is a reproduction of East Hertfordshire Level 1 SFRA Table 2 and shows the fluvial flood events that have occurred in the past 30 years.

Table 2: East Hertfordshire District SFRA Table 2 - Historic Flood Extents

RIVER	YEAR
Rib	1993, 2001
Ash	1993, 1998, 1999, 2000, 2001
Stort	1993, Oct 2000, Nov 2000, Feb 2001, Oct 2001, 2002, 2003
Lee/Lea	1993, 2000, 2002
Beane	1978, 1979, 1993, 2000, 2003
Mimram	1993, 1997

FLOOD RISK FROM CANALS

There are a number of canals within East Hertfordshire. The River Lee Navigation and River Stort Navigation are canalised watercourses alongside their respective rivers. The canals are managed by the Canal and River Trust who are responsible for ensuring the water level within the channel is high enough to allow navigation. However, Navigations are still classed as rivers with the River Lee Navigation and River Stort Navigation classed as Main Rivers. These are therefore responsive to larger changes in water level than a standard canal.

The River Lee Navigation begins at Hertford Castle Weir in Hertford and runs through Hertford, Ware and Great Amwell before continuing south through the Borough of Broxbourne. The River Stort Navigation begins in Bishop's Stortford and runs south towards its confluence with the River Lee Navigation at Feildes Weir near Rye House, Broxbourne.

SURFACE WATER FLOODING

Map 9 of the SFRA shows historic flood events including surface water flood event. However, more recent flood events have also been provided by Hertfordshire County Council and East Hertfordshire District Council (EHDC). Where relevant to the hotspot selection process, these are included in the Hotspot Selection Technical Note; there are also summarised here for reference.

- Bishop's Stortford – A number of locations have been reported by EHDC:
  - August 2015 – Flooding was recorded at Wharf Road and in the junction of Stansted Road and Parsonage Lane;
  - Flooding has been recorded in the area surrounding The Grange Leisure Centre and Stane Close however this area is located within Flood Zone 2;
  - Flooding has been recorded along The Causeway and around Jackson Square shopping centre. This area is located within the Flood Zone 2 extent of the adjacent River Stort;
  - Thorn Grove has flooded in the area around Thorn Grove Primary School. It is thought this is due to a blocked drain and poor ditch maintenance.
- Buntingford – Flooding was recorded on 16th to 17th July 2015 and is currently being investigated by HCC;
- Ford End – EHDC have historical flooding incidences of flooding and the area was affected by flooding in February 2014. This area is downstream of Little Hadham and should benefit from the proposed flood alleviation scheme;

- Green Street Village – EHDC have recorded incidences of flooding in the area near Green Street Village near Little Hadham;
- Hertford – 24th August 2015 – Flooding was reported at Globe Court, Bengeo Street in Hertford. Flooding was also reported in Port Vale with water flowing down Byde Street towards Port Vale;
- High Cross – EHDC has raise issues that a number of properties within High Cross have experienced surface water flooding;
- Little Hadham – 24th July 2015 and February 2014 – Little Hadham sits at the crossroads of the A120 and Albury Road. The village is at the confluence of a number of Main Rivers including the River Ash. A joint bypass/flood alleviation scheme is proposed in to the north of the village and will provide upstream flood storage, thereby reducing flood risk to the village;
- Puckeridge / Standon – February 2014 – Flooding was reported by the Parish Council and East Hertfordshire District Council; the areas raised by EHDC are within the Flood Zone 2 and 3 extents. The Environment Agency has been conducting updated modelling within the area and has produced updated Flood Zone extents which were incorporated into the Flood Map for Planning in the October 2015 update. The Environment Agency found the tributaries are highly susceptible to flooding during blockages and the Environment Agency is investigating whether there are potential options to reduce flood risk such as upstream flood storage;
- Stanstead Abbotts – Flooding has been recorded in a number of locations and was reported by both EHDC and Stanstead Abbotts Parish Council. The Environment Agency is conducting a fluvial study into Stansted Drain which enters the area from the east;
- Watton-at-Stone – EHDC have recorded incidents of flooding in Great Innings North.

Information provided by parish councils is provided below. Whilst likely to be caused by surface water flooding, this cannot be confirmed. Incidents are grouped into parish councils.

ASTON PARISH COUNCIL

- Flooding has been reported in the junction of Long Lane and Tatlers Lane. This is reported due to surface water runoff from the nearby residential area within Stevenage Borough. An interceptor has been put in to the west of Gresley Way but at times this is insufficient.

BENGEO RURAL PARISH COUNCIL

- Flooding was recorded in November 2012 and attributed to a broken land drain resulting in flooding in the lane near Paynes Hall. Remedial work has been carried out but no permanent repair has occurred;
- October 13th 2014 & Nov 2014 – Flooding occurred near The Well House and several places on Anchor Lane. The roundabout on the A602 was also flooded causing tailbacks;
- January 2015 – Surface water flooding near Rickeys Farmhouse causing two accidents. Parish council report daily running water but nothing to do with rainfall.

BRENT PELHAM & MEESDEN PARISH COUNCIL

- Brent Pelham & Meesden Parish Council reported that when heavy rain floods outside Down Hall Farm, this causes septic tanks to overflow into garden of several houses in an adjacent road. Hertfordshire Highways constructed a new road past the farm along with a gully under what was once a ford. Ringway records do not show this gully and has consequently never been maintained and the Parish Council attribute this to the flooding.

DANE END PARISH COUNCIL

- Flooding was recorded on 24th December 2013. This was believed to be caused by a lack of maintenance by the riparian owner of Dane End Tributary between Whitehills Road and the property called 'Cascades'; the banks have also been damaged due to tractors being driven close to banks. The Environment Agency has promised to take action against riparian owner.

HORMEAD PARISH COUNCIL

- Flooding from the River Quin was recorded on the 8th February 2014. This flooded the Parish Council's pavilion which has been flooded twice in the last 15 years. Flooding was also recorded on this date to the properties to the north of Hare Street village;
- Hormead Parish Council has also reported regular flooding in other locations: in the B1038 to the east of The Three Tuns Pub; Worsted Lane where it crosses the River Quin and in the B1038 to the west of Hare Street Village by the catholic cemetery. The causes of flooding in these three locations in unknown.

HUNSDON PARISH COUNCIL

- Hunsdon Parish Council raised a number of different locations that flood however only provided one dated incident of flooding. Flooding has been reported:
  - B180: water pools / floods on the B180 just before and just after the turning into Hunsdonbury Lane;
  - Acorn Street, particularly near Spellers: water in the field bypasses the drainage features and pools next to the road, causing flooding to the road and property. Inadequate road drainage along with capacity issues in gullies also results in water backing up into the road;
  - Acorn Street/High Street junction: water backs up from the road gully; it is unclear whether this is a capacity issue relating to the gully or problems with the wider drainage network;
  - The top of Tanners Way / behind the High Street: potential blockages;
  - Area to the north-west of Wicklands Road, to the south of Dury Lane: this area floods in heavy rain; development is proposed in this area and is currently being considered within the planning system;
  - Dury Lane: an old brick culvert runs under the northern footway of the lane and is prone to collapse. This takes significant runoff from the pond at the eastern end of the lane draining the fields of the old airfield;
  - Wicklands Road: The turning circle end of the road regularly floods and residents have had to take personal protective measures;
  - B180: Flooding on the road by the outfall from Bonningtons Lake onto the B180 where it should enter culvert under the road. The culvert either becomes blocked or is inadequate;
  - High Street: residents in the High Street sometimes block the brook in dry weather potentially causing flooding issues;

- Flooding 2014 - Gardens were flooded to the rear of the village hall and the two adjacent cottages to the south. The ditch and culvert to the rear of the hall on the boundary of the large fields at the rear were completely blocked. The farmer Mr E Bone cleared this and it remains to be seen whether this will stop further flooding. The culvert appears to run under the Village Hall Car Park to the rear thence under the garden of Rose Cottage under Back Lane and feeds into Hunsdon Brook in the garden of the cottage adjacent to Back Lane.

LITTLE MUNDEN PARISH COUNCIL

- Little Munden Parish Council raised the possibility of ditch maintenance and reconstruction of the banks along Mill Lane leading to Levens Green;
- Little Munden PC also raised the same issue as Dane End Parish Council in that Dane End Tributary between Whitehills Road and the property 'Cascades' has not been maintained. LMPC raised the issue that the tributary used to be approximately 4ft deep and is now approx. 2ft deep. The owner of 'Cascades' has spent money altering the tributary to limit flooding but is limited by a listed bridge.

STANDON PARISH COUNCIL

- Standon Parish Council stated they were affected by the flooding in February 2014.

STANSTEAD ABBOTTS PARISH COUNCIL

- A number of houses at risk in Marsh Lane, drainage ditches are believed to be the cause;
- 50 Properties at risk on the west side of Cappell Lane. The parish council believe blocked drainage ditches are creating high levels of standing water in areas that were once well drained;
- 20 Properties at risk in the high street near the car park, the parish council also believe blocked drainage ditches to be the cause.

WARE TOWN COUNCIL

- Ware Town Council raised four locations that have experienced surface water flooding. Flooding was recorded in the 1980s in Priory Street and Berkeley Close as a result of blocked culverts/drains. Blocked drains in Cozens Road have also caused surface water flooding however the parish council state this has been rectified by Thames Water;
- Water also comes out of a drain on Kingsway near High Mill during heavy rain. The parish council believe this due to tree root ingress blocking the sewers.

GROUNDWATER FLOODING

Six incidents of groundwater flooding are recorded within the East Hertfordshire District SFRA on Map 9: Historic Flooding. These are located across the district and no further information is provided as to the cause of these events.

With regards to groundwater flooding the SFRA states: "*Isolated ground water flood events have occurred but these are rare and tend to affect small areas or individuals gardens. It has been noted that many previously dormant springs become active as a result of nearby construction or groundwork operations.*"

It should be noted from the data provided and following consultation with the key stakeholders, it is sometimes difficult to ascertain if a source of flooding is from groundwater only. This is because flood risk may be as a result of a combination of sources, or a culverted watercourse may have been mistaken for a spring or underground stream.

WATER COMPANIES FLOOD RISK REGISTER

The water company for the district (Thames Water) has also been consulted to obtain the sewer flooding records from their flood risk register. This register lists the areas and properties which have previously experienced an internal or external sewer flooding incident caused by overloaded sewers or other causes (temporary problems) (whether foul, combined or surface water sewers).

Temporary problems such as blockages, siltation, sewer collapses and equipment or operational failures have been excluded from the register. An entry upon this register will not be removed until the problem has been solved. It should be recognised that reporting is not necessarily complete as some property owners do not report sewer flooding events. In addition, instances of surface water flooding in remote areas are unlikely to be reported.

The water companies have subsequently supplied postcodes of places that have been subject to sewer flooding. The listing gives the number of properties which suffered internal flooding and the number of places subject to external flooding. External flooding includes highways, public open space, open land, parkland, as well as private gardens

5.3 AVAILABLE DATA

DATASETS

In recent years, the risk of flooding from non-fluvial sources has become better understood and information about the risk has become more informed. This information is now publicly available with further data held by stakeholders or commercially available; these datasets are:

- Areas Susceptible to Groundwater Flooding (greater than 75%);
- Risk of Surface Water Flooding Maps – 1 in 30, 1 in 100 and 1 in 1,000 year (this is sometimes known as the updated Flood Map for Surface Water, uFMfSW);
- Flood Map for Planning Flood Zones 2 and 3;
- Areas Benefitting from Defences.

AREAS SUSCEPTIBLE TO GROUNDWATER FLOODING (ASTGWF)

This is a strategic scale map showing groundwater flood areas on a 1km square grid. It was developed specifically by the Environment Agency for use by Lead Local Flood Authorities (LLFAs) to inform their Preliminary Flood Risk Assessments (PFRA). Greater than 75% refers to the percentage of the 1km square that has the potential for groundwater flooding.

RISK OF FLOODING FROM SURFACE WATER MAPS (SOMETIMES REFERRED TO AS THE UPDATED FLOOD MAP FOR SURFACE WATER, UFMFSW)

These maps are the third generation of surface water flooding maps produced by the Environment Agency. The earlier generations were “Areas Susceptible to Surface Water Flooding” and “Flood Map for Surface Water Flooding.” The Risk of Flooding from Surface Water maps are the most recently produced dataset developed by the Environment Agency. They represent the mechanisms that cause surface water flooding in the following ways[10]:

- Better ground and surface elevation data in many areas – using ‘local’ data;

[10] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297432/LIT_8988_0bf634.pdf

- Drainage capacity – using a single 'national' figure of 12mm/hour;
- Infiltration now represented – using 'national' figures;
- Storm duration more representative – using a single 'national' figure;
- Buildings now included – using 'local' data;
- Different roughness figures for urban and rural now included – using 'national' figures.

It is considered that the latest map is the best available Hertfordshire-wide representation of potential surface water flood risk, using the Historic Flooding incidents as supporting evidence.

The Environment Agency has put in place an update cycle in conjunction with the LLFAs to ensure that these maps are based upon the latest available information.

FLOOD MAP FOR PLANNING

The Environment Agency Flood Map for Planning was previously the only available flood map for fluvial and coastal flooding. There are Flood Risk Maps available online; these are largely based upon the National Flood Risk Assessment undertaken by the Environment Agency. However, it was determined that for the purposes of this stage of the study, the Flood Map for Planning would be more suitable given, that it is largely based upon more detailed modelling and focuses on the Main River network. Assessment of flooding from Main Rivers is not within the scope of SWMP studies, yet any detailed modelling previously undertaken could be suitable for using as boundary conditions for any future modelling work undertaken as part of the East Hertfordshire District SWMP.

These maps show areas that could be affected by flooding from rivers or the sea. It does not show the effects of climate change, ignores the presence of flood defences and is divided into 3 main flood zones. Flood Zone 3 is land assessed as having a 1% (1 in 100 year) or greater annual probability of fluvial flooding. Flood Zone 2 shows land assessed as having between a 1% (1 in 100 year) and 0.1% (1 in 1,000 year) annual probability of fluvial flooding.

AREAS BENEFITTING FROM FLOOD DEFENCES (ABD)

The ABD maps highlights areas of land that may benefit from the presence of major defences during the 1% (1 in 100 year) annual probability of fluvial flood events. These are areas that would flood if the defence were not present, but may not flood because the defence is present.

PUBLISHED STUDIES

STRATEGIC FLOOD RISK ASSESSMENT (SFRA)

Flooding can result not only in costly damage to property, but can also pose a risk to life and livelihood. It is essential that future development is planned carefully, steering it away from areas that are most at risk from flooding, and ensuring that it does not exacerbate existing known flooding problems. The Strategic Flood Risk Assessment is the first step in this process, and it provides the building blocks upon which the council's planning and development control decisions will be made.

PRELIMINARY FLOOD RISK ASSESSMENT (PFRA)

The Preliminary Flood Risk Assessment was published by Hertfordshire County Council (HCC), in June 2011 to meet their duties as Lead Local Flood Authority (LLFA) and the requirements of the Flood Risk Regulations 2009 (FRR 2009). The Flood Risk Regulations came into force in England and Wales in December 2009. The Regulations transposed the EC Floods Directive (2007/60/EC)

on the assessment and management of flood risks across EU Member States into domestic law and now implements its provision.

The Preliminary Flood Risk Assessment represents the first stage of the requirements of the Regulations. The PFRA process is aimed at providing a high level overview of historical and future flood risk from local sources, including surface water, groundwater, ordinary watercourses and canals. Flooding from the sewerage systems will also be included. Flooding associated with the sea, Main Rivers and reservoirs is the responsibility of the Environment Agency and does not need to be considered by the LLFA as part of the PFRA, unless it is considered that it may affect flooding from one of the sources listed above.

The PFRA is a high-level screening exercise and must therefore consider floods which have significant harmful consequences for human health, economic activity, the environment and cultural heritage. The PFRA identifies such areas and if they are considered to be nationally significant, as defined by Defra, they are highlighted as 'Flood Risk Areas'. Flood Risk Areas warrant further examination and management through the production of flood risk and flood hazard maps and flood risk management plans.

The methodology for identifying a Flood Risk Area involves the assessment of the national flood risk information, which was used to identify 1km grid squares where local flood risk is considered to be an issue. Thresholds for these squares are:

- Number of people at risk greater than or equal to 200;
- Number of Critical Services (i.e. schools, hospitals, fire and police stations, sewage treatment works) at risk greater than or equal to 1;
- Number of non-residential properties at risk greater than or equal to 20.

A Flood Risk Area is identified using the above set of criteria to form a cluster. Where more than 5 highlighted grid squares are touching a cluster is formed. If these clusters contain more than 30,000 people at risk, the cluster is identified as an indicative Flood Risk Area.

No Flood Risk Areas with a total population of greater than 30,000 people were identified within Hertfordshire. The three largest clusters identified were around Watford (11,946 people), Hemel Hempstead (5,655) and Stevenage (5,110), all outside of the East Hertfordshire District.

HYDRAULIC MODELS

The SWMP will build upon previous flood investigations and other capacity assessments (e.g. hydraulic models to assess the surface water runoff, surface water sewer capacities and fluvial flooding). This will ensure consistency between all previous work and on-going assessments, while minimising any duplication and data collection requirements. It will also maximise the local knowledge, the number of sites that can be assessed and the potential to secure funds for future mitigation schemes.

5.4 AREAS IDENTIFIED AT SIGNIFICANT RISK OF FLOODING

The methodology used to select the hotspots is contained within the Hotspot Selection Technical Note, included in Appendix B of this report. The Summary section of the Hotspot Selection Technical Note is also presented here.

A Desk-Based analysis was conducted to assess the flood risk to receptors within East Hertfordshire District. From this, 44 hotspots were analysed using a GIS Multi-Criteria Analysis (MCA) to prioritise the hotspots most at risk of flooding within East Hertfordshire.

A stakeholder meeting was held on 15th May 2015 to discuss the results of the analysis with relevant stakeholders and allow the stakeholders to share information and recommend further sites that should be analysed.

Site visits were conducted with Hertfordshire County Council in attendance on 3rd June 2015. The aim of the site visits was to assess hotspots on the ground and determine if the proposed solutions would be appropriate and cost-beneficial.

The initial top five Desk-Based Identified Hotspots, produced as a result of the Multi-Criteria Analysis (MCA) were:

- Hotspot 42 Central Hertford;
- Hotspot 8 St Margarets, / Stanstead Abbotts;
- Hotspot 39 East Ware;
- Hotspot 44 Benhooks Avenue - Bishop's Stortford;
- Hotspot 1 Buntingford.

Following stakeholder engagement and site visits, three of the Desk-Based Identified Hotspots have been chosen to be progressed as SWMP Modelled Hotspots. It was decided that Hotspot 39 – East Ware and Hotspot 42 – Central Hertford would not be taken forward for detail modelling, and are therefore SWMP Non-Modelled Hotspots. Two other hotspots as a result of site visits, further analysis and the stakeholder input have been chosen to be included as SWMP Modelled Hotspots. The final SWMP Modelled Hotspots to be taken forward for further assessment and detailed hydraulic modelling are:

- Hotspot 1 Buntingford;
- Hotspot 40 Bengeo, Hertford;
- Hotspot 43 Hadham Road, Bishop's Stortford;
- Hotspot 44 Benhooks Avenue, Bishop's Stortford;
- Hotspot 47 Raynham Road, Bishop's Stortford; and
- Hotspot 60 Potter Street, Bishop's Stortford.

The following hotspots are not being progressed further as SWMP Modelled Hotspots; however, they are detailed in Appendix B and summarised here as SWMP Non-Modelled Hotspots. Possible recommendations and actions are provided where appropriate in the following table (Table 3).

Table 3: Initial Recommendations and Actions for East Hertfordshire District SWMP Non-Modelled Hotspots

	HOTSPOT NUMBER	LOCATION	RECOMMENDATIONS AND ACTIONS
→	Hotspot 3	Puckeridge / Standon	Work with the Environment Agency as they assess potential options.
→	Hotspot 5	Watton-at-Stone	Increased maintenance of the ditch to the rear of properties on Great Innings North may alleviate some flood risk to nearby properties.
→	Hotspot 8	St Margarets / Stanstead Abbotts	Work with the Environment Agency as they finalise their hydraulic model and potentially develop options.
→	Hotspot 18	Hormead	Property Level Protection (PLP) surveys could be conducted to make recommendations for home improvements to

HOTSPOT NUMBER	LOCATION	RECOMMENDATIONS AND ACTIONS
		reduce flood risk.
→ Hotspot 25	Dane End	HCC to explore the possibility of a cut-off drain and channel diverting flows around residential properties.
→ Hotspot 27	Thundridge / High Cross	Work with EHDC and HCC Highways to gain a better understanding of the causes of historical flooding and if there are any small improvements that could reduce flood risk, before considering recommending PLP
→ Hotspot 28	Hadham Cross / Much Hadham	An Excel based analysis of the culvert underneath the Bull Inn could determine if there is adequate capacity in the culvert.
→ Hotspot 30	Hunsdon	Work with landowners to ensure maintenance is undertaken; consider enlarging the pond and/or improving outfall connectivity. Assess options for utilising the highway as a preferential flowpath prior to considering PLP.
→ Hotspot 39	Ware (east)	PLP surveys are to be considered for houses in the southern part of the hotspot in the areas surrounding Garlands Road.
→ Hotspot 41	Sele, Hertford	Ensure maintenance is prioritised to the highest risk areas to facilitate rapid drainage.
→ Hotspot 42	Central Hertford	No recommendations and actions for this hotspot at this stage. HCC, in conjunction with the Environment Agency, has undertaken an Initial Assessment into the combined fluvial/pluvial flooding in Hertford. This study is due to encompass this Central Hertford area.
→ Hotspot 46	Stansted Road, Bishop's Stortford	No recommendations and actions for this hotspot at this stage. Part of this hotspot will be included as part of the Raynham Road, Bishop's Stortford model, as part of the downstream flowpath that flows through Parsonage Lane and Stansted Road towards the River Stort.
→ Hotspot 58	Green Street, near Little Hadham	Assess options for utilising the highway as a preferential flowpath prior to considering PLP.
→ Hotspot 61	Rhodes Avenue, Bishop's Stortford	Work with the Environment Agency to ensure that this section of main river is considered for hydraulic modelling, potentially with a view for developing attenuation options on public open space between Lower Park Crescent, Thorley Hill and Thornbera Road.
→ Hotspot 75	Little Hadham	No recommendations and actions for this hotspot at this stage. This is due to the proposed A120 bypass and associated flood alleviation scheme, which is due to reduce flood risk at Little Hadham.
→ Hotspot EH01	Grange Paddocks / Stane Close	Consider the preferential flowpaths and work with residents to ensure that these are not obstructed, ensure flap valves are present on the surface water drainage network if deemed appropriate.
→ Hotspot EH02	Jackson Square / The Causeway, Bishop's Stortford	Consider the preferential flowpaths, gully maintenance regimes and work with property owners to consider PLP as appropriate, ensure flap valves are present on the surface water drainage network if deemed appropriate.
→ Hotspot EH03	Thorn Grove, Bishop's Stortford	Work with landowners to ensure maintenance is undertaken and the gully maintenance regime is appropriate.

HOTSPOT NUMBER	LOCATION	RECOMMENDATIONS AND ACTIONS
→ Hotspot EH04	Ford End, Hadham Ford (near Little Hadham)	No recommendations and actions for this hotspot at this stage. This is due to the proposed A120 bypass and associated flood alleviation scheme, which is due to reduce flood risk at Ford End, Hadham Ford (downstream of Little Hadham).
→ Hotspot EH05	Marsh Lane Industrial Estate	Work with landowners to consider PLP as appropriate, ensure riparian maintenance is undertaken and the gully maintenance regime is appropriate.
→ Hotspot EH06	Ware (south)	Consider the preferential flowpaths, gully maintenance regimes and work with property owners to consider PLP, if required.

6 DETAILED RISK ASSESSMENT - APPROACH

6.1 INTRODUCTION

The intermediate assessment (Section 5.4) identified six hotspots for a detailed assessment of surface water flood risk through hydraulic modelling. The Defra SWMP technical guidance suggests that hydraulic modelling must be outcome-focussed and improve the understanding of the surface water flood risk. The key components of the detailed assessment are shown in Table 4.[11]

Table 4: Key components of detailed assessment *(based on Table 6-1 in the Defra SWMP technical guidance)*

COMPONENT	DESCRIPTION
Purpose	To understand the causes, probability and consequences of surface water flooding in a greater level of detail, and to consider mitigation measures to reduce surface water flooding.
Scale	Hotspot level.
Inputs	Information from the intermediate assessment. Additional evidence collated from site visits, surveys or modelling. Local knowledge (Hertfordshire County Council / East Hertfordshire District Council / Environment Agency / Thames Water).
Process	Use of modelling approaches to assess surface water flood risk (where the conceptual equation is used: risk = probability x consequence).
Outputs	Understanding of 'annualised' surface water flood risk, both now and in the future. Understanding the benefits and costs of mitigation measures to reduce surface water flooding. Detailed mapping of baseline flood risk and flood hazard.
Benefits	Improved understanding of the probability and consequences of flooding. Detailed understanding of the flood risk will enable informed judgements to be made of the benefits and costs of potential mitigation measures. Assess benefits of mitigation measures (where a benefit is a reduction in damages due to surface water flooding). Justification for mitigation measures based on benefits and costs.

Each of the hotspots identified for further assessment within the intermediate phase are covered in turn below, with their specific considerations and modelling approach.More specific information on the considerations, constraints and adopted approach can be found in the modelling methodology (Appendix C).

[11] Based on Table 6-1 in the Defra guidance, page 44 - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69342/pb13546-swmp-guidance-100319.pdf

6.2 DATA COLLECTION

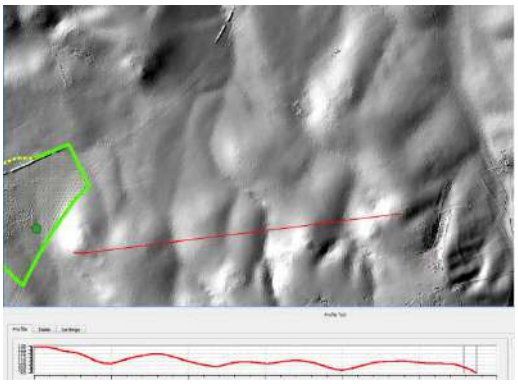
The hydraulic models were generally constructed utilising the data outlined below, the exact data/combinations are detailed in the hotspot specific modelling report (Appendix C):

TOPOGRAPHY

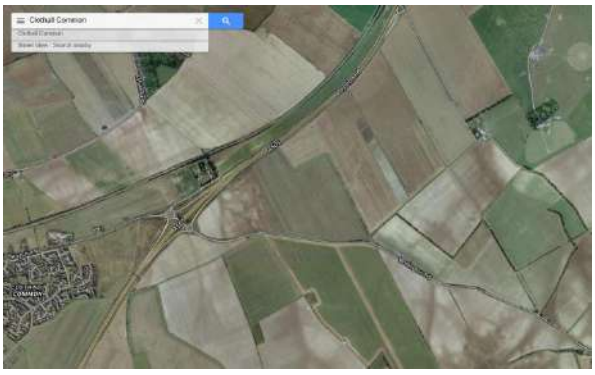
DTM

The Environment Agency provided a Digital Terrain Model (DTM) for all the hotspots, in some instances this was based upon LiDAR (which has a vertical accuracy of 5-15cm +/- RMSE and a horizontal accuracy of 40cm +/- RMSE), in others NEXTMap Height Data (which has a vertical accuracy of around 1m +/- RMSE and a horizontal accuracy of 2.5m +/- RMSE). In some instances a combination of sources were used to construct the DTM, with preference given to the highest level of accuracy.

Prior to the commencement of the modelling, investigations were undertaken into ground truthing the DTM to ensure that any processing undertaken by others (e.g. the Environment Agency to construct their Risk of Flooding from Surface Water Maps) did not adversely impact the accuracy or level of resolution. These investigations established that the LiDAR part of the DTM was suitable for use across all hotspots where the data was available. However, questions were raised over the presence of small pit like features in some of the areas covered by the NEXTMap part of the DTM. One example of this is to the west of Clothall Common, Baldock, which is within North Hertfordshire District but the assessment was undertaken concurrently. At this location the features are observed to the east of the main hotspot, as shown in Figure 10, but are not visible in the aerial imagery or during site inspections. A representative area of the maximum flood depth of these pit like features was extracted in GIS and the volume within the raster extract calculated. The total area of the model domain with these features present was then estimated in comparison to the whole area. The volume of the extract was scaled up to cover the affected area and this was compared to the whole model domain volume. These calculations suggested less than 2% of the volume was present in the pit like features, and therefore these features can be considered insignificant with respect to the overall model accuracy, given that no other appropriate DTM was readily available.



a) DTM extract



b) Google Aerial Image

Figure 10: Example of uncertainties in the DTM

SURVEY

A topographical survey was specified for each hotspot to enable the DTM to be refined and key elements within the flowpath to be better represented within the model. Topographical survey

generally included road levels and kerb heights in specific locations, footpath levels and some property thresholds.

BELOW GROUND INFRASTRUCTURE

The hydraulic models required a representation of the culverted watercourses and public surface water drainage network, as these networks can be complicated to model and limited data is available for some aspects (particularly the connectivity aspects of the highway drainage). The following aspects were included to provide a suitable level of representation within the strategic scale models:

- Pipes equal to or greater than 225mm;
- Flow between the pipe network and the floodplain was represented by connectors at every pipe junction;
- Pipe information was sourced from the sewage undertaker (i.e. Thames Water);
- Where information was missing or considered to be incorrect, engineering judgement was used to estimate the pipe direction, location or gradient.

LAND USE

The locations of land use features across the study area were identified through the incorporation of Ordnance Survey MasterMap data and the National Receptor Database to combine location with the type of building. This enabled temporary/outbuildings etc. to be removed from the modelling (i.e. buildings which are unlikely to be barriers to flow) in accordance with best practise. The mapping also enable varying roughness coefficients to be applied, along with ensuring that preferential flowpaths (i.e. highways) were suitably represented, lowered by 125mm (the height of a standard kerb) and buildings raised by 300mm (a typical freeboard level). This is also in accordance with the updated Flood Map for Surface Water Modelling Guidance.

CONSIDERATIONS

Prior to and during the modelling process some elements were identified that required further consideration to ensure that they were suitably represented in the model. For instance at some hotspots there was a degree of uncertainty that could not be addressed through engineering judgement and modelling assumptions, these required further site specific investigations to establish linkages. These are detailed in each hotspot as applicable; these included a range of features, an example of which is Hotspot 30, Cambridge Road, Hitchin (North Hertfordshire District SWMP). In this hotspot, the sewer records were considered ambiguous when compared to the current land uses and the inferred discharge routes and mechanisms could no longer operate. To provide a suitable level of certainty for the modelling, a separate investigation into the sewer connectivity was commissioned and undertaken by the surveyor.

MODEL APPROACH

All the modelled hotspots use a direct rainfall approach. An ESTRY-TUFLOW (hydraulic modelling software) approach was preferentially undertaken as this combines an accurate 1D channel and pipe solver (with the allowance for complicated structures) with a 2D floodplain model based on a finite grid approach. The two solvers are dynamically linked, such that water can flow from the channel/pipe to the floodplain, and vice-versa. In some instances it was necessary to use other software packages such as InfoWorks ICM or Flood Modeller Pro; this was largely dependent on previous studies.

Hydrological analysis was undertaken with reference to the Flood Estimation Handbook (FEH) and the Flood Estimation Guidelines[1] to produce flow estimates following best practice techniques.

More information is provided in the modelling methodology reports (Appendix C) and individual model reports.

The hydraulic modelling provides estimates of flood risk in terms of extent, depth, velocity and hazard. Flood hazard is defined by the Environment Agency's Flood Risks to People Guidance Document[12] as being a function of depth and velocity with a debris factor and breaks the resulting hazards into four categories:

- Caution – Less than 0.75 – very low hazard;
- Danger for some – 0.75 to 1.25 – includes children, the elderly and the infirm;
- Danger for most – 1.25 to 2.0 – includes the general public;
- Danger for all – More then 2.0 – includes the emergency services.

6.3 MITIGATION OPTIONEERING

For each hotspot, a review of the flood extents and mechanisms was undertaken following completion of hydraulic modelling. From this review it was possible to determine the types of measures which could be implemented in each hotspot to mitigate the impacts and damage associated with flooding. At each hotspot several measures were identified and assessed as a first step in evaluating the various options to manage surface water flood risk in line with the SWMP objectives. The mitigation measures have not been modelled within the hydraulic models, given the strategic nature of this study. If the economic benefits are such that schemes are considered suitable for a funding application, detailed studies which will include further hydraulic modelling will be required,

The following categories of measures have been considered:

- Technical;
- Maintenance;
- Development, building control and policy;
- Awareness;
- Resilience;
- Other.

A measure is defined as a proposed individual action or procedure intended to minimise current and future surface water flood risk. An option (or options) is made up of a single, or a combination of defined measures.

The measures and options were discussed during meetings and site visits. Throughout this process the criteria in Table 5 were considered to ensure the options were viable and beneficial.

[1] Published by the Environment Agency as Operational Instruction 197_08, Version 3 on 06/11/2009
[12] Defra/Environment Agency R&D Outputs: Flood Risks to People, Phase 2 FD2321/TR2

Table 5: Option Criteria

CRITERIA	DESCRIPTION
Technical	Is it technically possible and buildable? Will it be robust and reliable?
Economic	Is it affordable and will benefits exceed costs?
Social	Is the option socially acceptable and in keeping with the local area.
Environmental	Is the option environmentally acceptable and in keeping with the local area and designations.
Objectives	Will it help to achieve the objectives set at the beginning of the SWMP?

In addition to the criteria in Table 5, certain land uses (e.g. cemeteries) are unsuitable for flood storage.

6.4 ECONOMIC ASSESSMENT

INTRODUCTION

Economic analysis has been undertaken to assess the predicted economic damages that may occur from flooding in each hotspot. This economic analysis is based on the current arrangements for management of surface water, and the benefits that may accrue from the proposed mitigation options. This has been undertaken to a level of detail which is suitable to inform inclusion of potential schemes within the Environment Agency's Medium Term Plan (MTP). It will also enable the LLFA to establish the order of priority for further assessment and implementation of the mitigation options across all SWMPs in Hertfordshire. The inclusion of schemes within the Environment Agency's MTP is the first step towards securing funding, once a scheme is included, further studies are undertaken to refine the assumptions and demonstrate its financial viability.

METHODOLOGY

The financial viability of a flood defence scheme is assessed by looking at the *Benefit Cost Ratio* (BCR) between the present value benefits and the present value costs. The *present value benefits*, is the *present value damages* (the damages that are forecast to be incurred over the assessment period, in this instance 100 years) minus the reduced damages that would be realised with the scheme in place through the alleviation of flooding at events below the design threshold (standard of protection of the scheme). The *present value costs* are the costs associated with design and build along with maintenance of the scheme.

In all instances the present value is utilised as this provides a standardised approach for comparing the differing levels of investment that will be required to deliver and maintain the scheme, it also assumes that all the funding required for this is allocated at the approval stage of the scheme.

PRESENT VALUE DAMAGES

The calculation of economic damages from flooding has used the standard approaches and data of Flood and Costal Risk Management - A Manual for Economic Assessment (Flood Hazard Research Centre 2013)[13] and the 'Green Book' (HM Treasury, 2003)[14].

The properties shown by the hydraulic modelling to be within the main surface water flowpaths have been identified using OS MasterMap and the National Receptor Database. The economic analysis assessment area for each hotspot is shown in the study area plans included in Appendix F.

This assessment has taken into account and monetised the direct damages to properties, the costs of evacuation, the costs to the emergency services, damages to parked vehicles at residential properties and the impact of flooding on human health. Other damages that have not been monetised include disruption of road traffic, disruption to rail traffic, risk to life, damage to utilities/highway etc.

Damages have only been calculated for the flood risk associated with the main surface water flowpaths in each hotspot, for the mitigation specific standard of protection, which the SWMP will seek to address. Isolated flooding of properties within the hotspots outside of these areas have not been included as it is unlikely that any options proposed by the SWMP will be able to have any impact on reducing this type of flooding.

Climate change has been incorporated into the assessment of damages to obtain present value damages that are expected to occur over the next 100 years. This has utilised the allowances for increases in peak rainfall intensity given by Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities (Environment Agency, 2016). This guidance gives a central and upper estimate of the expected change in peak rainfall intensity over the next 100 years. A conservative approach has been taken using the central estimate so that the economic damages from flooding are not overestimated.

PRESENT VALUE COSTS

Mitigation options were identified at a strategic scale for each hotspot and these are illustrated in the plans in Appendix E and discussed in the relevant parts of Section 6.3 above. The likely requirements and impacts of the options were identified utilising engineering judgement. This has mainly been to identify the return period for which a standard of protection can be achieved, the associated properties that are likely to be removed from the flood risk area and the possible engineering intervention. The costs for the selected mitigation options have been developed through the use of the Environment Agency's Long Term Costing Tool.

6.5 ECOLOGICAL VIABILITY

There are important designated sites (SSSI and SAC) along the River Lee corridor within and in close proximity to East Hertfordshire District. To ensure that the implementation phases of the SWMP will not lead to adverse impacts within these sites a Habitats Regulation Assessment (HRA) has been undertaken in conjunction with this study. This is provided in Appendix H and demonstrates that the SWMP will not lead to adverse impacts on the designated sites.

[13] https://www.mdx.ac.uk/our-research/centres/flood-hazard/projects/multi-coloured-manual
[14] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

7 DETAILED RISK ASSESSMENT - INVESTIGATION

7.1 DEFINITIONS

The Environment Agency uses a variety of terms when describing the flood risk in their Risk of Flooding from Surface Water Maps, for consistency these have been adopted here when describing the risk in the baseline information section for each of the hotspots, these are:

- Very Low – means that each year, this area has a chance of flooding of less than 1 in 1000 (0.1%);
- Low – means that each year, this area has a chance of flooding of between 1 in 1000 (0.1%) and 1 in 100 (1%);
- Medium – means that each year, this area has a chance of flooding of between 1 in 100 (1%) and 1 in 30 (3.3%);
- High - means that each year, this area has a chance of flooding of greater than 1 in 30 (3.3%).

7.2 MITIGATION CONSIDERATION

When determining whether the use of PLP is the most appropriate scheme for an individual hotspot, HCC will need to consider the following aspects:

- PLP have been used as a benchmark to determine the likely economic viability of interventions. This is based on the speed of implementation and that they will not require further investigations/ studies;
- Non PLP may perform better, and protect a wider area, but may be more complex due to the required engineering works as opposed to protecting individual or rows of properties;
- Benefits of non PLP are generally noticeable across wider areas and can protect areas outside immediate risk area e.g. through adjusting the flow conveyance/direction;
- Flood mitigation measures such as flood storage and attenuation keep the water away from the properties. Whereas PLP is a form of resilience; a form of flood defence that resists the ingress of water at the site of the actual property.

7.3 HOTSPOT 1 - BUNTINGFORD

KEY CONSIDERATIONS

This hotspot was selected for hydraulic modelling to refine the understanding of the following elements (as shown in **Error! Reference source not found.**):

- The Environment Agency's Risk of Flooding from Surface Water map which shows:
  - Surface water flowing eastwards along Baldock Road (B1038) towards the High Street;
  - The flowpath along Monks Walk, which is a residential area, also leads to the High Street.
- The High Street and Monks Walk are both known to be historic flooding sites; flooding was reported along the High Street on 16/17 July 2015.

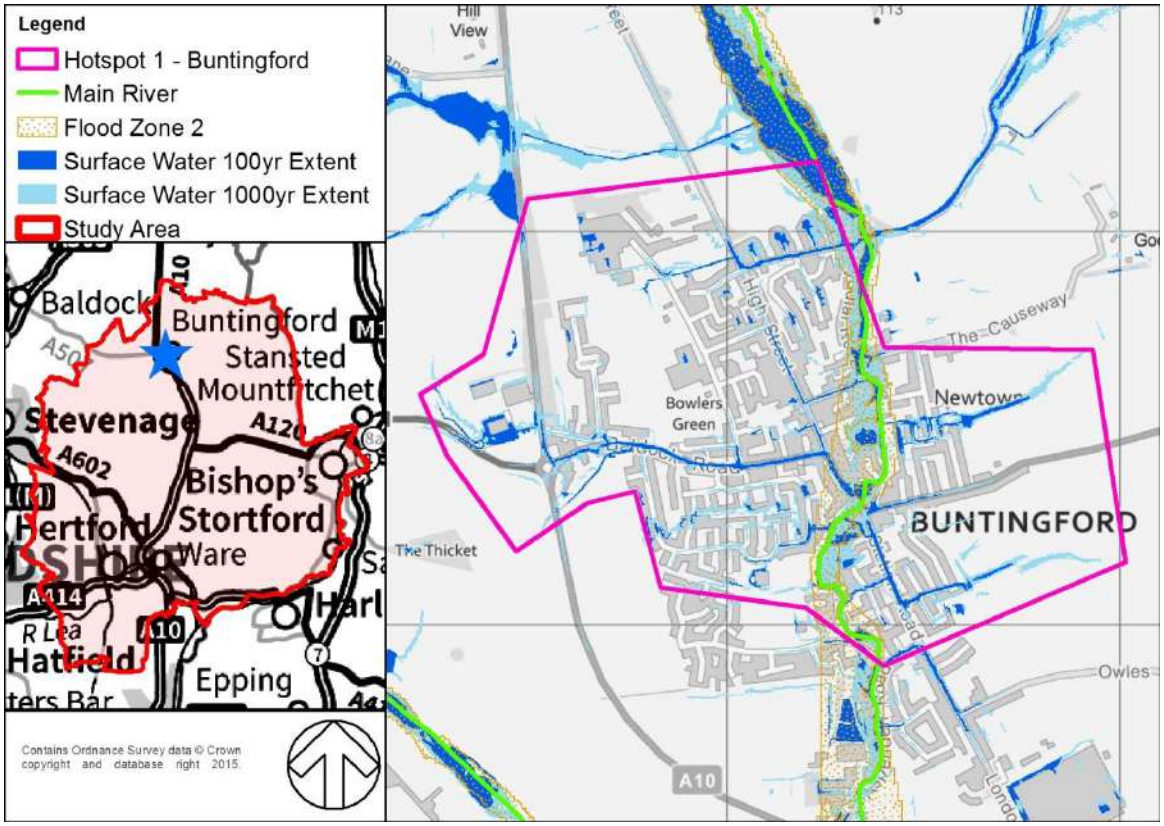


Figure 11: Hotspot 1 - Buntingford – extents and baseline information

HYDRAULIC MODEL SUMMARY

This hotspot has been modelled as two different models, one covering the area to the west of the River Rib and the other covering the area east of the river. These models have been developed in ESTRY-TUFLOW with a direct rainfall approach, utilising a LiDAR based DTM for the whole study area. The downstream boundary conditions of these models were based on the 20 % AEP fluvial levels for the River Rib, extracted from the model provided by the Environment Agency.

KEY CONSTRAINTS

Due to the strategic level of the study it was agreed that we would drop road levels by 125mm to represent the kerb height and ensure that represent the preferential flowpath. This may have removed some of the flowpaths to some properties due to lower kerbs in some locations.

KEY ASSUMPTIONS

The main assumption of this hydraulic model is the location of culverts along the A10, in particular at the section west of Freman College. To ensure that maximum model coverage across the SWMPs could be achieved, widespread topographical surveys were not possible, therefore the culverts along this section of the road were modelled as openings to minimise ponding upstream and to identify the drainage flowpath downstream. Topographic survey along the A10 will be required if a detailed mitigation model is to be developed.

KEY FINDINGS

The key findings of the hydraulic modelling for the 1 in 30 and 1 in 100 year events are shown in Table 6; mapping of the whole hotspot is in Appendix D, which provides better resolution maps and a legend.

Table 6: Key Findings – Hotspot 1 - Buntingford

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Depth	Some highly localised flooding is predicted on the estate roads that are off Vicarage Road. These roads are sloping north; hence runoff will naturally accumulate at the northern tip of the roads. Maximum flood depths are estimated to vary from 0.2m to 0.3m at these locations.	The flood extents are similar to the 1 in 30 outlines, but ponding is shown on the most eastern branch of Vicarage Road during this event. Deeper flooding (maximum depth of 0.6m) and potential flooding of several properties is predicted.
		
	Flooding is predicted along Monks Walk, with flood depths approaching 0.7m in the south before the bend of the road. There is also predicted flooding from runoff draining from Station Road into the area north of Rib Way, which reaches a maximum depth of 0.5m.	The extent of flooding has increased along Monks Walk with deeper flooding (maximum depth of 1m) predicted for the 1 in 100 year event. Minor flooding is predicted along the High Street above Chapel End, with the maximum flood depth reaching 0.3m. The flood depth around the area north of Rib Way is similar to that in the 1 in 30 year event but the extent of flooding has increased.
		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Depth	A relatively deep region of flooding is shown in the area south of the Business Park in the western end of the hotspot. A maximum depth of 0.8m is predicted.	The flood depth remains the same around the Business Park during the 1 in 100 year event, but the area of flooding has increased marginally.
		
Flood Hazard	The areas of greatest flood hazard rating, mirror the regions of greatest flood depth, with a small area of danger for most around the Business Park and along Monks Walk.	Flood hazard shows the same pattern as in the 1 in 30 year outlines. Flood hazard ratings are similar for the 1 in 100 year event, but small pockets on Vicarage Road and in the area north of Rib Way are showing hazard of danger for most. The extent of the hazard areas also increased in this event.
		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Hazard		

SENSITIVITY TESTING

In line with the modelling methodology, no sensitivity testing was undertaken on this hotspot.

POTENTIAL MITIGATION

The most viable mitigation measure for Hotspot 1 - Buntingford is Property Level Protection (PLP), the locations in which this measure could be considered are outlined below and are shown in Appendix E:

- Buildings in the south of the Business Park;
- Properties along Monks Walk;
- Properties along the High Street, in particular the section between Baldock Road (B1038) and Chapel End;
- Properties in the area north of Rib Way, and
- Properties off Vicarage Road.

RECOMMENDATIONS

The following recommendations are made for further consideration of this site and for inclusion within the Action Plan:

- Investigation into measures to keep the preferential flowpath along Station Road, e.g. by raising kerbs, using rills and reprofiling levels. This will reduce runoff draining into Rib Way;
- Further reductions to the overland flows impacting properties in Monks Walk are likely to be achieved as a result of the proposed development within the land between the A10 and Monks Walk. The development should consider drainage and/or attenuation storage to minimise runoff along the B1038;
- Modify drainage along the side branches of Vicarage Road and introduce permeable pavements if financially viable;
- Investigate option to upsize pipes that drain the area of Newtown to increase drainage into the river;

- Modify drainage upstream of Snells Mead; this involves investigating an option to install a small drain to improve conveyance of flow towards the pipe;
- Investigate option to upsize pipes along Snells Mead and Station Road to increase drainage into the river.

7.4 HOTSPOT 40 - BENGEO, HERTFORD

KEY CONSIDERATIONS

This hotspot was selected for hydraulic modelling to refine the understanding of the following elements (as shown in **Error! Reference source not found.**):

- Risk of Flooding from Surface Water map shows two flow paths within this hotspot. One flow path begins in the area surrounding Church Road, where water flows south down Byde Street, towards Port Vale and finally towards the River Beane. The second flow path begins at Bengeo Street, where surface water flows towards Globe Court, Bengeo Street, here, the Risk of Flooding from Surface Water map shows water flowing easterly through residential area towards the River Rib;
- Flooding was reported in this hotspot in August-September 2015, with the flood event occurring on 24th August 2015. Flooding was reported at Globe Court, Bengeo Street. Flooding was also reported in Port Vale, with water flowing down Byde Street towards Port Vale;
- Historical flooding has been reported by residents at Globe Court, Bengeo Street. Some historical flooding can be attributed to tree roots blocking pipes; there has also been foul flooding. Properties have also been affected by surface water ponding in the road, where it flows off into houses;
- Flooding at Port Vale and Byde Street will be included in the Initial Assessment being undertaken by Hertfordshire County Council in conjunction with the Environment Agency.

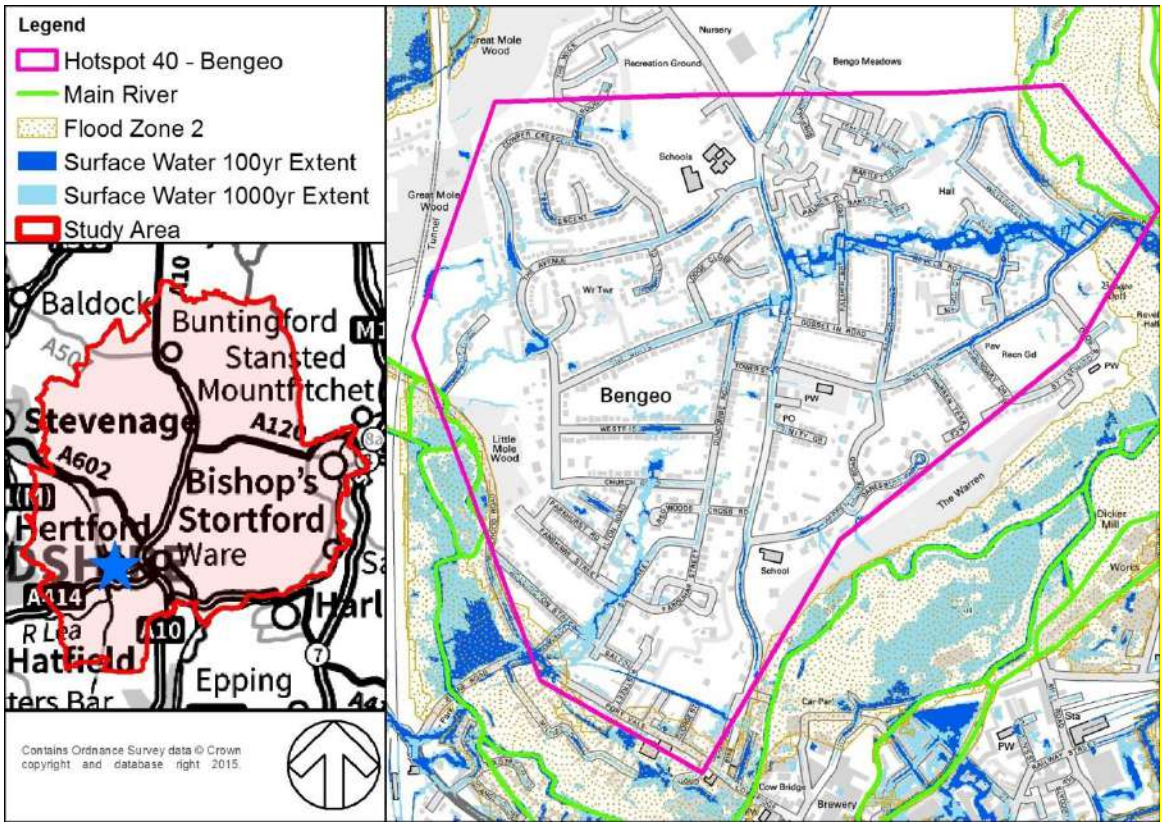


Figure 12: Hotspot 40 – Bengeo, Hertford – extents and baseline information

HYDRAULIC MODEL SUMMARY

The model has been developed in ESTRY-TUFLOW with a direct rainfall approach. The uFMfSW DTM was used for the whole study area.

KEY CONSTRAINTS

The modelling has assumed that there are no barriers to flow (i.e. fences and walls) within the private gardens associated with the flowpath that runs from Bengeo Street to the River Rib, behind the properties that front Revels Road. This will need to be investigated and confirmed by HCC, as any impermeable barriers could lead to localised flooding or alterations of the preferential flowpath.

KEY ASSUMPTIONS AND LIMITATIONS

A key assumption, in line with the modelling methodology, but of more importance in this hotspot given the confluence of flowpaths and the preferential flowpath along Bengeo Street is that the roads were lowered to represent the kerb height. However, if there are drop kerbs, to provide vehicular access at critical/convergence locations, there may be additional spills leading to further water being directed to adjacent properties. A site visit could be undertaken with the model outputs (particularly the velocity maps) to refine the understanding of this risk.

Analysis of the Thames Water sewer network maps shows a surface water sewer running in a south-easterly direction off New Road, running down St Leonard's Road between the recreation ground and Bengeo Hall. When it reaches St Leonard's Church this surface water sewer appears to stop. However, given the fall in this pipe it is expected that this would continue further to the south.

Given that the upstream invert level of the sewer running along St Leonard's Road is lower than the downstream invert level of the pipe running along New Road, water running along New Road would preferentially flow along St Leonard's Road as opposed to continuing in its alignment towards the River Rib to the north-east.

Surveyors were asked to inspect the manhole where the surface water sewer along St Leonard's Road is shown to stop. This showed that there were various inlets from St Leonard's Road coming in from both directions and an outlet downstream towards Bengeo Old House / the River Beane.

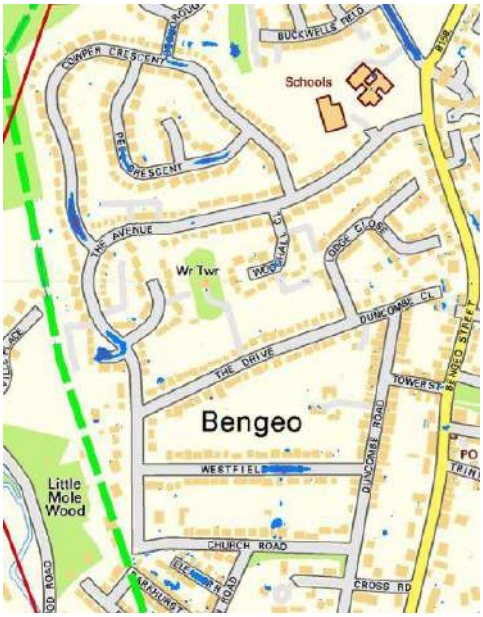
It was therefore assumed in the hydraulic model that the surface water drainage pipe does not stop, but continues beyond St Leonard's Church in a 300mm surface water sewer (same diameter as the surface water sewer along St Leonard's Road) and outfalls to the River Beane.

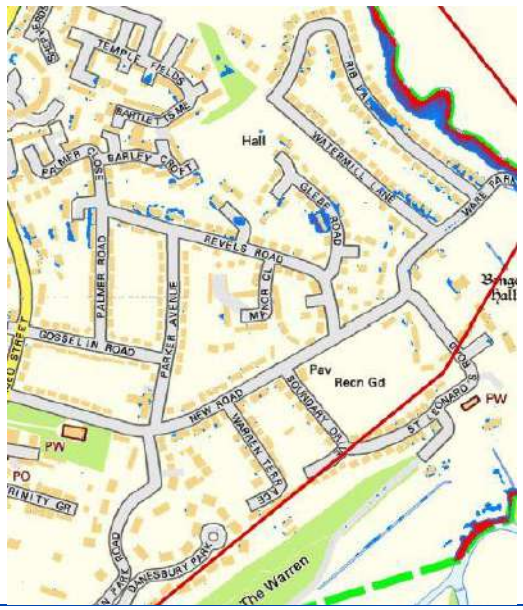
KEY FINDINGS

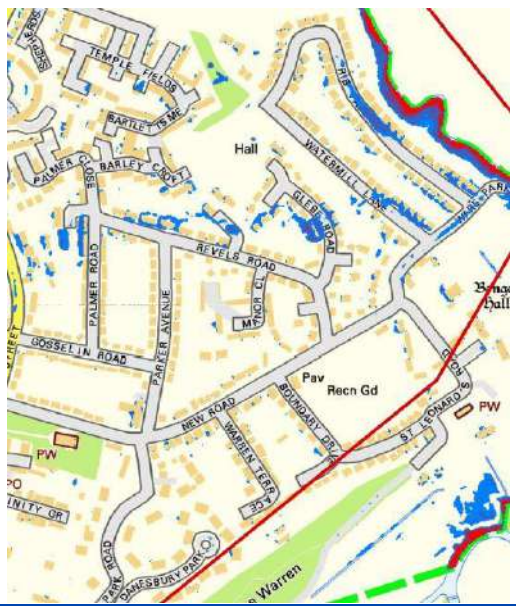
The key findings of the hydraulic modelling for the 1 in 30 and 1 in 100 year events are shown in Table 7; mapping of the whole hotspot is in Appendix D, which provides better resolution maps and a legend.

Table 7: Key Findings – Hotspot 40 – Bengeo, Hertford

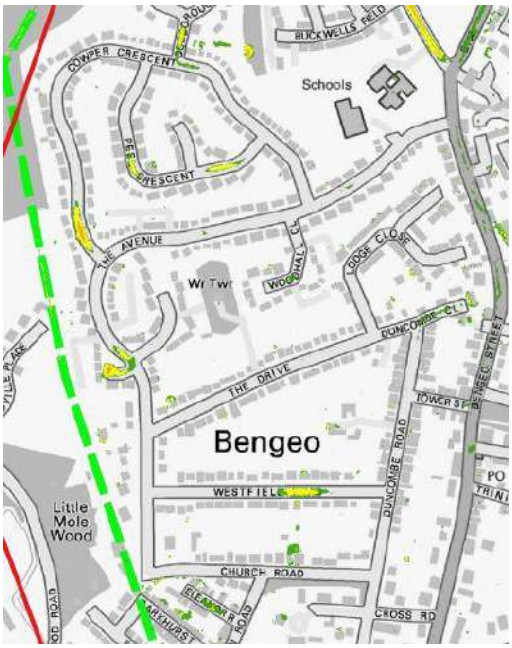
MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Depth	On the west side of the hotspot, some highly localised flooding up to depths of 0.9m is predicted on south-east corner of Cowper Crescent. Areas where localised flooding is predicted up to a depth of 0.6m include Peel Crescent, a cul-de–sac just off the Avenue, Westfield Road, and extensive area along Sacombe Road. In the east side of the hotspot, flooding up to depths of 0.6m is predicted around properties to the west of Glebe Road and along Rib Vale.	On the west side of the hotspot, the flood extents in the 1 in 100 event are similar to the 1 in 30 outlines, with a slightly larger extent of flooding particularly along Westfield Road and between Church Road and Westfield Road. On the east side of the hotspot flooding is more extensive, with additional flooding to that predicted in the 1 in 30 year event, with depths of 0.6m predicted to properties on the north side of Watermill Lane.

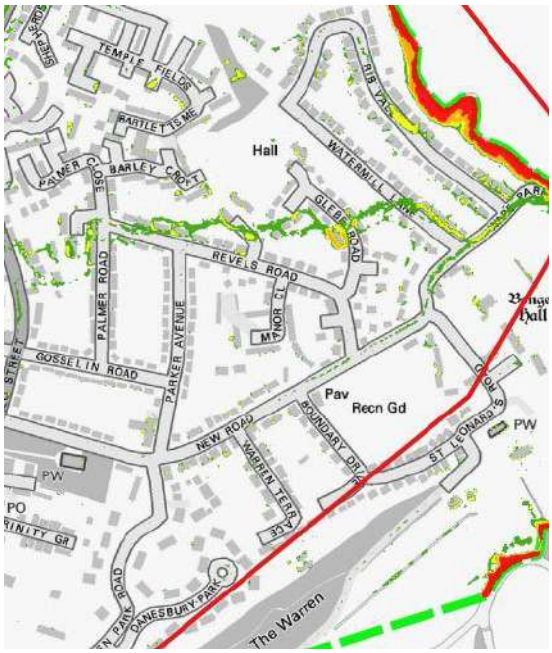


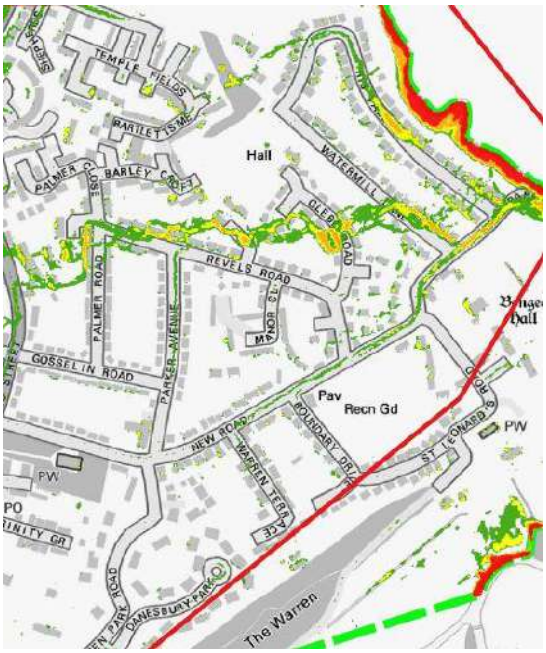




MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Hazard	On the west side of the hotspot, there are three areas posing danger for most, these comprise of the south-west corner of Cowper Crescent, a cul-de–sac just off the Avenue, and Sacombe Road. On the east side of the site there are three areas posing danger for most, these are to properties along the west side of Glebe Raod, on the northern side of Watermill Lane and to Ware Park Road.	On the west side of the hotspot, there is no significant change to the flood hazard areas noted in the 1 in 30 year event. On the east side of the hotspot there are additional areas to those identified with the 1 in 30 year event that pose a danger to most. These include Rib Vale, properties between Palmer Road and Bengeo Street, and properties to the north of Revel Road.







SENSITIVITY TESTING

Sensitivity testing was undertaken to establish the impact of a complete and partial failure of the soakaway system within the new development located along the west side of Sacombe Road, just north of Bengeo Primary School, shown in yellow in Figure 13.

Figure 13: Hotspot overview and existing development (shown in yellow)

Three scenarios were run for the 1 in 100 year event:

- **Scenario 1**: Mimic of on-site soakaways failure

  This was modelled by including the development as an impermeable area, with an imperviousness factor of 0.9 (which is the same as that applied to roads within the model).

- **Scenario 2**: Mimic of on-site soakaways partial failure

  This was modelled by applying less rainfall over the development area. The event applied over the development area was the difference between the 1:100 year and the 1:30 year event. As current design requirements are for the surface water drainage systems to manage the 1:30 year flows beneath the ground.

- **Scenario 3**: Mimic of on-site soakaways fully functioning

  This was modelled by applying no rainfall over the development area, as the surface water strategy for the site would be to contain all runoff up to and including the 1:100 year plus climate change event within the site.

In order to establish the impact of the development soakaways partially and fully failing on potential receptors, downstream flood difference maps were created (produced by calculating the difference between Scenario 1 and Scenario 3, and Scenario 2 and Scenario 3). These are included in the flood model summary report in Appendix C and the findings are summarised in Table 8.

Table 8: Sensitivity Test Findings (1 in 100 year) – Hotspot 40 – Bengeo, Hertford

FAILURE TYPE	FINDINGS
Soakaway Partial Failure	The impact of a total failure in the soakaways would be felt a lot further downstream along Sacombe Road and along Bengeo Street towards the north. This is seen to be an increase of 30 – 70mm along Sacombe Road and increase of up to 30mm along the rest of the flowpath. This also causes small areas to flood, which do not flood with fully functioning soakaways. This can be seen in Appendix C.
Total Failure of Soakaways	The impact of a total failure in the soakaways would be felt a lot further downstream along Sacombe Road and along Bengeo Street towards the north. This is seen to be an increase of 30 – 70mm along Sacombe Road and increase of up to 30mm along the rest of the flowpath. This also causes small areas to flood which do not flood with fully functional soakaways. This can be seen in Appendix C.

POTENTIAL MITIGATION

Given that most of the flooding on the west side of the hotspot appears to be restricted to isolated locations on roads, mitigation measures are mainly proposed on the east of the hotspot where flowpaths are present in the 1 in 100 year event. These include:

- Speedbump to direct the preferential flowpath from The Avenue towards Wadesmill Road to the north. This would stop the flowpath from going down Bengeo Street and reduce flooding of the properties downstream;
- Property Level Protection for the houses in Globe Court and the properties downstream in the same flowpath;
- Property Level Protection for the properties around Watermill Lane and Rib Vale.

RECOMMENDATIONS

The following recommendations are made for further consideration of this site and for inclusion within the Action Plan:

- The option to divert runoff from The Avenue to Wadesmill Road would reduce flooding of properties in Globe Court, which may remove the need for Property Level Protection in some of these properties. However, further investigation to the viability of this option is recommended;
- Investigation into measures to keep the preferential flowpath along Watermill Lane, e.g. raising kerbs, using rills and reprofiling levels;
- Introduce permeable pavement and ensure a preferential flowpath through the footpath at the end of Duncombe Close, e.g. using rills or road reprofiling;
- Increase infiltration in the upstream area of the hotspot, for example by encouraging gravelled driveways or grassed front gardens;
- Ensure flowpaths between properties are maintained, for example by preventing expansions between detached or semi-detached houses;
- HCC to carry out a general investigation about garden boundary lines to ensure there are no impermeable fences.

7.5 HOTSPOT 43 - HADHAM ROAD, BISHOP'S STORTFORD

KEY CONSIDERATIONS

This hotspot was selected for hydraulic modelling to refine the understanding of the following elements (as shown in):

- → The Environment Agency's Risk of Flooding from Surface Water map which shows:
  - Surface flowpath begins in the residential area to the west and flows through properties before reaching Matching Lane. It then flows through further residential areas before reaching Hadham Road (A1250);
  - The flowpath along Hadham Road (A1250) seems to be well contained within the highway extent.

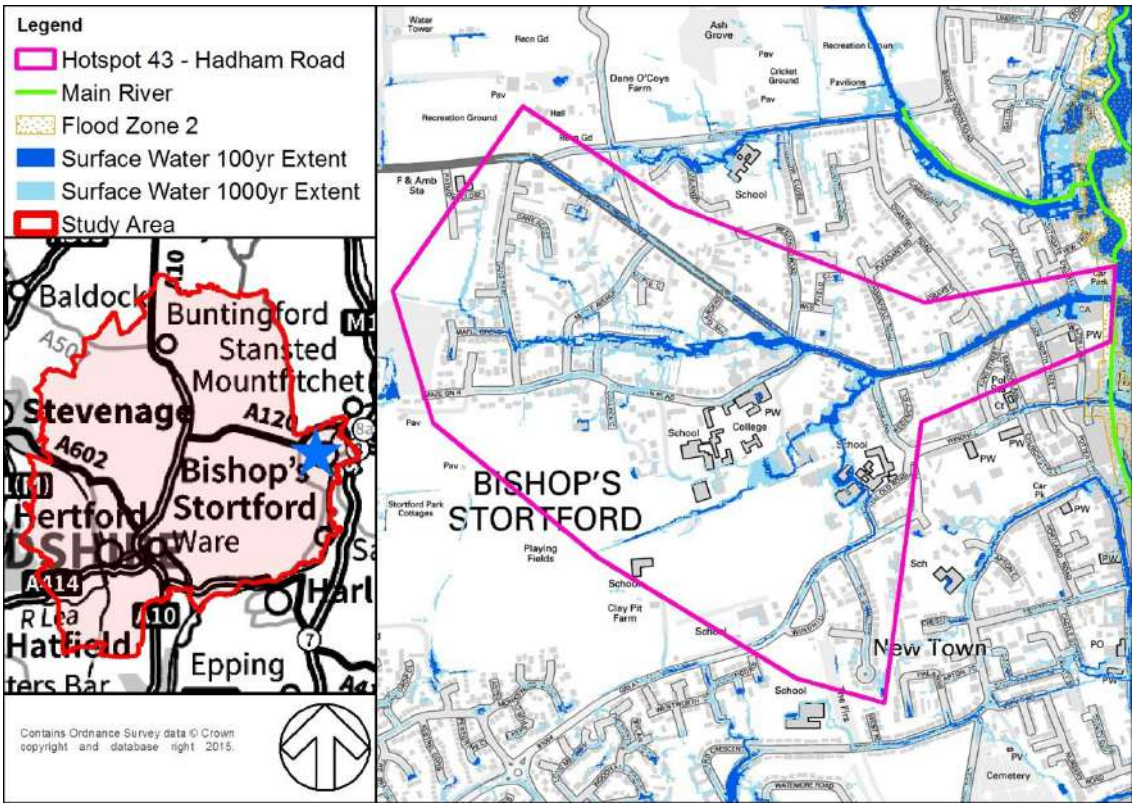


Figure 14: Hotspot 43 - Hadham Road, Bishop's Stortford – extents and baseline information

HYDRAULIC MODEL SUMMARY

This hotspot has been modelled with Hotspot 44 (Benhooks Avenue) and Hotspot 60 (Potter Street/South Street) in the south because there are flowpaths between their boundaries. The model has been developed in ESTRY-TUFLOW with a direct rainfall approach utilising a LiDAR based DTM for the whole of the model domain. The downstream boundary conditions of these models were based on the 20% AEP fluvial levels for the River Stort, extracted from the model provided by the Environment Agency.

KEY CONSTRAINTS

No significant constraints with the surface water model construction were observed.

KEY ASSUMPTIONS AND LIMITATIONS

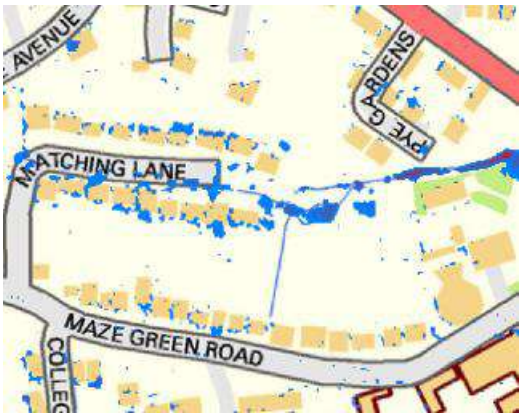
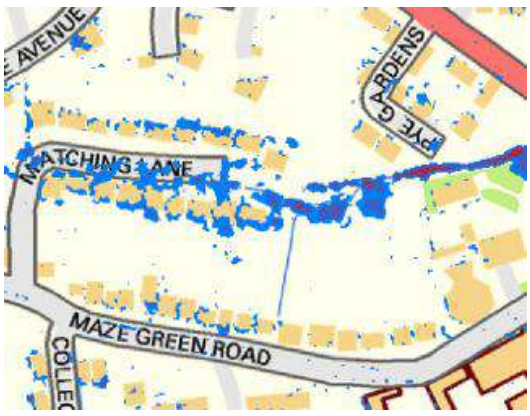
Some of the information provided by the survey Draincare undertook for East Hertfordshire District Council in November 2012, were not incorporated into the model, these include:

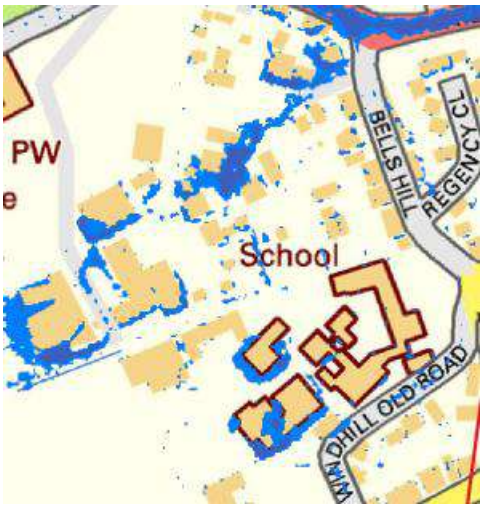
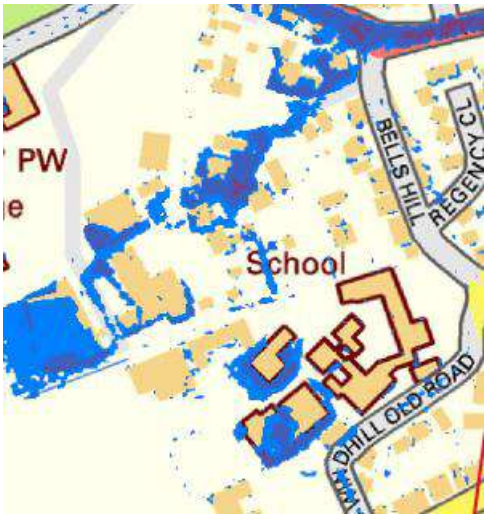
- The culverted watercourse that drains from the surface water pond, south of Dane Acres, to the section of open channel located in Maple Avenue;
- The open channel that runs along a property in Maple Avenue; and
- The culverted watercourse that drains in Matching Lane.

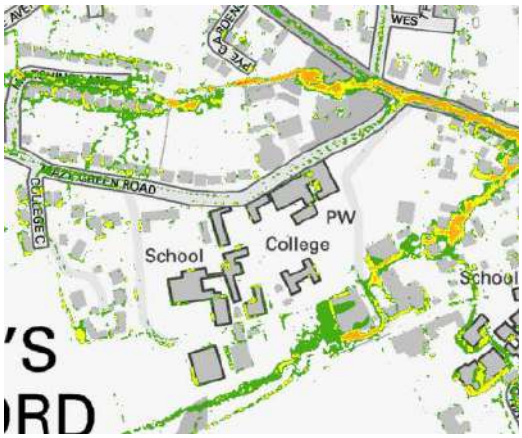
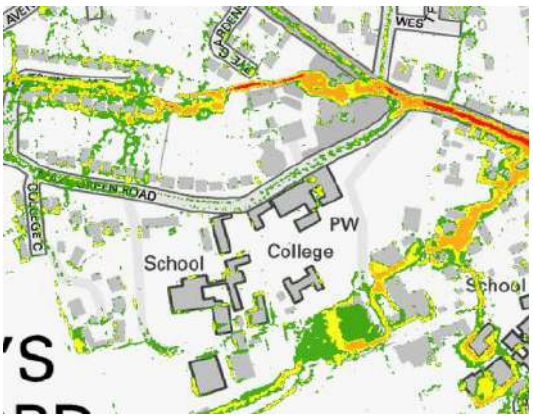
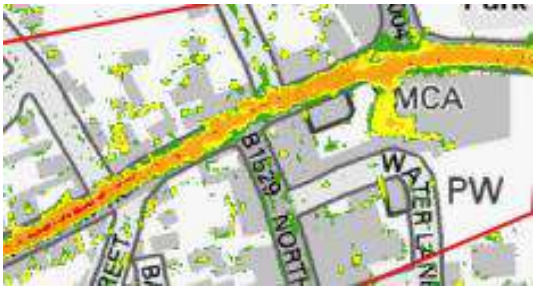
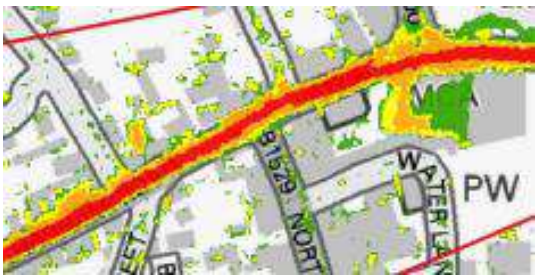
KEY FINDINGS

The key findings of the hydraulic modelling for the 1 in 30 and 1 in 100 year events are shown in Table 9; mapping of the whole hotspot is in Appendix D, which provides better resolution maps and a legend.

Table 9: Key Findings – Hotspot 43 - Hadham Road, Bishop's Stortford

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
	Flooding is predicted at properties along Matching Lane due to preferential flowpaths draining from Maze Green Road. Maximum flood depths are estimated to vary from 0.2m to 0.3m at these locations.	Flooding is predicted to increase in the 1 in 100 year event, for properties along Matching Lane, with the maximum flood depths reaching 0.5m.
Flood Depth		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
	Flooding is expected around the buildings, including the Bishop's Stortford Swimming Club and Leo Price Theatre, south of the Bishop's Stortford College and around the school buildings of Saint Mary's Catholic School off Windhill Old Road to the south. Surface water runoff is expected to drain in a north-easterly direction through these buildings towards Hadham Road. Maximum flood depths approach 0.55m at these locations.	The extent of flooding has increased around the buildings in the school area with deeper flooding (maximum depth of 0.7m) is predicted for the 1 in 100 year event.
		
	Flooding (maximum depth of 0.8m) is also predicted along the eastern end of Hadham Road, where water may spill to impact the properties north and south of the road.	Flood depth increases (maximum depth of 1m) along Hadham Road, with flood risk increasing to adjacent properties.
		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Hazard	The areas posing as danger for most mirror the regions highlighted in the flood depth analysis, in particular along the preferential flowpaths towards Hadham Road. Some areas of danger for most are also expected around the properties along Matching Lane and around the buildings within the school area to the south.	Flood hazard shows the same pattern as in the 1 in 30 year outlines, but flood hazard ratings have increased particularly along Matching Lane and along Hadham Road where flood hazard of danger for all is predicted.
		
	Flood hazard of danger for most is generally shown along the eastern end of Hadham Road, except for areas of deeper flooding where danger for all is predicted.	The extent of the danger for all areas along the eastern end of Hadham Road is increased in this event. The extent of the flood hazard ratings for properties adjacent to the road has also increased.
		

SENSITIVITY TESTING

Sensitivity testing was undertaken to assess the impact of depth varying roughness for the buildings in the model. The baseline uses a single roughness coefficient of 0.3 for the buildings. For the sensitivity test, roughness varies with depth in the following format:

- Depth <0.03m, roughness=0.02;
- Depth>0.1m, roughness=0.3, and
- Depth between 0.03m and 0.1m, roughness is an interpolation between 0.02 and 0.3.

Results (details provided in the flood model summary report in Appendix C) show that the mean difference in flood levels is less than 1mm between the baseline and sensitivity scenarios.

POTENTIAL MITIGATION

Mitigation measures which could be considered for Hotspot 43 - Hadham Road in Bishop's Stortford are outlined below and are shown in Appendix E:

- There is a preferential flowpath from northwest to southeast with water draining from the field to the residential area in Maple Grove. It is recommended to maintain a bund to attenuate water within the field;
- Runoff from the recreation ground, north of Hadham Road, will likely spill onto the road, so it is recommended to maintain a bund or raise the kerb to attenuate water upstream;
- Maintain a bund to attenuate water within open areas/playing fields south of Maze Green Road. This will reduce runoff from draining north through the properties along Maze Green Road and towards Matching Lane, as well as east into the school area of Bishop's Stortford College;
- Consider increasing the capacity or improving the conveyance by re-profiling the ditches east of Matching Lane;
- Maintain a bund to retain water within the car park of Saint Mary's Catholic School; this will minimise flow across the school buildings;
- Introduce Property Level Protection along the eastern end of Hadham Road, though mitigation measures upstream may reduce flooding of the road and adjacent properties in this area. This measure is therefore considered low priority if attenuation could be implemented upstream.

RECOMMENDATIONS

The following recommendations are made for further consideration of this site and for inclusion within the Action Plan:

- Review the recommendations made by Draincare as part of their 2012 survey for East Hertfordshire District Council; these can be summarised as:
  - Increase gully and pipe capacity outside the Junior School at Bishop's Stortford College;
  - Repair of collapsed sections of pipe and removal of tree root ingress;
  - Desilting key sections of the pipe network;
  - Restore blocked open watercourses to its original width and work with the riparian owners to educate them on the associated risks and need to undertake maintenance.
- Ensure suitable maintenance regime/pre-storm Action Plan is in place to reduce the risks of the grilles becoming blinded;
- Work with the riparian owners to encourage deculverting, particularly along Matching Lane;
- Consider increasing the attenuating capacity of the balancing pond located in the grounds of Bishop's Stortford College.

7.6 HOTSPOT 44 - BENHOOKS AVENUE AND HOTSPOT 60 - POTTER STREET/SOUTH STREET, BISHOP'S STORTFORD

KEY CONSIDERATIONS

These hotspots were selected for hydraulic modelling to refine the understanding of the following elements (as shown in Figure 15):

- The Environment Agency's Risk of Flooding from Surface Water map which shows:
  - Surface water runoff flowing east along Benhooks Avenue and past the cemetery towards the River Stort. In some locations, the flow is confined to the highway and in other locations, the surface water flows through residential areas;
  - Hotspot 60 to the north contributes some flows in to Hotspot 44.
- Flooding was reported in August 2015 at Wharf Road at the downstream (eastern) extent of Hotspot 44. This follows the Risk of Flooding from Surface Water flowpath as runoff flows towards Flood Zone 2.

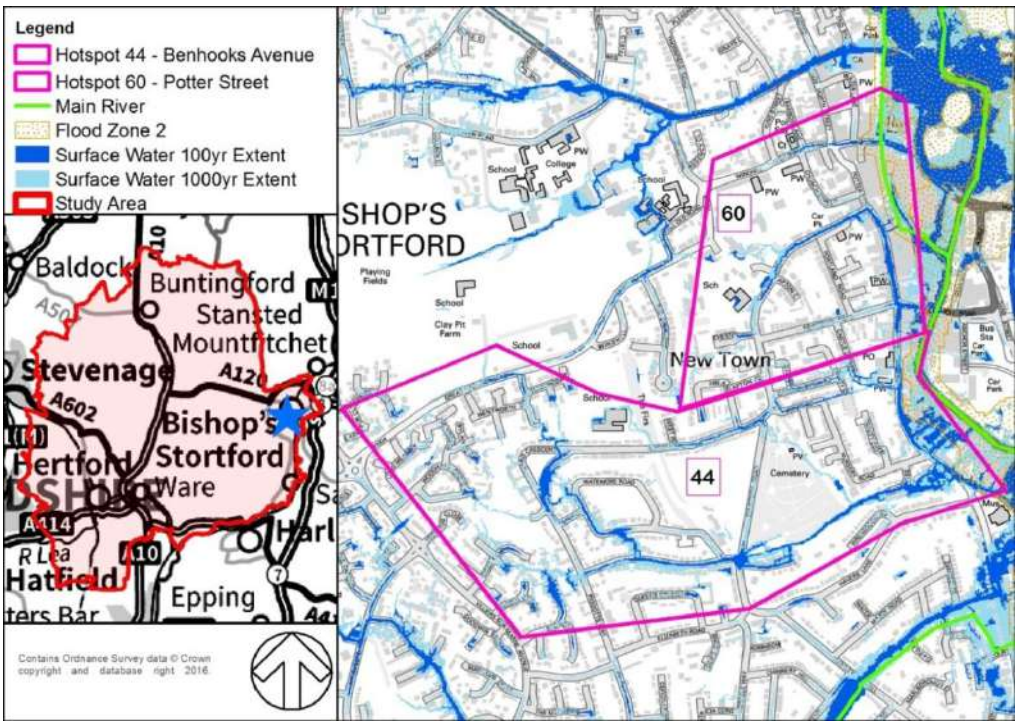


Figure 15: Hotspot 44 - Benhooks Avenue and Hotspot 60 - Potter Street/South Street, Bishop's Stortford – extents and baseline information

HYDRAULIC MODEL SUMMARY

These hotspots have been modelled with Hotspot 43 (Hadham Road) to the north because there are flowpaths between their boundaries. The model has been developed in ESTRY-TUFLOW with a direct rainfall approach utilising a LiDAR based DTM for the whole of the model domain. The downstream boundary conditions of these models were based on the 20 % AEP fluvial levels for the River Stort, extracted from the model provided by the Environment Agency.

KEY CONSTRAINTS

The strategic level of the study meant that assumptions needed to be made, one of which was that the road levels would be dropped by 125mm to represent the kerb height and ensure that

they represent the preferential flowpath. This may have removed some of the flowpaths to some properties due to lower kerbs and to the shops having no threshold levels, in particular along Potter Street and South Street.

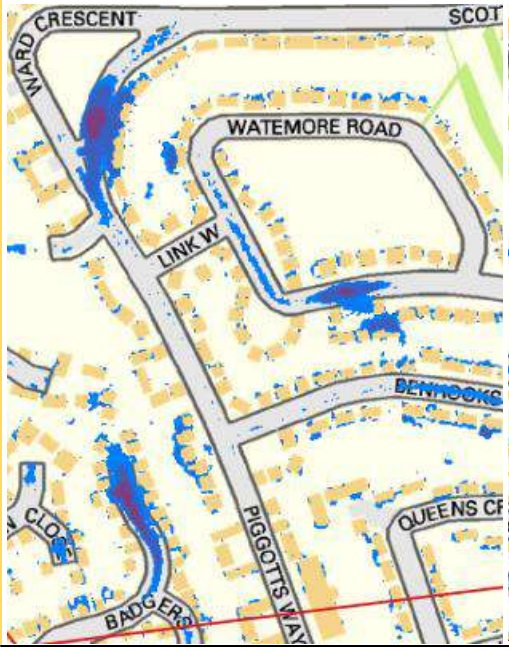
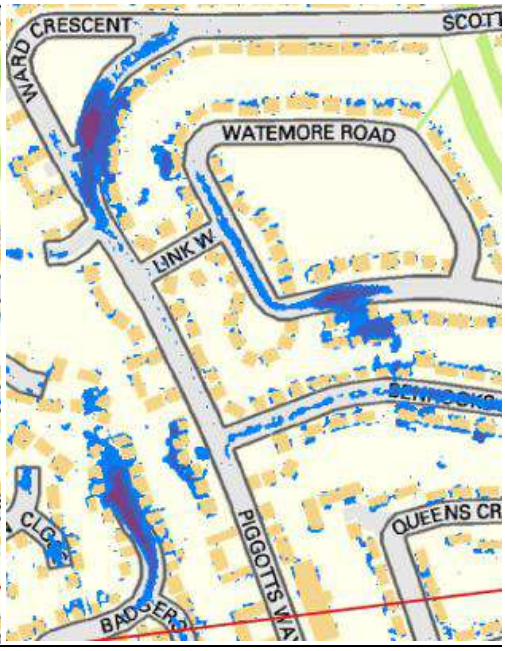
KEY ASSUMPTIONS

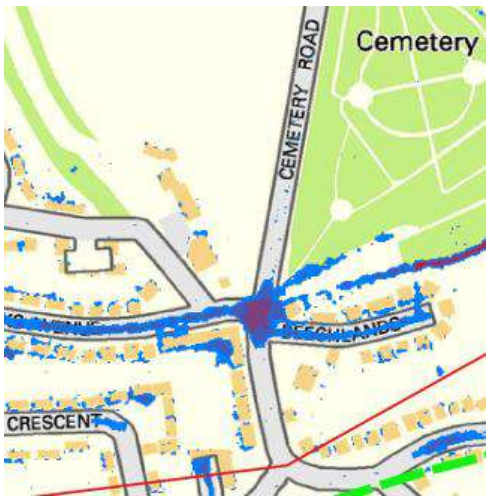
The lack of topographic survey for the open channel that runs between Cemetery Road and South Street means the dimension of the watercourse was estimated based on 1m LiDAR. For the purpose of the study, this level of accuracy was considered suitable to represent the flow conveyance of the watercourse. However, it is important to note that this level is not suitable for a flood map challenge or flood risk assessment.

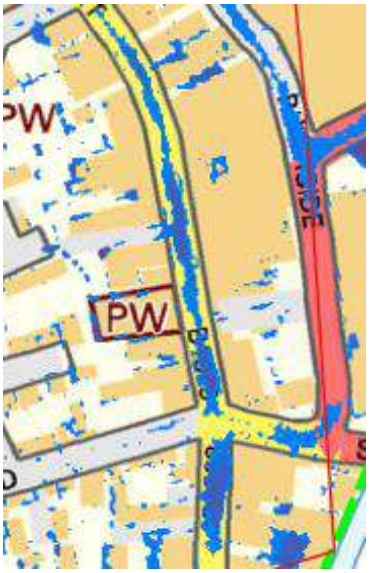
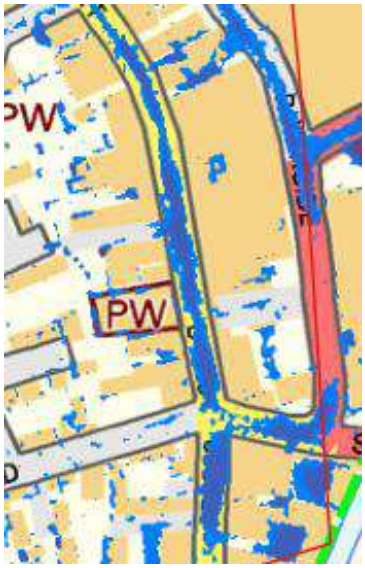
KEY FINDINGS

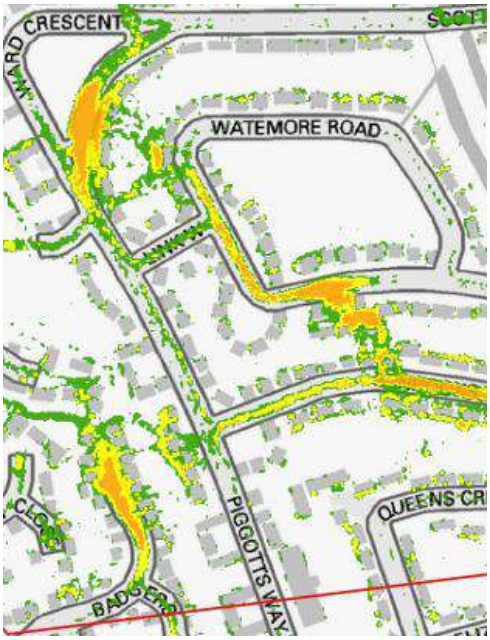
The key findings of the hydraulic modelling for the 1 in 30 and 1 in 100 year events are shown in Table 10; mapping of the hotspots is in Appendix D, which provides better resolution maps and a legend.

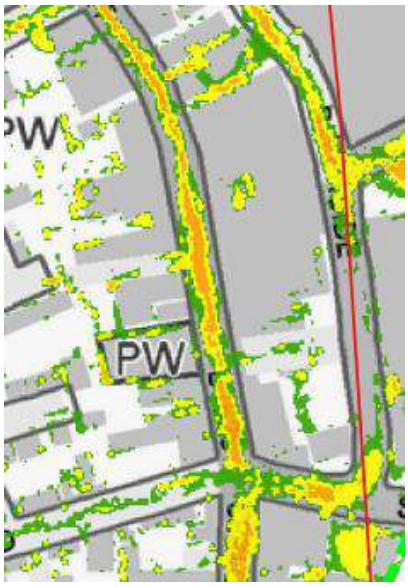
Table 10: Key Findings – Hotspot 44 - Benhooks Avenue (H44) and Hotspot 60 - Potter Street/South Street (H60), Bishop's Stortford

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Depth	Flooding with a maximum depth of 0.75m is predicted along Scott Road, which may impact on adjacent houses. Surface water runoff from Scott Road will drain east and south along Waytemore Road, and pond at the lowest section of Waytemore Road to the south. Maximum flood depth is expected to reach 0.65m at this location. Accumulated runoff from Waytemore Road will then drain south towards Benhooks Avenue. Some highly localised flooding is predicted at the northern end of Badgers. Maximum flood depth is estimated to reach 0.7m at this location.	The flood extents for the 1 in 100 year event are similar to the 1 in 30 year outlines, with flooding along Scott Road reaching a maximum depth of 0.8m. Waytemore Road has a maximum depth of 0.74m. The extent of flooding at the northern end of Badgers remains approximately the same as in the 1 in 30 year event, but the maximum flood depth has increased to 0.8m at this location.
		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
	Surface water runoff is draining south along Cemetery Road and east along Benhooks Avenue, causing ponding at the road intersection. Maximum flood depth is predicted to reach 0.6m at this location. Accumulated runoff from the intersection may spill east and impact on properties along Beechlands.	The area of flooding at the intersection of Cemetery Road and Benhooks Avenue remains the same in this event, as the 1 in 30 year event, but the maximum flood depth has increased to 0.75m.
		
	Surface water is flowing east from Benhooks Avenue towards South Street and into Stort Road, Wharf Road and Braziers Quay. Flood depth is up to 0.65m in this area.	Overall, the extent of flooding has increased significantly in the 1 in 100 year event and the number of properties impacted around South Street, Stort Road and Wharf Road has also increased. Maximum flood depths are estimated to vary from 0.7m to 0.75m in this area.
		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
	Surface water is draining east from Apton Road and south into Potter Street/South Street within Hotspot 60; some of the flows will then continue south into Hotspot 44. Flood depth is up to 0.4m along the road in the 1 in 30 year event.	The extent of flooding has increased along Potter Street/South Street, with maximum flood depth up to 0.5m in the 1 in 100 year event.
		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Hazard	For flood hazard, the areas posing a danger to most lie in the areas predicted to have the greatest flood depth, with areas of danger for most along Scott Road, Waytemore Road and the northern end of Badgers.	Flood hazard shows the same pattern as in the 1 in 30 year event along Scott Road, Waytemore Road and Badgers. Flood hazard ratings remain the same but the extent of danger for most has increased.
		
	Flood hazard of danger for most is shown at the intersection of Cemetery Road and Benhooks Avenue,.	Small areas of danger for all are predicted at the road intersection and west along Benhooks Avenue.
		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
	Flood hazard shows a few small areas of danger for most along Stort Road and Wharf Road where the greatest flood depths are predicted.	For flood hazard, there is a greater extent of danger for most shown for Stort Road and Wharf Road in the 1 in 100 event. This corresponds with the areas of greatest flood depth.
		
	Flood hazard of danger for some is generally shown along Potter Street/South Street within Hotspot 60.	The hazard rating has increased from danger for some to danger for most along Potter Street/South Street within Hotspot 60.
		

SENSITIVITY TESTING

Sensitivity testing was undertaken to assess the impact of depth varying roughness for the buildings in the model. The baseline uses a single roughness coefficient of 0.3 for the buildings. For the sensitivity test, roughness varies with depth in the following format:

- Depth <0.03m, roughness = 0.02;
- Depth>0.1m, roughness = 0.3; and
- Depth between 0.03m and 0.1m, roughness is an interpolation between 0.02 and 0.3.

Results (details provided in the flood model summary report in Appendix C) show that the mean difference in flood levels is less than 1mm between the baseline and sensitivity scenarios.

POTENTIAL MITIGATION

Mitigation measures which could be considered for Hotspot 44 - Benhooks Avenue and Hotspot 60 - Potter Street/South Street in Bishop's Stortford are outlined below and are shown in Appendix E:

- Property Level Protection for the properties at the northern end of Badgers;
- Surface water runoff is flowing from Clay Pit Farm towards Great Hadham Road and into the residential areas within Hotspot 44. Maintain a small bund around the farm to attenuate water upstream;
- Retain water within the allotment area, west of Piggotts Way, by maintaining a small bund along the eastern boundary. This will reduce water flowing into Ward Crescent and Waytemore Road;
- Further investigation into reprofiling ground levels at the intersection of Cemetery Road and Benhooks Avenue to improve conveyance into the drain downstream (east) of Cemetery Road;
- Property Level Protection for the houses to the south of Waytemore Road. It is recommended that a site visit is undertaken to ensure a preferential flowpath from Waytemore Road to Benhooks Avenue exists;
- Property Level Protection for the properties around South Street at the eastern end of Hotspot 44. However, this is low priority because upstream measures should reduce flooding at this location;
- Property Level Protection for properties along Potter Street/South Street within Hotspot 60;
- Property Level Protection for properties along Stort Road and Wharf Road.

RECOMMENDATIONS

The following recommendations are made for further consideration of this site and for inclusion within the Action Plan:

- Modification to highway drainage along the northern branch of Badgers and introduce permeable pavements if financially viable;
- Modification to highway drainage along South Street within Hotspot 44, but this is low priority because upstream measures should reduce flooding at this location;
- Further investigation to look at thresholds in the shops along Potter Street/South Street may provide evidence to support the business case for Property Level Protection.

7.7 HOTSPOT 47 - RAYNHAM ROAD, BISHOP'S STORTFORD

KEY CONSIDERATIONS

This hotspot was selected for hydraulic modelling to refine the understanding of the following elements (as shown in Figure 16):

- There are several ordinary watercourses to the east of Dunmow Road (A1250), which contribute to the drain that runs parallel to the disused railway. The drain then flows towards the west until it meets Dunmow Road (A1250);
- There is a significant section of culverted watercourse within the hotspot that does not follow the natural flowpaths. As a result, it is likely that the surface water flood risk is overestimated;
- There are also areas of flood risk which are likely to be overestimated as a result of the lack of representation of surface water sewers, particularly in the industrial estate area, the implications of watercourses and the disused railway to the east of the hotspot.

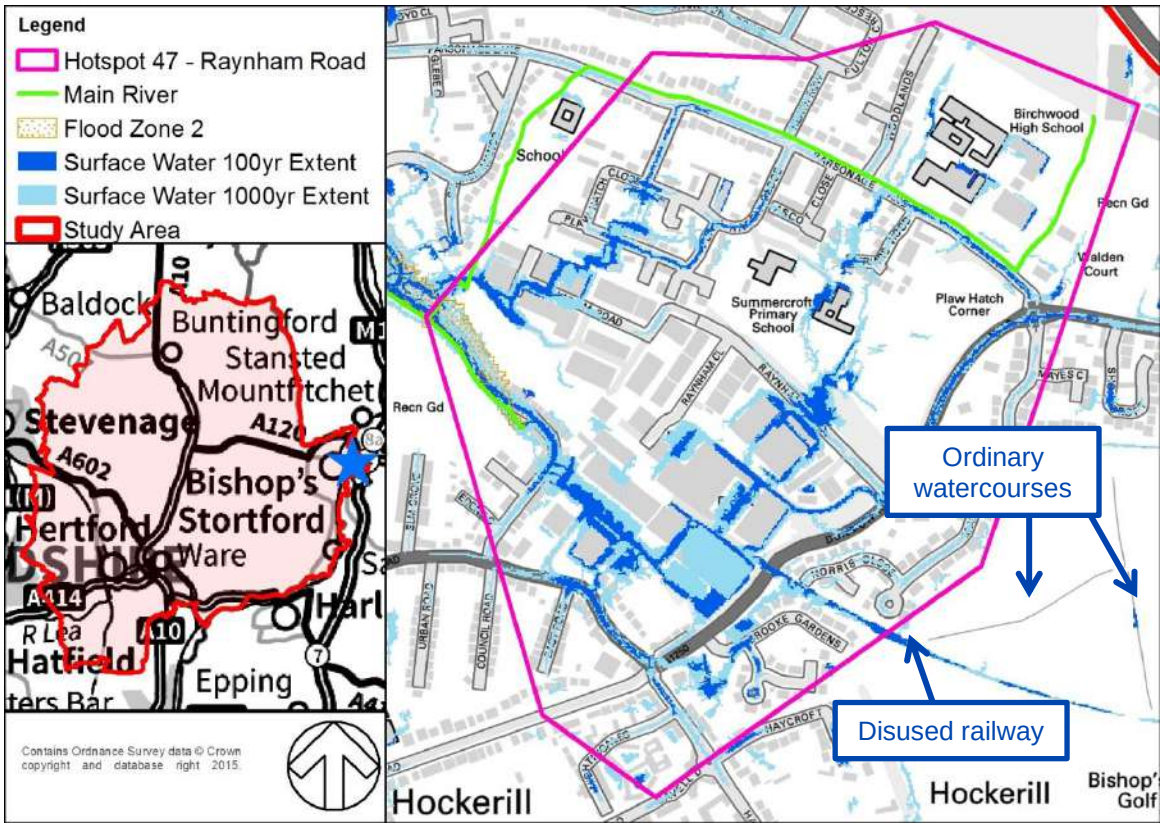


Figure 16: Hotspot 47 - Raynham Road, Bishop's Stortford – extents and baseline information

HYDRAULIC MODEL SUMMARY

The model has been developed in ESTRY-TUFLOW with a direct rainfall approach utilising a LiDAR based DTM for the whole of the model domain. The open watercourses within the hotspot, including the Parsonage Lane ditch and the Stortford Hall Park ditch, are represented within ESTRY, based on the sections modelled in ISIS by the Environment Agency. The downstream boundary condition of the model was based on the 20% AEP fluvial levels for the River Stort, extracted from the Environment Agency model.

KEY CONSTRAINTS

No significant constraints with the surface water model construction were observed.

KEY ASSUMPTIONS AND LIMITATIONS

There was limited data available on the Dunmow Road (A1250) bridge in the south of the hotspot. This is the location where the drain along the disused railway discharges to and contributes to the industrial estate area within the hotspot. The topographic survey only consists of information on the upstream face of the bridge, not the downstream; hence some assumptions had to be made based on the upstream data.

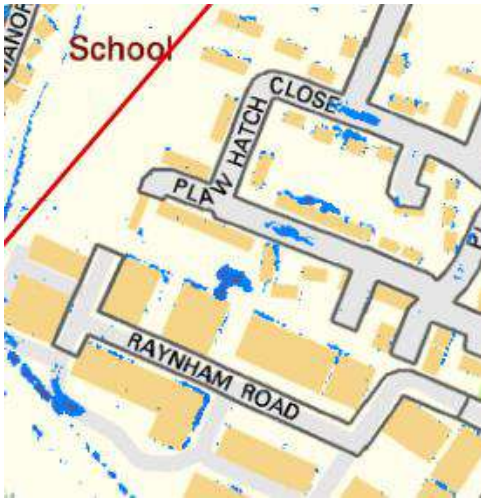
The lack of topographic survey for the ordinary watercourses, east of the hotspot, has meant that the dimensions of the channels were estimated based on 0.5m LiDAR. For the purpose of the study, this level of accuracy was considered suitable to represent the flow conveyance of the drains.

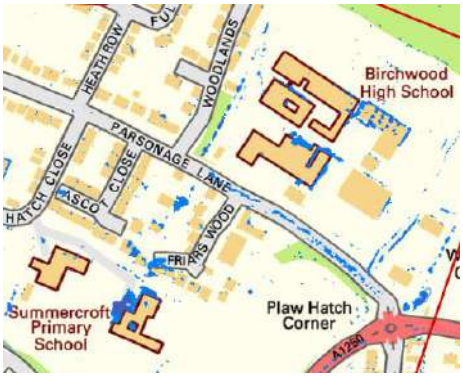
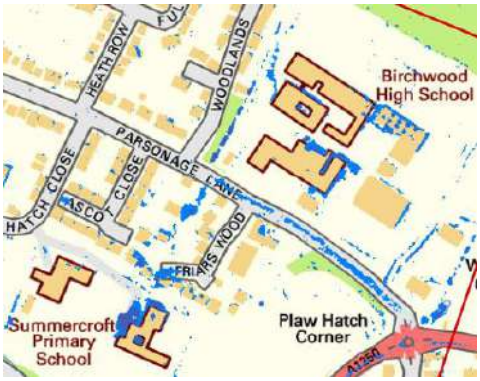
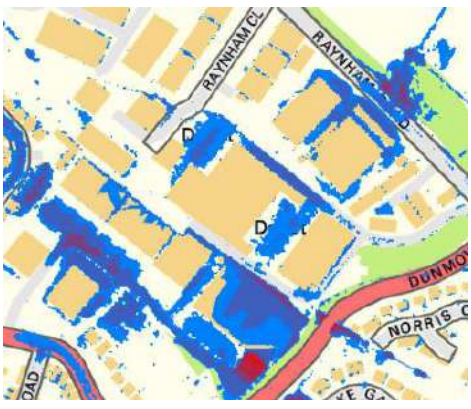
The model domain encompasses a much larger area than the hotspot boundary. While effort has been made to ensure the accuracy of the model for the area contributing too and within the hotspot, the level of accuracy for the area downstream is likely to decrease. Hence it is important to review the model before it is used for other purposes.

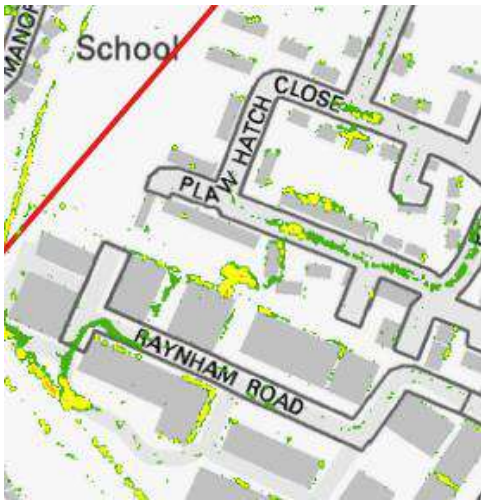
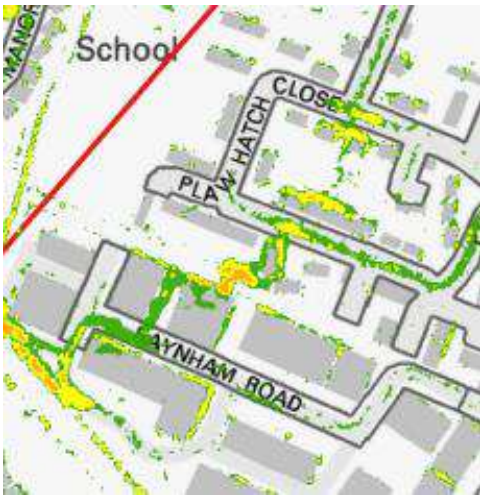
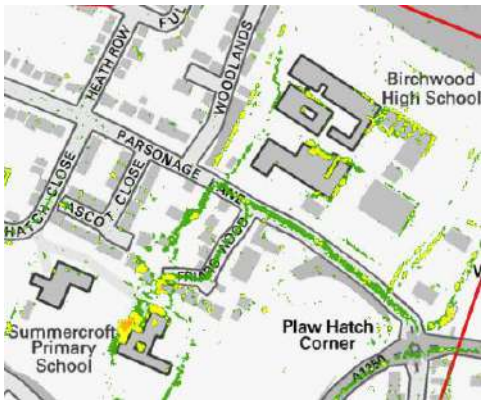
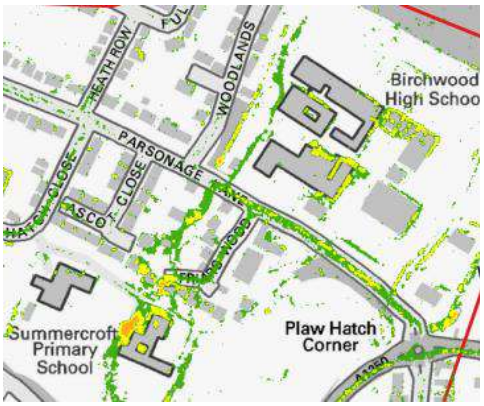
KEY FINDINGS

The key findings of the hydraulic modelling for the 1 in 30 and 1 in 100 year events are shown in Table 11; mapping of the whole hotspot is in Appendix D, which provides better resolution maps and a legend.

Table 11: Key Findings – Hotspot 47 - Raynham Road, Bishop's Stortford

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Depth	Surface water is flowing from north to south through the properties around Plaw Hatch Close and Raynham Road. Maximum flood depths are estimated to vary from 0.3m to 0.45m in this area.	Flood depths remain approximately the same in the 1 in 100 year event as they do in the 1 in 30 year event around the properties along Plaw Hatch Close and Raynham Road, but the area of flooding has increased.
		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
	Flooding is observed around Birchwood High School. Maximum flood depth approaches 0.6m at this location. Surface water runoff along Parsonage Lane is spilling south to impact on properties along Friars Wood and Summercroft Primary School further south. Deeper flooding is predicted around the school building with the maximum flood depth approaching 0.65m.	For the 1 in 100 year event, the flood extent around Birchwood High School is similar to the 1 in 30 year event, but flooding is predicted to be slightly deeper (maximum depth of 0.7m). Flood depth and extent around Friars Wood and Summercroft Primary School remain approximately the same as in the 1 in 30 year event.
		
	Surface water runoff is predicted to enter the industrial estate from the north via Raynham Road and from the east via the drain along the disused railway. Runoff from the industrial estate then flows towards the open channel that runs parallel to Stortford Hall Park. Significant flooding is observed within the industrial estate with flood depth exceeding 1m.	Both flood depth and extent within the industrial estate have increased in the 1 in 100 year event, with the maximum flood depth approaching 1.2m in this area.
		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Hazard	Flood hazard of danger for some is generally shown around the properties along Plaw Hatch Close, Raynham Road, around	In the 1 in 100 year event, flood hazard shows a similar pattern to the 1 in 30 year event, but the area of danger for most has increased, particularly for properties between Plaw Hatch Close and Raynham Road and the area adjacent to Summercroft Primary School.
		
	Flood Hazard of danger for some is shown in isolated areas around Birchwood High School and the houses south of Friars Wood. A small area of danger for most is predicted adjacent to Summercroft Primary School.	In the 1 in 100 year event, flood hazard shows a similar pattern to the 1 in 30 year event, but the area of danger for most has increased in the area adjacent to Summercroft Primary School.
		

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
	The areas posing a danger for most mirror the regions predicted to have the greatest flood depth within the industrial estate. Some areas of danger for most are also predicted upstream of Raynham Road.	In the 1 in 100 event, flood hazard areas have increased wihin the industrial estate, particularly the area of danger for most, in association with the areas predicted to have the greatest flood depth.
		

SENSITIVITY TESTING

In line with the modelling methodology, no sensitivity testing was undertaken on this hotspot.

POTENTIAL MITIGATION

The most viable mitigation measure for Hotspot 47 - Raynham Road in Bishop's Stortford is Property Level Protection (PLP); the locations in which this measure could be considered are outlined below and shown in Appendix E:

- Properties along Plaw Hatch Close;
- Properties along Raynham Road, and
- Commercial buildings within the industrial estate.

RECOMMENDATIONS

The following recommendations are made for further consideration of this site and for inclusion within the Action Plan:

- Investigate possible upstream storage attenuation and/or widening of drains within the golf course, consultation with the owner is required before any planning of mitigation works could be carried out;
- Investigate potential storage within recreation grounds in Walden Court;
- Investigate potential attenuation within the school grounds of Summercroft Primary School and/or the possibility of constructing a wall or raising the kerb along Raynham Road to retain water in the school fields;
- Investigation needed on the flowpath (culverted or open channel) downstream of the Dunmow Road (A1250) bridge. Potential upsizing of pipes along the car park within the

industrial estate is needed to increase drainage towards the open channel along Stortford Hall Park;

- Speedbumps to keep water along Parsonage Lane and potential controlled spillage into the school fields of All Saints C of E Primary School. However, further investigation is needed on the capacity of the open channel (adjacent to Church Manor) that drains the school grounds and the downstream pipes to accommodate this additional discharge.

8 VIABILITY SUMMARY

The results of the baseline economic analysis for each hotspot are summarised in Table 12. This illustrates the number of properties currently at risk of internal flooding, in line with the Environment Agency's bands for economic assessment.

Table 12: Number of Commercial and Residential Properties at Risk of Flooding

HOTSPOT	PROPERTIES AT RISK OF FLOODING		
	VERY SIGNIFICANT (>5% AEP)	SIGNIFICANT (5% – 1.33% AEP)	MODERATE (1.33% – 0.5% AEP)
Hotspot 1 - Buntingford	5	13	66
Hotspot 40 – Bengeo, Hertford	3	33	66
Hotspot 43 - Hadham Road, Bishop's Stortford	1	71	127
Hotspot 44 - Benhooks Avenue, Bishop's Stortford	11	26	192
Hotspots 47 - Raynham Road, Bishop's Stortford	0	21	112
Hotspot 60 - Potter Street, Bishop's Stortford	0	1	87

The results of the mitigation option economic analysis for each hotspot are summarised in Table 13. This illustrates the expected present value economic damages from flooding over a 100 year period. It also provides the present value benefits and costs associated with the mitigation options that have been considered at each hotspot. For each mitigation option the Benefit Cost Ratio is provided to demonstrate its viability. When considering the findings of the economic assessment it needs to be considered that this has been undertaken at a strategic scale and the associated benefit cost ratio will be refined as the scheme is progressed through later stages of the funding process, where greater information is available on the local flood mechanisms and associated depths, along with the associated mitigation requirements and cost.

Each mitigation option as identified in Section 7 was assigned a standard of protection, below which it is considered, through engineering judgement, that property flooding would be alleviated. The area which would benefit from the mitigation scheme, the 'benefit area' is identified in the Option Maps (Appendix E).

Table 13: Baseline and Mitigation Options Economic Damages

HOTSPOT	MITIGATION OPTION	PRESENT VALUE DAMAGES [£]	PRESENT VALUE BENEFITS [£]	PRESENT VALUE COSTS [£]	BC RATIO
1 - Buntingford	Baseline	18,500,000	/	/	/
	100yr SOP	9,200,000	9,300,000	1,410,000	6.6
40 – Bengeo, Hertford	Baseline	13,570,000	/	/	/
	75yr SOP	9,850,000	3,720,000	1,725,000	2.2
43 - Hadham Road, Bishop's Stortford	Baseline	28,600,000	/	/	/
	30yr SOP	18,600,000	10,000,000	3,750,000	2.7
44 - Benhooks Avenue, Bishop's Stortford	Baseline	23,300,000	/	/	/
	30yr SOP	11,850,000	11,450,000	3,010,000	3.8
47 - Raynham Road, Bishop's Stortford	Baseline	38,100,000	/	/	/
	100yr SOP	18,500,000	19,600,000	1,850,000	10.6
60 - Potter Street, Bishop's Stortford	Baseline	25,600,000	/	/	/
	100yr SOP	14,400,000	11,200,000	1,680,000	6.7

The viability assessment demonstrates that all the proposed mitigation options are economically viable, as the benefit cost ratio is greater than 1.

To secure FCERM GiA funding, a benefit cost ratio of greater than 1 is needed in order for a scheme to be viable. The current funding process, which aims to get third party funding (e.g. from Local Levy, private or public contributions) means that the majority of the schemes proposed here, would not be viable without attracting additional (partner) funds. The types and availability of these additional funding streams are discussed in the following section (Section 9).

9 FUNDING

The hydraulic modelling and optioneering phases have identified a range of potential mitigation measures that could be implemented to help reduce flood risk. Where these measures are the promotion of capital local flood risk management schemes, the delivery depends on sufficient funding being available, either from ongoing revenue funding or project based support for capital schemes.

The funding available for any measure will be linked to the outcomes it will provide. Measures that deliver benefits beyond flood risk management, such as enhanced ecosystems, public amenity, economic growth or cultural heritage, are likely to attract funding from alternative sources beyond those typically used to support flood risk management. Funding is therefore based on the economic viability of schemes; not all potential flood alleviation schemes will be viable and not all will achieve funding.

This chapter describes the available sources of funding that could be used to support the measures previously identified. Hertfordshire County Council have already achieved funding for flood risk projects from various sources, including Local Levy and Grant in Aid. HCC as the LLFA also receives separate funding from government to fund delivery of their statutory duties under the Flood and Water Management Act (2010). This is separate from the funding described in the following sections that are focused on delivery of specific flood risk management schemes.

9.1 NATIONAL FUNDING

FLOOD AND COASTAL EROSION RISK MANAGEMENT GRANT IN AID FUNDING

Defra has the national policy responsibility for Flood and Coastal Erosion Risk Management (FCERM) and provides funding through Grant in Aid (GiA) to the Environment Agency, who then administer grants for capital projects; Risk Management Authorities (RMAs), such as Hertfordshire County Council as LLFA, are able to request FCERM GiA.

A contribution to flood risk management schemes from the Flood and Coastal Erosion Risk Management Grant in Aid (FCERM GiA) funding will be provided whenever there is a positive ratio of benefit to cost. However, a positive ratio does not necessitate full funding and the formula determines the amount of Central Government funds based on the calculated ratio.

Funding levels for each scheme are linked to the number of households protected, the damages prevented, environmental benefits, amenity improvements, agricultural productivity and economic benefits. The payment rates for household protection will vary depending on the index of multiple deprivation; with more deprived households receiving higher payment rates. This ensures that schemes identified within poorer areas are more likely to receive full funding from Central Government.

The calculation of funds to be provided by FCERM GiA is as follows[15]:

$$\text{Share of costs funded by Defra} = \frac{\text{Household benefits + other whole-life benefits + environmental outcomes}}{\text{Amount of funding required}} \times \text{Fixed payment rates}$$

The benefit of this approach is that more schemes will be eligible for some national funding including minor schemes and those not solely related to fluvial and/or surface flooding. However, it will be more difficult to obtain 100% funding from national sources and therefore cost saving measures and other sources of funding are likely to be required to ensure that the scheme is fully funded.

9.2 REGIONAL FUNDING

LOCAL LEVY

Local Levy funding is an additional locally-raised source of income, gathered by way of a levy on Local Authorities and collected via the council tax. The levy is used to support (with the approval of the Regional Flood and Coastal Committee) flood risk management projects that are not considered to be national priorities and hence do not attract national funding through FCERM GiA. Alternatively, local levy funding can be applied to FCERM GiA projects, at the discretion of the Regional Flood and Coastal Committee (RFCC), to meet the partnership funding requirements. Each RFCC annually sets the level of local authority funding that local authorities will contribute in the following year.

Hertfordshire is covered by the Thames and Anglian Central RFCC. Each RFCC collects Local Levy funds from the county, which are used to contribute towards locally important flood risk management schemes across their areas of responsibility.

To obtain these funds it is important to engage with the RFCC early in the allocation process once possible schemes have been identified. To facilitate this officers and elected members from the council attend and are part of the RFCC.

9.3 LOCAL FUNDING

Depending on the shortfall from FCERM GiA and the number of schemes competing for the RFCC's allocation, it is possible that the Local Levy will not solely provide all the required funding for a scheme and therefore other measures could be explored in the future if necessary.

Potential sources of local funding could include:

- **Section 106 Agreements**, in accordance with the Local Planning Authority – this is a contribution, linked to specific developments and the related infrastructure required to make them acceptable in planning terms;
- **Community Infrastructure Levy (CIL)** – this is a sum levied upon development in line with a locally set charging schedule to be used by local authorities to provide the necessary infrastructure to support development generally:
  - Currently only four of the ten districts in Hertfordshire (Dacorum, Hertsmere, Three Rivers, and Watford) have adopted CIL charging schedules;

[15] Taken from the Framework to assist the development of the Local Strategy for Flood Risk Management, 2nd Edition (Local Government Association, 2011)

- Where there is a neighbourhood plan in place the parish or town council are eligible for 25% of the CIL charge relating to a development in the plan area.

→ **Local Authority Funding** – for capital schemes funded through Council Tax and Revenue Support Grant. Where there is benefit to business, Business Rates levies and Business Improvement Districts could provide source funding;

→ **Private Funding Sources** – Landowners, Natural England and other relevant agencies in some circumstances may be willing to contribute funds to flood risk management where they can see a direct benefit to reducing their flood risk or improving their land drainage.

9.4 COMBINATION OF FUNDING SOURCES

The preferred approach for funding schemes is to use a variety of funding sources. No flood risk mitigation schemes proposed in this SWMP are likely to have sufficient benefits to be 100% funded through the FCERM GiA system. The use of multiple and combined sources of funding is shown in Figure 17[16] as "Payment for Outcomes (anticipated)".

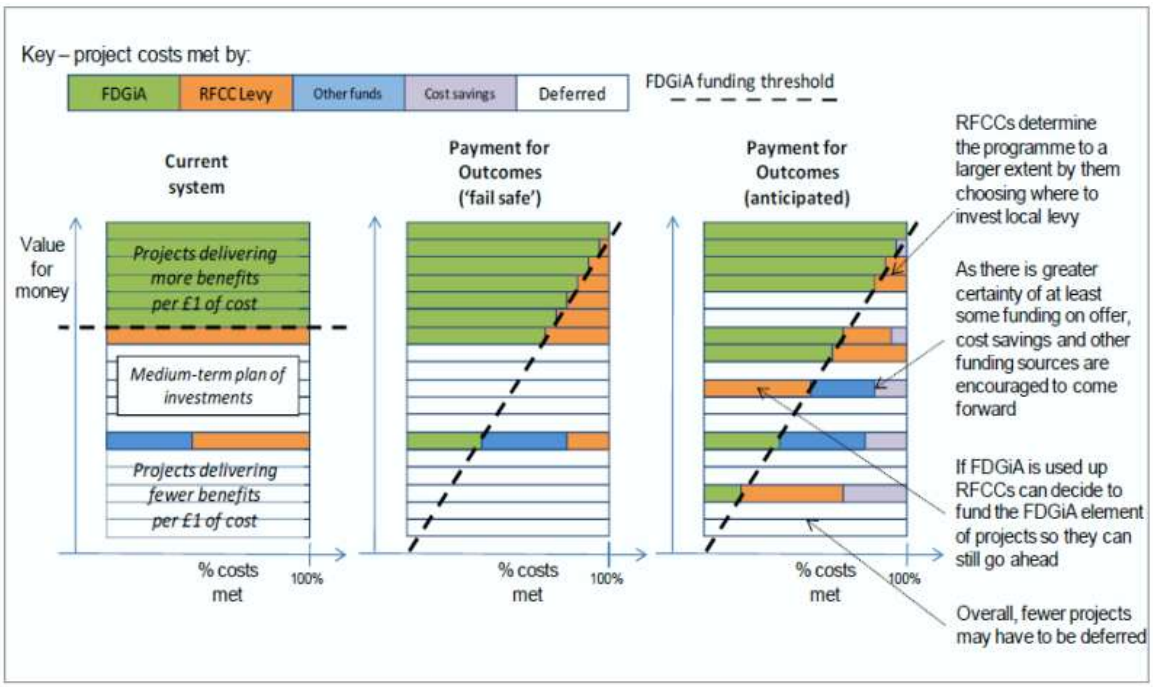


Figure 17: Combination of possible different funding sources to cover costs of flood risk management schemes

[16] Taken from the Framework to assist the development of the Local Strategy for Flood Risk Management, 2nd Edition (Local Government Association, 2011)

9.5 FUNDING CONCLUSIONS

The economic assessment finds that the schemes across the hotspots are considered to be submitted to the Environment Agency for inclusion on their MTP and further assessments undertaken to refine the schemes to a level suitable for a formal funding application (Outline Business Case). For these schemes HCC will need to work with key stakeholders in Hertfordshire to secure additional third party funds to ensure the schemes to have sufficient funding for delivery. Alternatively, smaller more localised schemes could be considered as part of current operational and capital work streams.

10 IMPLEMENTATION AND REVIEW

The Surface Water Management Plan (SWMP) is to be a living document that should be reviewed approximately every five years, to ensure the correct implementation of the agreed actions and that any new issues are addressed. A review may be required following any new flood event, when new flood data becomes available, new modelling techniques are developed or when there is a change of policy.

The SWMP will be used as an evidence base for the Local Flood Risk Management Strategy (LFRMS) for Hertfordshire. It will inform the Local Plan and lead the direction of flood risk projects within each district and borough.

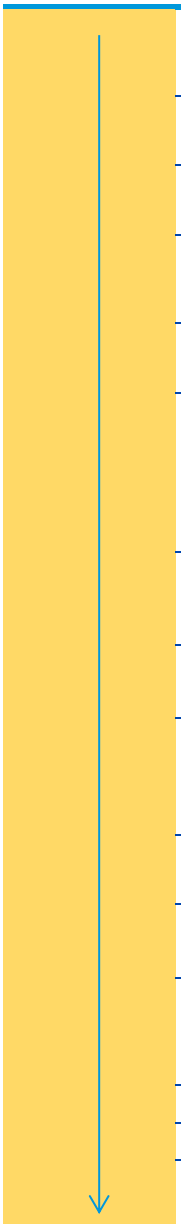
10.1 ACTION PLAN

The Action Plan for each hotspot details recommendations for options to be explored, in addition to what actions will be needed if this hotspot is taken forward for further assessment after the completion of this SWMP. The Action Plan is targeted towards each of the assessed hotspots and provides a summary of all the mitigation measures that are likely to lead to a reduction in flood risk if they are implemented. As many of these actions are likely to require capital costs to be implemented, funding will need to be secured to fully investigate their feasibility.

Any options involving construction works will require the development of a detailed study, refining the assumptions and undertaking hydraulic modelling of the option in order to verify the approaches adopted within this strategic study. This detailed study will also enable a better understanding of the baseline risk prior to testing a range of mitigation measures to determine the best option in both economic and environmental terms.

The stages that would be involved in this process are outlined in Table 14; during this process community involvement should be considered at each stage to ensure that they have a greater stake in project design and delivery. Involving the community at an early stage of flood risk management schemes ensures ownership of the final solution. Other elements which will run throughout a scheme include consideration of how the scheme will be funded, how to maximise the environmental benefits and reduce the impacts of flooding.

Table 14: Further Assessment Phases

TIME	ACTION	REASON/WHAT IS NEEDED FOR THIS?
	County Wide Priority Site Review	HCC LLFA team to review priority sites from this SWMP in conjunction with other SWMPs to determine the list of overall priority sites.
	Determine Workstream	HCC LLFA team to determine the approach for incorporating SWMP findings in overall deliverables.
	Agree funding approach	Assess third party funding options, FCERM GiA, HCC or contributions from stakeholders.
	Set up project Steering Group	Co-ordinated approach between the EA, HCC, EHDC, TW and other stakeholders.
	Appoint Project Team	Consult with stakeholders involved. This should include, if necessary, consultants.
	Undertake further studies	Undertake modelling and further studies to fully understand surface water flooding issues at the site. Any surveys required to facilitate and future mitigation solutions or modelling are to also be undertaken (i.e. soakaway tests / topographical surveys etc.).
	Mitigation Review	Based on the results of the further studies, review mitigation options and confirm adopting authority (LLFA, Hertfordshire Highways, EHDC, and TW).
	Economic Viability	Undertake a review of the economic assessment for the updated mitigation studies.
	Funding	Identify and maximise all other funding sources including CIL, local authorities, environmental funding, and other external organisations.
	Supplementary Studies	Undertake any additional studies (ecology / site investigations / additional topographical surveys).
	Apply for Funding	Apply for funding.
	Detailed Design	Undertake detailed design of the proposed mitigation option and gain approvals from the LPA, regulators and adopting authorities.
	Tender	Issue proposed design for tender.
	Appoint Contractor	A rigorous selection programme.
	Construction	Construction and final approval (including amending the flood map).

10.2 EMERGENCY PLANNING

The findings from the SWMP should be used to inform the Major Incident Plan and improve the Multi Agency Flood Plan.

The findings and outputs of the SWMP such as the flood hazard maps should be used to inform the emergency plan for Hertfordshire in terms of drainage and flooding issues. This should include the identification of properties within the floodplain inhabited by vulnerable people, to ensure they are prioritised should evacuation be required.

The Multi Agency Flood Plan which will assess flood risk in terms of Health, Social, Economic and Environmental issues.

10.3 NEXT STEPS

Hertfordshire County Council, as LLFA, will prioritise the actions of this SWMP. Outcomes of this SWMP will need to be undertaken in conjunction with the LFRMS and HCCs role as LLFA. This will lead to a prioritisation of actions into their workstream, which includes the findings of other SWMPs and Section 19 Flood Investigations, amongst other aspects of the LLFA role.

To ensure a successful implementation and review of the Surface Water Management Plan, all stakeholders must contribute to the process. Clear lines of communication and defined responsibilities are critical.

The SWMP should be used to inform and advise the Plans and Policies for the area and emergency planning as well as inform local planning decisions.

A program of further works to include implementation of the elements within the Action Plan should be prepared and a provisional timetable for completing follow up actions should be agreed. As a SWMP study is considered to be a long-term plan, all stakeholders should continue to work together after the SWMP study has been completed.

The SWMP will inform the LLFA workstream as well as a range of further studies/measures which will include:

- → LFRMS evidence base;
- → Focus for future projects;
- → Strategy for local flood risk management in each district / borough.

11 CONCLUSIONS

WSP | Parsons Brinckerhoff has completed a Surface Water Management Plan (SWMP) for East Hertfordshire District on behalf of Hertfordshire County Council, as Lead Local Flood Authority. The study has been undertaken in consultation with key stakeholders who are responsible for surface water management and drainage in the area. This SWMP has worked with key stakeholders to understand the causes and effects of surface water flooding and agree the most cost effective processes of managing surface water flood risk for the long term. This SWMP has been designed to encourage the development of innovative solutions and practices as well as identifying funding streams to assist in the delivery of the outcomes of the SWMP.

The Defra SWMP Technical Guidance (2010) suggests that a SWMP study will not be required in all locations but rather where areas are "considered to be at greatest risk of surface water flooding or where partnership working is considered essential to both understand and address surface water flooding concerns".

The first stage of East Hertfordshire District SWMP was the Preparation Phase; this identified the need for the SWMP. The need for the SWMP was identified within the Local Flood Risk Management Strategy (LFRMS) for Hertfordshire 2013-2016[17]. The SWMP study was then scoped and the aims and objectives set. The level of assessment needed was identified, as well as the identification of the available information.

The second stage of the SWMP was the Risk Assessment Phase, this was undertaken in two parts; the first, a Strategic and Intermediate Assessment, and the second, a Detailed Assessment. The principle purpose of the Strategic and Intermediate assessment was to identify broad locations which were considered to be vulnerable to surface water flooding. This was undertaken using the best information available, including some GIS analytical techniques. Potential hotspots (areas perceived and identified locally as being at greatest risk of surface water flooding) were identified from this information, and information made available from stakeholders. This list of hotspots was presented to the key stakeholders for discussion and finalisation. It was determined that six were to be taken forward to Detailed Assessment.

The Detailed Assessment part of the SWMP involved detailed hydraulic modelling. Individual hotspot models were constructed to assess the baseline flood mechanisms, pathways and extents. Following the hydraulic modelling, a review of the revised flood extents was undertaken and the numbers of properties in the floodplain determined. From this review it was possible to determine the type of mitigation measures which could be possible to implement for each hotspot to reduce the impacts and damage associated with flooding.

During the Preparation Phase of the SWMP when the objectives were set, one of the aims of this SWMP for East Hertfordshire District was to determine the economic viability of mitigation schemes. This was undertaken to ensure that HCC could prioritise their future work to focus on measures, which not only would reduce flood risk, but also be the most attractive in securing funding to facilitate their construction.

All suggested options are considered to be economically viable; however, those with higher cost benefit ratios, third party contributions or demonstrable history of flooding should be progressed first, as these are most likely to attract funding.

[17] Local Flood Risk Management Strategy for Hertfordshire, available at: http://www.hertfordshire.gov.uk/services/envplan/water/floods/floodrisk/lfrmsherts/

The final phase of the SWMP is the Implementation and Review Phase. During this phase an Action Plan is prepared. Action Plans have been developed to cover the measures identified in the Strategic and Intermediate Assessment, and the Detailed Assessment. The Detailed Action Plan is accompanied by a workstream which identifies the process that would need to be undertaken for each element in order to acquire the capital funds to facilitate its implementation.

This Surface Water Management Plan for East Hertfordshire District is to be a living document that should be reviewed approximately every five years, to ensure the implementation of the agreed actions is correct and that any new issues are addressed. A review may be required following any new flood event, when new flood data becomes available, or new modelling techniques are developed, and when there is a change of policy, which affects the district.