Appendix B

HOTSPOT SELECTION TECHNICAL NOTE

TECHNICAL NOTE
HOTSPOT SELECTION

Project	Borough of Broxbourne SWMP
Date	03 December 2019
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Project Reference	70009115 – TN1

1 INTRODUCTION

1.1.1 This Technical Note has been prepared to record the approach taken to the hotspot identification and selection process, in order to enable the project stakeholders to make an informed decision as to which hotspots should be taken forward for detailed hydraulic modelling. This Technical Note will be adapted to form part of the Strategic and Intermediate Phase SWMP Report.

1.2 AIMS OF STUDY

- Increase Hertfordshire County Council's (HCC) understanding of the key flooding mechanisms in the Borough of Broxbourne in their role as Lead Local Flood Authority (LLFA);
- Give HCC a better understanding of how the Environment Agency's Risk of Flooding from Surface Water map corresponds to the flooding mechanisms that occur in this borough;
- To identify hotspot sites which have the potential to benefit from scheme investment from funding such as Flood Defence Grant in Aid (FDGiA);
- To identify hotspots which do not need hydraulic modelling (e.g. due to flood mechanisms being well represented in the Risk of Flooding from Surface Water map), but are identified with suggested actions as part of the SWMP;
- Identify potential actions and recommendations to be undertaken by HCC and/or other Risk Management Authorities (RMAs);
- Identify mitigation measures where necessary; and
- Provide the general public with a tool which better represents the surface water flood risk in their area.

2 HOTSPOT DEFINITION

2.1.1 For the purpose of this Surface Water Management Plan (SWMP), a hotspot is defined as a spatially limited area in which there are a number of residential or commercial properties at risk from flooding resulting from surface water; other sources of flooding and their interaction with surface water flooding are also recognised. An example of such a hotspot is shown in Figure 1.

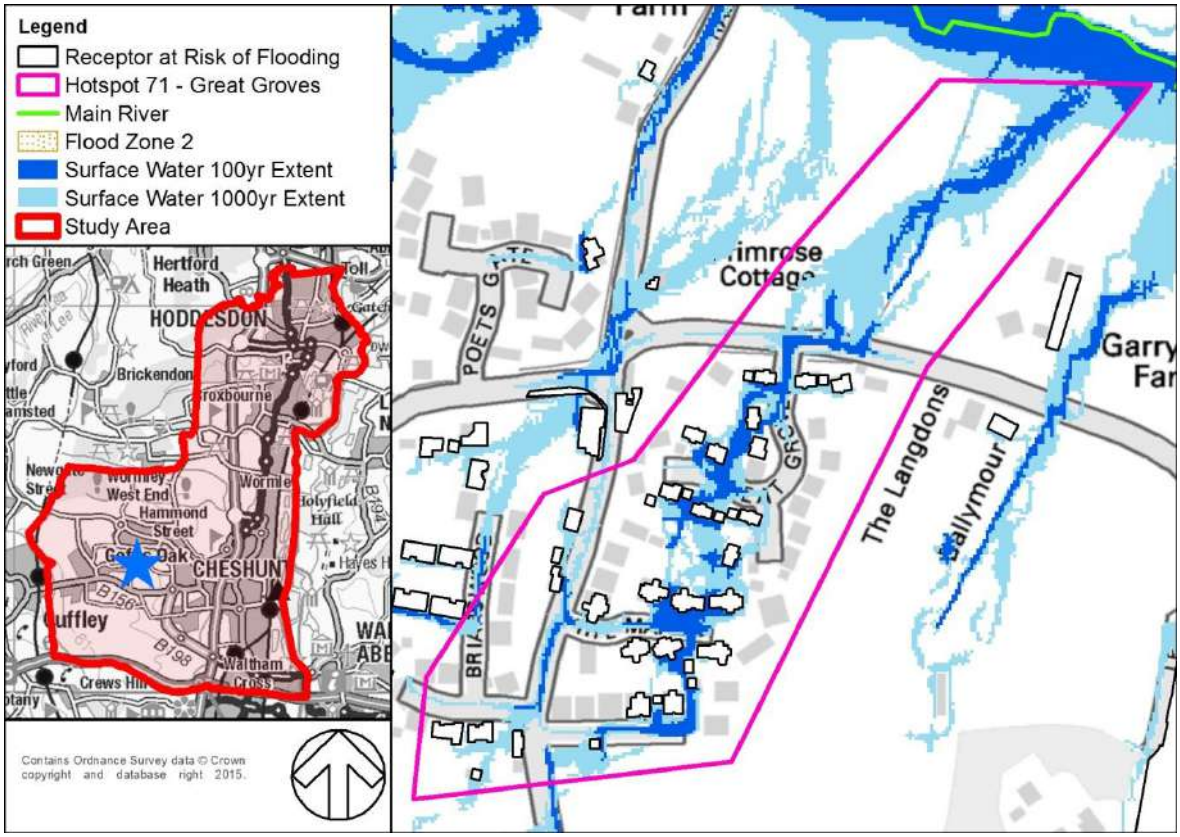

Figure 1: Example Hotspot

2.1.2 A number of different terms are used to describe how the hotspots are identified and how they are selected to be taken forward for detailed hydraulic modelling. The flow chart in Figure 2 illustrates the process for selecting hotspots and the terms used to describe each type of hotspot during the hotspot selection process. The Glossary (Section 10) also provides definitions of all terms used.

2.1.3 The methodology and analysis conducted as part of the early SWMP process is documented in Section 3 and 4. These sections explain the “Initial Hotspot identification and Multi-Criteria Analysis (MCA)” process and how this produced a list of Desk-Based Identified Hotspots which were discussed at the stakeholder meeting. At the meeting, stakeholders brought forward information on other areas within the Borough of Broxbourne and this updated information was included in the SWMP hotspot assessment.

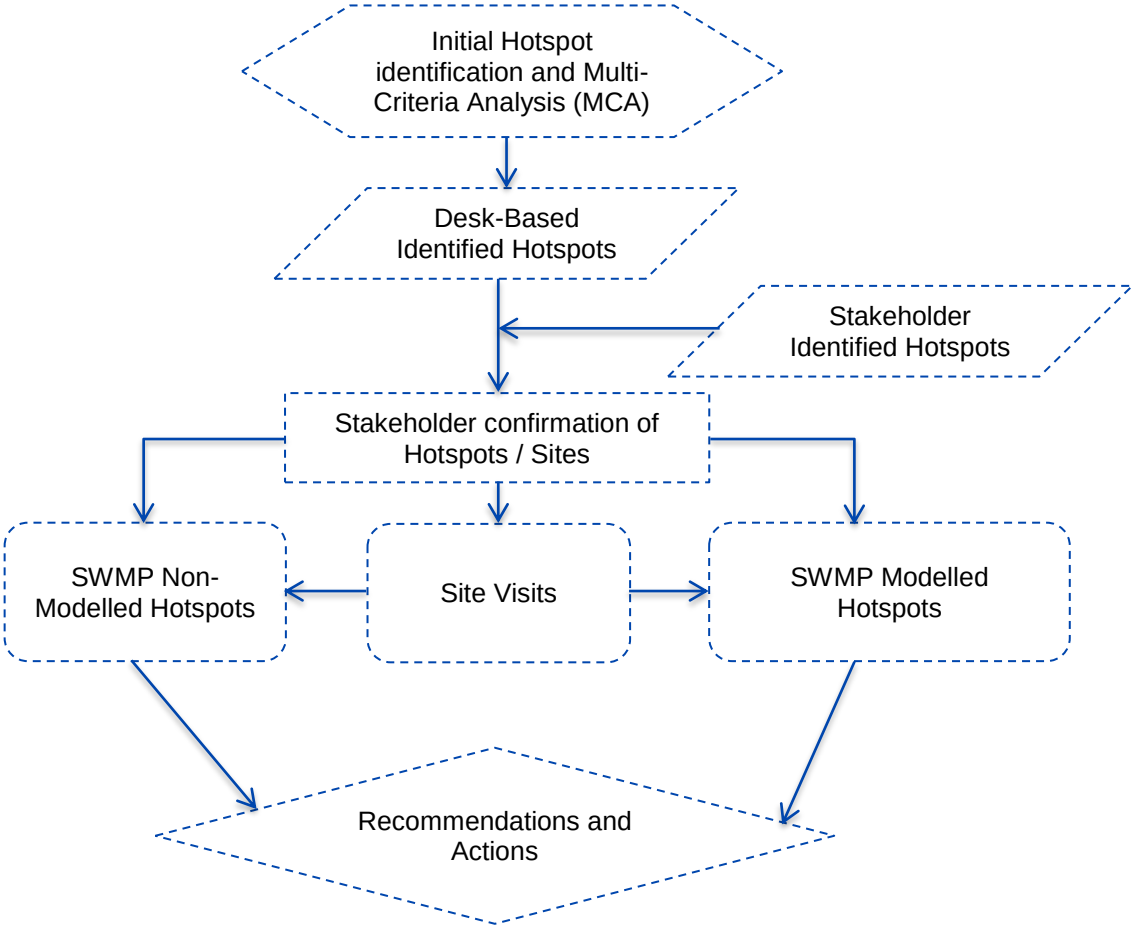

Figure 2: Hotspot Selection Process

2.1.4 Following stakeholder input, the Desk-Based Identified Hotspots and Stakeholder Identified Hotspots were assessed in combination, and the need for on-site assessments was identified; subsequently site visits were undertaken. Following the site visits, hotspots were assessed again and divided into SWMP Modelled and SWMP Non-Modelled Hotspots. SWMP Modelled Hotspots are those to be taken forward for detailed hydraulic modelling. Recommendations and Actions will be identified for all SWMP Modelled Hotspots, it is therefore anticipated that the majority of the Recommendations and Actions will be identified as a result of the detailed hydraulic modelling. However, Recommendations and Actions may also be identified for a number of SWMP Non-Modelled Hotspots.

2.1.5 Reasons for not modelling a hotspot include:

- The hotspot has already been extensively investigated, or is due to be investigated as part of current or planned works (by one or more of the stakeholders);
- The benefits from any further work would not be proportionate to the scale of the issue;
- The site visit confirmed that the surface water flow paths within the hotspot are well represented by current models and/or the Risk of Flooding from Surface Water map;
- Likely recommendations and actions would not have the potential to secure sufficient capital funding (Flood Defence Grant in Aid (FDGiA), Local Levy or third party contributions) to reduce flood risk;
- During the Initial Hotspot identification and MCA, the Desk-Based Identified Hotspots were ranked. If a hotspot ranked too low, it was not included in this round of assessment;
- The hotspot has already secured capital funding.

2.1.6 It should be noted that **all** hotspots identified through this process will be mapped within the SWMP, with the GIS layer information provided to HCC. This will allow periodic re-assessment and review (e.g. when making decisions regarding funding or post flooding). This re-assessment and review would likely involve looking again at the hotspots to see if there is any potential to reduce flood risk.

2.2 SWMP MODELLED HOTSPOTS

2.2.1 SWMP Modelled Hotspots will require some degree of hydraulic modelling to provide a greater understanding of the current flood mechanisms, pathways and receptors within the hotspot. The aim of this is to develop, where possible, a potential mitigation solution which is community focused and feasible in terms of funding and sustainability.

2.2.2 As part of this SWMP, Hertfordshire County Council (HCC) have requested five modelled hotspots are investigated in detail (detailed hydraulic modelling is undertaken) within the Borough of Broxbourne.

2.2.3 The SWMP Modelled Hotspots will be selected from the hotspots listed within this Hotspot Selection Technical Note. As part of the hotspot selection process a number of factors influence the decision to progress a hotspot to the detailed modelling stage, these factors can include one or more of the following:

- The accuracy to which the current modelled flood extents (e.g. from the Risk of Flooding from Surface Water map) are represented;
- Site specific risks (e.g. details including surface water infrastructure, threshold levels, on site flow paths) that cannot be assessed as part of a desk based study;
- Potential for economically, sustainable and environmentally beneficial mitigation options to be derived and promoted;
- Potential sites where options identified could meet the criteria for funding from the Flood Defence Grant in Aid[1] (FDGiA) programme; and those sites which could be potentially brought forward in the short to medium term by other stakeholders through local funding;
- The level of additional ancillary works needed to facilitate any future hydraulic modelling/assessment;
- Progressing will provide an evidence base for HCC as Lead Local Flood Authority (LLFA) and the Local Planning Authority (LPA) to help inform future development decisions.

2.2.4 This Technical Note is the hotspot selection stage of the SWMP, not all sites explained in this note will be taken forward for further modelling. In addition, this Technical Note does not quantify the hydraulic modelling required, as this is still dependent on the receipt of available data from stakeholders and the extent of topographical surveys required for each location.

2.3 SWMP NON-MODELLED HOTSPOTS

2.3.1 If a Desk-Based Identified Hotspot or a Stakeholder Identified Hotspot does not meet the requirements of a SWMP Modelled Hotspot; it is not suitable to be taken forward for further assessment or it is not possible to undertake detailed hydraulic modelling, then it will be classified as a SWMP Non-Modelled Hotspot. For a SWMP Non-Modelled Hotspot a potential sustainable mitigation solution or further study recommendation, if applicable, will be promoted through the SWMP (and included as part of the Recommendations and

[1] Flood Defence Grant in Aid (FDGiA) funding is the mechanism through which the Environment Agency funds flood defence measures in England and Wales. Funding is based on the how much public benefit a project will have, e.g. economic value, how many households are better protected from flooding and the amount of environmental/habitat improvements are gained. As such, areas of land which do not meet the above criteria and are unable to demonstrate they meet the FDGiA criteria would be unable to secure funding, without substantial third party contributions. These include both undeveloped areas such as farmland and developed areas such as car parks.

Actions). This will ensure that any recommendations and actions are recorded for future reference and future funding can be focussed accordingly if appropriate.

2.3.2 A SWMP Non-Modelled Hotspot will also include hotspots where there is potential for works to be undertaken by HCC and/or other Risk Management Authorities (RMAs) to alleviate flooding without the need for detailed hydraulic modelling. This includes using Property Level Protection (PLP) measures, changes to current practices and readily implementable mitigation solutions, such as a change in maintenance regime, new manholes or gully installations, or for example highway flow control and restrictions such as raised kerbs or speed humps. These kinds of recommendations and actions will be things that can be implemented without further study or need to go through large financing or funding arrangements.

2.3.3 SWMP Non-Modelled Hotspots will not be economically assessed as part of the SWMP but will be included in the final SWMP report with associated recommendations and actions.

3 HOTSPOT SELECTION METHODOLOGY

3.1.1 The potential hotspots were selected as part of a phased approach, as follows:

- Phase 1 – Dataset and location review (by an experienced hydrologist);
- Phase 2 – (a) Initial Assessment and (b) Multi-Criteria Analysis (GIS and Excel based);
- Phase 3 – Stakeholder discussions and site visits;
- Phase 4 – Hotspot selection process (by an experienced hydrologist).

3.1.2 The first phase involved reviewing a range of technical datasets (GIS based information) available from Hertfordshire County Council (HCC), the Environment Agency (EA) and the Water and Sewerage Company (WaSC) servicing the borough, which for the Borough of Broxbourne is Thames Water Utilities Ltd (TWUL).

Phase 1 – Dataset and location review

3.1.3 The data was reviewed by an experienced hydrologist familiar with the relevant flooding mechanisms and SWMP assessments and mitigation designs. The datasets used from the aforementioned stakeholders were:

- Borough of Broxbourne boundary;
- OS MasterMap data and background mapping;
- Environment Agency's National Receptor Database (NRD);
- Environment Agency's Main River network;
- Environment Agency's Risk of Flooding from Surface Water map (High (3.33 % AEP, 1 in 30 year), Medium (1% AEP, 1 in 100 year) and Low (0.1% AEP, 1 in 1,000 year) extents);
- Environment Agency's Flood Map for Planning (Flood Zone 2 & 3);
- Environment Agency's Historic Flood Map;
- Index of Multiple Deprivation (IMD) (2010);
- Lower Super Output Area (LSOA) boundaries.

Phase 2 – (a) Initial Assessment

3.1.4 The Environment Agency's National Receptor Database (NRD) was combined with the underlying OS MasterMap layer. This created a spatial receptor layer with information on each "Receptor Type" such as "DWELLING" or "POST OFFICE" etc.

3.1.5 Each receptor was also combined with deprivation data using the Indices of Multiple Deprivation (IMD) (2010) dataset and the associated Lower Super Output Areas (LSOAs).

The LSOAs are areas with a population of 1,000 – 3,000, the boundaries are available online. In the IMD, higher deprivation scores indicate more deprived areas and from this deprivation score the national deprivation rank is determined. Within this initial assessment process, the deprivation score is applied to each receptor within the score's administrative area, hence all receptor types have deprivation scores associated with them. The deprivation scores were only taken into account when assessing the residential receptors.

3.1.6 Each receptor was updated with its maximum probability flood extent for fluvial, surface water and historic flooding sources. An example slice of data is shown in Table 1.

Table 1: Example Receptor Data

RECEPTOR TYPE	FLOOD ZONE	RISK OF FLOODING FROM SURFACE WATER	HISTORIC FLOOD MAP	LOWER SUPER OUTPUT AREA (LSOA) DESCRIPTION	INDEX OF MULTIPLE DEPRIVATION (IMD) SCORE	RANK
DEPOT	3	1,000	YES	Broxbourne 002D	20.23	13,818
ELECTRICITY SUB STATION	2	1,000		Broxbourne 003A	12.61	20,830
PLAYING FIELD	2	30	YES	Broxbourne 010B	9.83	24,243
DWELLING	2	100		Broxbourne 006D	30.02	8,185

3.1.7 The OS MasterMap polygons associated with the records shown in Table 1 were converted to points and plotted as density. This allowed clusters of point receptors at risk of flooding to be symbolised and hotspots developed from this.

3.1.8 The analysis was iterative with the first instance producing five hotspots within the Borough of Broxbourne. Through subsequent analysis the hotspot sizes were reduced and the number of hotspots analysed increased. The second analysis produced eight hotspots and this was increased to 19 hotspots within the Borough of Broxbourne that were taken forward as part of the Desk-Based Hotspots brought to the stakeholder meeting.

3.1.9 In each iteration of analysis the selected hotspots were analysed in Excel using the Multi-Criteria Analysis (MCA) methodology detailed in Section 4.

4 HOTSPOT ANALYSIS – MULTI-CRITERIA ANALYSIS (MCA)

Phase 2 – (b) Multi-Criteria Analysis

4.1.1 The Multi-Criteria Analysis (MCA) conducted and described below was developed during the Watford and St Albans SWMP updates and refined during the development of the North Hertfordshire and Dacorum SWMPs. This MCA was undertaken on all Desk-Based Identified Hotspots (where Stakeholder Identified and Desk-Based Identified Hotspots coincided, MCA was also undertaken).

4.1.2 The MCA has been developed based on the principles from the Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal (Multi-Coloured Manual, 2013).

4.1.3 The MCA was used to assess the impacts of flooding on each hotspot and provide measurements to the prioritisation of hotspots.

4.1.4 Using the Receptor Type information from the National Receptor Database (NRD) dataset, buildings were assessed based on Residential or Non-Residential classes. This was further supplemented by Listed Buildings, Roads and Rail networks within each hotspot.

4.1.5 As there were some receptors within the NRD dataset which had no assigned receptor type (these were blank in the original dataset), an assumption was made as to their designation using the logic flow chart shown in Figure 3.

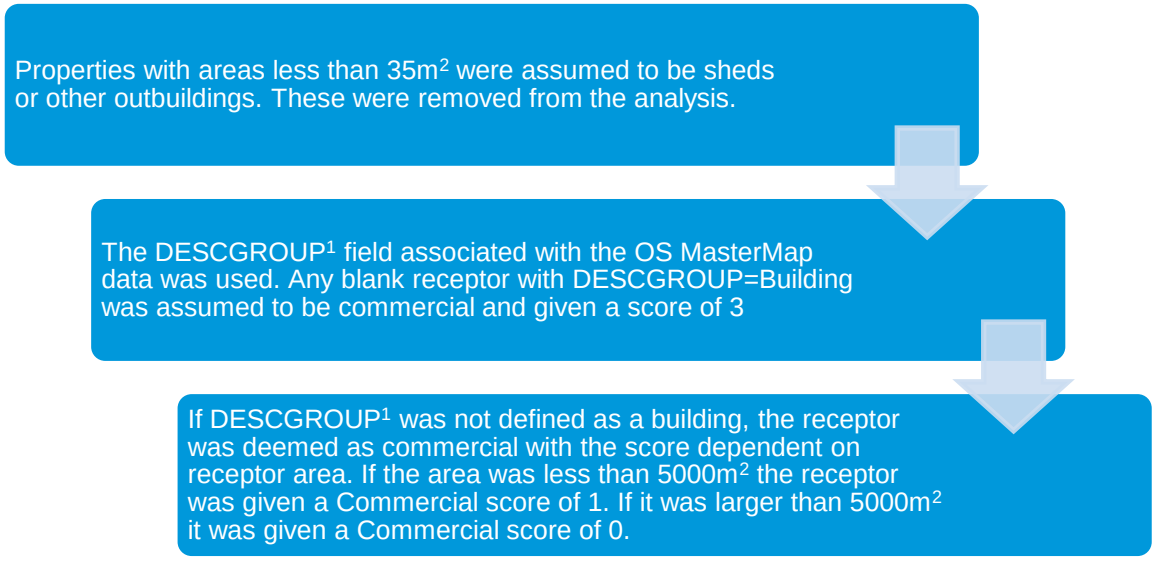

Figure 3: Logic Flow Chart – Assessing Missing Receptor Type[2]

4.1.6 Residential and Non-Residential receptors were separated out and scored based on the criteria outlined in Table 2. The score was assigned to each individual receptor and summed for Residential and Non-Residential receptors for each hotspot.

4.1.7 During the initial analysis of the data, it was deemed that the large fluvial Flood Zone 2 and 3 extents across the Borough of Broxbourne were skewing results in favour of hotspots with large numbers of properties located within Flood Zone 2 or 3. Flooding from Main

[2] The DESCGROUP (Descriptive Group) is an attribute of the OS MasterMap data. It is used to theme the map data. The 'Building' Descriptive Group describes all buildings excluding glasshouses. More information can be found in the OS MasterMap Topography Layer User Guide Chapter 4 located at https://www.ordnancesurvey.co.uk/docs/user-guides/os-mastermap-topography-layer-user-guide.pdf

Rivers is outside the scope of the SWMP therefore to compensate for this, Residential and Non-Residential receptors were removed where they were not located within a surface water flood extent. Where a receptor was located within a surface water flood extent, the Flood Zone / Historic flood extent data was analysed.

4.1.8 For the Road areas and Rail lengths located within fluvial Flood Zones or Historic Flood Map extents these were disregarded from the analysis. Only the area/length within Risk of Flooding from Surface Water map extents was analysed.

Table 2: Receptor Type and Scoring Values

RECEPTOR TYPE		SCORING VALUE		
		1	3	9
Residential		60% Least Deprived	20-40% Most Deprived	20% Most Deprived
Non-Residential	Commercial	Retail Buildings	Warehouses & Offices	Industrial Buildings
	Critical Infrastructure	Hospitals, Hotels, Prisons, Residential homes etc.	Fire/Ambulance/Police Station	Electrical/sewage infrastructure etc.
	Educational, Cultural or Civic Buildings	Schools / Colleges Universities / Nurseries / Museums and Libraries	Churches	Community Centres / Village Halls / Law Courts etc.
Listed Buildings		n/a	n/a	n/a
Road		All Other	B Roads	Motorways / A Road
Rail		All rail tracks	n/a	n/a

4.1.9 The six flood extents used in the analysis are shown in Table 3. Each of the six flood extent types carries an associated weighting value, this was used to ensure priority was given to the highest probability flooding mechanism, these being the Risk of Flooding from Surface Water map 3.33% AEP (1 in 30 year) extent or in Flood Zone 3 (greater than 1% AEP, 1 in 100 year) extent. These extents are associated with the highest probability / highest frequency flooding and therefore relate to the most damage and greatest impact on people's lives. Therefore, they were considered the most important surface water and fluvial flood mechanisms.

4.1.10 Within each hotspot, a total count of the number of receptors affected by each flood extent was made. The total count was multiplied by the flood extent weighting (see Table 3). Flooding Index was calculated by summing the number of properties within each extent and multiplying by that extent's weighting.

$$\text{Flood Impact Score} = \frac{\text{Flooding Index} \times \text{Priority Scoring}}{\text{Hotspot Area}}$$

4.1.11 The Flood Impact Score was calculated using the above formula. The Flooding Index × Priority Scoring was divided by the Hotspot Area to ensure that larger urban areas did not dominate the analysis. Dividing by hotspot area ensured that the Flood Impact Score for each hotspot (no matter the hotspot's size) was comparable.

4.1.12 Data from Hotspot 62 – Rosedale North – Flamstead End has been included in Table 3 to provide an illustrative example.

Table 3: Flood Extents and Weightings (including example data from Hotspot 52 – Cheshunt)

FLOOD EXTENT	FLOOD EXTENT WEIGHTING APPLIED	EXAMPLE RESIDENTIAL COUNT DATA FROM HOTSPOT 52 – CHESHUNT	FLOODING INDEX (FLOOD EXTENT WEIGHTING × RESIDENTIAL COUNT)
No. of receptors in Flood Zone 2	0.1	35	3.5
No. of receptors in Flood Zone 3	0.25	1	0.25
No. of receptors in Risk of Flooding from Surface Water (3.33% AEP, 1 in 30 year)	0.25	14	3.5
No. of receptors in Risk of Flooding from Surface Water (1% AEP, 1 in 100 year)	0.15	66	9.9
No. of receptors in Risk of Flooding from Surface Water (0.1% AEP, 1 in 1000 year)	0.05	346	17.3
No. of receptors in Historic Flood Map	0.2	35	7
		Sum of Flooding Index:	41.45
		Sum of Residential Scoring (Priority Scoring):	710
		Hotspot Area (ha):	72.1
		Flood Impact Score:	408.1

4.1.13 The Road and Rail receptors were analysed on the area of road or length of rail track within the flood extent.

4.1.14 For the Road receptors, the Flooding Index was obtained in a similar way to that of the Residential and Non-Residential receptors. For each hotspot, the total area of road within each flood extent was multiplied by the same weightings (for the flood extents) shown in Table 3.

4.1.15 To calculate the Priority Scoring for each hotspot, the total road area for each class of road was summed and multiplied by the scoring value given in Table 2. This weighted the Road receptor score to hotspots with large areas of main roads flooded. Example Road data is shown in Table 4.

4.1.16 As can be seen in Table 4, there was typically less than 1ha of road area within each road class and flood extent. Therefore, flooding was assessed on a m^2 basis rather than hectare flooded basis. As discussed below, the analysis between hotspots is based on it's ranking therefore as long as units are consistent within each receptor type, the ranking will not be affected.

4.1.17 The same methodology, as that for roads, was used for the Rail receptors, calculating the length of rail (as opposed to area of road) within each flood extent within each hotspot (and weighted for each flood extent accordingly, as it was for buildings and roads). The Scoring Value used for Rail receptors was 1 (see Table 2).

Table 4: Hotspot 52 – Cheshunt Example Roads Data

ROAD CLASS	ROAD AREA FLOODED (m^2) RISK OF FLOODING FROM SURFACE WATER (3.33% AEP, 1 IN 30 YEAR)	RISK OF FLOODING FROM SURFACE WATER (1% AEP, 1 IN 100 YEAR)	RISK OF FLOODING FROM SURFACE WATER (0.1% AEP, 1 IN 1,000 YEAR)	TOTAL AREA OF EACH ROAD CLASS IN FLOOD EXTENT (m^2)	SCORING VALUE (FROM TABLE 2)	WEIGHTED SCORE
A Road	113.4	3,380.2	7,849.3	11,342.9	9	102,086.1
B Road	682.0	5,498.7	4,070.6	10,251.3	3	30,753.9
Local Street	2,780.5	4,999.1	14,328.3	22,107.9	1	22,107.9
Minor Road	937.3	2,529.5	3,275.5	6,742.3	1	6,742.3
Private Road – Restricted Access	0.0	259.7	744.5	1,004.2	1	1,004.2
Total Area of road in each flood extent (ha):	4,513.2	16,667.2	30,268.2		**Sum of Road Scoring (Priority Scoring):**	162,694.4
Flood Zone Weighting:	0.25	0.15	0.05			
Flooding Index (Weighting × Total Road Area)	1,128.3	2,500.1	1,513.4		**Sum of Flooding Index:**	5,142
					Hotspot Area (m^2):	721,130
					Flood Impact Score:	1,160

When all Flood Impact Scores had been calculated, the Flood Impact Score for each receptor type was ranked from low to high with high ranking hotspots having the greatest scores. The ranks were then multiplied by an Importance Factor to gain a weighted rank. The weighted ranks were then summed together across Receptor Types for each hotspot to obtain the "Total Risk Ranking." Hotspot 52 is provided as an example below in

4.1.18 Table 5.

Table 5: Receptor Type and associated Importance Factor (Example data provided for Hotspot 52 – Cheshunt)

RECEPTOR TYPE	FLOOD IMPACT SCORE	RANK	IMPORTANCE FACTOR	WEIGHTED RANK
Residential	408.1	16	10	160
Non-Residential	8.32	14	7	98
Listed Buildings	0	1	1	1
Roads	1,160	18	3	54
Rail	0	1	2	2
	Un-weighted Hotspot score:	50	**Total Risk Ranking Weighted Hotspot score:**	315

5 MULTI-CRITERIA ANALYSIS (MCA) RESULTS

5.1.1 The top five hotspots from the Multi-Criteria Analysis (MCA) are shown in

5.1.2 Table 6.

Table 6: Total Risk Ranking – Top Ranked Hotspots

HOTSPOT NUMBER*	HOTSPOT NAME	UN-WEIGHTED HOTSPOT SCORE**	TOTAL RISK RANKING WEIGHTED HOTSPOT SCORE
9	Rye House/North Hoddesdon	74	397
55	Cozens Lane East, Wormley	85	394
56	Broxbourne town	80	341
50	South Waltham Cross	65	332
52	Cheshunt	50	315

* Note: Each hotspot was assigned a number across the Borough of Broxbourne (and East Hertfordshire District as these were assessed concurrently). The Hotspot Number just corresponds to the assigned hotspot, GIS polygon number/ID, and does not have any reference to the hotspot ranking.

6 STAKEHOLDER MEETING AND SITE VISITS

Phase 3 – Stakeholder discussions and site visits

6.1.1 In addition to the GIS and Excel review detailed in the previous sections, parish councils and Broxbourne Borough Council were contacted to put forward their knowledge of surface water historical flooding, in order to inform the process of selecting SWMP Modelled Hotspots. Any hotspots stakeholders put forward were termed "Stakeholder Identified Hotspots." The information provided by stakeholders was cross referenced with the emerging hotspots selected as part of the Phase 1 and Phase 2 works and discussed further at the stakeholder meeting.

6.1.2 A stakeholder meeting was undertaken on 15th May 2015 to discuss the outcome of the Desk-Based hotspot analysis (GIS and MCA), with the additional aims to share information and flooding knowledge on issues within the Borough of Broxbourne. This included reviewing the hotspots analysed by the MCA within the Borough of Broxbourne, discussing where they ranked and their potential as SWMP Modelled Hotspots, in addition to identifying any high level recommendations and actions at this initial stage.

6.1.3 The suggested approach determined by WSP | Parsons Brinckerhoff was also discussed along with any existing and previous studies conducted by stakeholders.

6.1.4 Following a review of the Stakeholder Identified Hotspot sites raised during the meeting, site visits were subsequently conducted at a number of locations on 4th June 2015. The primary aims of the site visits were to:

- Assess on site the land elevation and topographical changes.
- Understand if the site met the criteria detailed in Section 2 for a SWMP Modelled or SWMP Non-Modelled Hotspot.
- If the hotspot visited was considered to meet the criteria for a SWMP Modelled Hotspot, then to gain an understanding of the most appropriate modelling approach.
- Understand if there were any immediate recommendations and actions identified for the site.

6.1.5 This all led onto Phase 4 – Hotspot selection process, which is detailed in Section 7 and 8.

7 SWMP MODELLED HOTSPOTS

7.1.1 This section (Section 7) identifies the proposed SWMP Modelled Hotspots for the Borough of Broxbourne. These have been put forward for modelling as they meet the criteria for a SWMP Modelled Hotspot as detailed in Section 2.

7.2 HOTSPOT 9 – RYE HOUSE / NORTH HODDESDON

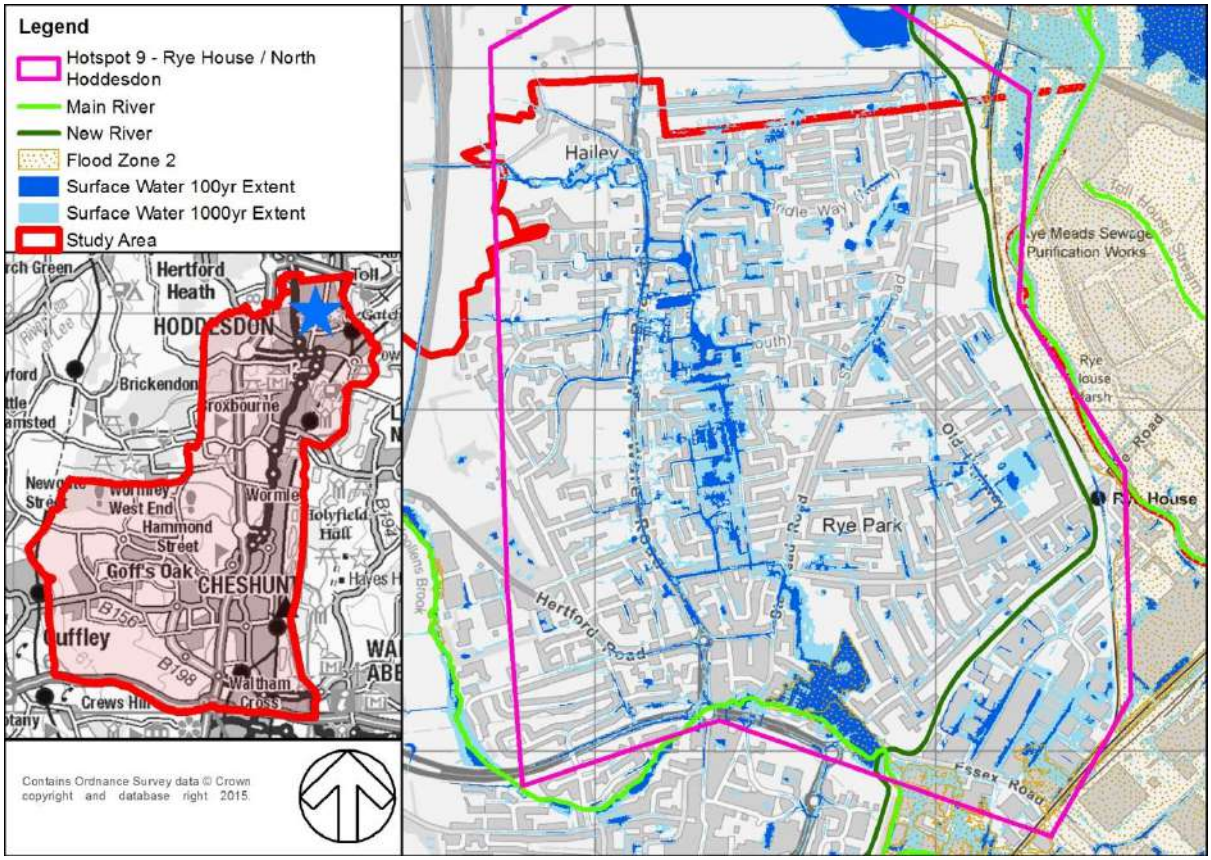

Figure 4: Hotspot 9 – Rye House / North Hoddesdon

KEY ISSUES

- Flat catchment;
- Surface water flow route through the central residential area;
- Fluvial flooding from the Woollens Brook (Main River), shown by the Flood Zone 2 and the green line representing Main River along the southern hotspot boundary.

SUGGESTED APPROACH

- Consideration of flood storage in the park land in the south of the hotspot;
- Consideration of kerb heights, highway water management (speed humps) and property level protection (PLP) in the northern and central residential parts of the hotspot.

LOCAL KNOWLEDGE/SITE VISIT OBSERVATIONS

- The preferential flow paths and key areas of inundation within the residential areas on the Risk of Flooding from Surface Water map were observed during the site visit.

- Surface water flooding is shown to be largely constrained to the highway network at shallow depths in the northern parts of this hotspot in the 1% AEP event. If flooding is constrained to the highway network, it would therefore not be expected to cause significant impact to properties in this area, though would cause indirect impact through impeded access. Including the existing surface water drainage network in a hydraulic model of this area could potentially reduce the current surface water flood extents as shown in the Risk of Flooding from Surface Water map.
- The park area in the south of the hotspot was also assessed on site to investigate the possibility of providing flood storage for the purpose of attenuating local surface water flooding in this area. The park is partially located within an existing fluvial Flood Zone extent meaning that any proposed mitigation is at risk of altering the existing fluvial conditions. The Flood Zone 2 map was confirmed during the site visit when assessing the local topography. As a result of this, any proposed mitigation would be limited to smaller areas of the park; areas outside Flood Zone 2 (which may limit capacity). Any flood storage area may impact on the amenity value of the park; though above ground flood storage areas (depending on the size) can be landscaped to be more in keeping with the local area and amenities.

AGREED APPROACH

- Discussions were had on the utility of undertaking detailed hydraulic modelling in this area. During the site visit it was identified that surface water flow routes in the northern areas of this hotspot would be confined to the highway in the 1% AEP event. As surface water flows towards the south, the surface water flood map is less well defined and would benefit from more detailed modelling. The numbers of residential properties within the surface water flow routes in the larger 0.1% AEP event across the central area of this hotspot, in addition to this hotspot ranking first in the GIS and MCA analysis justified undertaking detailed hydraulic modelling for this hotspot.
- The aim of detailed hydraulic modelling would be to provide a greater degree of certainty in the surface water flood extents. This would be achieved by including the surface water sewer drainage network within the model. This greater degree of certainty would be beneficial for this hotspot site, and aid understanding of surface water flooding in this area in the future.
- This hotspot is therefore being taken forward as a SWMP Modelled Hotspot.

SITE VISIT PHOTOS

Figure 5: Rye Park – Looking south-westwards

The Risk of Flooding from Surface Water map shows a flow route along the far boundary of the park.

Figure 6: Rye Park - Looking north-westwards

The surface water flow route is along the far side (in front of the buildings) then comes around to the left site of the photo.

7.3 HOTSPOT 52 – CHESHUNT

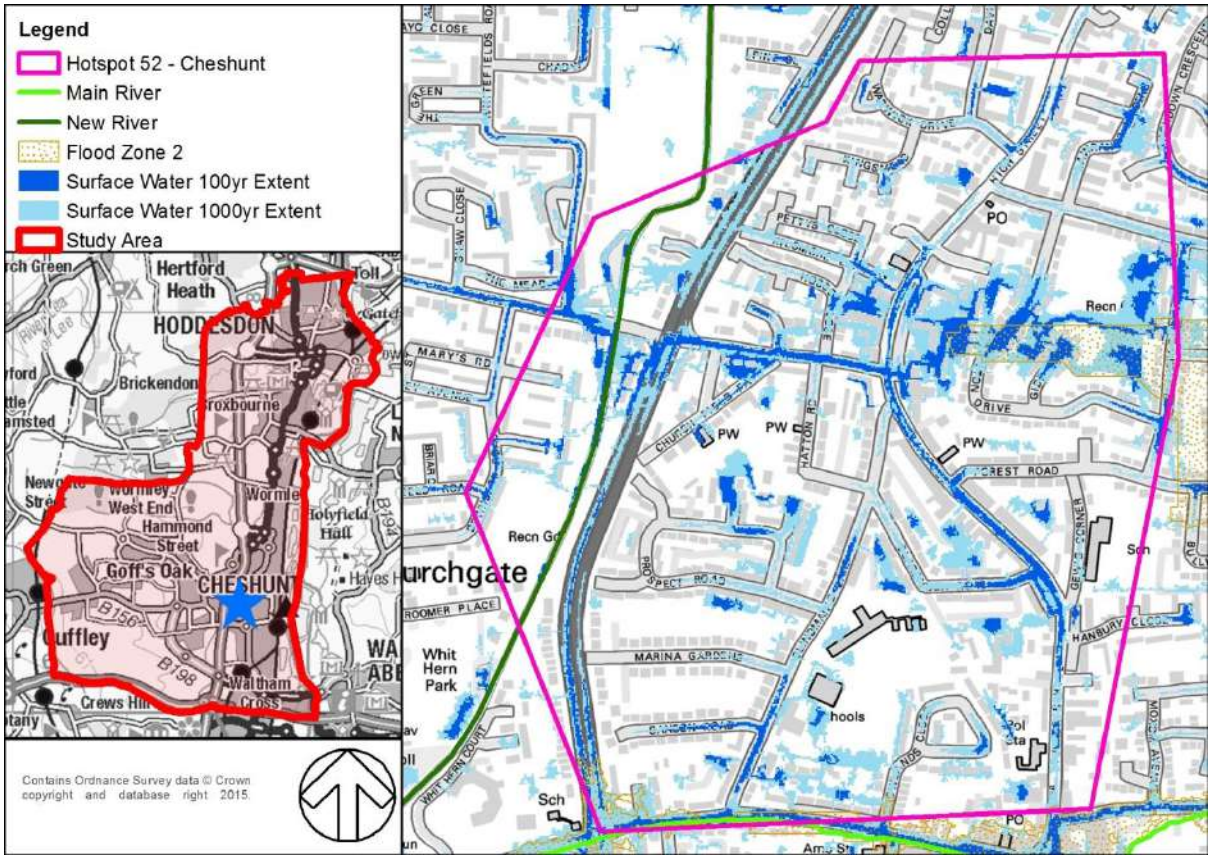

Figure 7: Hotspot 52 – Cheshunt

KEY ISSUES

- The surface water flow path runs eastwards along Church Lane, across the cross road with Great Cambridge Road (A10) and further eastwards towards Church Lane's junction with High Street (B1176) and Turners Hill. It is at this point that the surface water flood water leaves the highway and flows across the residential area towards the Small River Lea or Lee, the River Lee Navigation, River Lee Country Park and marshes.
- Flooding was recorded on 20th June 2015 on College Road on the southern boundary of the hotspot. Main River is located within this area, as shown by the bright green polyline on the southern boundary of the hotspot, in this area it is culverted in part.

SUGGESTED APPROACH

- Hydraulic modelling will include the existing surface water drainage network and the New River (shown by the dark green polyline). This approach will likely result in the site benefitting from a reduced catchment area and resulting in a more accurate flood extent representing multiple flood sources.

LOCAL KNOWLEDGE/SITE VISIT OBSERVATIONS

- The New River is located to the West of the A10, which may result in reductions to the surface water flow paths, as they will be restricted to culverts beneath this watercourse.

AGREED APPROACH

- Take forward as a SWMP Modelled Hotspot. The boundary of this hotspot will be confirmed as part of the Modelling Methodology Technical Note.

7.4 HOTSPOT 55 – COZENS LANE EAST, WORMLEY

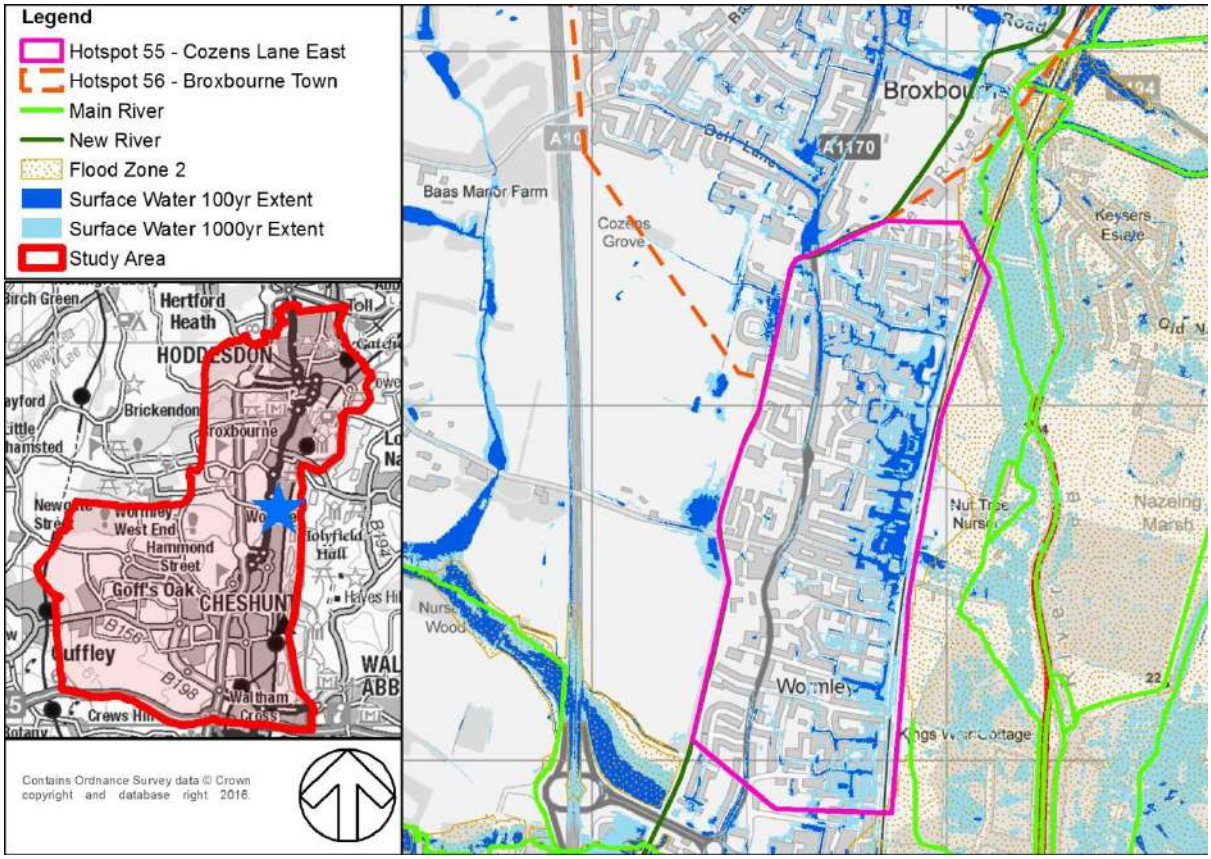

Figure 8: Hotspot 55 – Cozens Lane East, Wormley

KEY ISSUES

- Flow paths on the Risk of Flooding from Surface Water map show flow from the upstream hotspot, Hotspot 56 – Broxbourne Town, into the Cozens Lane East area (Hotspot 55). The existing mapping is considered to be over predicting the flow into the hotspot and not taking into account the cut-off provision of the New River.
- Surface water is shown to pond in the housing estate (and Cozens Lane East) bounded by the railway.

SUGGESTED APPROACH

- Model surface water flow paths accurately from the north, as observed during the site visit. This will involve representing in the model that the New River acts as a cut-off for incoming flows from the north, it was observed on site that there is a steeply arched bridge (High Road Broxbourne, A1170) over the New River, surface water sewers beneath the road and the New River will be accounted for.

LOCAL KNOWLEDGE/SITE VISIT OBSERVATIONS

- New River is a managed aqueduct supplying drinking water to London. On the day of the site visit, the water level was approximately 200-300mm below the top of the bank and there was a steady southerly flow.
- It can therefore be considered that the New River acts as a cut-off drain preventing flows from entering this hotspot (55 – Cozens Lane East) from Hotspot 56 – Broxbourne Town.
- The arch bridge of High Road Broxbourne (A1170) as it passes over the New River will impede flow continuing along the highway into the hotspot.

AGREED APPROACH

→ Take forward as a SWMP Modelled Hotspot with the New River as an upstream boundary limiting overland flows from the adjacent Broxbourne Town hotspot to the north.

SITE VISIT PHOTOS

Figure 9: Cozens Lane East – Near to Wormley Primary School

From site visit observations, any exceedance flow will stay within the road channel on the inside of the bend against the kerb

Figure 10: Cozens Lane East – Culvert under railway near Lammasmead

7.5 HOTSPOTS 62 & 63 – ROSEDALE NORTH & ROSEDALE SOUTH – FLAMSTEAD END

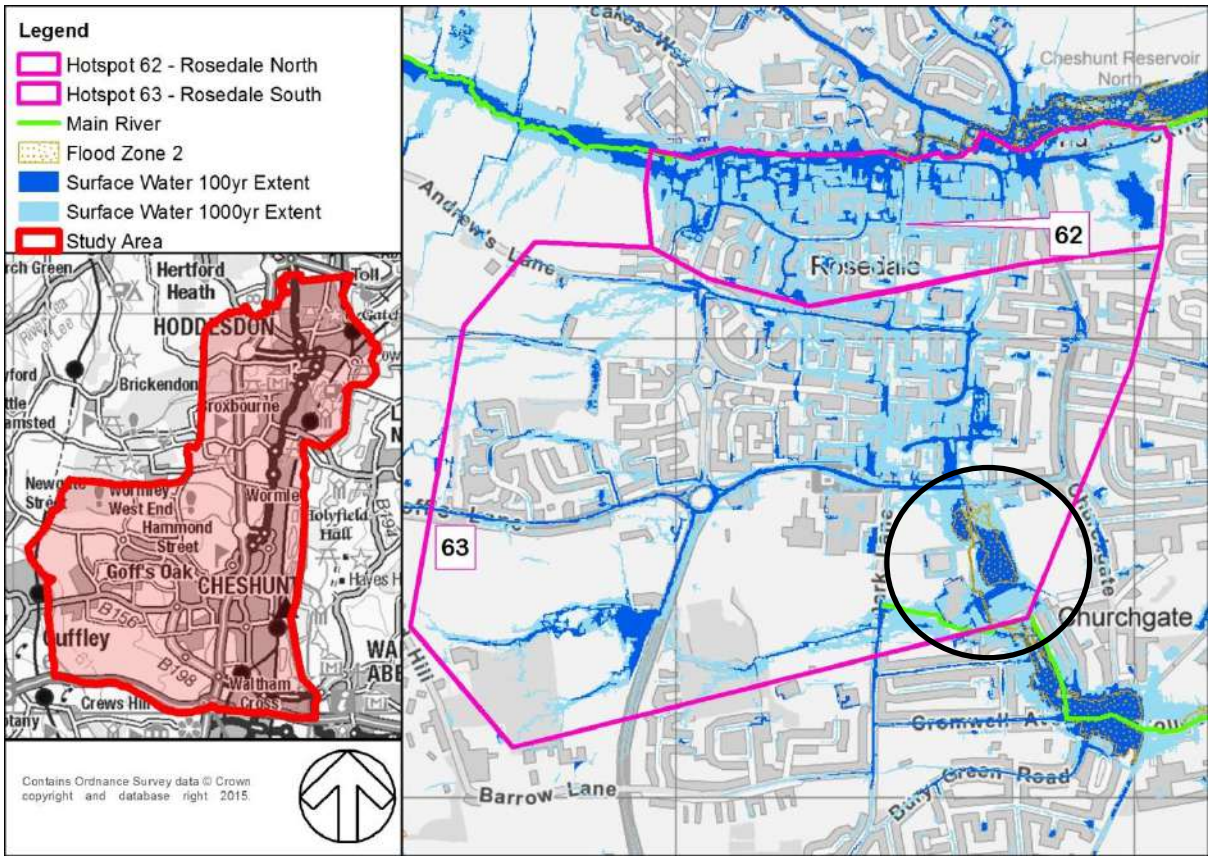

Figure 11: Hotspots 62 and 63 – Rosedale North and Rosedale South, Flamstead End

KEY ISSUES

- The surface water hotspot extends across a relatively flat area, with the Risk of Flooding from Surface Water map demonstrating interaction between the two Main Rivers, Rags Brook to the north and College Brook to the south, with a third preferential flow path in the central area of Hotspot 63.
- Event magnitude, severity and flood depth determine which catchment/hotspot (62 or 63) the surface water drains towards.
- Development is currently proposed in the south east corner of the hotspot in the circled area.

SUGGESTED APPROACH

- Ideal Approach – Obtain existing hydraulic modelling and extend this to incorporate surface water flooding.
- Alternative Approach – Should the Environment Agency not hold a model of the Rags Brook a staged approach is proposed to ensure the modelling and survey can be accommodated within the available budget:

  (1) Stage One: Refine existing maps – This will be undertaken by cutting the Rags Brook (the Main River in the north of the hotspot) into the LiDAR as the majority of the channel is incised. During the site visit Rags Brook was observed to be approximately 2m deep, narrow channel, largely surrounded by trees/other significant vegetation, to the west (though the channel varied in size nearer the more central residential areas). It is highly likely that Rags Brook is not currently included within the current surface water model (used to produce the Risk of Flooding from Surface Water map), in which case

the flood waters shown in the Risk of Flooding from Surface Water map would spill across the land far more frequently and extensively than what is likely to occur in reality.

(2) Stage Two: Review the refined maps – This refined mapping will be reviewed to determine whether this area remains a hotspot. If so discussions will be held with HCC to confirm an appropriate scope and methodology (i.e. determine whether detailed topographical and channel survey is required to facilitate full modelling of the watercourse).

LOCAL KNOWLEDGE/SITE VISIT OBSERVATIONS

- On the site visit, the majority of Rags Brook was observed to be in a well incised channel. In some locations the channel is a deep man made open culvert and in other locations is a more natural shallow channel.
- Observations during the site visit suggested that it is unlikely for flood waters during the smaller surface water events to spill from Rags Brook (the northern Main River) as extensively as shown in the Risk of Flooding from Surface Water map due to the relative depth of the river channel in this location.

AGREED APPROACH

- Take both hotspots forward as a combined SWMP Modelled Hotspot, with specification to be provided following discussions with the Environment Agency. The boundary of these hotspots will be confirmed as part of the Modelling Methodology Technical Note.

SITE VISIT PHOTOS

Figure 12: Rags Brook, Main River

Main River has been incised into channel

Figure 13: Culvert under Rosedale Way

Near Stockwell Lane, looking upstream

Figure 14: Culvert under Rosedale Way

Near Stockwell Lane looking downstream

Figure 15: Culvert under Valence Drive

Figure 16: Rags Brook upstream of Valence Drive

Figure 17: Culvert under Rosedale Way

Near to Fourfields Quantum Care Home. Maintenance work was being conducted on the day of the site visit, grass cutting, channel debris removal etc.

Figure 18: Rags Brook

Upstream of Figure 17, channel is well incised; water level is approx. 1.5m – 2m below top of bank.

Figure 19: Rosedale Way Telemetry Station

Near to Fourfields Quantum Care Home.

Figure 20: Rosedale Way Telemetry Station

Figure 21: Pond to the north of Goff's Lane B156

Opposite playing fields, between Peace Close and Edenvale

Figure 22: Pond to the north of Goff's Lane

Figure 23: Culvert under Goff's Lane from nearby pond

8 SWMP NON-MODELLED HOTSPOTS

8.1 HOTSPOT 49 – CROSSBROOK STREET, CHESHUNT

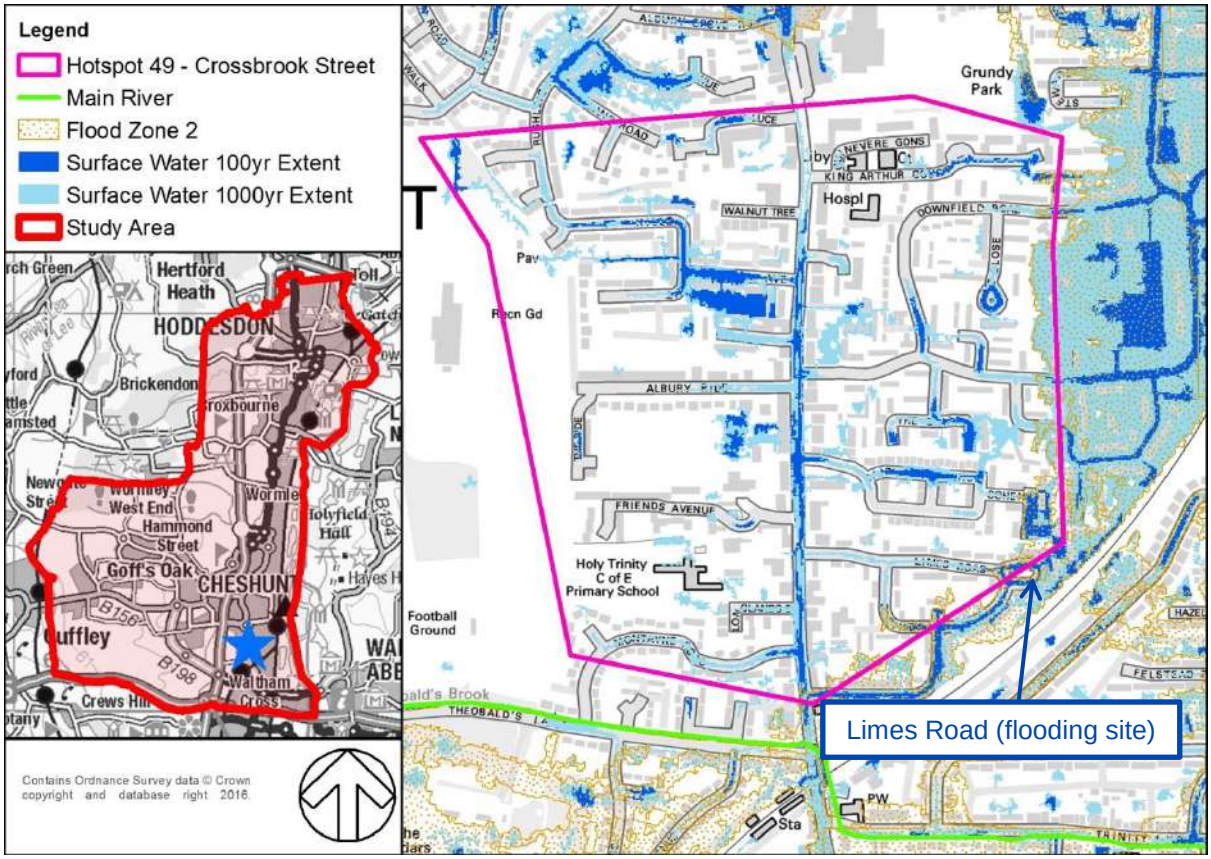

Figure 24 - Hotspot 49 – Crossbrook Street, Cheshunt

KEY ISSUES

- This hotspot was raised by Broxbourne Borough Council due to previous flooding incidents, in particular, the area in Limes Road on the southeast boundary of the hotspot.
- There is a possible culvert running west to east underneath the railway to the east of Limes Road. This culvert is shown on OS data as a watercourse either side of the railway.

SUGGESTED APPROACH

- Increased maintenance of the culvert could aid in preventing surface water runoff ponding to the north and west of the railway.

LOCAL KNOWLEDGE/SITE VISIT OBSERVATIONS

- Site visit was conducted to check for evidence of a culvert running underneath the railway to the east of Limes Road.
- The area to the edge of railway was heavily overgrown with brambles and weeds; any evidence that a culvert exists was obscured by vegetation in this area.
- This area was also heavily residential so any access near to the railway was prevented by residential and garden fencing.

AGREED APPROACH

→ A culvert could not be observed during the site visit. Further works are being undertaken to assess Thames Water and Network Rail Asset information for any possible information on a culvert underneath the railway.

SITE VISIT PHOTOS

Figure 25: Crossbrook Street – To rear of Green Close

Vegetation along the railway embankment obscuring any possible culvert in this location

Figure 26: Crossbrook Street – To rear of Green Close

8.2 HOTSPOT 50 – SOUTH WALTHAM CROSS

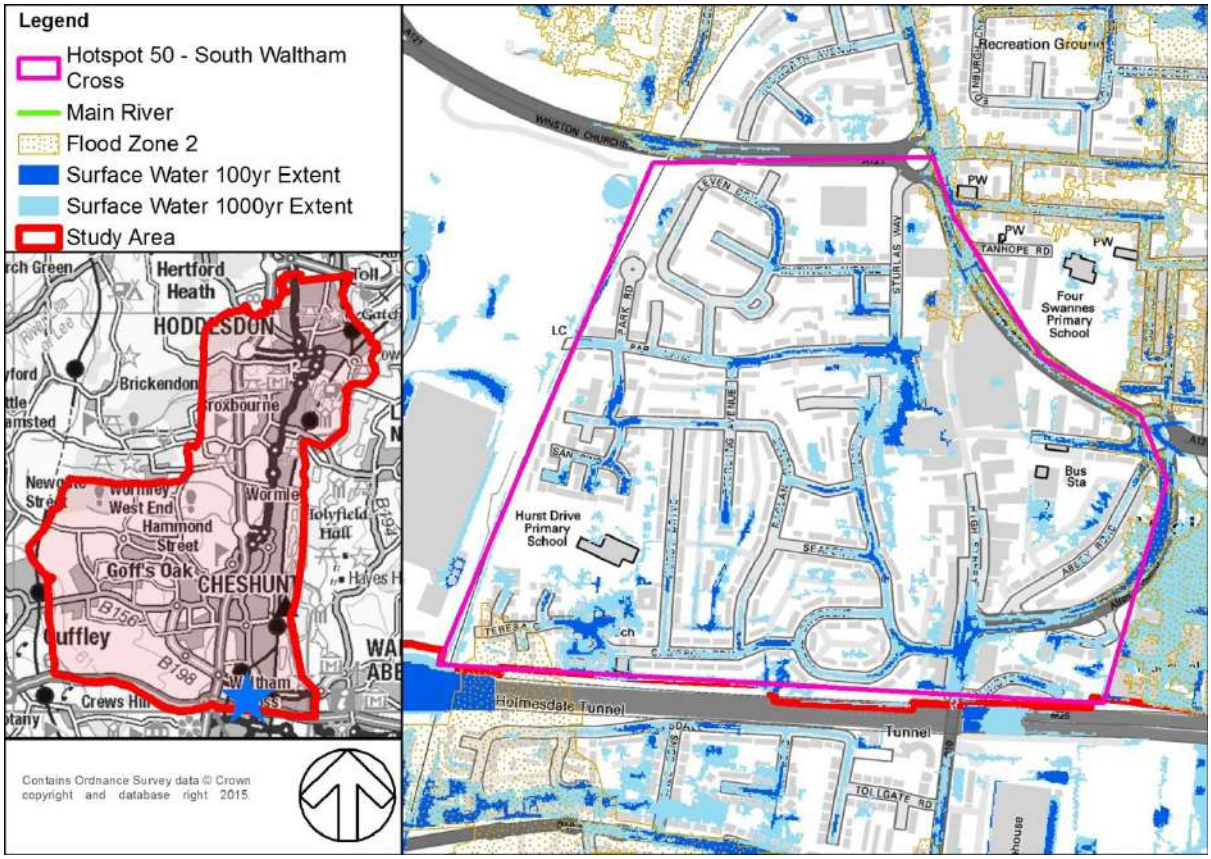

Figure 27: Hotspot 50 – South Waltham Cross

KEY ISSUES

- Lots of isolated areas of surface water ponding with no well-defined flow path through the hotspot.
- This hotspot scored highly due to the influence of deprivation in the priority scoring (during the Desk-Based analysis (GIS and MCA).

SUGGESTED APPROACH

- If this hotspot were to be taken forward for detailed hydraulic modelling, the modelling would include the existing surface water drainage network. This approach would likely result in the site benefitting from the surface water sewer network representation, in addition to identifying potential reductions to the existing surface water flood extents as the flow routes across/around the Holmesdale Tunnel could be incorporated.

LOCAL KNOWLEDGE/SITE VISIT OBSERVATIONS

- No site visit was undertaken.

AGREED APPROACH

- This site has not been recommended for further hydraulic modelling as part of the SWMP process due to much of the flood extents being limited to the highway network or single properties. This means that the benefits of undertaking detailed hydraulic modelling and the potential for the implementation of any resulting mitigation measures are unlikely to be economically viable.

8.3 HOTSPOT 56 – BROXBOURNE TOWN

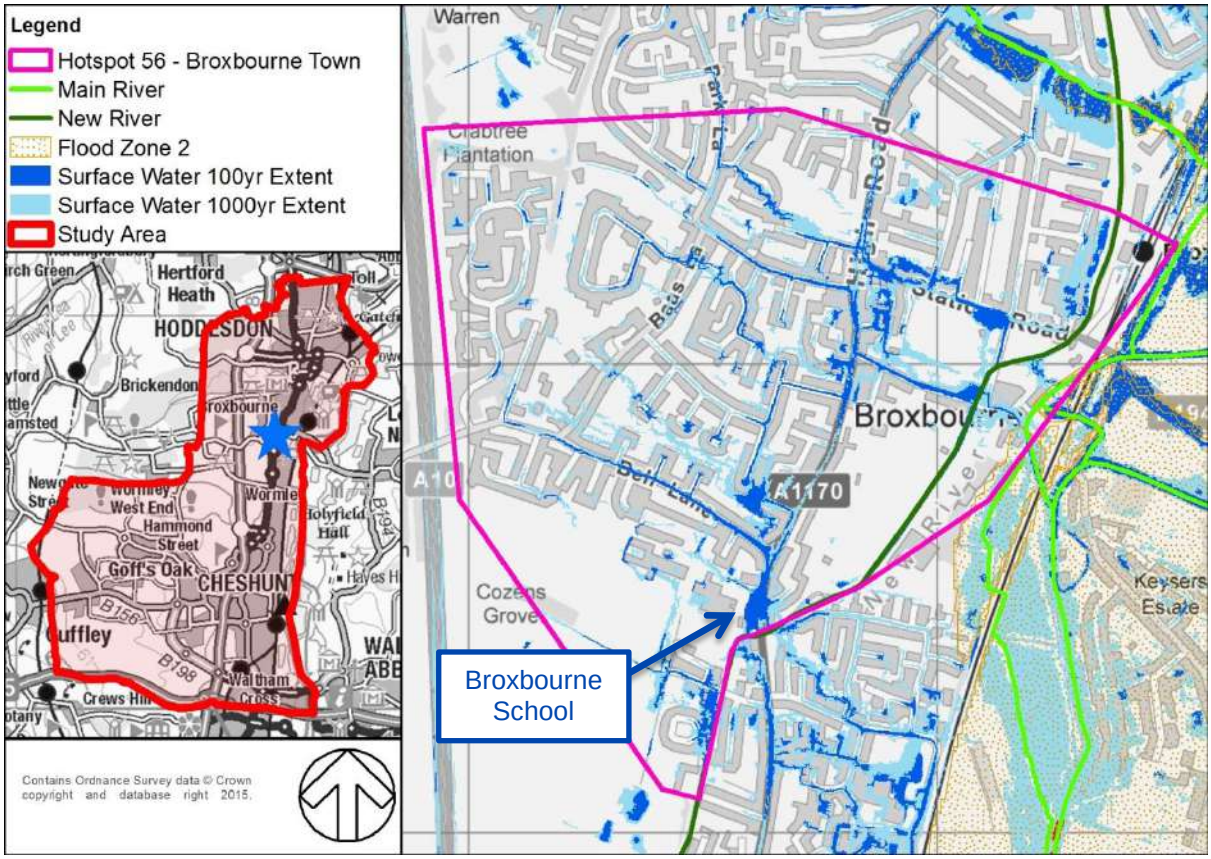

Figure 28: Hotspot 56 – Broxbourne Town

KEY ISSUES

- Significant ponding is shown on the Risk of Flooding from Surface Water maps located around the New River adjacent to Broxbourne School.
- The New River runs through the hotspot and acts as a cut-off drain for any flows draining into it in addition to stopping surface water flow paths flowing south of it.

SUGGESTED APPROACH

- If detailed hydraulic modelling were to be undertaken, we recommend the following approach:
  - Survey of the New River may be required to check levels and inflows into the channel;
  - Following survey, model the flow paths from Bell Lane and check the extent of ponding adjacent to the school.

LOCAL KNOWLEDGE

- The New River is a managed aqueduct supplying drinking water to London. On the day of the site visit, the water level was approximately 200-300mm below the top of the bank and there was a steady southerly flow.
- From the observations on the site visit it is thought that the New River acts as a cut-off drain; bounding surface water flows either side of it.

AGREED APPROACH

- This hotspot won't be taken forward for detailed hydraulic modelling, because further modelling is not thought to improve the current Risk of Flooding from Surface Water map.

- The hotspot doesn't meet the strategic aims of the SWMP; it is not thought any suitable mitigation options will able to be identified or implemented.
- Part of the Risk of Flooding from Surface Water map appears to be within the car park area of Broxbourne School and the highway in front of it. Due to the economic criteria, it would be difficult to secure FDGiA funding to provide mitigation for car park flooding.

SITE VISIT PHOTOS

Figure 29: The New River

View looking upstream up the New River from the arch bridge, where High Road Broxbourne (A1170) crosses the New River.

Figure 30: High Road Broxbourne (A1170) looking northwards towards Broxbourne School

The Risk of Flooding from Surface Water maps show water ponding beyond the trees within this figure.

8.4 HOTSPOT 65 – LONGFIELD LANE, CHESHUNT

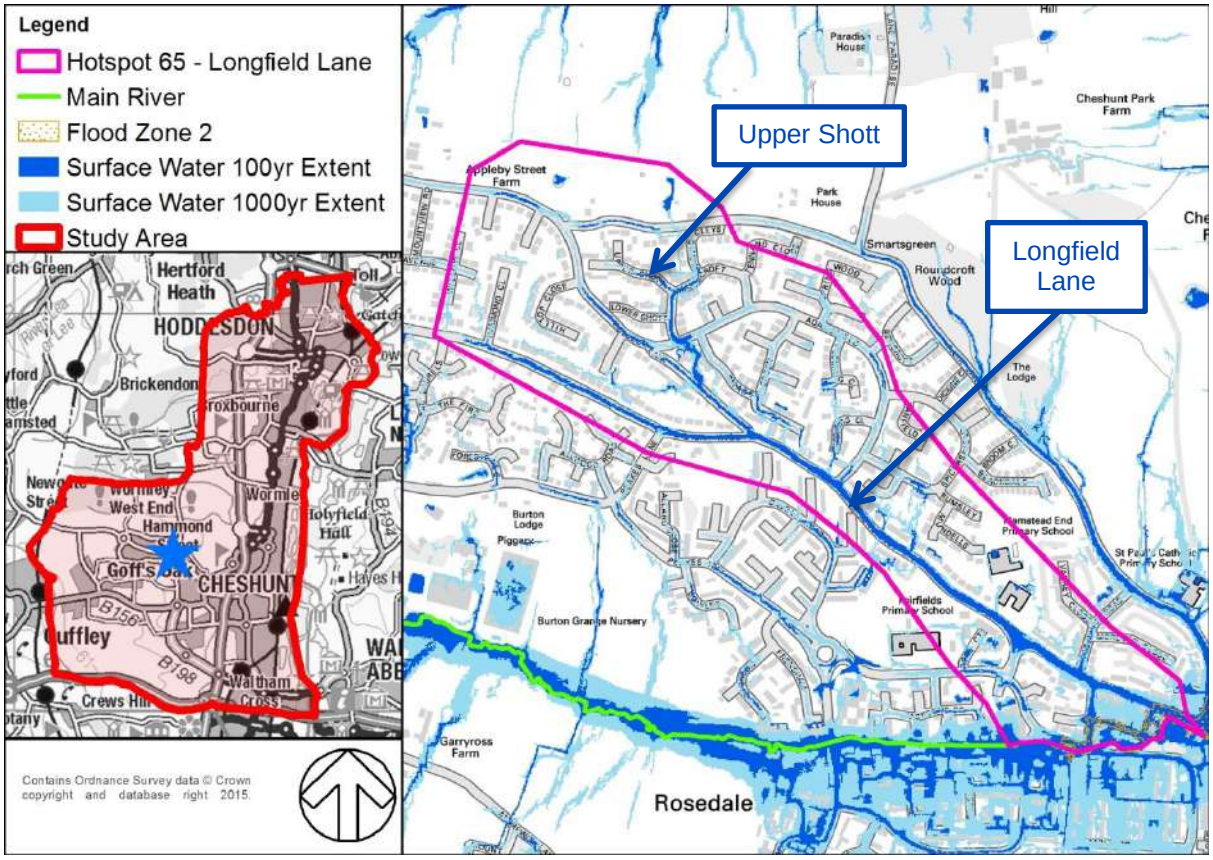

Figure 31: Hotspot 65 – Longfield Lane, Cheshunt

KEY ISSUES

- The primary surface water flow path in this hotspot begins near Upper Shott and flows down the hill and through residential properties and gardens before joining Longfield Lane.
- The Risk of Flooding from Surface Water map suggests that the 1% AEP event is almost exclusively confined to the highway with the exception of the area in the north part of the hotspot.

SUGGESTED APPROACH

- If detailed hydraulic modelling were to be undertaken then we would recommend: consideration of kerb heights, highway water management (speed humps) and property level protection (PLP), alternatively swales or storage measures could be included within the primary school grounds to provide a degree of attenuation.

LOCAL KNOWLEDGE

- From local knowledge there is a ditch/culvert in this area that blocks and then causes excess runoff to flow along the highway.

AGREED APPROACH

- Include in the SWMP as a SWMP Non-Modelled Hotspot with recommendations for an increase in the maintenance schedule for the aforementioned ditch, which could reduce the risk of blockages.

8.5 HOTSPOT 69 – LITTLE GROVE AVENUE, CHESHUNT

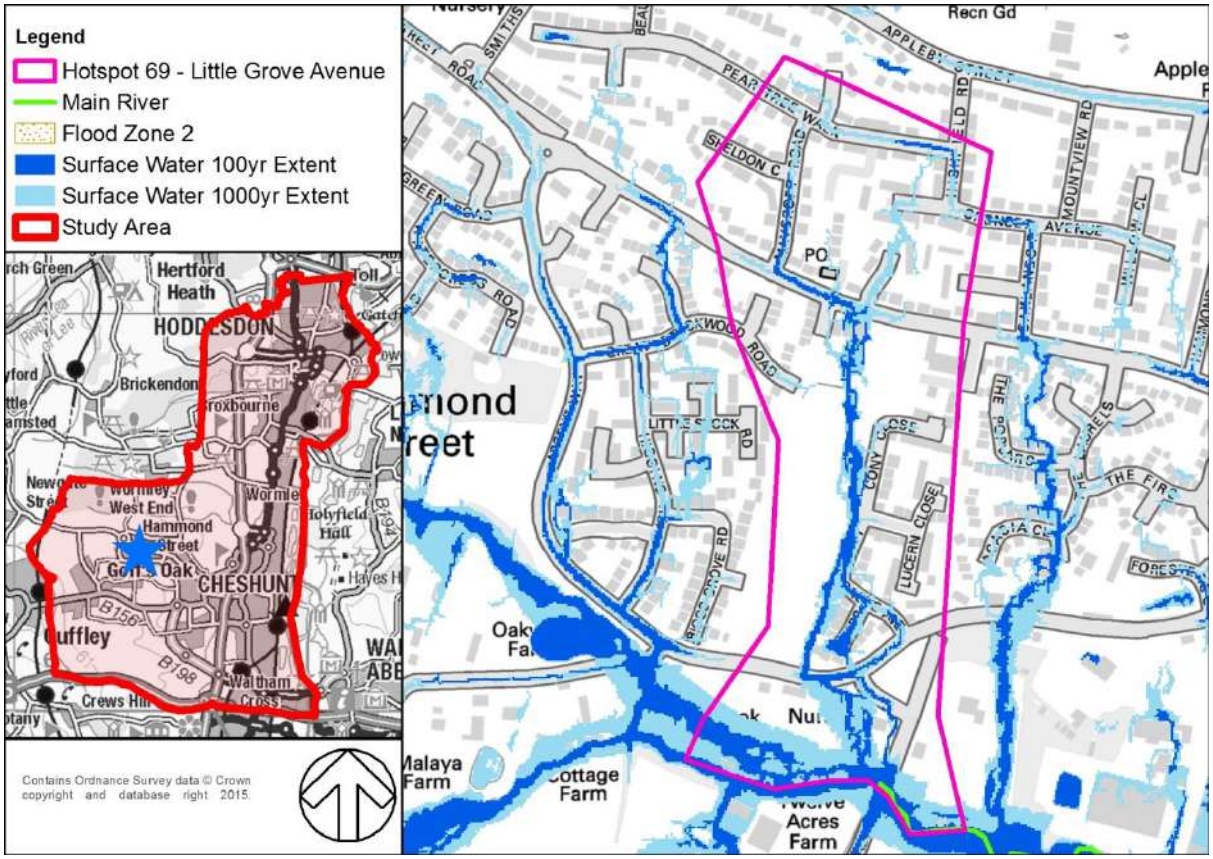

Figure 32: Hotspot 69 – Little Grove Avenue, Cheshunt

KEY ISSUES

- The Risk of Flooding from Surface Water map shows a flow path that runs in a southerly direction beginning on Peartree Walk and flowing southwards, confined within the highway until it flows past the Post Office.
- Once past the post office, the flow path leaves the highway and continues south across open land to the west of Cony Close, before entering a residential area.

SUGGESTED APPROACH

- Open land to the west of Cony Close could provide land for a cut-off drain that would provide protection for the properties within the Cony Close residential area.
- The extent of flood protection available would be dependent on the topography and the ability to redirect flows away from properties.

LOCAL KNOWLEDGE

- No local knowledge is available for this site, and a site visit was not undertaken.

AGREED APPROACH

- HCC should consult with the land owner regarding their maintenance regime and the potential to increase storage within the open land, although consideration will need to be given to changes to flow paths and how this will impact further downstream and to residential properties.

8.6 HOTSPOT 71 – GREAT GROVES, GOFF'S OAK, WALTHAM CROSS

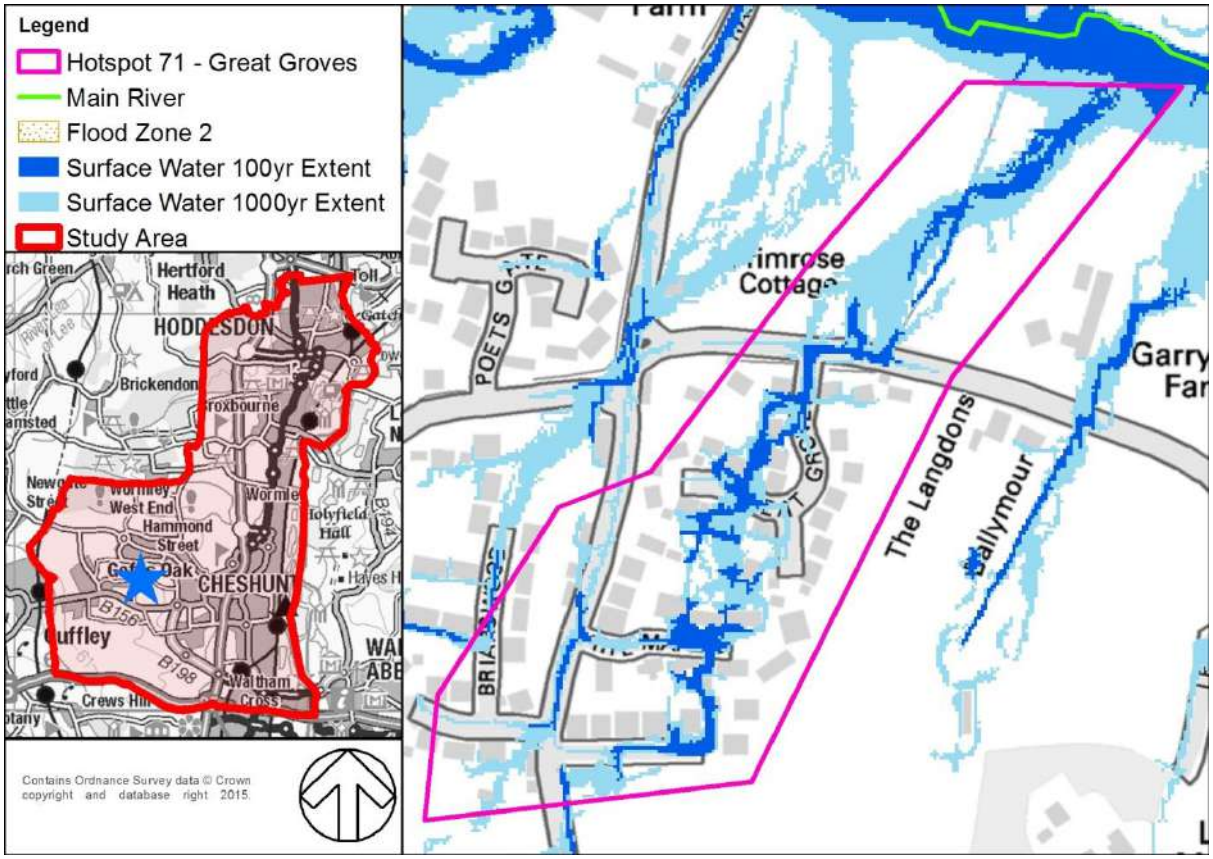

Figure 33: Hotspot 71 – Great Groves, Goff's Oak, Waltham Cross

KEY ISSUES

- The Risk of Flooding from Surface Water map shows a flow path running in a northerly direction through a residential area, from Whitehaven Close, to The Maples, and then on towards Great Groves.
- A small amount of ponding is shown in the highway at the junction of Whitehaven Close and Burton Lane; this could be relatively easily mitigated with structures on the highway. However, highway and threshold levels as well as the downstream implications of such measures should be tested.

SUGGESTED APPROACH

- In practice, fences and other barriers installed as part of landscaping of the residential areas will limit wide spread runoff generation and the current flow path of surface water. Householders may already have such fences in place, or the addition of some fences could help manage surface water flow.
- A review of the gully maintenance regime in this area is recommended.

LOCAL KNOWLEDGE

- OS Mapping suggests properties in this area are detached properties with rear gardens. As much of the flow paths are through individual plots and their landscaping/fencing has the potential to impact flow paths significantly, time consuming detailed survey would be required in this hotspot to increase the quality of the model and provide any substantial increase in the representation over the Environment Agency Risk of Flooding from Surface Water model output.

AGREED APPROACH

→ This hotspot will not be taken forward as a SWMP Modelled Hotspot due to the likely cost and time associated with the survey which would provide a representation of the flow paths at that time. However, minor changes in private property could have significant impacts on the flow path. The potential for mitigation measures given the local topography and space constraints are unlikely to be cost effective.

8.7 HELL WOOD (POTENTIAL) FLOOD STORAGE AREA

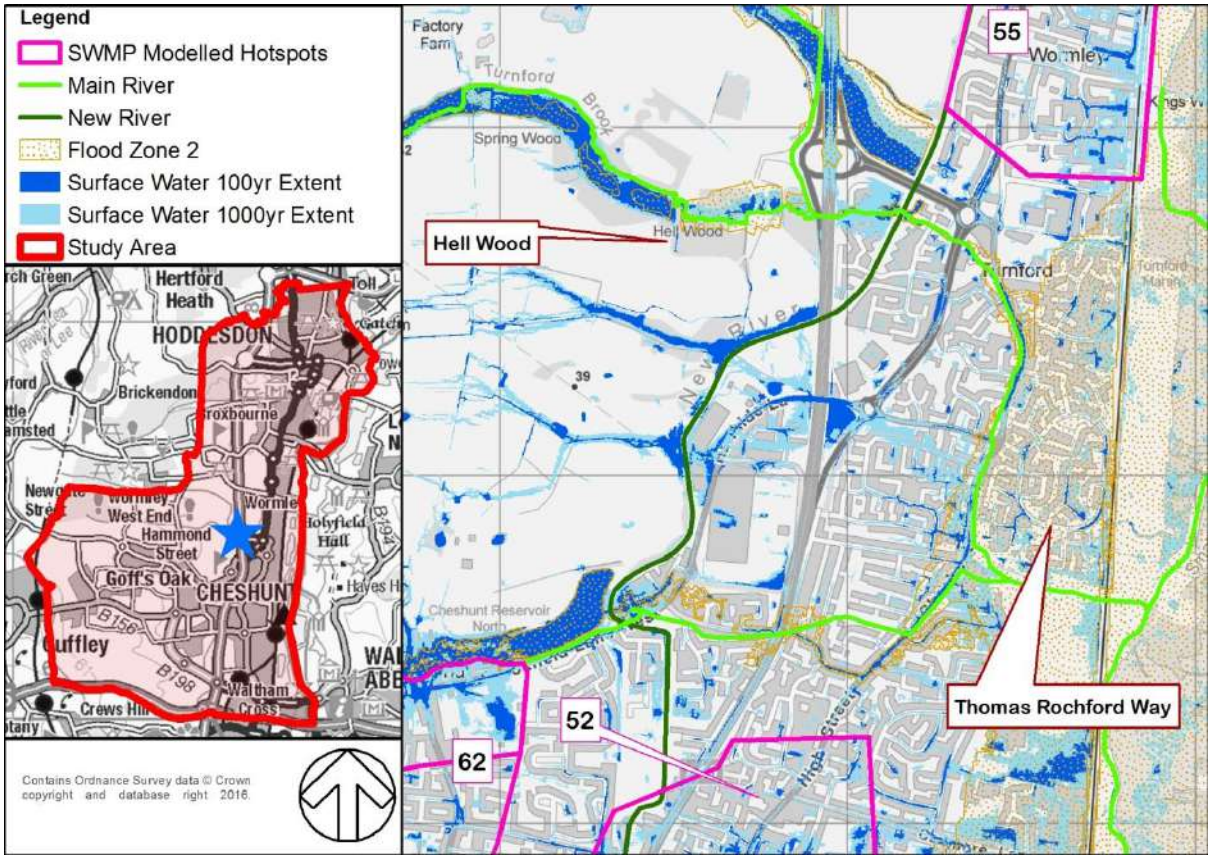

Figure 34: Hell Wood (Potential) Flood Storage Area

KEY ISSUES

- Broxbourne Borough Council reported there have been flooding incidents in Thomas Rochford Way. The Risk of Flooding from Surface Water maps do not show extensive surface water flooding in this area, instead the likely source of flooding is a combination of the pipe system and interactions with the fluvial system from the nearby River Lea/Lee Navigation.
- The area was reviewed in the Stakeholder Meeting discussing the potential for Turnford Brook providing some upstream flood storage in the area surrounding Hell Wood.

SUGGESTED APPROACH

- Fluvial flooding is outside the scope of the Surface Water Management Plan (SWMP) except where it interacts with surface water runoff. A further study could be undertaken in this area as part of a Strategic Flood Risk Assessment (SFRA), or further investigation as to the causes of the flooding in Thomas Rochford Way.
- Flood storage could also be provided by any proposed development in this area.

LOCAL KNOWLEDGE

- Site recommended by Broxbourne Borough Council due to reported flooding incidents.

AGREED APPROACH

- This area will not be taken forward as a SWMP Modelled Hotspot. However, it could be reviewed later within the SWMP process in terms of recommending that any development in the Hell Wood area should provide some degree of upstream storage.

9 SUMMARY

9.1.1 A Desk-Based analysis was conducted to assess the flood risk to receptors within the Borough of Broxbourne. From this, 19 hotspots were analysed using a GIS Multi-Criteria Analysis (MCA) to prioritise the hotspots most at risk of flooding within the Borough of Broxbourne.

9.1.2 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.

9.1.3 Site visits were conducted with Hertfordshire County Council in attendance on 4th 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.

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

1. Hotspot 9 Rye House / North Hoddesdon
2. Hotspot 55 Cozens Lane East, Wormley
3. Hotspot 56 Broxbourne Town
4. Hotspot 50 South Waltham Cross
5. Hotspot 52 Cheshunt

9.1.5 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 56 – Broxbourne town and Hotspot 50 – South Waltham Cross would not be taken forward for detailed modelling, and are therefore SWMP Non-Modelled Hotspots. Two other hotspots as a result of site visits, further analysis and 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:

1. Hotspot 9 Rye House / North Hoddesdon
2. Hotspot 52 Cheshunt
3. Hotspot 55 Cozens Lane East, Wormley
4. Hotspot 62 Rosedale North – Flamstead End
5. Hotspot 63 Rosedale South – Flamstead End.

9.1.6 The following hotspots are not being progressed further as SWMP Modelled Hotspots; however, they will be included in the SWMP as SWMP Non-Modelled Hotspots. Possible recommendations and actions are provided where appropriate in the following table (Table 7):

Table 7: Initial Recommendations and Actions for the Borough of Broxbourne SWMP Non-Modelled Hotspots

HOTSPOT NUMBER	LOCATION	RECOMMENDATIONS AND ACTIONS
→ Hotspot 49	Crossbrook Street	Investigation of any culverts under the railway and increased maintenance of said culvert could reduce the flood risk in the area around Limes Road where existing flooding incidents have been reported
→ Hotspot 50	South Waltham Cross	Ensure gully pots are operational and advise

			property owners where site visits confirm flood extents are likely to be similar to those mapped
→	Hotspot 56	Broxbourne Town	Ensure highways can act as preferential flow paths and excess water can discharge into the New River
→	Hotspot 65	Longfield Lane, Cheshunt	Increased maintenance of the ditch running alongside Longfield Lane may alleviate some flood risk in the area
→	Hotspot 69	Little Grove Avenue, Cheshunt	Possible inclusion of a cut-off drain to the west of Cony Close may reduce the flood risk to the residential area.
→	Hotspot 70	Great Groves, Goff's Oak, Waltham Cross	Consideration of additional fences/preferential flow paths and gully maintenance
		Hell Wood Flood Storage Area	Possible recommendation for any development in the Hell Wood area to include some flood storage and reduce the flood risk to Thomas Rochford Way estate.

10 GLOSSARY

Hotspot – a spatially limited area in which there are a number of residential or commercial properties at risk from flooding resulting from one or more sources/mechanisms.

DESCGROUP – The Descriptive Group is an attribute of the OS MasterMap data. It is used to theme the map data. The 'Building' Descriptive Group describes all buildings excluding glasshouses. More information can be found in the OS MasterMap Topography Layer User Guide Chapter 4 located at https://www.ordnancesurvey.co.uk/docs/user-guides/os-mastermap-topography-layer-user-guide.pdf

Desk-Based Identified hotspots – ranked hotspots identified by GIS/mapping analysis of density of receptors at risk from flooding.

Flood Defence Grant in Aid (FDGiA) – Flood Defence Grant in Aid funding is the mechanism through which the Environment Agency funds flood defence measures in England and Wales. Funding is based on the how much public benefit a project will have, e.g. economic value, how many households are better protected from flooding and the amount of environmental/habitat improvements are gained. As such, areas of land which do not meet the above criteria and are unable to demonstrate they meet the FDGiA criteria would be unable to secure funding, without substantial third party contributions. These include both undeveloped areas such as farmland and developed areas such as car parks.

Stakeholder Identified hotspots – hotspots identified by key stakeholders (districts, boroughs, parishes, Environment Agency, relevant water company/ies) based upon local knowledge and evidence.

SWMP Modelled Hotspots – five hotpots within the administrative boundary to have detailed assessment and hydraulic modelling undertaken to better understand the risks from surface water flooding as part of this iteration of the SWMP. These were identified from a review of both Desk-Based and Stakeholder Identified Hotspots.

SWMP Non-Modelled Hotspots – hotspots within the administrative boundary not put forward for detailed hydraulic modelling; these hotspots may not be modelled for a number of reasons including:

- The hotspot has already been extensively investigated, or is due to be investigated as part of current planned works (by one or more of the stakeholders);
- The benefits from any further work would not be proportionate to the scale of the issue;
- The site visit confirmed that the surface water flow paths within the hotspot are well represented by current models and the Risk of Flooding from Surface Water Map;
- The hotspot is deemed not to have the potential to secure sufficient capital funding (Flood Defence Grant in Aid (FDGiA), Local Levy or third party contributions) to reduce flood risk;
- During the Desk-Based analysis, the hotspot ranked too low, and it was therefore not one of the higher priority sites in this round of assessment;
- The hotspot has already secured capital funding.

It should be noted that **all** hotspots identified are recorded within the SWMP and will go forward to be periodically assessed for the potential to reduce flood risk. Recommendations and actions (see definition) could be identified for these hotspots.

Recommendations and actions – actions which could be undertaken to reduce the risk of surface water flooding. These actions could range from enhanced maintenance regimes through to capital funded flood alleviation schemes. They could be identified for both SWMP Modelled and SWMP Non-Modelled Hotspots.