Flood Investigation

Flood Investigation Section 19 Report

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London Borough of Havering

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Contents

Executive Summary

The London Borough of Havering experienced a major flood event on 15 and 16 August 2020. There were reports of flooding at approximately 72 different locations within the borough. As Lead Local Flood Authority, London Borough of Havering has a duty to investigate, where appropriate, all flood events that occur within its jurisdiction in accordance with the Flood and Water Management Act (2010). Jacobs was therefore commissioned in January 2021 to complete a flood investigation report in accordance with Section 19 of the Flood and Water Management Act. The scope of the investigation includes:

- an assessment of the magnitude of the rainfall event that resulted in the flooding;
- flood defence asset and watercourse conditions at the time of the flood event on 15 and 16 August;
- high level analysis of the possible causes of the flooding;
- liaison with responsible Flood Risk Management Authorities to establish incident response functionality and how these functions were carried out as part of their response to the flood event in question; and
- recommendations for improvements to flood response for Flood Risk Management Authorities, where necessary.

This report focuses on 13 groupings of reported flooding locations across the borough. The findings of this investigation suggest that the primary cause of the flooding experienced throughout the 15 and 16 of August was the volume and intensity of rainfall experienced. It is estimated that one month's rainfall fell across the borough over 36 hours. Hydrological analysis indicates event frequencies for the 15-16 August events varying between 8 to 12 years (13% and 8% Annual Exceedance Probability respectively). The rain gauge closest to the observed flooding locations was found to be faulty on the day. As such, one significant caveat within this investigation is attached to the rainfall frequency estimated. Given the extent and magnitude of flooding experienced, it is considered likely that the localised rainfall event was in fact of a greater magnitude than the analysis of local gauges presented. The faulty rain gauge is located on a roof which has since been deemed too dangerous to access and is therefore now considered inaccessible. At the time of writing the EA are investigating an alternative site.

Poor correlation between the Environment Agency's Risk of Flooding from Surface Water mapping extents and the observed flood extents for the August 2020 event was identified in several locations across the borough. There is the potential that the surface water flood risk mapping underestimates the extent of flooding in these locations. It is therefore recommended that surface water flood maps and designated Critical Drainage Areas are reviewed by the London Borough of Havering in light of this discrepancy and the anecdotal evidence suggesting some areas have experienced frequent flooding.

It was apparent that the differences in reporting systems for the various Flood Risk Management Authorities resulted in mismatches between specific locations detailed in this investigation. Therefore, it is also recommended that a more refined, detailed and consistent reporting system be applied across all Flood Risk Management Authorities. This would assist in delineating mechanisms of flooding and allow for improved lessons learnt and identification of potential mitigation following flood events.

Various stakeholders and Flood Risk Management Authorities have provided views on the contributing factors to the observed flooding in the location near Brookway, South Rainham. It was not considered possible to delineate one or several sources as a primary cause of flooding to these areas, where considerable property flooding occurred. Therefore, it is recommended a separate investigation be undertaken, which should aim to more fully understand flooding in the area and allow agreement of an updated, cross-agency Water Management Plan for the marshes and surrounding areas, including participation from Thames Water, Royal Society for the Protection of Birds, London Borough of Havering, Environment Agency and Network Rail.

1. Introduction

1.1 Background

The London Borough of Havering (LBH) experienced a major flood event on 15 and 16 August 2020. There were reports of flooding at approximately 72 different locations within the Borough. According to the LBH incident register, more than 70 properties were flooded across the Roding, Beam and Ingrebourne catchments. This flood investigation report focusses on the hydrological conditions at the time of the event, possible factors contributing to the event and the response of Flood Risk Management Authorities (FRMAs).

Jacobs was commissioned by LBH in January 2021 to complete a flood investigation report in accordance with Section 19 of the Flood and Water Management Act (2010)[1]. The scope of the investigation includes:

- an assessment of the magnitude of the rainfall event that resulted in the flooding;
- flood defence asset and watercourse conditions at the time of the flood event on 15 and 16 August;
- high level analysis of the possible causes of the flooding;
- liaison with responsible FRMAs to establish incident response functionality and how these functions were carried out as part of their response to the flood event in question; and
- recommendations for improvements to flood response for FRMA's, where necessary.

This report focuses on 13 groupings of reported flooding locations across the Borough (see Appendix A and B). The locations investigated do not include all locations reported to have flooded within LBH during the August 2020 event. Grouped flooding locations investigated were primarily selected based on reported locations where properties were affected by internal flooding, then supported and combined with other reports in the vicinity of these. Reports of flooding where locations could not be confirmed or where there were no reports of internal flooding or significant disruption to infrastructure, have not been investigated further. A small number of isolated properties where internal flooding was reported to a single FRMA with limited details available, were not in the original scope for this report and have not been investigated further. Table 1-1 provides details of the reported flood locations provided by LBH and identifies those considered further as part of this investigation report. Reported locations were included in this investigation where a LBH report was supported by other sources (see Section 3) or where internal flooding was reported. Where a source included a specific location within the report, a point location within the maps is provided. Otherwise, a general location, as provided by the report, has been shown. Appendix B outlines the full list of reported flooding locations included within the scope of this Flood Investigation Report, compiled into grouped locations.

Table 1-1 Locations of reported flooding provided by LBH

Location	Issue reported	Investigated further?	Figure reference
Orange Tree Hill, Havering-atte-Bower	Carriageway	N – No internal property flooding	
Gabriel Close, Collier Row.	Carriageway and property	N – No internal property flooding	
Glenton Way (2 reports)	Carriageway	N – No internal property flooding	
Moray Way (2)	Carriageway	N – No internal property flooding	

[1] Flood and Water Management Act (2010). Available from: http://www.legislation.gov.uk/ukpga/2010/29/pdfs/ukpga_20100029_en.pdf

Location	Issue reported	Investigated further?	Figure reference
Clovelly Gardens Collier Row (2)	Internal flooding including roadway	Y	**A1**
King Georges Close, Collier Row.	Carriageway	N – No internal property flooding	
Front Lane & Pond Walk (2)	Carriageway	N – Lack of information	
Abbs Cross Road	Carriageway	N – Lack of information	
Station Lane	Carriageway	N – Lack of information	
Morecambe Close	Carriageway	N – No internal property flooding	
Ennerdale Avenue	Carriageway	Y	**A2**
Conistan Way	Carriageway	Y	
25 Penrith Crescent	Carriageway	Y	
109 Southend Road	Extensive pathway flooding	Y	**A3**
Blacksmiths Lane	Carriageway	Y	
South Hornchruch Library/Community Hall	Frontage	Y	
124 - 152 Rainham Road (15)	Carriageway Internal- (1 property flooded internally - door number not confirmed)	Y	
Nelson Road (7)	Internal	Y	**A4**
Spinney Close (2)	Internal	Y	
Betterton Road	Rear Garden	Y	
2 Manser Road	Rear Garden	Y	
3 Monarch Close	Carriageway and property	Y	**A5**
South End Road	Carriageway	N – No internal property flooding	
Farm Road (2)	Internal	Y	**A6**
70 Farm Road	Carriageway and property	Y	
Kenway	Carriageway and property	Y	**A7**
Stirling Close	Carriageway and property	Y	**A8**
Rainham Village Primary School	Internal	Y	**A9**
Upminster Road South j/w Cowper Road	Carriageway and property	Y	
Cowper Road	Carriageway	Y	

Location	Issue reported	Investigated further?	Figure reference
St Helen's Court	Carriageway	N – No internal property flooding	
76 Brights Avenue	Internal	Y	**A10**
67 Brights Avenue	Carriageway and property	Y	
Baille Close	Carriageway	Y	
Crammerville Walk	Carriageway	Y	
Lambs Lane South (3)	Internal	Y	**A11**
Brady Primary School	Internal	Y	
Brookway (24)	Internal and Carriageway	Y	
Elizabeth Road	Carriageway	Y	
35a South Hall Drive	Internal and Carriageway	Y	
32-38 South Hall Drive	Groundwater/surface water under floors - including road	Y	
River Close	Carriageway	Y	
Thames Close	Carriageway	Y	
Manstead	Carriageway	Y	
80 Rothbury Avenue	Garage	Y	
A1306/Sandy Lane	Carriageway	N – Lack of information	
Ferry Lane[2]	Carriageway	Y	**A12**

The figure references in Table 1-1 correspond to those in Figures A1 – A12 in Appendix A

1.2 Flood and Water Management Act, Section 19

As Lead Local Flood Authority (LLFA), London Borough of Havering has a duty to investigate, where appropriate, all flood events that occur within its jurisdiction in accordance with the Flood and Water Management Act (2010). The Act details the responsibilities of a LLFA with respect to investigating flooding and any action taken by FRMAs. Section 19 states:

"(1) On becoming aware of a flood in its area, a lead local flood authority must, to the extent that it considered it necessary or appropriate, investigate –

(a) Which risk management authorities have relevant flood risk management functions, and

(b) Whether each of those risk management authorities has exercised, or is proposing to exercise, those functions in response to the flood.

(2) Where an authority carried out an investigation under subsection (1) it must –

(a) Publish the results of its investigation, and

[2] Reported Ferry Lane Roundabout flooding was not included within the LBH incident logs. However, given the significant disruption reported by Transport for London due to necessary closures of the off slip to the A13, this location has been included within scope of this investigation.

(b) Notify any relevant risk management authorities."

The introduction of Section 19 clearly defined a responsibility for LLFAs to investigate flooding within their jurisdiction where considered 'necessary or appropriate'.

1.3 Risk management authority responsibilities

On 22 December 2011, the EA published guidance for LLFAs on producing Preliminary Flood Risk Assessments (PFRAs)[3], updated December 2019. In light of this guidance, it is the responsibility of LLFAs to record flooding information if an event occurs.

Table 1-2 indicates the FRMA responsible for all sources of flooding. It is important to note that in Havering, LBH assumes the position of LLFA, District Council and Highways Authority.

Table 1-2 Flood risk management authority responsibilities for all flood sources

Flood source	Environment Agency (EA)	Lead Local Flood Authority (LBH)	Thames Water (TW)	Transport for London (TfL)	Highways Authority (LBH)
Main River	✓				
The sea	✓				
Surface water		✓			
Surface water (on/from highways)				✓	✓
Sewer flooding			✓		
Ordinary watercourse		✓			
Groundwater		✓			
Reservoirs (as defined by the Reservoirs Act)	✓				

Transport for London (TfL) is responsible for the maintenance of several major roads within the Borough. However, the majority of the roads fall under the jurisdiction of LBH Highways. LBH Highways are also responsible for highway gullies and any lateral drainage to the Thames Water (TW) sewer infrastructure.

[3] PFRA Guidance. Available from: https://www.gov.uk/government/publications/preliminary-flood-risk-assessments-and-flood-risk-areas/preliminary-flood-risk-assessments-and-flood-risk-areas, accessed on 21/05/21

2. Flood incident, extent and impact

2.1 Sources of information

A number of sources were used to inform this section of the report:

- Environment Agency Flood Map for Planning[4];
- Environment Agency Risk of Flooding from Surface Water[5];
- Environment Agency rain gauge, gauging station and radar data (14 – 17 Aug 2020);
- LBH Strategic Flood Risk Assessment (2016);
- Photographs and articles available online from local press and media sources;
- Responses from FRMAs (see Table 2-1); and
- Site walkover observations.

Table 2-1 summarises responses received to request for information from FRMAs and other relevant stakeholders/sources, contacted in February 2021.

Table 2-1 Reponses received from FRMAs and other sources under the Freedom for Information Act 2000.

Source	FRMA?	Response Received
London Borough of Havering	Y	• Flood incident register • Property flood records • Overview of response during event (incident response log)
Environment Agency	Y	• Rain gauge and river gauging station data • Radar data in the vicinity of the Borough • Records of calls to Floodline, Extended Floodline Service and of flood warnings and alerts
Highways England	Y	• Flooding incident record
Transport for London	Y	• Flooding incident record
Thames Water	Y	• Flooding incident record
London Fire Brigade	Y	• Flooding incident record
Metropolitan Police	Y	• Flooding incident record
Royal Society for the Protection of Birds	N	• Overview of response during the event • Views on the event

[4] Available from: https://flood-map-for-planning.service.gov.uk/. Accessed 18/04/21
[5] Available from: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map. Accessed 18/04/21

Inner Thames Marshes		
Network Rail	N	• Drainage system inspections conducted in the area (2015-2019) • Overview of response during the event (post event report) • Views on the event
High Speed Rail 1	N	None

2.2 Antecedent conditions

The EA water situation report[6] and the UK Centre for Ecology and Hydrology hydrological summary[7] indicate that rainfall for the UK in August 2020 was higher than the average with persistent wet weather either side of heatwave conditions. Above normal levels were recorded for the south-east as a whole. The monthly rainfall recorded for the Thames region was 96mm which was 170% above the long-term average.

Four intensity rainfall gauges are located within or in proximity to the London Borough of Havering. These are Nag's Head Lane (TQ 56664 91532), Havering-atte-Bower (TQ 50240, 93425), Gascoigne (TQ 44757, 83014) and Central Park (TQ 49922 86450), see Figure 2:1. There are also two river level gauges, one at Gaynes Park on the River Ingrebourne and the second at Bretons Farm on the River Beam (see Figure 2:1). Both rivers are tributaries of the River Thames. See Table 1 of the Rainfall Frequency Analysis Report (Appendix C) for a summary of data received and utilised in the analysis.

Revitalised Flood Hydrograph model (ReFH2) software was used to attempt to recreate observed peak flow at the Gaynes Park and Bretons Farm river flow gauges (see Figure 2:1) during the event. Hydrological analysis was undertaken to attempt to simulate the observed peak flow at both river gauges using the observed 15-minute rainfall data from the Havering-atte-Bower rain gauge over the 14th to the 18th of August, all provided by the EA. The approach taken was to assume that the same depth and duration observed at the Havering-atte-Bower rain gauge was experienced over the entire catchments represented by the gauged locations. This approach led to a considerable overestimation of flow when compared to the observed flow data at Gaynes Park and Bretons Farm gauges. This further supports the evidence from the tracked radar that the rainfall occurred in discrete intense bursts across Havering rather than as a catchment wide storm, resulting in small areas experiencing much higher rates of runoff than others, the most intense burst being over the southern extent of Havering.

Further hydrological analysis of the peak flow observed at both the Gaynes Park and Bretons Farm river gauges showed that both values were below the recorded QMED (the median flood from the annual maximum series, equivalent to the 50% (1 in 2) Annual Exceedance Probability (AEP) event) at each site based on total flow records[8]. Therefore, the event frequency of the peak flow for these catchments is less than that of a 50% (1 in 2) AEP event. More details on this and further hydrological assessment undertaken can be found in Appendix C.

2.3 Rainfall and river flow analysis

15- minute tipping bucket gauges are located at Havering-atte-Bower and Gascoigne in the Roding Beam and Ingrebourne catchment, providing a good spread across the north and south of the study area, as presented in Figure 2:1. The Gascoigne Road gauge data shows that 17.74mm of rainfall was recorded over the 14 to 18 August 2020. With the majority of this: 12.17mm, falling over the 14 and 15 August. Radar data in the vicinity of

[6] Environment Agency, 2020. Monthly Situation Report, August 2020. Available from: www.gov.uk/environment-agency
[7] UKCEH, 2020. Hydrological Summary for the United Kingdom. Available from: http://nrfa.ceh.ac.uk/monthly-hydrological-summary-uk
[8] Record from the National River Flow Archive. Available from: https://nrfa.ceh.ac.uk/.

the Havering-atte-Bower indicates totals of up to 64mm. The Havering-atte-Bower gauge recorded 62.27mm of rainfall from the 14 to 18 August with the majority falling over the 15 and 16 August in two separate events.

Over the 15 and 16 August during a 36 hour period 56.3mm of rainfall was recorded at the Havering-atte-Bower gauge which is over half of that recorded for the whole month of August in 2020 in the EA Thames region, which was 96mm. The differences in the Gascoigne Road recorded rainfall and the Havering-atte-Bower recorded rainfall shows that the rainfall over the period of study was not consistent and fell in localised events. This could explain why flooding was seen in certain parts of the catchment.

The evidence supports anecdotal reports that the storms were very localised and that the amount of rainfall experienced throughout the borough varied. The radar data shows the areas of highest intensity tracked across the borough from the north east and east to the west and south west, with the highest intensity area falling over the Havering-atte-Bower gauge and mostly missing the Gascoigne gauge. The Havering-atte-Bower rain gauge was nearest to the locations flooded.

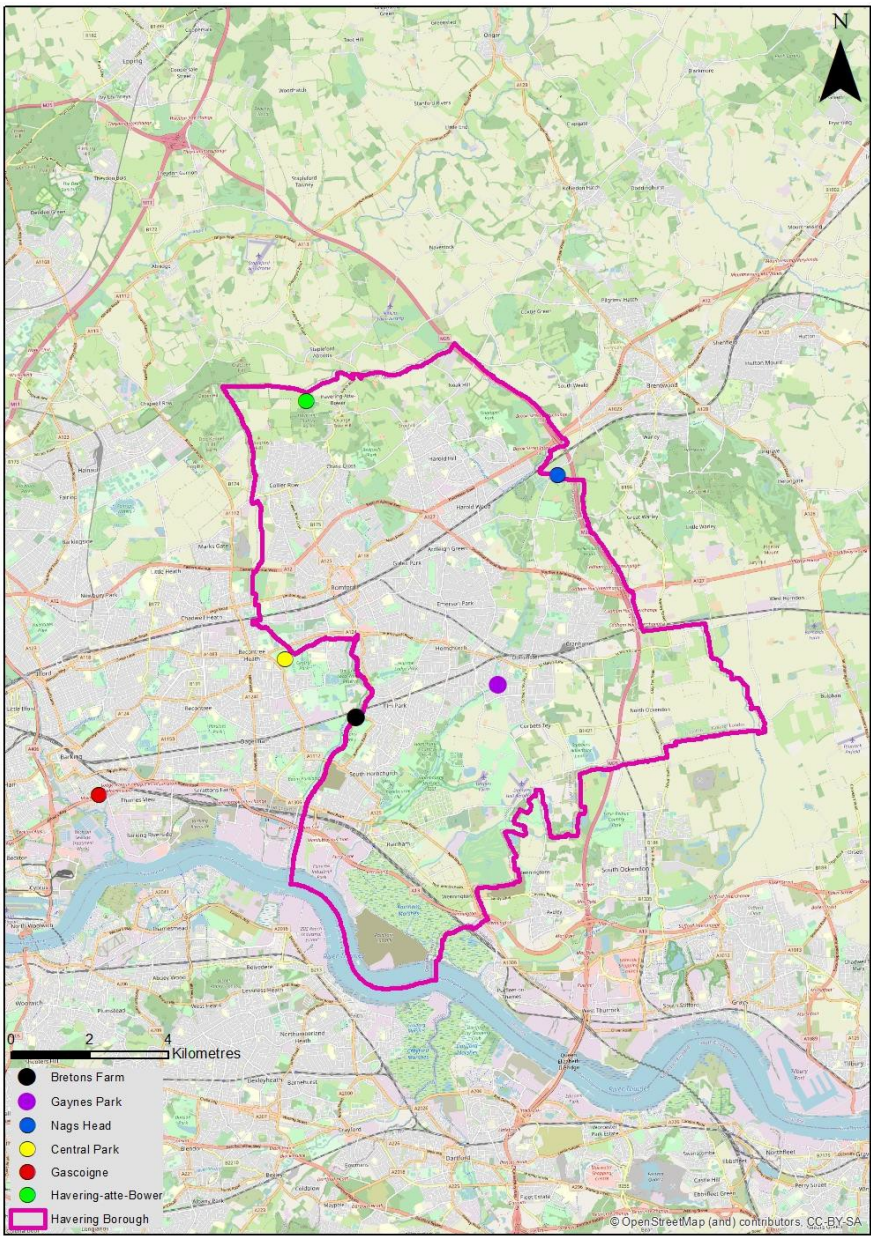
Analysis of the rainfall depths for both the most intense rainfall period and a 36-hour duration indicates event frequencies for 14 -16 August 2020 events varying between 8 to 12 years (13% and 8% AEP respectively).

The data supports the statement that a month's rainfall fell in the 36 hours around the 16th August.

It should be noted that the EA caveated the rainfall data as follows:

- the closest rain gauge (Central Park) was faulty at the time of the August 2020 event and therefore there was no rainfall data available from this location;
- the rain gauge at Nags Head was partially blocked at the time of the August 2020 event and therefore the data from this gauge was not suitable for use in the hydrological analysis; and
- due to the localised nature of the rainfall showers, the rain gauges may not have recorded all the rainfall that actually resulted in flooding.

Figure 2:1 Location of Environment Agency rainfall gauges across and near to London Borough of Havering.



2.4 Observed flooding

In all, 13 areas of reported flooding have been investigated as part of this study (see Appendix A and B). Individual reported flooding locations from LBH have been included within the scope of this report if the record was supported by other sources, or if flooding was reported as internal property flooding. Otherwise, locations that were reported only within the LBH logs or only reported by other sources are considered outside the scope of this investigation. However, it is anticipated that the general cause of flooding is likely to have been heavy rainfall in almost all cases and any recommendations made as part of this report are likely to apply to many of the other areas affected.

Table 2-2 indicates the number of flooded properties at the investigated locations based on all reported sources of data, where sufficient information is available. These figures are reliant on flooding being reported to the appropriate agencies; therefore, it is possible that additional unreported property flooding occurred. In addition, it should be noted that a number of the reports from the various sources did not clearly identify certain details such as type of flooding (internal or external property), specific location of reported flooding (carriageway or

property) or number of properties affected by flooding at a location (such as where a postcode location or road name only was provided). For instance, a total of 24 of the received reports included within scope (Appendix B) do not specify what type or specific location of flooding and 37 of the reports provided only a general location (such as a post code or road name) for recorded flooding. Where reports included within the scope of this investigation did not confirm internal or external flooding of reported property flooding, external property flooding was assumed in the values included in Table 2-2. Where a report did not detail type of flooding at all (unknown if carriageway or property), it has not been included in the values in Table 2-2.

Table 2-2 Number of known flooded properties by grouped location (all sources), within scope of this investigation.

Grouped Location	Number of Reported Flooded Properties		Total
	Internal	External	
1. Clovelly Gardens	2	-	**2**
2. Elm Park	-	-	**-**
3. Penrith Crescent	-	-	**-**
4. Blacksmith Lane & Rainham Road	4	27	**31**
5. Nelson Road, Spinney Close & Betterton Road	9	3	**12**
6. Monarch Close	-	1	**1**
7. Farm Road	2	1	**3**
8. Kenway	11[9]	1	**12**
9. Stirling Close	-	1	**1**
10. Upminster Road	1	1	**2**
11. Brights Avenue & Baille Close	1	-	**1**
12. Brookway & South Rainham	11-34	1	**12-35**
13. Ferry Lane	-	-	**-**
Total	**41-64**	**36**	**77- 100**

Figures A1 – A12 in Appendix A indicate the locations investigated as part of this investigation. The Figures within Appendix A include the EA's Risk of Flooding from Surface Water (RoFSW) mapping as the only available existing surface water mapping. The agreement between this mapping and investigated reported flooding locations in considered in Section 2.5.2.

2.5 Predicted Flood Risk

To assist with assessing the likely cause of flooding in each of the identified locations, an assessment of predicted flood risk from the two most likely sources of flooding, fluvial and surface water, was undertaken.

2.5.1 Environment Agency Flood Zones

The EA Flood Map for Planning identifies areas at risk of flooding from rivers or the sea. Flood Zone 1 indicates the areas that are not at risk of flooding from rivers or the sea in an event with greater than 0.1% (1 in 1000) Annual Exceedance Probability (AEP). Flood Zone 2 indicates the areas at risk of flooding from fluvial sources

[9] 10 properties were stated in the Romford Recorder to have been flooded internally. Available from: https://www.romfordrecorder.co.uk/news/weather/rainham-residents-desperate-after-torrential-downpour-3266132 Accessed 21/05/21

from an event with between 1% (1 in 100) AEP and 0.1% (1 in 1000) AEP (or 0.5% to 0.1% for flooding from the sea). Flood Zone 3 indicates the area at risk if flooding, from fluvial sources, from an event with greater than 1% (1 in 100) AEP (0.5% from the sea).

The following investigated flooding locations are within the EA's Flood Zone 2 and 3 extents:

- Location 5 (associated with the River Beam):
    - Spinney Close
    - Manser Road
    - Seaburn Close
- Location 9:
    - Stirling Close (within Flood Zone 2 only, associated with the River Ingrebourne)
- Location 12 (floodplains of multiple tributaries of the River Thames):
    - Lambs Lane South
    - Brady Primary School
    - Wennington Road
    - Brookway
    - Elizabeth Road
    - Rothbury Avenue
    - Thames Close
    - River Close
    - Manstead
- Location 13 (floodplains of multiple tributaries of the River Thames):
    - Ferry Lane

The observed flood event is not believed to be attributed to fluvial flooding given flooding was observed in discrete locations as opposed to across a greater geographical extent in line with Flood Zone extents. There were also no anecdotal reports of fluvial flooding received.

2.5.2 Environment Agency updated Flood Map for Surface Water

The EA Risk of Flooding from Surface Water (RoFSW) mapping is included in Figures A1- A12 in Appendix A. The RoFSW mapping indicates the extent of flooding likely to be observed for the:

- Low risk: between 0.1% (1 in 1000) and 1% (1 in 100) AEP event;
- Medium risk: between 1% (1 in 100) and 3.3% (1 in 30) AEP event; and
- High risk: greater than 3.3% (1 in 30) AEP event.

A comparison of the reported flood events with the EA RoFSW mapping extents, for the 13 grouped locations, can be found in Table 2-3. Overall, the comparison shows there are areas of both good and poor agreement between the predicted and reported extents for locations assessed. It should be noted that the EA RoFSW is not intended or considered suitable for identifying individual properties at risk, but that the risk refers to areas around a property. One of the limitations of the mapping, as caveated by the EA, is that often the mapping shows flooding only adjacent to a property, where the property itself could be at risk of internal flooding. Therefore, the RoFSW system returns the highest risk within a 20m radius of any defined property point. Locations referenced and the RoFSW mapping extents are included within Figures A1-A12, Appendix A.

Table 2-3 Comparison of observed and predicted flood extents

Location	Observed flood extent	Environment Agency RoFSW extent	Comparison
1. Clovelly Gardens	Reported flooding along Collier Row - no specific location given. LBH also reported two property flooding along Clovelly Gardens.	There is low risk of surface water flooding along Collier Row Lane. Affected properties along Clovelly Gardens are outside the surface water flood extent however, the carriageway directly in front of the properties is shown to be at a high risk of surface water flooding.	The affected properties are within an approximate 20m radius of the RoFSW mapping extents. This includes a surface water flow path along Clovelly Gardens.
2. Elm Park	No property flooding reported. Flooding reported along Ennerdale Avenue and Coniston Way carriageway.	There is low to medium risk of surface water flooding along Coniston Way carriageway and low risk to properties. Medium to high risk of surface water flooding along Ennerdale Road carriageway.	Good agreement between the reported flooding of the event and RoFSW mapping.
3. Penrith Crescent	Carriageway flooding reported in front of one property along Penrith Crescent and flooding at nearby Boulter Gardens (unknown type/location).	Low to medium surface water flood risk at reported location of carriageway flooding along Penrith Crescent and low to high along Boulter Gardens carriageway. It is unclear if any properties were affected by flooding at Boulter Gardens, the RoSFW mapping indicates none are at risk.	Good agreement between the observed carriageway and RoFSW mapping.
4. Blacksmith Lane & Rainham Road	The extensive footpath flooding reported at a location on South End Road and the carriageway flooding along Blacksmith Lane potentially constitute one flow path down to Rainham Road. Reported flood extents includes properties along Rainham Road,	Affected properties are predominantly within at least the medium surface water flood risk extent. Many are also within the high risk extent, namely the 15 LBH reported flooded properties. Properties to the west of the junction of Blacksmith Lane/Nelson Road and Rainham	Good agreement along Blacksmith Lane and the east side of the junction of Blacksmith Lane/Nelson Road and Rainham Road. Poor agreement in areas west of the above, both sides of Rainham Road (north and south). Potential for the low risk surface

	predominantly on the north side of the road, with a couple of notable exceptions (South Hornchurch Library and adjacent areas). Unclear if two TW reported flooded properties (Blacksmith Lane) within same flow path as reported flooding along Oliver Road (no specific location provided). Also, unclear if also the same flow path/flooding extent as flooding reported along Blacksmith Lane.	Road and along Oliver Road are within a 20m radius of the surface water flood extents.	water flow path originating north of Oliver Road to extent further south, which would explain the reported 25 properties affected along Rainham Road (west). Reports along Oliver Road, the Blacksmith Lane properties and also the reported property south of Rainham Road (west) are within an approximate 20m radius of the RoFSW mapping. However, it is unclear if flooding entered from the rear for properties along Blacksmith Lane or if carriageway or property flooding was observed along Oliver Road.
5. Nelson Road, Spinney Close and Betterton Road	Reported flood extent includes properties along Nelson Road (east side), and properties at the junction of Nelson Road and Stanley Road. Flooding also reported at the bottom of Spinney Close, along Betterton Road carriageway and a rear garden (both unknown locations) and another unknown property location along Betterton Road. Flooding also reported in Seaburn Close (unknown type) and at the rear of a garden in Manser Road.	All known locations of reported flooded properties are within the RoFSW extent. Only those at Spinney Close are within the high risk surface water extent. Properties along Nelson Road are within low surface water flood risk extents. There are two significant flow paths indicated in the mapping. One is shown to flow along Nelson Road south, to then flow west to intercept the bottom of Spinney Close. The other shown to originate from the open space north-west of Betterton Road to meet the first flow path further south near Manser Road.	Good agreement in locations reported flooding and the overall RoFSW mapping extents. Locations reported appear to match well within the two significant flow paths in the area. However, there is poor correlation to reported locations and areas of high risk. Though there are a number of reports in proximity to the high-risk areas (some within approximately 20m of the areas of high risk).
6. Monarch Close	Reported carriageway and property flooding at the end of Monarch Close and reported flooding at Wymark Close (unknown location/type).	Affected property within 20m of an area of low surface water flood risk. Monarch Close carriageway is not at risk of surface water flooding.	The affected property at Monarch Close is within approximately 20m of the RoFSW mapping extents.

		Wymark Close carriageway is within areas of low to high risk of surface water flooding. It is unclear if any properties were affected by flooding at Wymark Close.	
7. Farm Road	Reported (known) flood extent includes properties on the northern side of Farm Road and flooding along the carriageway.	According to the RoFSW the properties along Farm Road are not at risk of surface water flooding, with the exception of several properties between the junctions with Parsonage Road and Allen Road. Along this section the carriageway and properties are at medium to high risk. Farm Road carriageway is generally at low risk of surface water flooding. Behind the Farm Road properties there is a significant area of land at surface water flood risk. This area appears to be a surface water pathway towards the River Ingrebourne located north west of Farm Road.	Poor agreement between the reported flooding and RoFSW mapping along Farm Road west. Affected properties along Farm Road east are within an approximate 20m radius of the RoFSW mapping extents.
8. Kenway	No internal flooding reported. No RMA sources reported property flooding, although according to the Romford Recorder "water entered about 10 houses on the left-hand side" at Kenway.	Kenway carriageway is predominantly at low risk of flooding, with some areas of high risk of flooding towards the west end of the street and into the attached Kenway Close. The mapping indicates the surface water flow path along Kenway drains to Rainham Cemetery (west of the road), which is at low and medium risk of flooding.	Good agreement between the reported flooding and RoFSW mapping regarding potential carriageway flooding. Properties do not appear to be at risk along Kenway, the mapping suggests flooding could be expected predominantly along the carriageway. Therefore, the report of potentially 10 cases of internal flooding do not align with what is indicated in the mapping. However, some of these properties are within approximately 20m of the RoFSW

			extents and therefore could be at risk.
9. Stirling Close	Reported flood extent includes carriageway and property flooding along Stirling Close (exact location unknown).	According to the RoFSW mapping there are areas of high risk of surface water flooding Stirling Close along the carriageway and to some properties.	Generally good agreement between the reported flooding and RoFSW mapping as the entire location is at risk of flooding. However, it is unclear if properties were affected along Stirling Close.
10. Upminster Road	Reported flood extent includes Cowper Road carriageway and on the carriageway at the junction of Cowper Road and Upminster Road. Unknown property reported flooding near the junction. Internal flooding reported at the Rainham Village Primary as well as flooding along Upminster road (unknown if property or specific location along Road).	Reported carriageway flooding along Upminster Road is within the medium RoFSW mapping extent. The reported flooding at the junction of Cowper Road and Upminster Road is within an area shown by the mapping to be high risk. Areas along Cowper Road are within the low surface water flood risk extent. The Rainham Village Primary property is shown by the mapping to include a small area of low and medium surface water flood risk.	Good agreement between the surface water mapping and the reported locations of flooding along Upminster Road and Cowper Road, particularly at the junction. RoSFW mapping supports evidence of a surface water flow path along this route. Poor agreement in terms of the connection between these flow paths and the reported flooding at Rainham Village Primary. Potentially the surface water mapping underrepresents the surface water flow path from Upminster Road to the Rainham Village Primary property and (possible) through to the surface water ditch at the back of the Primary's property. Alternatively, there could be no connection between the surface water observed along Upminster Road and the internal flooding of the Primary School.

11. Brights Avenue and Baille Close	Flooding reported along Brights Avenue carriageway and to two properties. Flooding also reported along the carriageway of Baille Close and along the perpendicular Crammerville Walk (pedestrian pathway).	Areas of predominantly low surface water flood risk along Brights Avenue, small area of ponding of medium surface water flood risk. Surface water flood risk areas are shown by the RoFSW mapping along Baille Close, with an area of high surface water flood risk at the bottom of the Close. No areas of surface water flood risk indicated along Crammerville Walk, though there are areas of risk within 20m of the Walk. One report did not identify if properties were flooded along the Close.	Properties along Brights Avenue, Baille Close and the flooding along Crammerville Walk, are areas within an approximate 20m radius from of the RoFSW extents and therefore could be at risk.
12. Brookway and South Rainham	Reported flood extent includes properties along Lambs Lane (north-western side) and Brady Primary School. The postcode associated with Harris Academy and surrounding buildings also reported flooding. The reported flood extent continues south (including a property on the north-western side of the junction of Lambs Lane with Wennington Road). Extent includes 24 properties along the south-eastern side of Brookway (carriageway flooding also reported). The reported flood extent covers residential areas to the south. Flooding was reported at various locations along South Hall Drive, Rothbury Road and Eastwood Drive and along various side roads. These are predominantly carriageway or unreported types of	Predominantly most properties reported to have flooded are within or adjacent to areas of surface water flood risk. The footprint of the properties where internal flooding was reported along Lambs Lane, Brookway, Rothbury Avenue and Brookway are all outside of the surface water mapping flood extent. However, they are surrounded by areas of low to high surface water flood risk (within a 20m radius). The flow path along Lambs Lane is predominantly of medium surface water flood risk, along Brookway it is predominately high risk. Areas to the south, are within areas of high to low surface water flood risk (within and directly south of the residential area). The mapping indicates a surface water flow path down Lambs Lane and Brookway to then cut across properties along South Hall Drive and Rothbury Avenue and drain down to the	Predominantly good agreement in terms of the reported flooded locations and the overall surface water mapping extent. A resident on Lambs Lane reported flood waters entering the property from both the front and the back garden. This is supported by the surface water mapping. However, the reported extent of flooding north of Wennington Road is greater than represented in the surface water mapping. The surface water mapping supports the presence of a land drain running along the back of the residential areas, parallel with the railway line and flowing north-west to south-east. There is good agreement in the location of flooded

	flooding, however does include 6 reported properties flooded. Reported carriageway flooding and a property reported flooding on Elizabeth Road from an adjacent land drain.	surface water ditch or watercourse at the bottom of Brookway. The mapping suggests flows continue to drain east to a ditch at the back of Eastwood Drive. The southernmost sections of Elizabeth Road and the small side road off South Hall Drive are all within areas of high to low surface water flood risk.	properties/carriageways along Brookway and within the south residential areas.
13. Ferry Lane	Reported flooding near eastbound off slip from A13 to Ferry Lane and at Ferry Lane roundabout. Photos included within the TfL report also show carriageway flooding further west than the entrance to the off slip.	Areas of low to high surface water flood risk along the eastbound off slip to Ferry Lane and areas of high to low surface water flood risk at the Ferry Lane roundabout. No surface water flood risk areas indicated near the reported carriageway flooding further west of the off slip.	Good agreement between the RoFSW mapping and the reported flooding along the off slip and at the Ferry Lane roundabout. Poor agreement further with the reported flooding further west along the A13 carriageway.

2.6 Site walkover observations

A site walkover was conducted in April 2021, 36 weeks after the flood event, to make general observations of locations reported to have been affected by flooding during the August 2020 flood event and to assess the conditions of key assets and infrastructure in proximity to these locations. Site walkover observations and key information obtained from LBH staff or local residents during the walkover are highlighted in Table 2-4. It should be noted that during the time between the flood event and the site walkover, any evidence of flooding is likely to have been lost and asset conditions potentially changed significantly.

Table 2-4 Site walkover observations and information

Location of Flooding	Observations and information
1. Clovelly Gardens	• Resident stated flooded 3 times within 4 months around period of the 15/16 flood event and around 5 times in the last 20 years (including the most recent 3 times). • Potentially more than the 2 reported houses experienced flooding during the event. At least 4 of the properties on the same side of the road appear to be at similar levels,. • Resident described water up to approximately 30-50cm depth at front door. • Since event a new gully has been installed outside front of property and further up the road at Clovelly Gardens. Resident reported no flooding since installation of new gully, although there have not been rainfall events of a similar magnitude to identify if this has resolved any capacity issues. • General topography falls from Clovelly Row Lane (B174) towards and along Clovelly Gardens east to west. • Resident described ponding in the back garden as frequently occurring as well as observing water running east to west with topography down Clovelly Gardens whenever it rains. • Resident stated London Fire Brigade (LFB) provided sandbags to protect property.
2. Elm Park	• Carriageway at the junction of Conistan Way and Ennerdale Avenue is at topographical low point. It is unknown where along the carriageway of both roads flooding was observed. • Properties are slightly elevated above road level. One report does not specify flooding type/specific location.
3. Penrith Crescent	• Topography observed to fall along Penrith Crescent towards Boulter Gardens (LFB caller location), away from the reported location of carriageway flooding along Penrith Crescent • One report does not specify flooding type/ specific location.
4. Blacksmith Lane & Rainham Road	• Observed ground levels support possibility of a flow path along Blacksmith Lane (north-east to south-west), in line with reported carriageway flooding. However, the topographical low point was observed to be before the intersection with Rainham Road (A125) where the Police reported flooding . • Camber of Blacksmiths Lane suggests reported flooding location from TW weas more likely to be the other side of the road from reported location or to rear of properties. Properties along Blacksmiths Lane elevated slightly above road level. • Properties along Blacksmiths Lane have airbricks at low levels in the walls.

	• Building and property associated with South Hornchurch Library land with significantly lower ground levels than surrounding area and adjacent Rainham Road. This aligns with recorded standing water observed around the Library. • Observed ground levels support flow path along Rainham Road, with a slight fall towards the south-west and the junction with Nelson Road. Flooding reported on both north side of Rainham Road, both sides of the junction with Nelson Road. • Properties which reported flooding along Rainham Road (east) have airbricks at low levels in the walls. • Thame Water asset observed centre of Oliver Road, aligns with locations for manholes within the TW asset data.
5. Nelson Road, Spinney Close and Betterton Road	• Observed ground levels support flow path along Nelson Road, from north-east to south-west. Difficult to distinguish on site if ground levels continue to fall in this direction across residential properties towards Betterton Road as suggested by LiDAR. • Localised topographical low point observed along Nelson Road where properties reported flooding. The 6 properties reporting internal flooding did not appear raised above road level. No significant impediment observed from the road to the properties. • Several gullies observed both sides of Nelson Road. However, general camber of the road supports the reported location of the flooded properties. • Another local topographical low point observed along Stanley Road, near the intersection with Nelson Road. Location supports the reported flooding locations from TW and the LFB. • Aco Drains were located around the point in which ground levels of Spinney Close were observed to fall towards internally flooded properties. Aco Drains also observed at the edge of the properties/driveways. • Observed ground levels suggest potential for flow path along Betterton Road, from north to south, not shown in the surface water flood risk mapping. The specific location of flooding reported along Betterton Road is unknown.
6. Monarch Close	• Properties at Monarch Close clearly at a significant topographical low point. • Two gullies located at the edge of the Close in front of flooded property. • Considered likely another adjacent property also could have experienced flooding. • Site observations suggest catchpits associated with the gullies are at a shallow depth.
7. Farm Road	• Topographical low point at the junction of Farm Road and Parsonage Road. • Properties appear slightly below road level, with the exception of one of the properties which reported flooding, for which the garage is significantly below road level. • Properties have airbricks at low levels in the walls. • One property along west Farm Road reported both carriageway and property flooding. The camber of the road falls towards the property on this side. • Unclear flood mechanism for properties which experienced internal flooding on east Farm Road, camber of the road (and subsequent gully locations) means the road falls towards the other side of the road. Unclear if surface water could have entered properties from the rear.

8. Kenway	• Unable to distinguish specific location or side of road along Kenway for the reported property flooding. No specific location provided for reported internal flooded properties within the Romford Recorder report) 10.
9. Stirling Close	• Topographical low point approximately 10m east from intersection with Penny Close. Unknown location of reported carriageway and property flooding. Other reports do not specify flooding type/ specific location. • Vegetated embankment between properties and New Road to the north of the close.
10. Upminster Road	• Ground levels along Upminster Road predominantly fall from north-east to south-west. • Topographical low point observed at the junction of Upminster Road and Cowper Road (topography of Cowper Road observed gradual fall north-east to junction). This corresponds with reports of flooding at the junction (carriageway and unknown property location). • Observed ground levels support flow path along Upminster Road. However, unclear how flood waters could have entered the Rainham Village Primary School from that point (internal flooding reported). Potential entry point to the property near the corner of Cowper Road and topographical low point, where school property is not surrounded by brick wall. To the north-east along from this point, along the property boundary school is separated from the road by a short brick wall. • Observed what appeared to be a relatively new full width speed hump at the bottom of Cowper Road (at the junction with Upminster Road) with signs of resurfacing in the area. One report of flooding along Cowper Road does not specify flooding type/ location, one specifies carriageway flooding.
11. Brights Avenue and Baille Close	• Properties along Brights Avenue appear slightly elevated above road level. • Unclear how property along Avenue (north side) experienced internal flooding, given footpath directly at front of property raised and property also separated from the footpath by a short brick wall. Unclear if surface water could have entered property from the rear. • Topographical low point at end of Baille Close, where intersects with Crammerville Walk. Observed ground levels support flow path along Baille Close and ponding of water at the bottom (north) of the Close. Unknown location of reported carriageway flooding along Baille Close. • No gullies observed along Crammerville walk (reported carriageway flooding). One gully observed along what could also be considered Crammerville walk (parallel footpath at the edge of the residential area and the Glen Open Space).
12. Brookway & South Rainham	• Gushing manhole heard on site at the southern end of Brookway, believed to be TW asset, location of which is included in the TW asset data. • Network Rail owned land between the residential area and the railway line itself observed to be approximately 1m lower than the railway line. • Small watercourse observed flowing south from the bottom of Brookway (edge of residential area) through a headwall/culvert under the railway line. Watercourse then believed to flow south, through the marshes, under the A13 via a culvert, through sluices gates at the southern edge of the marshes (which are believed to control the water level of the watercourse and within the marshes), eventually discharging to the River Thames.

[10] 10 properties were stated in the Romford Recorder to have been flooded internally. Available from: https://www.romfordrecorder.co.uk/news/weather/rainham-residents-desperate-after-torrential-downpour-3266132 Accessed 21/05/21

	• Observed surface water ditch running along the southern edge of Southall Drive, which supports flow path indicated in surface water flood risk mapping. Multiple reports of flooding along South Hall Drive, specifically 4 properties reported on the southern side of the Drive, adjacent to the ditch. Carriageway flooding also reported along smaller side roads between South Hall Drive and the ditch. • TW Sewer along Lamb's Lane and Brookway believed to be connected, supported by the TW asset data. Internal property flooding was reported along both Roads. • Sewer runs under Brookway and discharges to an open ditch at the edge of the residential area (within Network Rail land). • Eastwood Drive believed to be on a separate, smaller sewer line. Report of flooding along Eastwood Drive does not specify flooding type/ location. • Observed ground levels support flow path running north-south, down Lamb's Lane South, across Wennington Road and along Brookway. Properties including Brady Primary School and Harris Academy, along Wennington Road, reported flooding. • The Romford Recorder reported a property owner along Lambs Lane South affected by this event stating that the household had already spent a significant amount in repairing damages from flooding in the last four years. In addition, the article includes a statement from a resident on Lambs Lane reporting flood waters entering the property from both the front and back gardens. • Three EA sluice gates, downstream of the residential area (near Coldharbour Lane) control the water level within the marshes. Sluices and watercourse flowing through the marshes believed to be subjected to tidal locking from the River Thames. • During heavy rainfall experienced in January/February it is understood that the area upstream of the culvert under the railway line was saturated with water visibly ponding at the culvert. • Anecdotal evidence suggests that the TW sewer is reportedly often carrying flows even a significant time after rainfall events, indicating slow discharge and that the system may therefore not have capacity during heavy rainfall events. • The Romford Recorder also reported around 50 residents were affected along Brookway, and 15 around South Hall Drive, with road closures required along Lambs Lane South.
13. Ferry Lane	• Ferry Lane roundabout at a clear local topographical low point corresponding to the reported flooding location.

2.7 Historic flood incidents

The LBH Level 1 Strategic Flood Risk Assessment Update (2016) compiled a list of historic flooding across the Borough from various sources. In the last 100 years, there have been 11 notable flood events (excluding the August 2020 event). The type of flooding is predominantly fluvial, with one recorded tidal event.

The two most recent events in 2007 and 2016 are attributed to sewer flooding, and surface water and fluvial flooding respectively. The 2007 event caused flooding across the Romford and Hornchurch area. Fluvial impacts of the 2016 event were caused by flooding of the River Rom and the surface water flooding was recorded across numerous locations in the Borough. No specific location for the recorded surface water flood events was provided within the SFRA. The 2016 event is understood to be as a result of intense rainfall onto already saturated ground, the cause of the 2007 event is also understood to be significant rainfall.

The Jacobs Section 19 Flood Investigation produced after the June 2016 flood event reported on flooding at several similar locations reported to have been affected by the August 2020 floods. These locations and types of flooding are listed below:

- Betterton Road – gardens and basement;
- Collier Row Road – internal;
- River Close – carriageway; and
- Spinney Close - carriageway and garages.

The five reports of internal flooding along Collier Row Road were assessed to be located at a topographical low point and immediately adjacent to the River Rom. The assessment identified the sources of flooding in this location as both fluvial, from the River Rom to the north of Collier Row Road, and surface water flooding. The observed flood extents were in good agreement with the EA Flood Zone extents and the EA RoFSW mapping.

3. Organisational responses

This section includes key actions undertaken by responsible authorities before, during and after the August 2020 flood event; a timeline is included in Section 3.1. Section 3.3 to 3.9 include additional actions undertaken by each authority during the event where a specific time was not given.

3.1 Timeline of key actions

Key actions during the flood event undertaken by LBH, LBH Highways, Highways England (HE), TW, the Metropolitan Police and the EA can be found, with the date and time of action in Table 3-1. This information is based on response provided by the RMA's to requests for activity logs and other available information on their flood response.

Table 3-1: Timeline of key actions

Logged date and time	Key information received	Action taken
14 August 2020		
TW – no time given	One report of internal flooding, near the junction of Wennington Road and Brookway (less than 30mm).	Not stated but report status is classified as complete.
15 August 2020		
HE - 00:00	Eastern Regional Control Centre (ERCC), police reported possible flooding on the A13.	An Incident Support Unit (ISU) crew was assigned. ISU crew went to site and reported no flooding and a small amount of surface water. Vehicles passing through the water and they felt it was safe to leave.
LFB – 15:08 to 23:50	40 reported incidents where the type of flooding is unknown, many assumed to be carriageway in RM5 and RM13.	Actions taken include 'make safe', 'advice only' and five incidents required pumping. Eight incidents required no action.
LFB – 21:25 to 23:34	13 incidents reported of internal flooding in RM13 This includes a report of flooding in a residential care home.	Action taken includes 'advice only' and 'make safe'. One incident required evacuation and three incidents required pumping and one requires 'special service' involving isolating the power supply in the property.
HE - 22:42	ERCC advised the police of reported flooding on A13 and a closure is required.	A request was made when an ISU crew arrived to close the carriageway from junction 30 roundabout. There was delay in getting to site due to other events on the network. The ISU put a L1 & L2 in place and the police had left the scene. Multiple gullies were cleared by the ISU. Once the rain stopped the water dispersed and there was no need for a gully sucker.
LFB – 22:44 to 23:08	Two reports of external flooding in RM13.	Action taken was 'advice only' and the other report was a false alarm.

Logged date and time	Key information received	Action taken
LBH – 22:53	Message received about flooding in Lambs Lane North.	
LBH – 23:17		Asked Local Authority Liaison Officer (LALO) and Havering Highways Representative for a situation report. LBH had been made aware that the out of hours response team (DSO) were attending flood call so was out assessing the situation. Checked hazard manager and river levels.
LBH – 23:35		LBH provided situation report and was receiving a lot of calls from Pinnacle (Police and Emergency Services).
LBH – 23:48	Email received about two incidents of flooding. One call about multiple addresses along Brookway, the second call about flooding at South Hall Drive	Evacuation required. LFB informed that there are no more sandbags available.
LBH – 23:55		Met Police called to discuss incident and agree a plan of action.
EA Floodline – no time given	Incidents reported at RM13 7RH and RM13 9PY.	No specific actions taken.
TW – no time given	One report of internal flooding at RM13 (less than 30mm). One report of external flooding at RM5.	Actions taken not stated (started).
16 August 2020		
LBH – 00:42 – 01:00		LFB Incident Commander called and provided a situation report, including incident at Farm Road and possible vulnerable persons. Agreed upon a plan of action with Havering Highways Representative.
LFB – 1:10 to 14:53	Six reports where the flooding type in unknown in RM12 and RM13.	Actions taken include 'make safe, 'standby - no action' and one incident required pumping.
HE (Ferry Lane) - 01:12	Hatton Traffic Management Ltd report that the Police have informed them of a flood at Ferry Lane.	
LFB – 01:15 to 16:24	Four reports of internal flooding in in RM12 and RM13.	Actions taken include 'advice only', 'stand by – no action' and two incidents of pumping.
HE (Ferry Lane) - 01:37	Police confirm that they need the Eastbound off slip to Ferry Lane closed.	Hattons inform Control that they will need to close the Eastbound Slip Road from Marsh Way to Ferry Lane Eastbound off slip.

Logged date and time	Key information received	Action taken
LBH – 01:47		Email sent to group (Emergency Planning, LALO and Havering Highways representative) providing an update on the situation and areas of flooding in Rainham and South Hornchurch that are currently being dealt with.
HE (Ferry Lane) - 02:30		Hattons and unknown on site.
HE (Ferry Lane) - 03:00		Control called LBH for an update on the clearing of floodwater from Ferry Lane Roundabout? As nothing appears to have been done?
LBH – 03:11		Email sent to group providing a situation update.
HE (Ferry Lane) - 03:15		LBH advise that Havering Council are unable to give an ETA as they only have 1 operative dealing with flood issues.
HE (Ferry Lane) - 03:36	All vehicles are off site and the flood cleared along Ferry Lane.	
HE (Ferry Lane) - 08:43		Ferry Lane off slip reopen.
LBH – 10:00		Visit to known flood locations. Situation was better than expected. Directly engaged with affected residents.
LBH – 12:00 to 12:40		Discussions with Councillors and Met Police about current situation. Agreed a tactical plan.
LBH – 13:31	Request to visit Farm Road to help a vulnerable person.	Action completed.
LBH – 16:09		Email to group providing a situation report and associated actions.
EA Floodline – no time given	Incidents reported at RM13 9TS and RM13 8GT.	No specific actions taken.
Police – no time given	One reported incident stating 25 properties have been affected although flooding type has not been recorded. Caller did not seek assistance.	LFB 3 pump special service was deployed.
TW – no time given	Three reported incidents of internal flooding (less than 30mm).	Actions taken not stated (report status complete x2.
TW – no time given	One reported incident of land drainage flooding.	Actions taken not stated.
15-16 August 2020		
LBH – no time given	17 reports of carriageway flooding.	Gullies cleared and cleaned. Thames Water Utilities (TWU) assets checked and cleared.

Logged date and time	Key information received	Action taken
		A downstream watercourse blocked (Network Rail).
LBH – no time given	10 (>10 properties) reports of internal flooding.	Gullies cleared and cleaned. TWU assets checked and cleared. Additional drainage to be installed. Care home – under capacity. Property on soakaways – under capacity. A downstream watercourse blocked (Network Rail).
LBH – no time given	One report of footway flooding.	Gullies cleared and cleaned. TWU assets checked and cleared.
LBH – no time given	One report of frontage flooding – visible standing water by South Hornchurch Library and Community Hall.	Gullies cleared and cleaned. TWU assets checked and cleared.
LBH – no time given	One report of rear garden flooding.	Gullies cleared and cleaned. TWU assets checked and cleared.

3.2 London Borough of Havering

As the LLFA, LBH was contacted to request data they have recorded from the event that will aid the Section 19 investigation. A response was received including a list of flooded locations and properties with the associated flooding type. An incident log from the 15 – 16 August was also received which noted communications between LBH, LBH Highways and other parties, including LFB and local councillors, as presented in Table 3-1.

3.3 Environment Agency

In a response to a request for information the EA stated that they did not issue any flood warnings or alerts between the 14 – 16 August in the Hertfordshire and North London area.

The EA did not receive any calls to the national incident reporting service between 14 – 16 August. However, they did receive four calls to their Floodline number on the 15 and 16 August, these are included in Table 3.1. As no calls were received through the national incident line, the field teams did not take any specific actions other than those associated with heavy rainfall notifications, where the field team were on site clearing screens across the east of the area.

LBH are participants in the EA's Extended Floodline Service, which provides answers to a range of Frequently Asked Questions about local flood risk issues, including flooding from surface water and drainage. Floodline operators, who are UK based, will then use the information to answer questions from the public on behalf of LBH. This service also accepts transfers for callers directly from Floodline to the LBH. Four calls to the Extended Service were made over the 15 and 16 of August, all were advised to contact the council.

The only details the EA were in possession of regarding flooded properties were originally provide by LBH.

3.4 Highways England

HE was contacted in order to establish their views on the event and how they responded as a FRMA.

A response was received from Connect Plus Services (managers, operators and maintainers of the M25 and its linking roads on behalf of HE). The response included an incident report including two flood events reported and action log of their response to the August 2020 flooding (see Table 3.1).

3.5 Transport for London

Transport for London (TfL) has a responsibility to manage London's principal road network; the A12 and A13 fall under their jurisdiction within the borough. The response included information regarding the A13. However, there were no reports relating to the A12 or the A127 (part of the Transport for London Road Network (TLRN)) also within the borough.

Hatton Traffic Management (Ltd) were deployed to the two flooding sites on behalf of TfL. According to the incident report, the Police confirmed that the Ferry Lane Eastbound Slip Road from Marsh Way to Ferry Lane Eastbound off slip needed to be closed at 01:37 and was reported to have been re-opened at 08:45. The TfL response specifies that the location of the flooding observed on the Ferry Lane Roundabout falls under the responsibility of LBH highways.

In their response, TfL confirmed that rail infrastructure was not affected by flooding on the 15 and 16 August. There were no London Underground station closures within the borough, or adjacent boroughs due to flooding on those dates.

The section of the A13 within the Borough is managed through the A13 Thames Gateway Design, Build, Finance and Operate (DBFO) concession. Under the A13 DBFO Contract, TfL as the client remains the Traffic and Highway Authority, however with a number of highway authority functions contracted out to the A13 DBFO concessionaire: Road Management Services (RMS). RMS are responsible for all aspects of maintenance and operation during the period of the contract which runs until July 2030. This section of the A13 although managed by RMS still forms part of the TLRN. Therefore, the contract manager for the DBFO team was contacted, however at the time of writing no response has been received.

3.6 Thames Water

A request for information was submitted to TW for TW's views on the event. In their response TW stated that they do not have any records of a substantial flood event occurring around the 15-16 August 2020 in Havering. As such, TW did not respond to the event. TW could not provide any sewer depth monitoring data for the period and could not identify any pumping stations as relevant.

TW did supply a record of internal/property incidents recorded in Havering around the requested time period. The data includes 10 reported flooded properties on the 15-16 August, with a total of 15 reported when taking into account the 14 and 17 August. Five of these were considered within the scope of this investigation (see Section 1.1), these reports are included within the List of Reported Flooding (Appendix B), and in Table 2-2.

3.7 London Fire Brigade

LFB provided an overview of their response during the August 2020 flood event, including an incident log of the calls made to the Fire Service across the 15 and 16 August. There were a total 65 incidents recorded across the Borough, with most of the reports within the Rainham area.

LFB pumped flood waters out of properties along eight streets in Rainham, including Brookway, Montague Street (outside the scope of this investigation), Stanley Road (outside the scope of this investigation), Farm Road, Rainham Road, Betterton Road and Lambs Lane South. Other actions described within the logs include providing advice to the public, records of 'making safe' properties and evacuating one property on Brights Avenue.

3.8 Metropolitan Police

The Metropolitan Police were contacted to provide an overview of their response during the August 2020 flood event. In their response two redacted computer-aided dispatch (CAD) messages were provided. Both incidents were recorded on 16 August, one at 15:07 and another at 15:28, both in reference to flooding at Rainham Road. Incidents referred to the LFB as responders to the incidents.

3.9 Royal Society for the Protection of Birds Inner Thames Marshes

The Inner Thames Marshes (made up of the Aveley, Wennington and Rainham Marshes) is the only Royal Society for the Protection of Birds (RSPB) nature reserve within the London Borough of Havering. In a response to a request for information and for RSPB views on the event, the RSPB stated they have no flooding records for the 15-16 August event.

In their response RSPB referenced a hydrology report for the Inner Thames Marshes SSSI from 2016 (commissioned by Natural England, the EA and LBH). RSPB highlighted that this report identified inappropriate culvert size under the HS1 route and the A13 as being a cause of flooding on land to the north of both these pieces of transport infrastructure. RSPB also highlighted in their response that the Inner Thames Marshes Site of Special Scientific Interest (SSSI) is a wetland site, and hydrology needs to be maintained that supports this designated interest.

The response specified that not all of the Rainham Marshes SSSI within the vicinity of Rainham village is managed by RSPB, LBH also manages areas within the marshes directly south of the residential area. The RSPB referenced working closely with LBH on flood risk management issues in the past and facilitated actions to help understand and resolve perceived problems, including an extensive programme of management to create scrapes and ditches that are connected to Main Rivers and creating new space for water on the floodplain.

LBH contacted Rainham Marshes on 4th September to investigate potential culvert blockages but none were found. LBH were notified of the results and Rainham Marshes shared resulting images with LBH.

3.10 Network Rail

Network Rail (NR) were contacted via a request for information and asked to provide an overview of their response during the August 2020 flood event. NR responded that they do not hold any flooding records for the event as they only report on matters of flooding when it relates to, or affects, NR infrastructure and during the August 2020 event no issues were reported within their area of responsibility.

However, as a response to NR's views on the event NR stated the following:

> "*We do not hold any recorded information for this point, however it is the view of experts within the business that the flooding issues were a result of water levels being controlled downstream on the marsh, resulting in the upstream drainage being unable to cope with the unprecedented volume of rainfall, as seen on this event. During the site visit at the time, a sluice gate on the downstream area of the marsh was observed to be high and thus controlling the rate at which any water would outfall from the upstream area. The water level at the culvert remains high to this day despite the works and efforts from both Thames Water and ourselves on our respective assets in the area, suggesting that the problem is downstream on the marsh area.*"

NR also stated within their response that they responded to concerns raised during the event and carried out reactive site visits with TW and LBH. In addition, NR also stated that they conducted vegetation clearance and slight widening of the bank area to ensure that their culvert (under the railway line south of the residential area near Brookway, at the edge of the Rainham marshes) was "fit for purpose". NR reported that on inspection, superficial silt deposits were present but there were *"no reported blockages or collapses that indicated any issues within the NR boundary".*

Within the NR response they also included a post event report, compiled by Senior Engineers in their drainage team. The report references a joint site meeting and inspection following the flood event with LBH and that following this inspection it was concluded that there is high water level generally in the area, which appeared to stem from a sluice gate on the marshes downstream of the sewer and railway. The reported concluded that NR:

"...continue to believe the elevated water levels are a significant factor in the flood risk for residents in the Brookway area and that managing this will reduce the risk in the future... We will continue to engage with Thames Water and the Council so we can contribute to the effective management of flood risk in this area...Should Havering/LLFA/Environment Agency undertake flood risk modelling for this area, particularly as we look to the future for adaptation to climate change, we are happy to feed into this process"

3.11 High Speed Rail 1

A request for information was submitted to High Speed Rail 1 in February 2020 for their views on the August 2020 flood event and any action they took during or after the event. At the time of writing, no information has been received.

4. Likely causes of flood incident

A combination of factors are considered likely to have contributed to the flooding on the 15 and 16 of August including:

- depth and intensity of rainfall experienced over the 36 hours around the 16 August;
- drainage capacity; and
- antecedent conditions.

4.2 Primary causes

The primary contributing factor to the flooding observed in August 2020 is considered the depth and intensity of rainfall that fell across the Borough. It is estimated that one month's average rainfall fell across the Borough over 36 hours. Over the 15 and 16 August during a 36 hour period 56.3 mm of rainfall was recorded at the Havering-atte-Bower gauge which is over half of what the Thames region recorded for the whole month of August in 2020, which was 96mm, which in turn was 170% above the long-term average for the region.

The surface water sewer infrastructure across the Borough is unlikely to be designed to convey surface water runoff in excess of a 3.33% (1 in 30) AEP event and in places the standard of protection would be anticipated to be lower than this as historically systems were designed for lower event frequencies. It is possible that, prior to the peak storms during August 2020 event, parts of the drainage system were at reduced capacity, either due to blockages of culverts or gullies or due to earlier rainfall having been unable to drain away. This is particularly likely to have been the case in the vicinity of Rainham Marshes. It is likely that localised storms resulted in flows and volumes that exceeded drainage capacity and therefore excess water was forced to flow overland.

It should be noted that not all the rain gauges identified in close proximity to the study area were fully functioning. The rain gauge closest to the majority of recorded flooding locations was found to be faulty and no data was available from this gauge. It is likely that the localised rainfall event was in fact of a greater magnitude than that estimated (which was between a 13% (1 in 8) AEP and a 8% (1 in 12) AEP event, see Section 2.3) given the number of recorded flooding locations and lack of reports of blockages or other causes other than the volume and intensity of rainfall.

Location-specific potential contributing factors have been considered for each of the grouped flooding locations in the following section.

4.3 Contributing factors

It is anticipated that predominantly flooding observed at the assessed locations was a result of rainfall exceeding sewer capacity and/or blocked gullies. A number of the reported flooded locations have poor agreement between the observed flooding and the EA RoFSW mapping extents (see Section 2.4). However, for a good number of these locations the surface water flood risk extent is in proximity to the reported flooding locations (within a 20m radius of the property location). Therefore, representative locations have been discussed in further detail within this section in order to consider potential contributing factors to the reported flooding in the borough.

4.2.1 Location 1: Clovelly Gardens & Location 4: Blacksmith Lane and Rainham Road

The properties themselves at location 1: Clovelly Gardens (Figure A1, Appendix A) are not shown to be within the predicted surface water mapping flood extent, however the carriageway in front of the properties is included and there are areas of risk given by the mapping within approximately 10m - 20m of the property locations. This location is an example of where it should also be considered that existing drainage infrastructure may not be providing the anticipated levels of protection, either due to under design or localised blockages. In the case of Clovelly Gardens, this is supported by the anecdotal evidence provided by a resident who described properties along the Close as frequently flooding recently, in addition to the August 2020 event.

One example of poor agreement between observed and EA flood mapping is at location 4: Blacksmith Lane and Rainham Road (Figure A3, Appendix A). There is the potential that the surface water flood risk mapping underestimates the extent of flooding. The fact that localised flooding was recorded outside of the predicted RoFSW mapping extents, suggests that the August event could potentially have been a greater than a 3.33% (1 in 30) AEP event, at least in localised areas. Again, sewer capacity and/or condition could be a contributing factor to the flooding observed outside of the RoFSW mapping extents. However, there is insufficient evidence to definitively conclude that this is the case for the locations for which the mapping had poor agreement with the observed flooding locations and there may be other underlying causes that have not been identified.

4.2.2 Location 5: Nelson Road, Spinney Close and Betterton Road

As discussed, there is the potential that the August 2020 rainfall event was of a greater magnitude than the analysis suggests. The counter argument to this is that if this were the case it would be anticipated for many of these grouped reported flooding locations there would be a greater total number of properties reported flooding and with better correlation to areas of high surface water flood risk mapping. It is again difficult to draw conclusions on this due to the deficiency in detailed reporting and the fact that the RoFSW mapping is not intended to be used for assessing risk on an individual property scale. There are locations, such as at location 5: Nelson Road, Spinney Close and Betterton Road (Figure A4, Appendix A), where there are properties within low surface water flood risk extents and within proximity to areas of high risk, but not a significant number within the high risk areas. The flooding reported along Nelson Road for instance, appears within a small area of localised topographical low points, where it could be assumed to have simply reached its local capacity during the event or perhaps gullies in the area were blocked. At this particular location there was also anecdotal evidence that the culvert under the A1306 (south of the reported flooding locations) could have been at capacity during the event. However, if this were a contributing factor to the observed upstream flooding it is anticipated that a greater number of properties would have reported flooding.

4.2.3 Location 10: Upminster Road

Some of the reported grouped flooding locations could also be considered isolated events driven by localised mechanisms. For instance, the flooding reported at location 10: Upminster Road (Figure A9, Appendix A). The local topography supports the specific reported flooding locations (where sufficient detail was provided), however it is unclear how the Rainham Village Primary experienced internal flooding from a surface water flow path from the adjacent Upminster/Cowper Roads. There is the potential the significant quantity of hardstanding within the property could have contributed to the flooding observed, in combination with the significant rainfall experienced and localised drainage failure or exceedance.

There is limited evidence to suggest other mechanisms contributed to flooding observed within these locations, outside of the rainfall exceeding sewer capacity and/or blocked gullies and local topography. There is the potential for other contributing factors such as localised significant areas of hardstanding contributing to significant runoff volumes, or temporary drainage asset blockages, to have played a role in the observed flooding. However, it is difficult to draw definitive conclusions and delineate these causes within most of these reported grouped flooding areas, in particular given the flooding was so localised and the lack of detailed information available.

4.2.4 Location 12: Brookway and South Rainham

The flooding observed at location 12: Brookway and South Rainham (Figure A11, Appendix A) is a location from the August 2020 event where the magnitude of impact appears to be potentially underestimated by the reporting. The locations of observed flooding correlated fairly well with the EA RoSFW mapping flood risk extent. However, based on the range of event frequencies estimated for the August rainfall event, less properties would be expected to have been affected. This suggests the EA RoFSW mapping could be presenting an underestimation of potential flood risk or, as previously discussed, that the rainfall event was of a greater magnitude than the analysis suggests. The reports of flooding in this location suggest potentially a lack of capacity of the sewer system could have contributed, with no evidence of obvious blockages or failures with regard to assets or infrastructure.

Various stakeholders and FRMAs have provided views on the contributing factors to the observed flooding in this location. Observations and anecdotal evidence provided by LBH for instance, suggests that the TW sewer is reportedly often carrying flows even a significant time after rainfall events, indicating slow discharge and that the system may therefore not have capacity during the heavy rainfall events. The TW system is believed to be of an insufficient gradient along Brookway, and as such controlling the discharge rate to the open ditch at the southern end of the road and the edge of the residential area.

The drains at the southern end of Brookway and running parallel to the edge of the residential area are believed to have been full around the time of the event. Anecdotal evidence from LBH suggests that the drain shown in Figure A11 (Appendix A) and represented by the RoFSW mapping to be flowing north-west to south-east was in fact flowing the opposite direction, towards the TW outfall and drain at the bottom of Brookway. NR reported that their culvert under the railway line was observed on a site visit prior to the event to have been "drowned" by high water levels from the marshes. Both the NR culvert and the TW outfall pipe were observed to be submerged but not silted. It is believed the water levels in the area are controlled by the three EA owned and operated sluice gates, downstream of the residential area (within the marshes, near Coldharbour Lane). Responses from NR and LBH suggest that the elevated water levels within the marshes are a significant factor in the observed flooding of the residential area. In addition, it is also believed that there is the potential for the water levels in the marshes to be tidally locked by the Thames River.

A response to a request for views on the event by RSPB referenced the findings of a hydrology report for the Inner Thames Marshes SSSI from 2016 (commissioned by Natural England, the EA and LBH). RSPB highlighted that this report identified inappropriate culvert size under the HS1 route and the A13 as being a cause of flooding on land to the north of both these pieces of transport infrastructure. Furthermore, in their response RSPB noted that in November 2019, they undertook an extensive programme of management on Unit 11 (unit of the marshes directly south of the residential area), to create scrapes and ditches that are connected to the Main River (ditch from the bottom of Brookway). RSPB believe that this work created new space for water on the floodplain. RSPB also noted that after the event, they checked several culverts for signs of blockages, and none were found.

It is considered not possible without further investigation to delineate one or several sources as a primary cause of flooding at this location. It is likely that the observed flooding at this location is driven by some combination of the above mechanisms, as described by the various FRMAs.

5. Conclusions and recommended actions

5.1 Conclusions

The primary cause of the flooding experienced throughout the 15 and 16 of August was the volume and intensity of rainfall experienced. It is estimated that one month's rainfall fell across the Borough over 36 hours. There is the potential for other factors and mechanisms to have contributed to flooding within most of the reported grouped flooded areas. Given the flooding was so localised and the lack of detailed information available, there is however limited evidence to support this.

The primary causes are difficult to manage without the implementation of capital works to attenuate or convey flood water or major changes in terms of installing SuDS across the borough. Opportunities to implement localised natural flood management could be considered, however further investigation into potential contributing factors and localised flooding mechanism would be required.

Various stakeholders and FRMAs have provided views on the contributing factors to the observed flooding in the location near Brookway, South Rainham. It is not considered possible without further investigation to delineate one or several sources as a primary cause of flooding at this location. It is likely that the observed flooding at this location is driven by some combination of the mechanisms described by the various FRMAs.

In accordance with the Flood and Water Management Act, the London Borough of Havering is the Lead Local Flood Authority within the Borough. Section 19 of the Act includes regulations relating to flood investigations within an LLFA's jurisdiction. LBH have adhered to these regulations by:

- Maintaining a register of properties flooded during the August 2020 flood;
- Investigating the actions of FRMAs during the August 2020 flood event; and
- Devising a list of recommended actions for FRMAs to ensure a more effective response is achieved if a similar event should occur in the future.

5.2 Recommended actions

One significant caveat within this investigation is attached to the frequency estimated for the August rainfall event as a result of the hydrological analysis. As discussed in Section 4.1, the key rain gauge closest to the observed flooding locations was found to have been faulty during the event. As a result, there is a risk that the localised rainfall event was in fact of a greater magnitude than the results of analysis presented. Given the extent and magnitude of flooding experienced, it is considered likely that this was the case. The EA have in place appropriate maintenance/management procedures to maximise likelihood of rain gauges functioning during heavy rainfall events. Rain gauges are visited regularly throughout the year and daily checks are undertaken to determine if gauges are recording. If a gauge is found to not be recording rainfall, where there is believed to have been rainfall, or where nearby and neighbouring sites are picking up recordings, a site will be added to a fault list. This site is then visited to address the fault at the earliest opportunity. The rain gauge (Central Park) that was not recording is located on a roof which has since been deemed too dangerous to access and is therefore now considered inaccessible. At the time of writing the EA are investigating an alternative site.

Poor correlation between the EA RoFSW mapping extents and the observed flood extents for the August 2020 event was identified in several locations across the Borough. There is the potential that the surface water flood risk mapping underestimates the extent of flooding in these locations. It is therefore recommended that surface water flood maps and designated Critical Drainage Areas are reviewed by LBH in light of this discrepancy and the anecdotal evidence suggesting some areas have experienced frequent flooding.

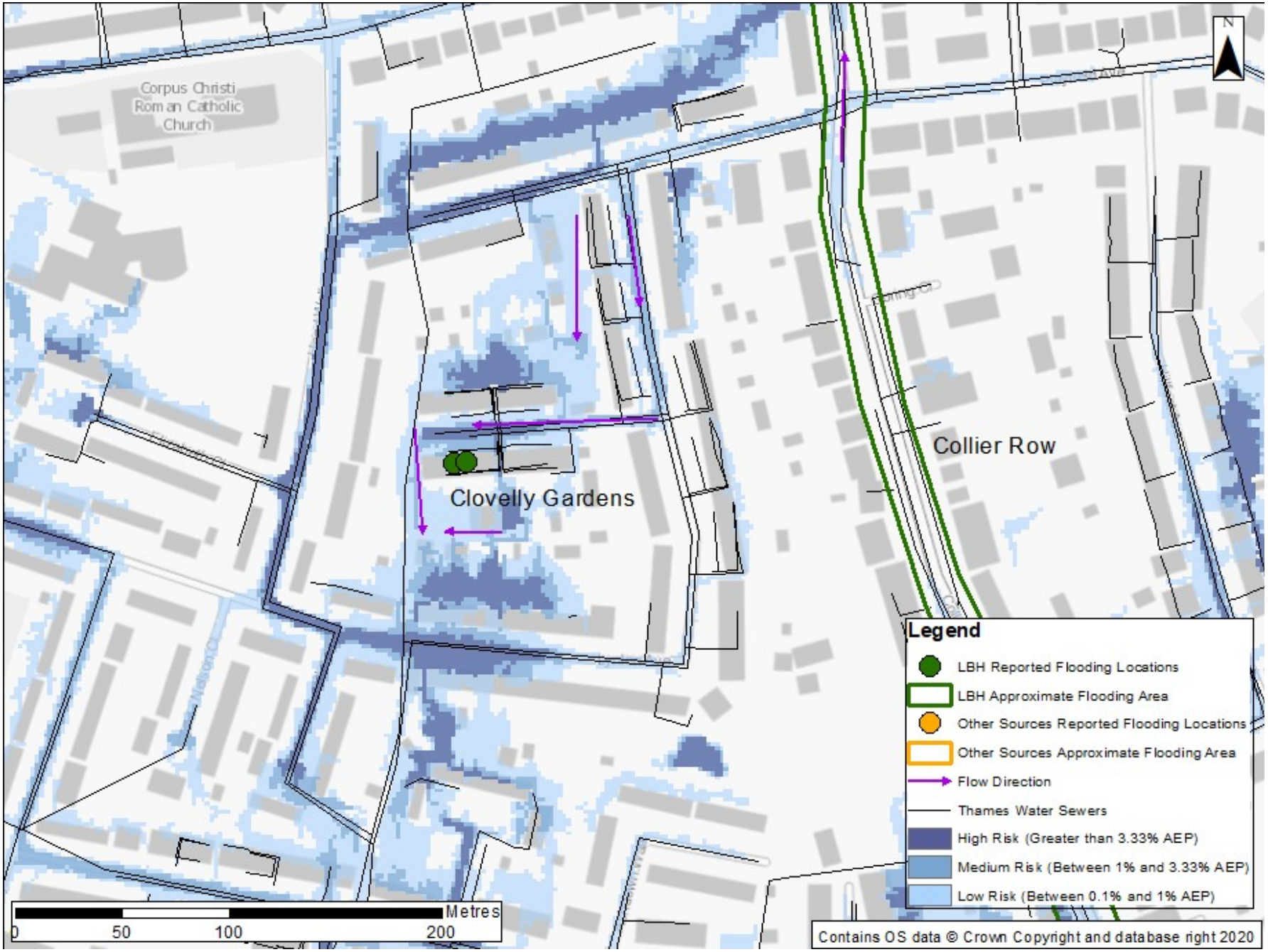
It is also recommended that a more refined, detailed and consistent reporting system be applied across all FRMAs. It is apparent that the differences in reporting systems for the various FRMAs resulted in mismatches between specific locations detailed in this investigation, even within grouped flooding locations. In particular,

some reports would only include a record of a post code without a type of flooding attributed to it, or any specific location provided. A more detailed and consistent reporting system for all FRMAs would potentially have allowed for the identification of specific flooding locations and types. This would assist in delineating mechanisms of flooding and allow for improved lessons learnt and identification of potential mitigation following flood events. Consistent and joined up reporting may also assist responders and members of the public. In addition, it is recommended that a clearer reporting system ensures it is confirmed when recommended actions associated with recorded flooding incidents are carried out.

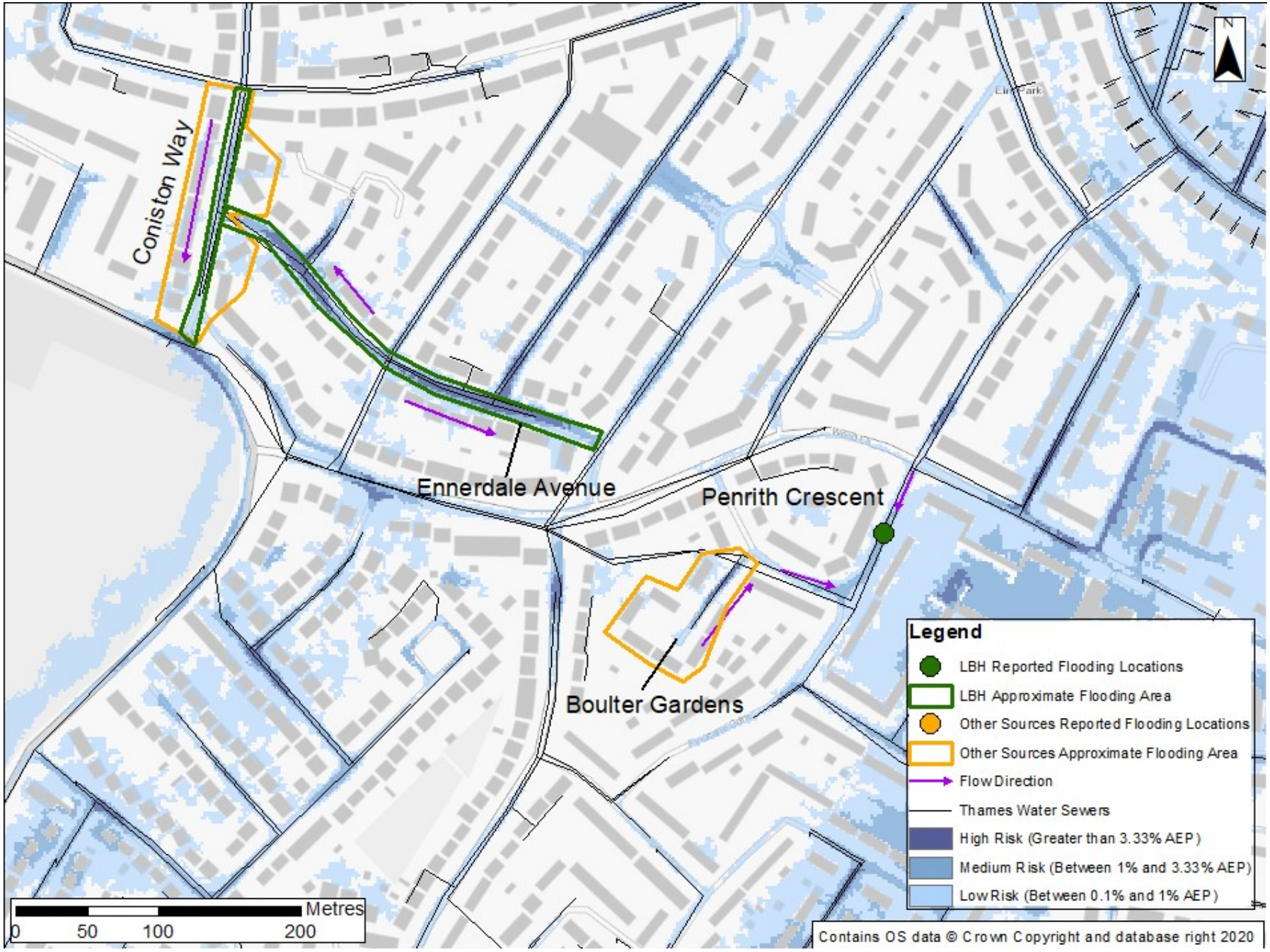
As it was not considered possible to delineate one or several sources as a primary cause of flooding to the areas near Brookway, South Rainham, where considerable property flooding occurred, it is recommended a separate investigation be undertaken. This investigation should aim to more fully understand flooding in the area and allow agreement of an updated, cross-agency Water Management Plan for the marshes and surrounding areas, including participation from TW, RSPB, LBH, EA and NR. The plan could include agreed upon emergency response procedures in the event of predicted severe weather and will facilitate joint understanding of the overall hydrology mechanisms in the area and cooperation between the agencies towards preventative measures through joint management.

Appendix A. Locations of Reported Flooding

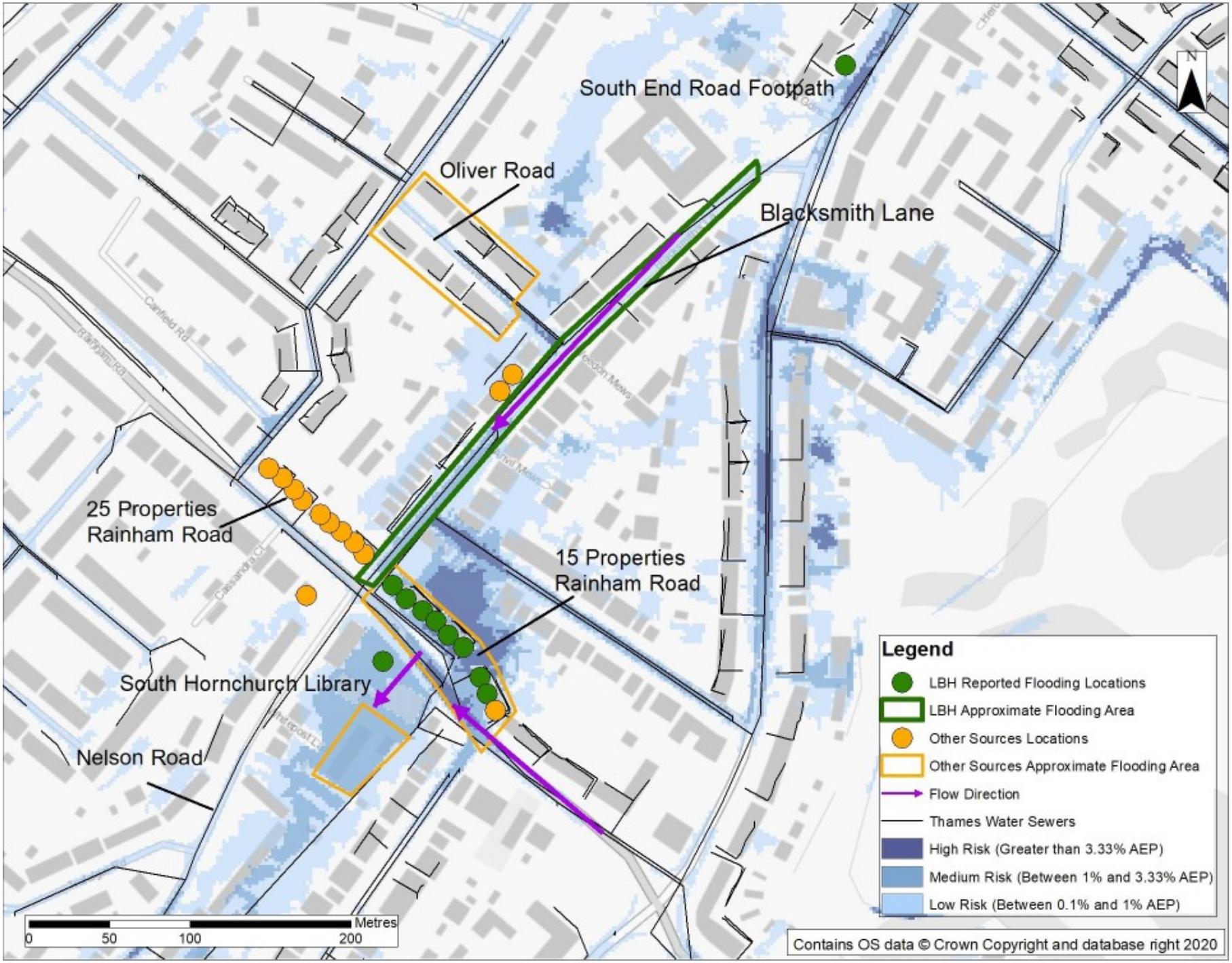
A.1 Clovelly Gardens



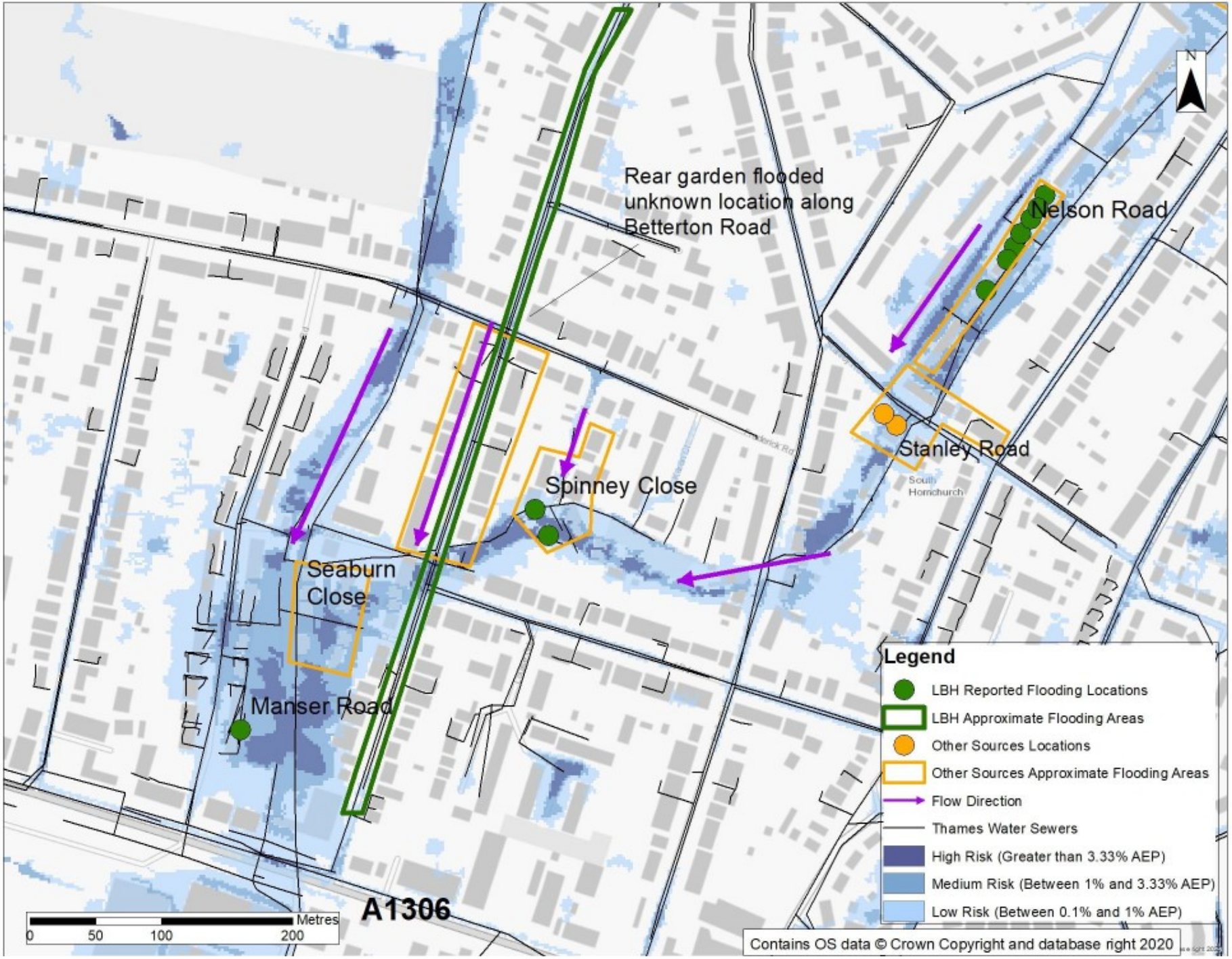
A.2 Elm Park and Penrith Close



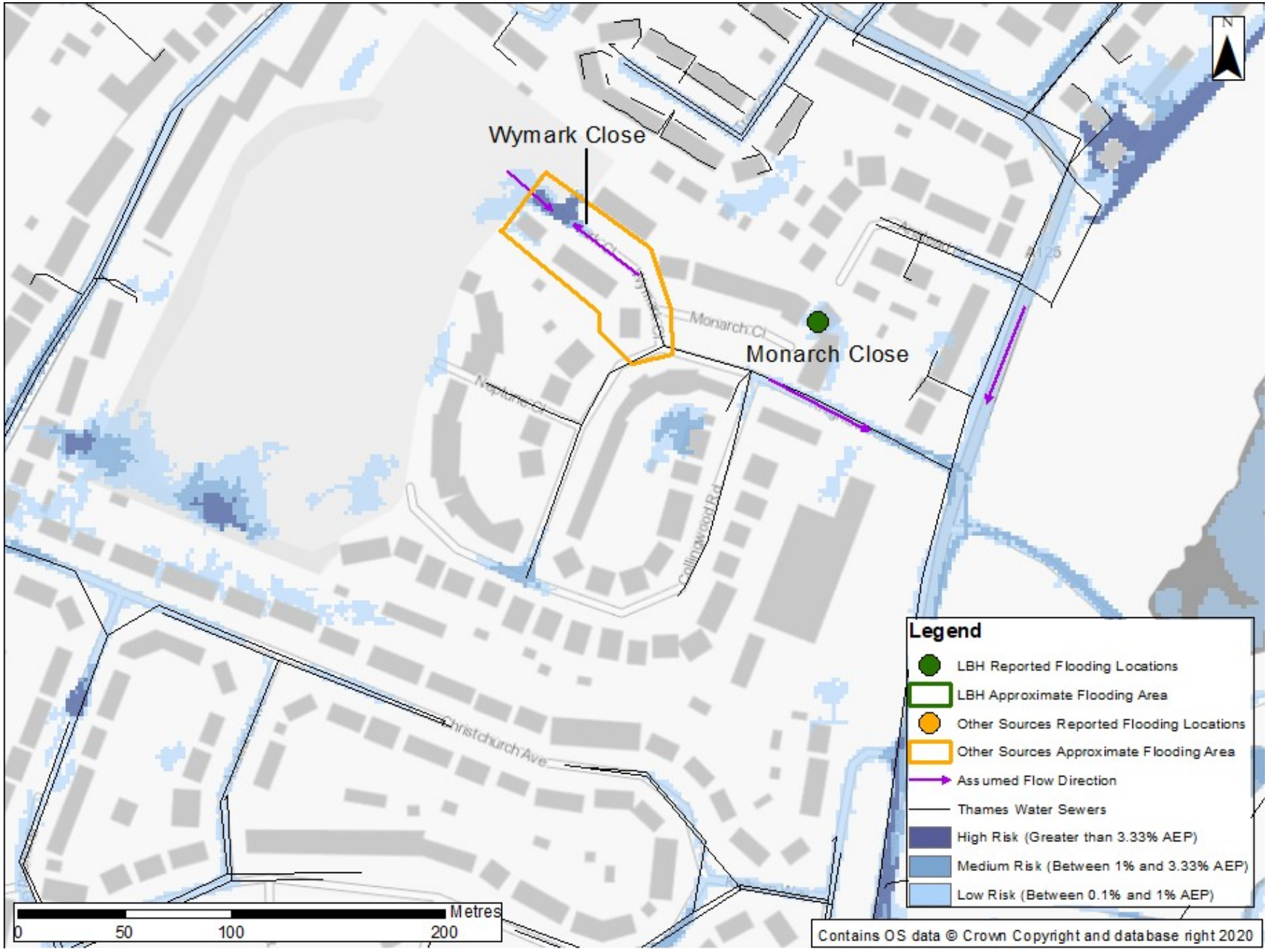
A.3 Blacksmith Lane & Rainham Road



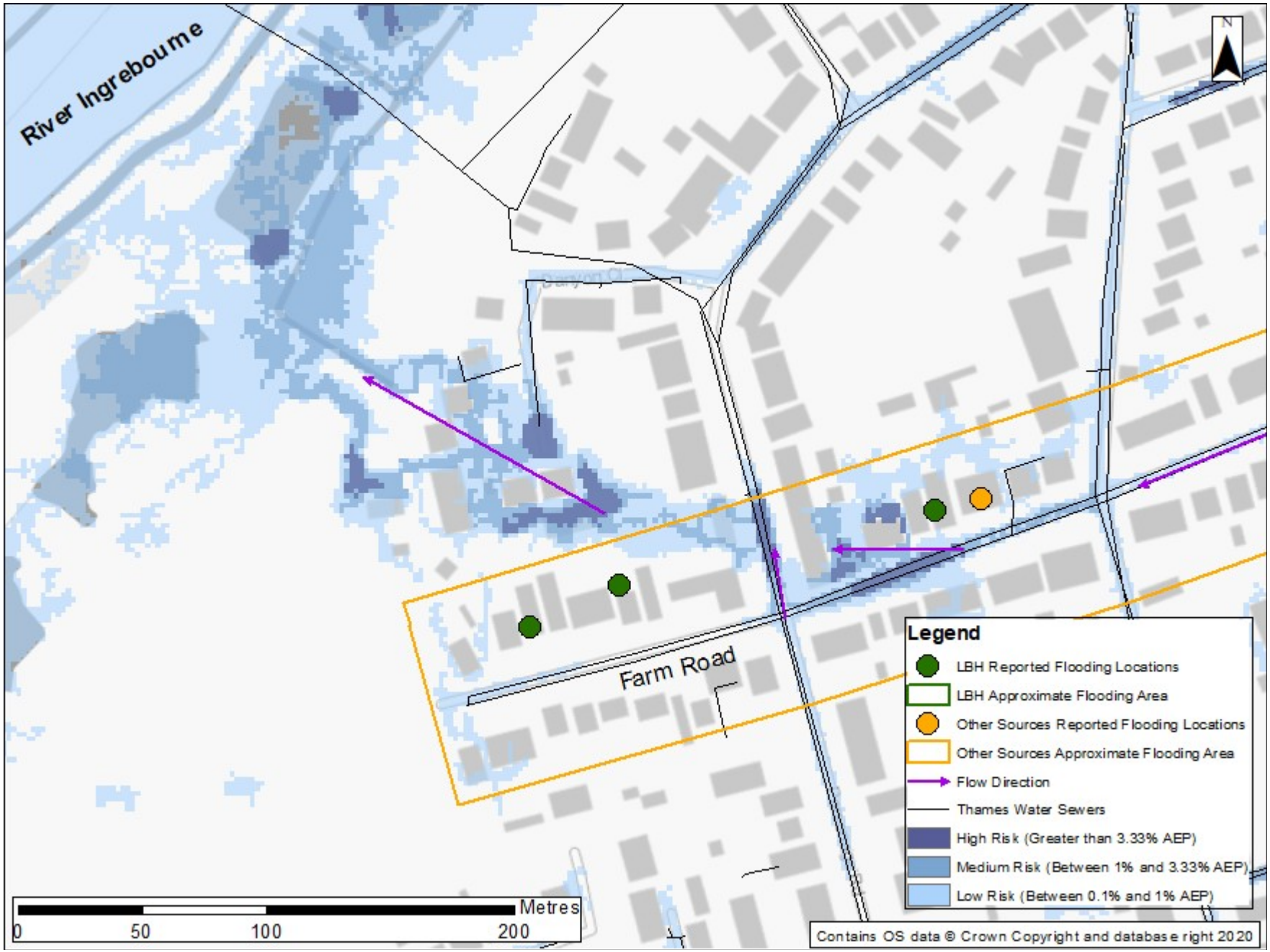
A.4 Nelson Road, Spinney Close and Betterton Road



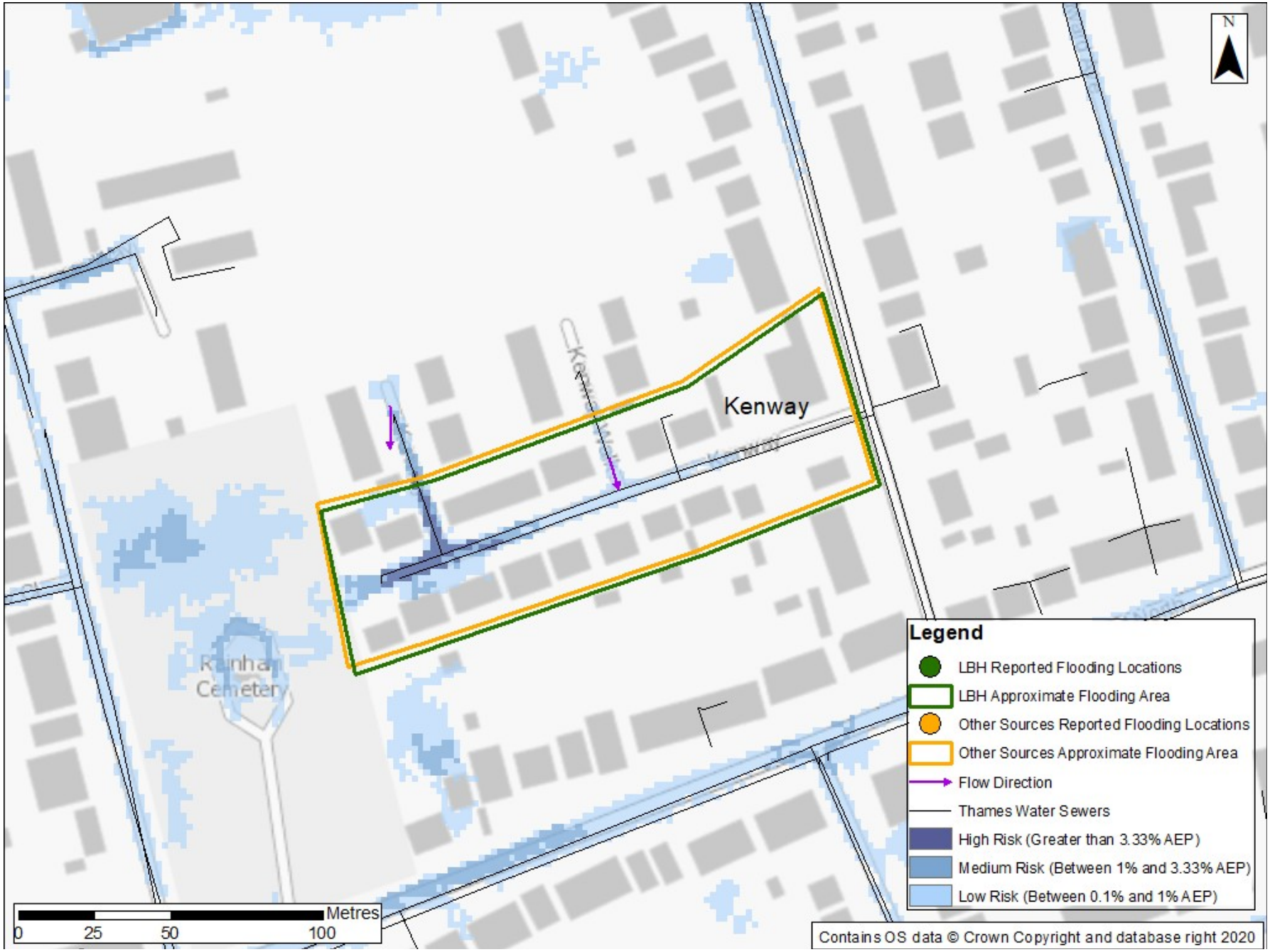
A.5 Monarch Close



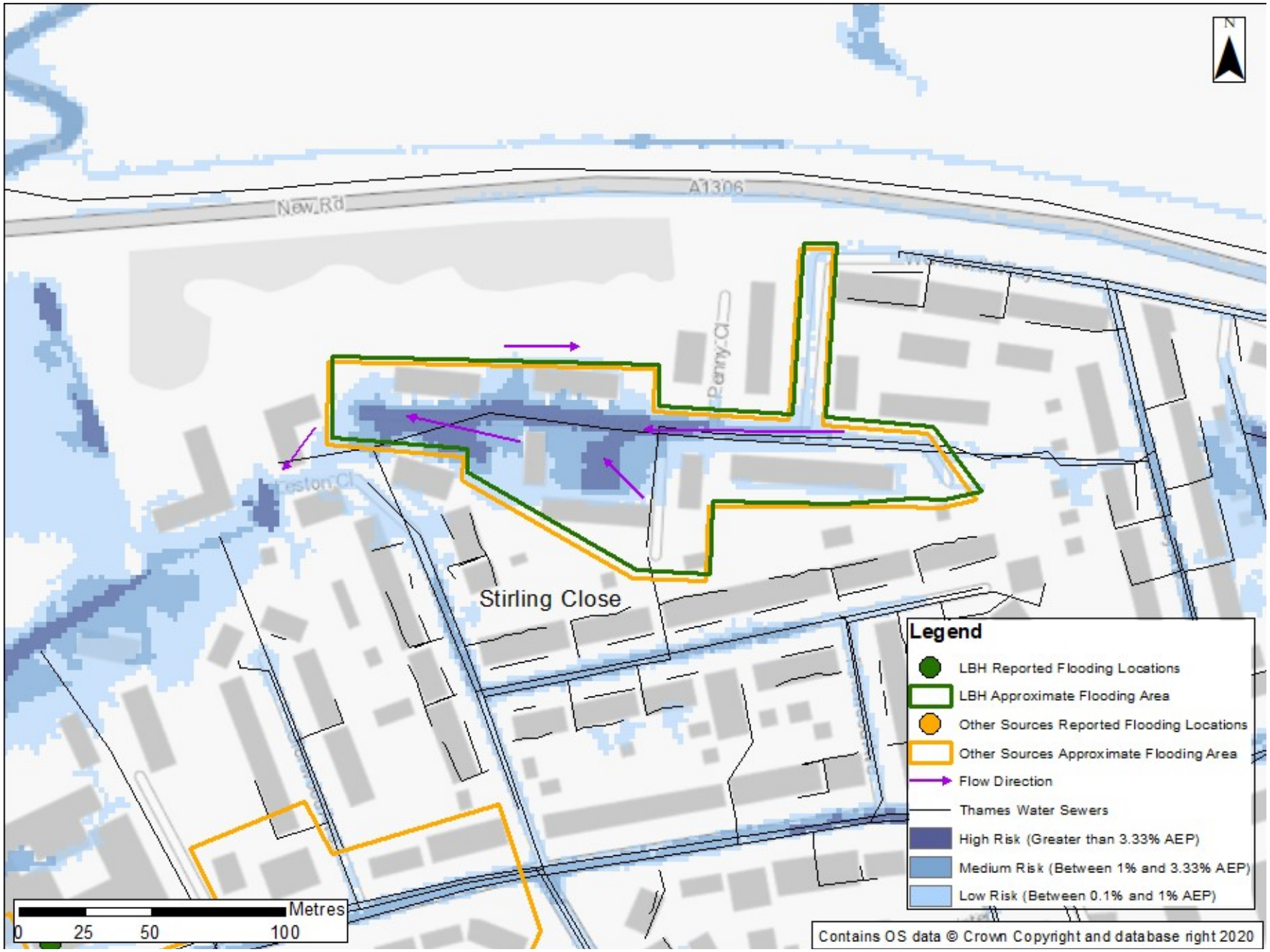
A.6 Farm Road


River Ingrebourne
Farm Road
N
Legend
LBH Reported Flooding Locations
LBH Approximate Flooding Area
Other Sources Reported Flooding Locations
Other Sources Approximate Flooding Area
Flow Direction
Thames Water Sewers
High Risk (Greater than 3.33% AEP)
Medium Risk (Between 1% and 3.33% AEP)
Low Risk (Between 0.1% and 1% AEP)
Metres
0
50
100
200
Contains OS data © Crown Copyright and database right 2020

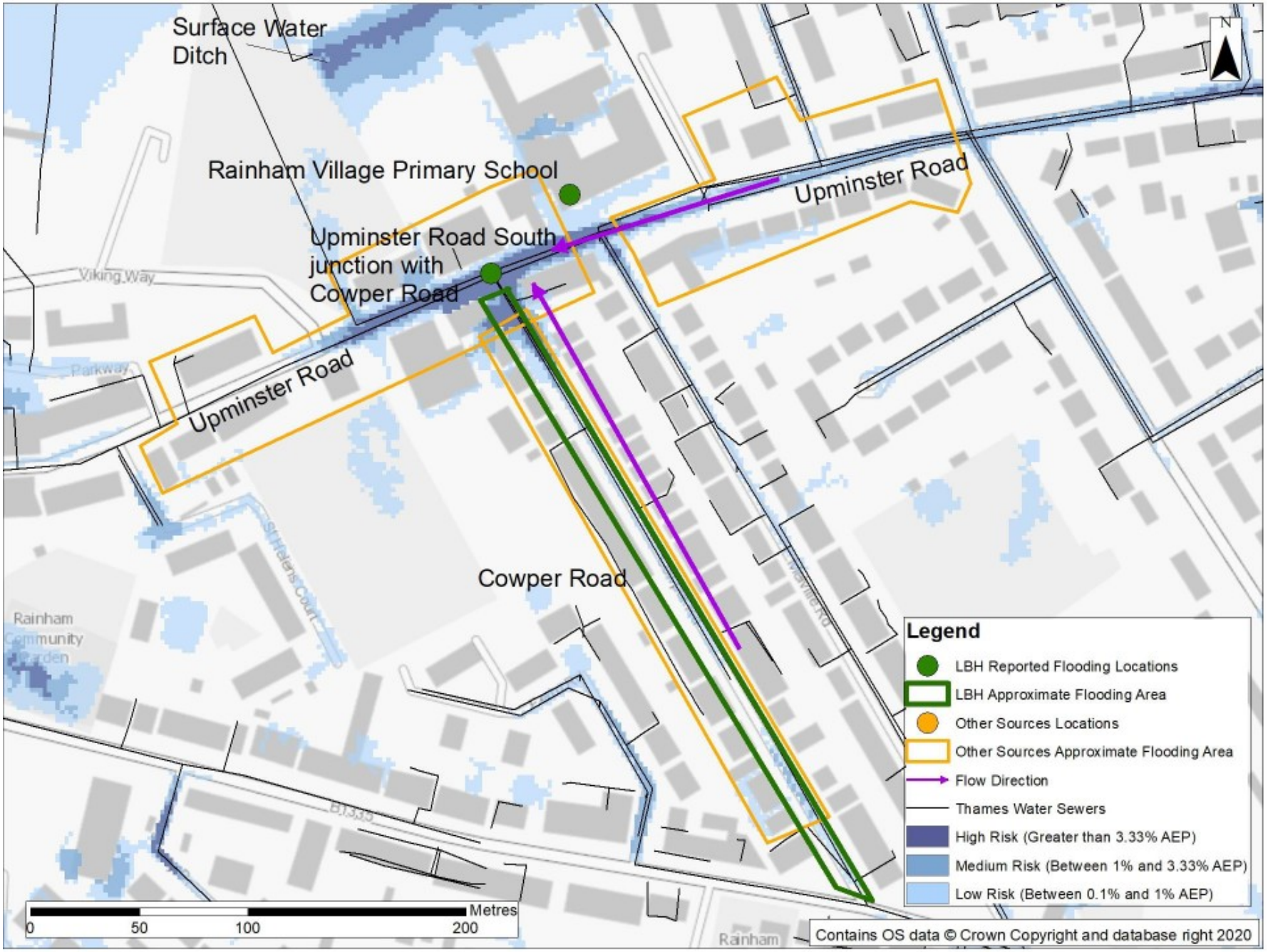
A.7 Kenway


N
Kenway
Kenway Walk
Rainham Cemetery
Legend
LBH Reported Flooding Locations
LBH Approximate Flooding Area
Other Sources Reported Flooding Locations
Other Sources Approximate Flooding Area
Flow Direction
Thames Water Sewers
High Risk (Greater than 3.33% AEP)
Medium Risk (Between 1% and 3.33% AEP)
Low Risk (Between 0.1% and 1% AEP)
Metres
0 25 50 100
Contains OS data © Crown Copyright and database right 2020

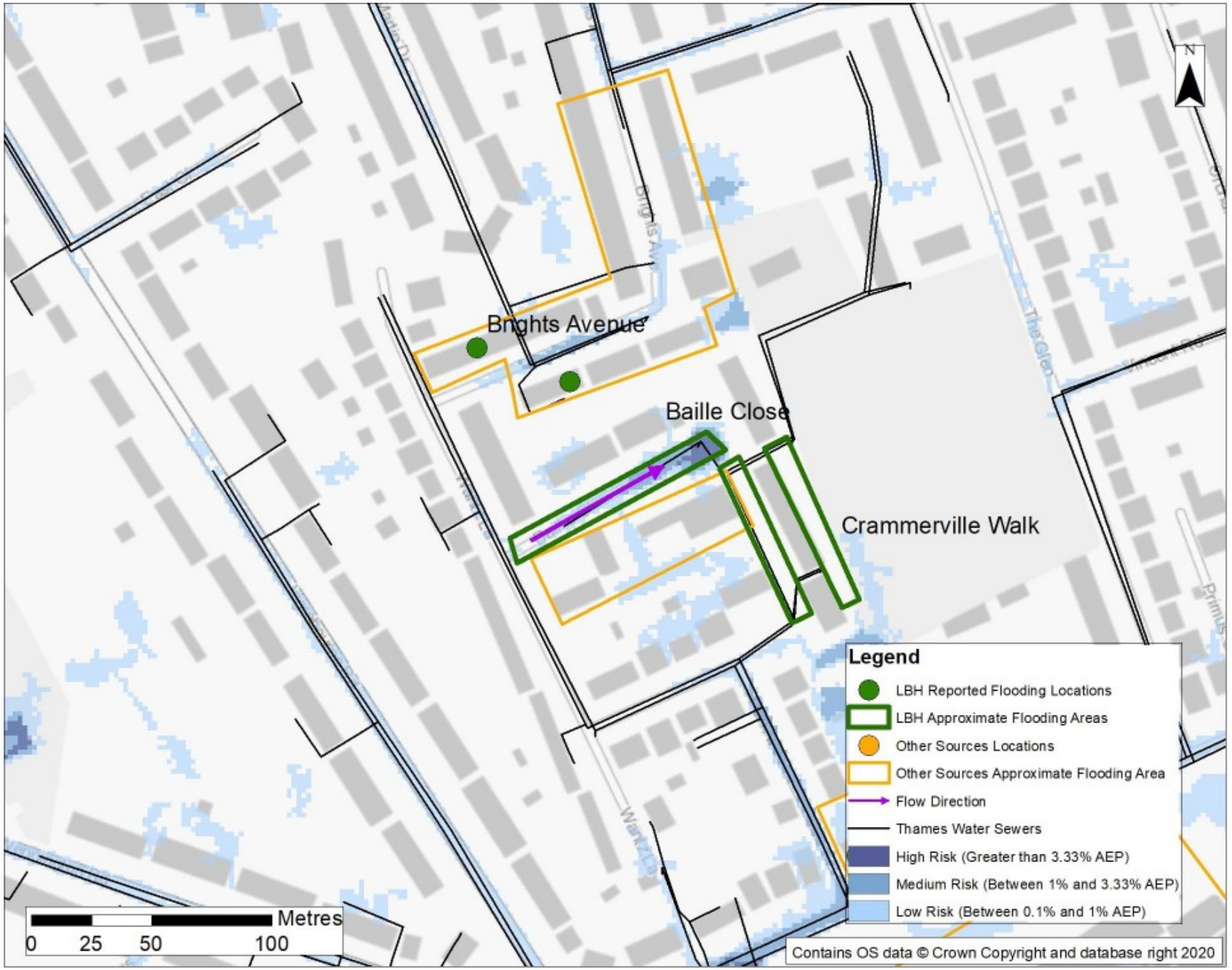
A.8 Stirling Close



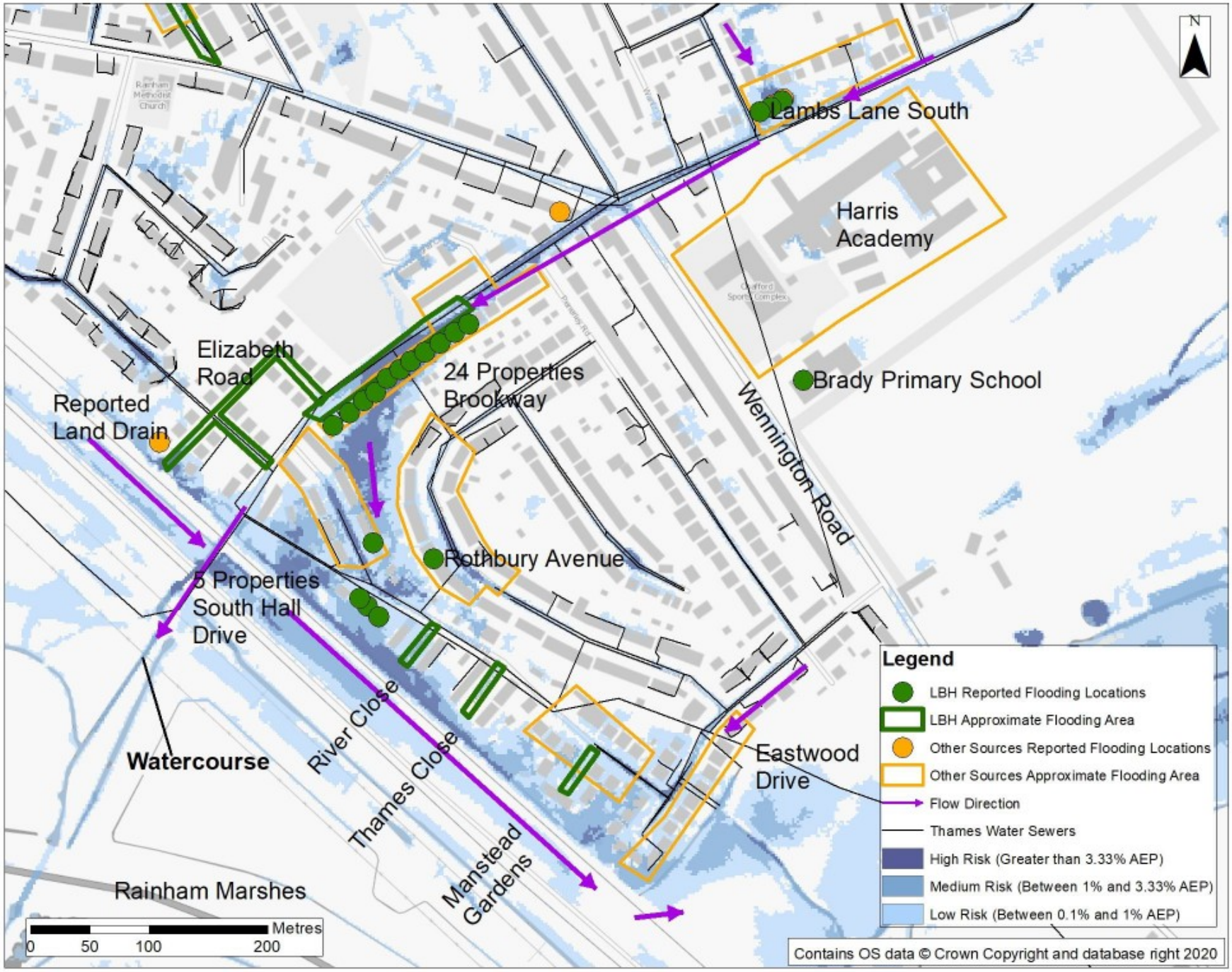
A.9 Upminster Road



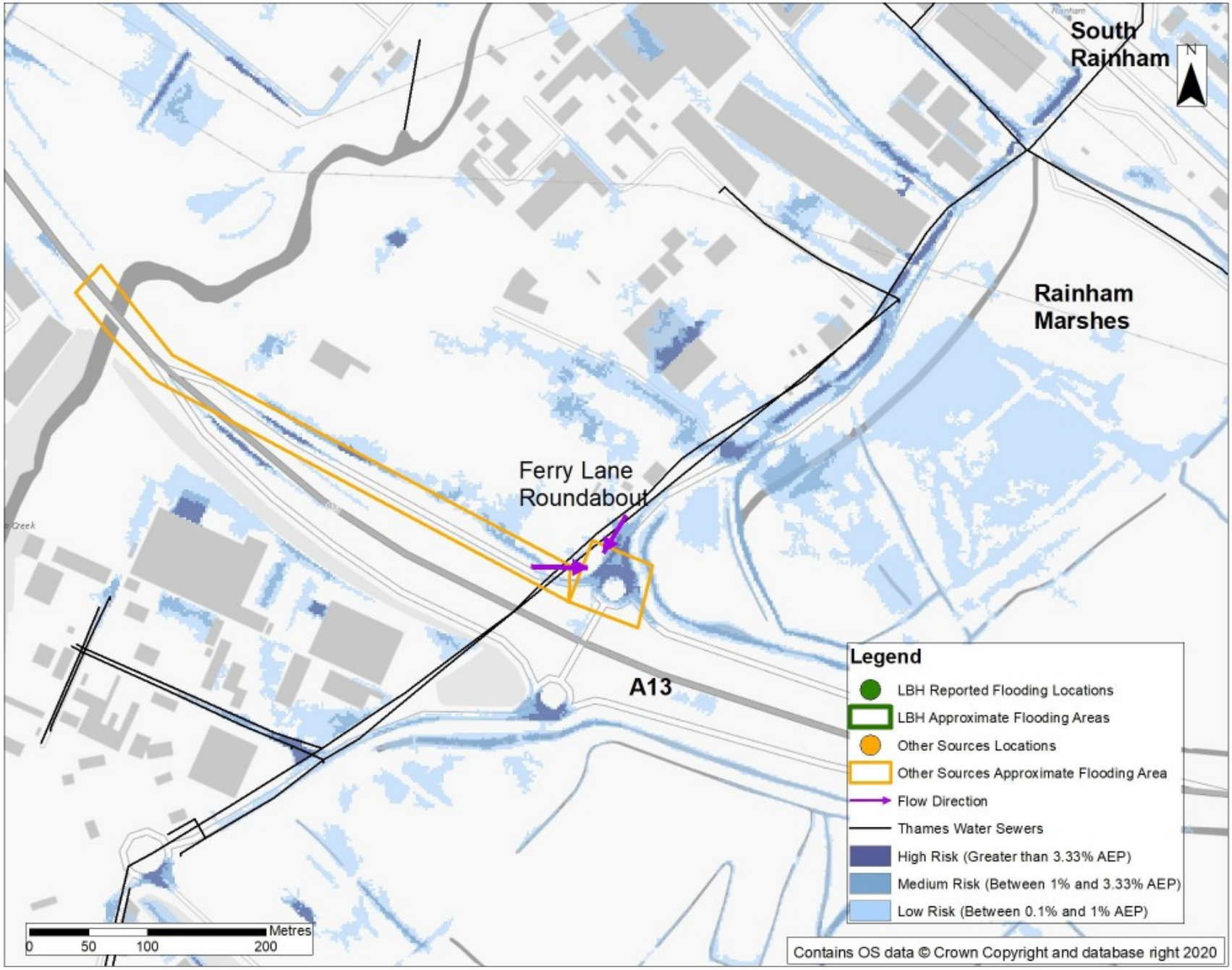
A.10 Brights Avenue and Baille Close



A.11 Brookway and South Rainham



A.12 Ferry Lane



Appendix B. List of Reported Flooding

Grouped in Scope

Grouped recorded flooding locations, predominantly based on those in the original LBH incident list where also supported by other sources (including the London Fire Brigade, the Police, Thames Water, Transport for London, Highways England or the Environment Agency

Number	Source	Date Reported	Report reference	Location	Location	Issue reported	Date investigated	Flooding type	Action taken
1a	**LBH**	15&16/08/2020	19/21 Clovelly Close, Collier Row.			Internal flooding including roadway	Aug/Sept 20	Internal	Gullies and TWU to be cleared
1b	**LBH**	15&16/08/2020	Cllr D. Patel ENQ-0873403	No specific location along long road		Flooding and drainage issues in Collier Row Lane	Aug/Sept 20	Carriageway	Gullies and TWU to be cleared
2a	**LBH**	15&16/08/2020	Ennerdale Avenue, South Hornchurch			Carriageway flooding	Aug/Sept 20	Carriageway	Gullies and TWU to be cleared
2b	**LBH**	15&16/08/2020	Conistan Way, South Hornchurch			Carriageway flooding	Aug/Sept 20	Carriageway	Gullies and TWU to be cleared
2c	LFB	16-Aug-20	105068-16082020	CONISTON WAY HORNCHURCH RM12 5EH		FLOODING	16-Aug-20	Unknown	Make safe, special service
3a	**LBH**	15&16/08/2020	25 Penrith Crescent, Elm Park.			Carriageway	Aug/Sept 20	Carriageway	Gullies and TWU to be cleared
3b	LFB	16-Aug-20	105100-16082020	BOULTER GARDENS RAINHAM RM13 7QD		RUNING CALL TO FLOODING F391 ATTENDING	16-Aug-20	Unknown	Make safe, special service
4a	**LBH**	15&16/08/2020	109 Southend road, Rainham			Nearby extensive pathway flooding	Aug/Sept 20	Footway	Gullies and TWU to be cleared
4b	LFB	15-Aug-20	104733-15082020	OLIVER ROAD RAINHAM RM13 7UH		FLOODING	15-Aug-20	Unknown	Make Safe
4c	TW	15- Aug-20	478818 and 478765 Neighbouring two properties	5519043	1837257	Hydraulic, Less than 30 mm	17-Aug-20	Internal	FA Started
4d	**LBH**	15&16/08/2020	Blacksmiths Lane			Carriageway	Aug/Sept 20	Carriageway	Gullies and TWU to be cleared
4e	Police	16- Aug-20		5395 552125	183125	177 RAINHAM RD,RAINHAM Assistance not requested from caller	-	Unknown	LFB 3 PUMP SPECIAL SERVICE DUE TO FLOODING
4f	Police	16-Aug-20		5395 116-180 Rainham Rd		25 propertpies effected		Property	
4g	EA Floodline	15-Aug-20	-	RM13 7RH		-	-	Unknown	-
4h	LFB	15- Aug-20	104743-15082020 and others	RAINHAM ROAD RAINHAM RM13 7RH		FLOODING -VULNERABLE PERSON	15-Aug-20	Internal	Pumping Out
4i	**LBH**	15&16/08/2020	South Hornchruch Library/Community Hall			Visible standing water around the site - no confirmation of internal flooding yet	Aug/Sept 20	Property	Gullies and TWU to be cleared
4j	EA Floodline	16- Aug-20	-	RM13 8GT -		-	-	Unknown	-
4k	**LBH**	15-Aug-20		152 - 124 RAINHAM ROAD RAINHAM RM13 7RH		I property flooded internally - door number not confirmed	Aug/Sept 20	Carriageway and internal	-
5a	**LBH**	15&16/08/2020	Nelson Road, Rainham no.26 to 32			6 properties with internal flooding	Aug/Sept 20	Internal	Gullies and TWU to be cleared
5b	**LBH**	15&16/08/2020	20 Nelson Road, Rainham.			Carriageway and property	Aug/Sept 20	Carriageway and Property	Gullies and TWU to be cleared
5c	LFB	15- Aug-20	104787-15082020	NELSON ROAD RAINHAM RM13 8AL		Unknown	15- Aug-20	Unknown	Stand By - No Action
5d	TW	16- Aug-20	478881 and 478880	STANLEY ROAD SOUTH		Hydraulic, Less than 30 mm	16- Aug-20	Internal	FA Started
5e	LFB	15-Aug-20	104667-15082020	STANLEY ROAD SOUTH RAINHAM RM13 8AJ		GARDEN AND ANEX BUILDING COVERING AREA OF 30M X 15M, AFFECTED BY APPROX 18 INCHES OF FLOOD WATER.	15-Aug-20	Internal	Pumping out
5f	**LBH**	15&16/08/2020	Spinney Close, South Hornchurch no.14&16			Internal flooding	Aug/Sept 20	Internal	Additional drainage to be installed
5g	LFB	15-Aug-20	104778-15082020	SPINNEY CLOSE RAINHAM RM13 8LR		FLOODING	15-Aug-20	Unknown	Advice Only
5h	**LBH**	15&16/08/2020	Betterton Road. Rainham.			Rear garden	Aug/Sept 20	Property	Gullies and TWU to be cleared

5i	LFB	15-Aug-20	104776-15082020	BETTERTON ROAD RAINHAM RM13 8NB		FLOODING	15-Aug-20	Unknown	Pumping out
5j	LFB	15-Aug-20	104685-15082020	SEABURN CLOSE RAINHAM RM13 8BP		FLOODING	15-Aug-20	Unknown	Advice Only
5k	**LBH**	15&16/08/2020	Cllr D. White	2 Manser road		rear garden	Aug/Sept 20	Property	Gullies and TWU to be cleared
6a	**LBH**	15&16/08/2020	3 Monarch Close. Rainham.			Carriageway and property	Aug/Sept 20	Carriageway and Property	Gullies and TWU to be cleared
6b	LFB	15-Aug-20	104738-15082020	WYMARK CLOSE RAINHAM RM13 8SW		FLOODING	15-Aug-20	Unknown	Advice Only
7a	**LBH**	15&16/08/2020	Farm Road, Rainham no.50 and 78			Internal flooding - Number 58 was a Residen	Aug/Sept 20	Internal	Under capacity
7b	**LBH**	15&16/08/2020	70 Farm road. Rainham			Carriageway and property	Aug/Sept 20	Carriageway and Property	Gullies and TWU to be cleared
7c	LFB	15-Aug-20	104740-15082020			FLOODING OF RESIDENTIAL CARE HOME	15-Aug-20	Internal	Pumping Out
7d	LFB	15-Aug-20	104686-15082020	FARM ROAD RAINHAM RM13 9LQ		FLOODING	15-Aug-20	Unknown	Advice Only
8a	**LBH**	15&16/08/2020	Kenway, Rainham.			Carriageway and property	Aug/Sept 20	Carriageway and Property	Gullies and TWU to be cleared
8B	EA Floodline	15-Aug-20	-	RM13 9PY	-	-	-	Unknown	-
8C	LFB	15-Aug-20	104655-15082020	KENWAY RAINHAM RM13 9PY		FLOODING	15-Aug-20	Unknown	
8D	News	15&16/08/2020	Kenway, Rainham. RM13 9PY			Potentially 10 houses	Aug/Sept 20	Internal	
9a	**LBH**	15&16/08/2020	Stirling Close, Rainham			Carriageway and property	Aug/Sept 20	Carriageway and Property	Gullies and TWU to be cleared
9b	LFB	15-Aug-20	104708-15082020	STIRLING CLOSE RAINHAM RM13 9NQ		FLOODING	15-Aug-20	Unknown	Advice Only
9c	LFB	15-Aug-20	104789-15082020	STIRLING CLOSE RAINHAM RM13 9NG		FLOODING	15-Aug-20	Unknown	Advice Only
9d	LFB	15-Aug-20	104726-15082020	STIRLING CLOSE RAINHAM RM13 9NJ		FLOODING	15-Aug-20	Unknown	Make Safe
10a	**LBH**	15&16/08/2020	Rainham Village Primary School Upminster Road South j/w			Internal Flooding	Aug/Sept 20	Internal	Gullies and TWU to be cleared
10b	**LBH**	15&16/08/2020	Cowper Road			Carriageway and property	Aug/Sept 20	Carriageway and Property	Gullies and TWU to be cleared
10c	**LBH**	15&16/08/2020	Cowper road, Rainham			Carriageway	Aug/Sept 20	Carriageway	Gullies and TWU to be cleared
10d	LFB	15- Aug-20	104662-15082020	UPMINSTER ROAD SOUTH RAINHAM RM13 9AA		FLOODING	15-Aug-20	Unknown	Advice Only
10e	EA Floodline	16- Aug-20	-	RM13 9TS	-	-	-	Unknown	-
10f	LFB	15-Aug-20	104692-15082020	SOUTH RAINHAM RM13 9AB		FLOODING	15-Aug-20	Unknown	Advice Only
11a	**LBH**	15&16/08/2020	76 Brights Avenue			no.76	Aug/Sept 20	Internal	Gullies and TWU to be cleared
11b	**LBH**	15&16/08/2020	67 Brights Avenue, Rainham.			Carriageway and property	Aug/Sept 20	Carriageway	Gullies and TWU to be cleared
11c	**LBH**	15&16/08/2020	Baille Close, Rainham.			Carriageway	Aug/Sept 20	Carriageway	Gullies and TWU to be cleared
11d	LFB	15-Aug-20	104773-15082020	BRIGHTS AVENUE RAINHAM RM13 9NW		FLOODING	15-Aug-20	Internal assumed	Evacuation
11e	LFB	15-Aug-20	104804-15082020	BAILLIE CLOSE RAINHAM RM13 9PR		FLOODING	15-Aug-20	Unknown	Advice Only
11f	**LBH**	15&16/08/2020	Cllr D. White	Crammerville Walk	ENQ-0873119	Blocked drains and flooding	Aug/Sept 20	Carraigeway	Gullies and TWU to be cleared
12a	**LBH**	15&16/08/2020	Lambs Lane South, Rainham no.29/31/33			Internal	Aug/Sept 20	Internal	Gullies and TWU to be cleared
12b	**LBH**	15&16/08/2020	Brady Primary School			Internal flooding	Aug/Sept 20	Internal	Properties on soakaways. Under capacity
12c	LFB	16-Aug-20	104838-16082020	LAMBS LANE SOUTH RAINHAM RM13 9XH		FLOODING	16-Aug-20	Internal	Pumping Out
12d	TW	14-Aug-20	478767	553018	181988	Hydraulic, Less than 30 mm	17-Aug-20	Internal	Report Status: completed
12e	LFB	16-Aug-20	105156-16082020	LAMBS LANE SOUTH RAINHAM RM13 9XD		FLOODING IN BASEMENT - DANGER OF FIRE	16-Aug-20	Internal	Pumping Out
12f	TW	15-Aug-20	479918	WENNINGTON ROAD		Hydraulic, Less than 30 mm	22-Sep-20	Internal	Report Status: Not Started
12g	**LBH**	15&16/08/2020	Brook Way, Rainham. No.19-65			Internal flooding including roadway	Aug/Sept 20	Internal	Downstream watercourse blocked. Network Rail
12h	LFB	15-Aug-20	104385-15082020	BROOKWAY RAINHAM RM13 9HW		FLOODING	15-Aug-20	Internal	Pumping Out

12i	**LBH**	15&16/08/2020	Elizabeth Road, Rainham				Carraigeway flooding	Aug/Sept 20	Carriageway	Gullies and TWU to be cleared
12j	TW	16-Aug-20		478819	5525243	1816768	LAND DRAINAGE	17-Aug-20	Unknown	FA Started
12k	**LBH**	15&16/08/2020	South Hall Drive, Rainham no.35a				Internal flooding including roadway	Aug/Sept 20	Internal	Downstream watercourse blocked. Network Rail
12l	**LBH**	15&16/08/2020	South Hall Drive, Rainham no.32 to 36				Groundwater/surface water under their floors - including road	Aug/Sept 20	Internal	Downstream watercourse blocked. Network Rail
12m	**LBH**	15&16/08/2020	38 South Hall Drive (next to 36)				Ground floor not flooded but water under h	Aug/Sept 20	Internal	
12n	LFB	16-Aug-20	104970-16082020	SOUTH HALL DRIVE RAINHAM RM13 9HS			GARAGES FLOODED	15-Aug-20	Internal	Pumping Out
12o	LFB	15-Aug-20	104702-15082020	ROTHBURY AVENUE RAINHAM RM13 9HZ			PROPERTY FLOODED NOT AFFECTED ELECRICS	15-Aug-20	Unknown	Make Safe
12p	**LBH**	15&16/08/2020	River Close, Rainham				Carraigeway flooding	Aug/Sept 20	Carriageway	Downstream watercourse blocked. Network Rail
12q	**LBH**	15&16/08/2020	Thames Close, Rainham				Carraigeway flooding	Aug/Sept 20	Carriageway	Downstream watercourse blocked. Network Rail
12r	**LBH**	15&16/08/2020	Manstead, Rainham				Carraigeway flooding	Aug/Sept 20	Carriageway	Downstream watercourse blocked. Network Rail
12s	LFB	15-Aug-20	104711-15082020	SOUTH HALL DRIVE RAINHAM RM13 9HJ			FLOODING FRONT AND BACK FLOODING UP TO KNEE LEVEL	15-Aug-20	Property	Make Safe
12t	LFB	16-Aug-20	105116-16082020	EASTWOOD DRIVE RAINHAM RM13 9HH			FLOODING	16-Aug-20	Unknown	Stand By - No Action
12u	**LBH**	15&16/08/2020	80 Rothbury Avenue	80 ROTHBURY AVENUE RAINHAM RM13 9HZ			Garage	Aug/Sept 20	Internal	
13	tfL	16-Aug-20	15786	Ferry Lane Roundabout			Floodwater from roundabout, needed to be closed	16-Aug-20	Carriageway	Offlip closed

Appendix C. Rainfall Frequency Analysis

Havering Section 19 Flood Investigation

Appendix C: Rainfall event return period analysis

March 2021

Havering Borough Council

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved

Distribution of copies

Revision	Issue approved	Date issued	Issued to	Comments

Contents

1. Introduction

1.1 Description of work

Jacobs have been commissioned by the London Borough of Havering to undertake a study into the flooding that occurred during the 14th – 16th August 2020. A flood Incident Report is to be produced and this hydrological analysis is required to inform the report of the likely rarity of the rainfall event.

1.2 Location Plan

Havering London Borough is located in East London and its administrative boundary covers an area of 111.4km2. Over 70% of the Borough is urbanised. The main communities are Romford located to the north, Hornchurch, Upminster in the centre and Rainham located to the south of the borough (See Figure 1-1). The main rivers within the borough are the River Ingrebourne, River Mardyke, River Ravensbourne, River Rom and River Beam. These rivers are tributaries of the River Thames. Four intensity rainfall gauges are located within or in close proximity to the study area. These are Nag's Head Lane, Havering-atte-Bower, Gascoigne and Central Park (See Figure 1-2). There are also two river level gauges, one at Gaynes Park on the River Ingrebourne and the second at Bretons Farm on the River Beam.

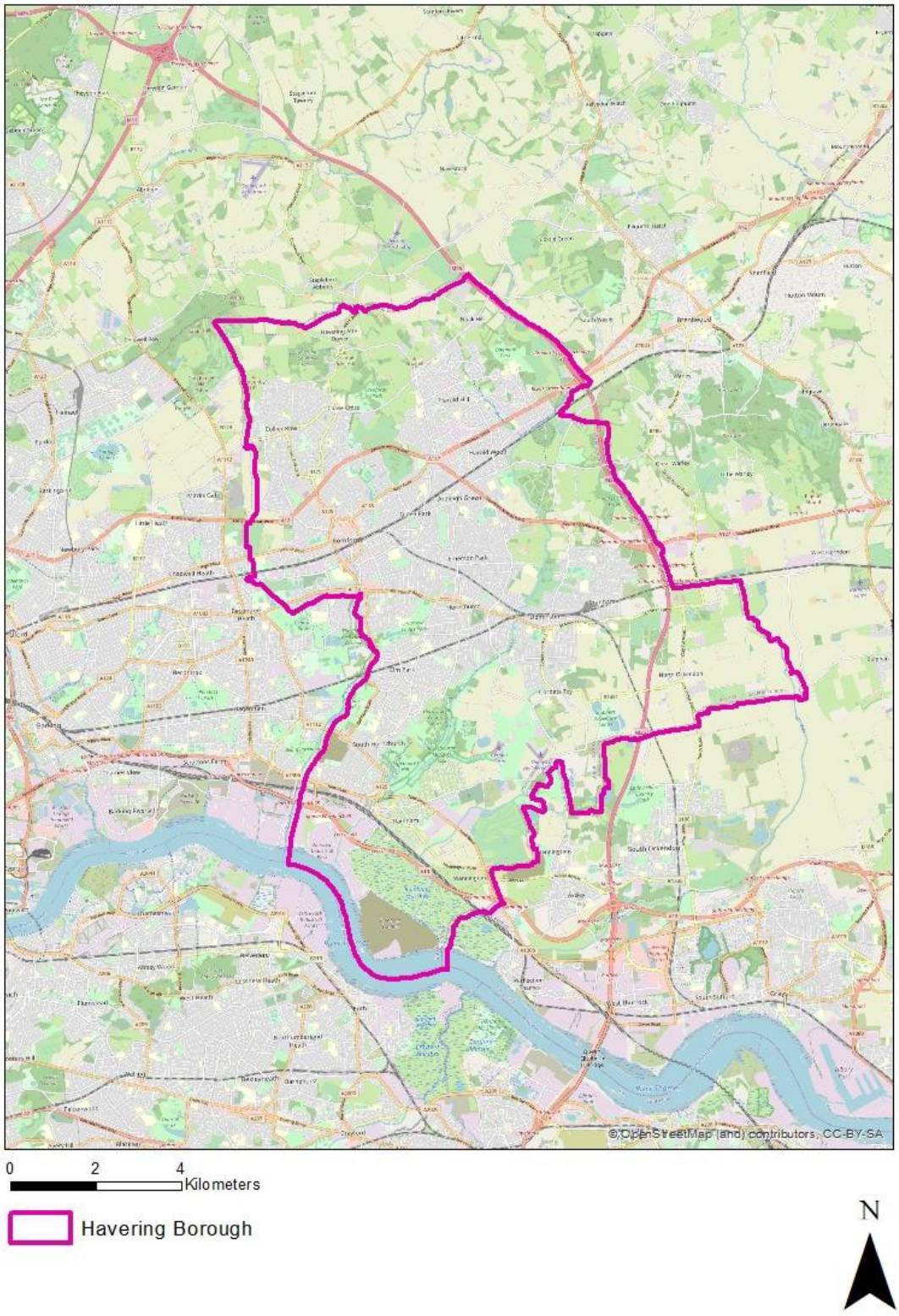


Figure 1 Location Plan

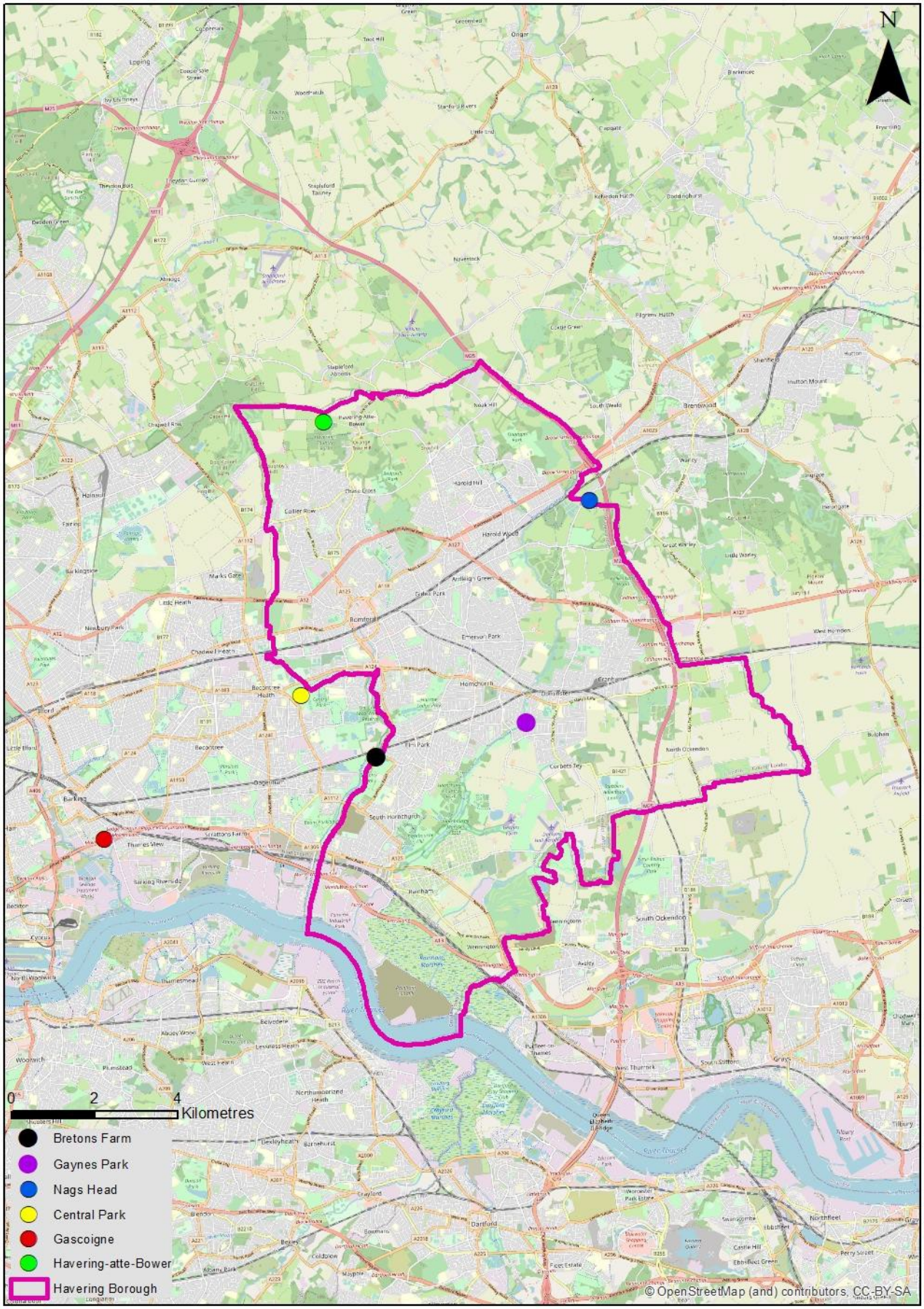


Figure 2 Location of Rainfall Gauges

1.3 Methodology

- Fifteen-minute rainfall data for the event were plotted against time at each rain gauge to establish the most intense rainfall period and overall storm durations.
- Total rainfall depths over differing storm durations were calculated from the recorded data at each of the rain gauges.
- Long term rainfall depth-duration-frequency statistics at each of the rain gauge locations were downloaded from the Flood Estimation Handbook (FEH) web service1. The FEH long term statistics were compared with the recorded rainfall data at each of the rain gauge locations and from the radar data and the return period for the rainfall event was estimated for different storm durations for each of the gauges.
- Peak flow data from two river level gauges were compared to the total flow record and an estimate of the magnitude of the event was made.
- ReFH software was used to ty and recreate the observed peak flow at the Gaynes Park and Bretons Farm flow gauges using observed rainfall.

1.4 Data received

Table 1. Data received

Rain Gauge	NGR	Data Received	Period of Record	Comments
Havering-atte-Bower	TQ 50240 93425	15 minute time series	14/08/2020:00:00 to 17/08/2020 23:45	Spike of 17.53 not seen in near neighbour although rain was recorded. To be confirmed after site visit.
Gascoigne	TQ 44757 83014	15 minute time series	14/08/2020:00:00 to 17/08/2020 23:45	Checked against near neighbour
Central Park	TQ 49922 86450	n/a	n/a	Gauge faulty, no data
Nags Head	TQ 56664 91532	Daily totals	13/08.2020:00:00 to 18/08/2020 23:45	Gauge partially blocked, data not of use
River Gauge				
Gaynes Park	TQ 55163 86177	15 minute time series	13/08/2020:00:00 to 18/08/2020 23:45	
Bretons Farm	TQ 51533 85330	15 minute time series	13/08/2020:00:00 to 18/08/2020 23:45	

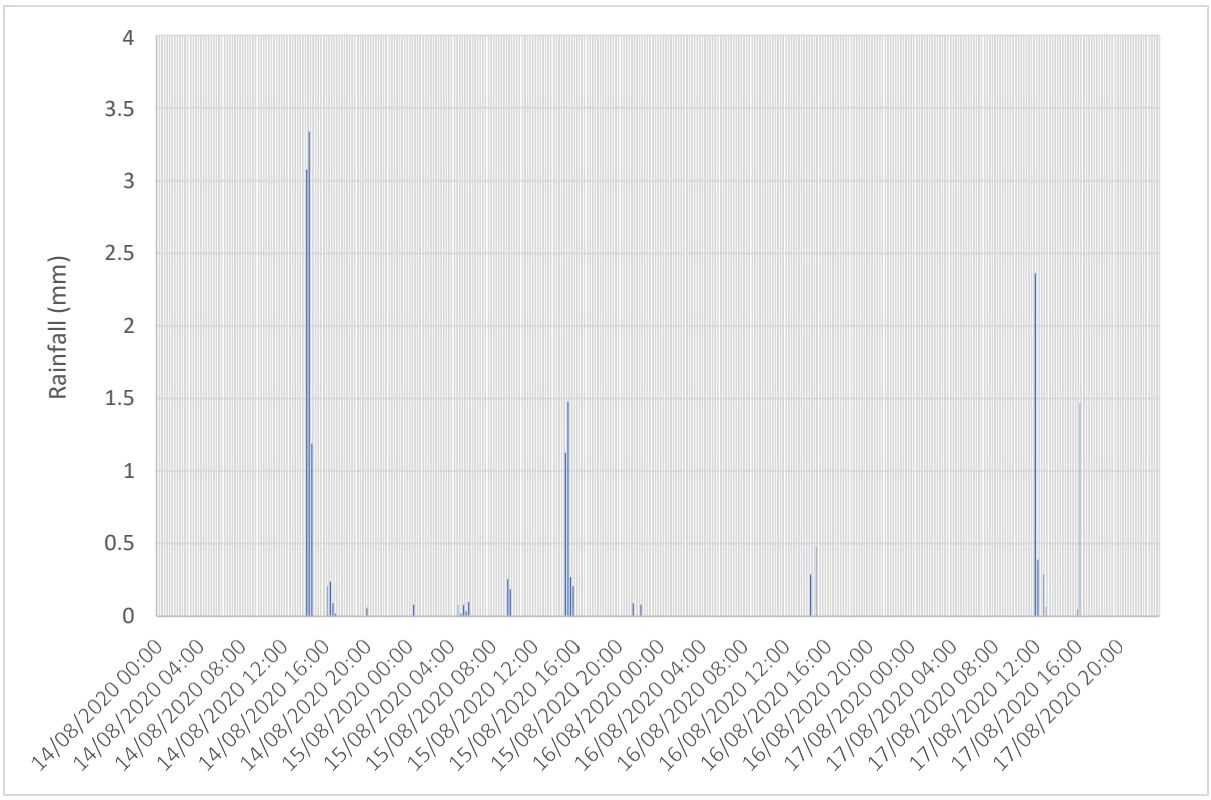


Figure 3 Recorded rainfall for the Gascoigne rain gauge over the 14th to 18th August

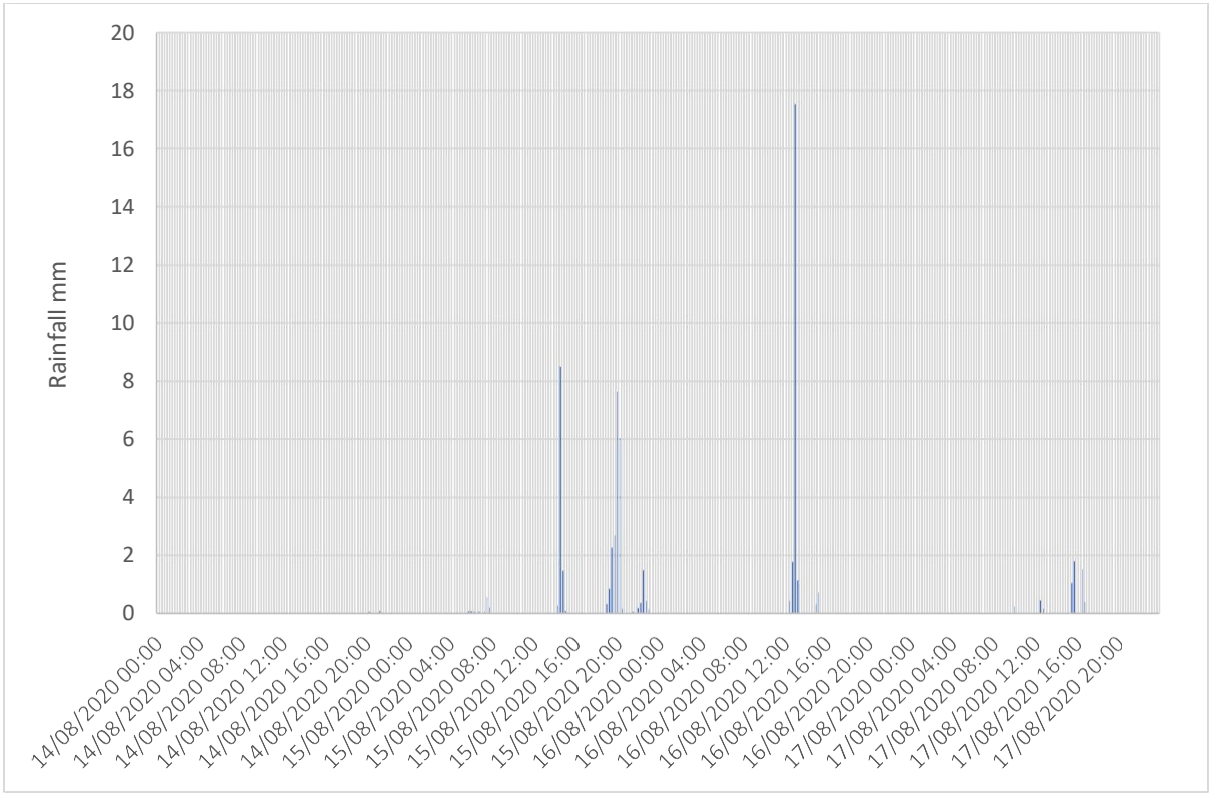


Figure 4 Recorded rainfall for the Havering rain gauge over the 14th to 18th August

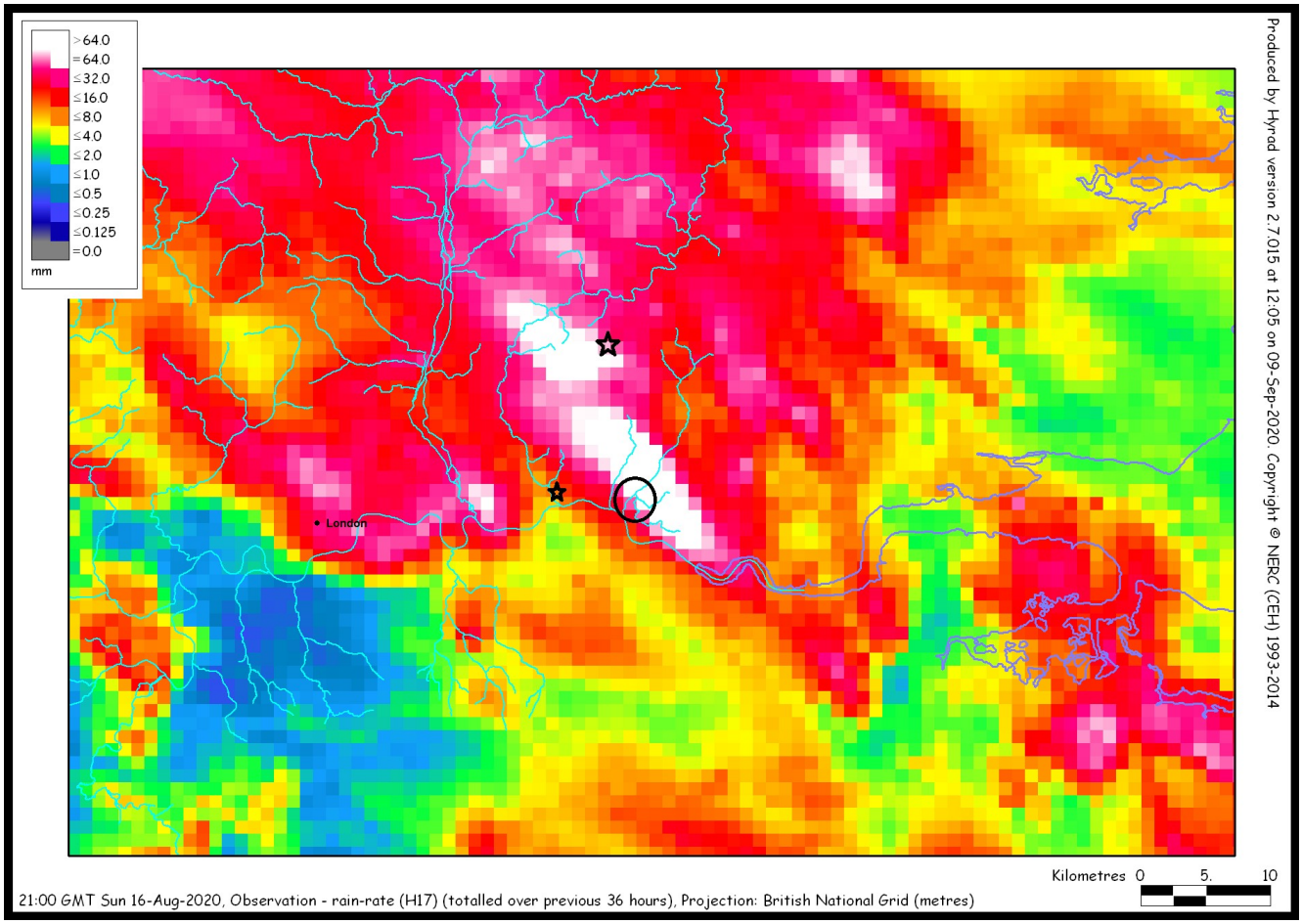


Figure 5 Radar, 36 hour accumulation at 21:00 on the 16th August 2020 showing location of rain gauges.

Radar rainfall data can be seen in Figure 5. It shows the accumulated rainfall over a 36-hour period up to 21:00pm on the 16th August. Figure 7 also shows the approximate locations of the rain gauges used to record the rainfall data. The highest intensity part of the rainfall tracked from the East and North East towards the West and South West. This means that the Havering gauge which recorded the highest amount of rainfall over the period would have recorded the rainfall before the other gauge at Gascoigne. The gauge at Gascoigne was outside the area of most intense rainfall for most of the duration.

1.5 Results

For the period 14th -16th August the maximum depths were calculated for different durations to capture periods of high intensity and the rarity of the rainfall depths over those periods was calculated.

Table 2. Rainfall event return period analysis results

Location	Duration	Period	Maximum Depth (mm)	Return period (years)
Havering	15 minute	16/08/2020:12:45 to 16/08/2020 13:00	17.53	12
	1 hour	16/08/2020:12:15 to 16/08/2020 13:15	20.9	6

Location	Duration	Period	Maximum Depth (mm)	Return period (years)
	1 hour 15 min (discrete event)	16/08/2020:12:00 to 16/08/2020 13:15	20.9	4.7
	2 hour	15/08/2020:19:00 to 15/08/2020 21:00	19.95	2.5
	3 hour	16/08/2020:12:30 to 16/08/2020 15:30	21.99	2.3
	6 hour	15/08/2020:18:00 to 16/08/2020 00:00	22.69	1.6
	24 hour	15/08/2020:05:00 to 16/08/2020 05:00	34.31	2
	36 hour	15/08/2020:09:00 to 16/08/2020 21:00	56.3	7.8

Table 3 Radar and point rainfall comparison

Rain gauge	36 hr accumulation (mm)	Radar (mm)
Gascoigne Road	4.48	<8
Havering	56.3	=64

Analysis of rainfall data from Havering-atte-Bower shows that the period of highest intensity rainfall was observed on the 16th August at 12:45 over a 15-minute period when 17.53 mm was recorded. This occurrence has a return period of 12 years (Table 2).

The maximum depth recorded at Havering over the 36 hour return period as 56.3. This occurrence has a return period of 7.8 years (Table 2). The rainfall radar suggests that at Havering the 36 hour rainfall could have been as high or equal to 64 mm (Table 3). Analysis of the rainfall radar totals at Havering for a 36 hour period gave a return period of 14.34 years

Analysis of the peak flow data showed that both gauges recorded relatively low peak flows, less than the recorded QMED (The median flood from the annual maximum series, equivalent to the 2 year, 50% AEP event).

River gauge	Catchment area (km^2)	Peak flow (m^3s^{-1})	QMED (m^3s^{-1})
Gaynes Park	47.9	2.19	6.42
Bretons Farm	49.7	6.13	8.32

1.6 Discussion

The water situation report and hydrological summary indicated that rainfall for the UK in August 2020 was higher than the average with persistent wet weather either side of heatwave conditions. For much of the UK rainfall was above average for the month with above normal levels for the south east as a whole. The monthly rainfall recorded for the Thames region was 96mm which was 170% above the long-term average. The monthly rainfall map for August 2020 shows rainfall at 50 to 75mm for much of the south east. The rainfall was the cause of landslips, power outages and travel disruption, some of which occurred in the south east.

Radar data shows that the area around the Gascoigne Road rainfall gauge received between 8 and 16mm of rainfall over a 36-hour period. The gauge data shows that 17.74mm of rainfall was recorded over the 14th to 18th August 2020. With the majority of this falling over the 14th and 15th August,12.17mm. Radar data in the vicinity of the Havering shows totals of up to 64mm. The Havering-atte-Bower gauge recorded 62.27mm of rainfall from the 14th to 18th August with the majority falling over the 15th and 16th August in 2 events. One where 34.31mm fell over a 24-hour period on the 15th and 16th August. A second event later on the 16th recorded 21.99mm of rainfall. On the 15th August rainfall peaked twice. The first peak was recorded at 8.5mm, which fell during a 1 hour 15-minute period where the total rainfall was 10.36mm. The second peak was recorded at 7.63mm during an event of 2 hours where 19.95mm of rain fell. Over the 15th and 16th during a 36 hour period 56.3 mm of rainfall was recorded at the Havering-atte-Bower gauge which is over half of what the Thames region recorded for the whole month of August in 2020, which was 96mm (Figures 3 and 4). The differences in the Gascoigne Road recorded rainfall and the Havering-atte-Bower recorded rainfall shows that the rainfall over the period of study was not consistent and fell in localised events. This could explain why flooding was seen in certain parts of the catchment.

Hydrological analysis of the peak flow recorded at both the Gaynes Park and Bretons Farm gauges showed that the value was below the observed QMED at each site. Therefore the return period of the peak flow for these catchments is less than 2 years (50%AEP). This support the evidence that the flooding was not catchment wide, but in discrete locations.

Further hydrological analysis was undertaken to try and simulate the observed peak flow at both gauges using the observed rainfall from Havering. The approach taken was to infer that the same depth and duration observed at Havering was experienced over the entire catchments represented by the gauged location. This approach led to a considerable overestimation of flow when compared to the observed data. This further supports the evidence from the tracked radar that the rainfall occurred in discrete intense bursts across Havering Borough rather than a catchment wide storm, resulting in small areas experiencing much higher rates of runoff than others, the most intense burst being over the southern extent of Havering Borough.

1.7 Limitations and Assumption

It is important to note the limitations and assumptions associated with this study. The following outlines these issues.

Not all the rain gauges identified as close proximity to the study area were fully functioning. The central park gauge was identified as faulty, and the Nag's Head gauge was partially blocked as noted in Table 1. An assumption is therefore made that the data from the gauges that were used was presumed as accurate.

For the hydrology analysis that was undertaken it was assumed that the storm was seen across the whole catchment as there was only the gauge at Havering-atte-Bower which could be used.

1.8 Conclusion

Analysis of the observed rainfall and flow data for August 2020 has been undertaken. These recorded data have been compared to the long-term rainfall and flow statistics from the Flood Estimation Handbook and FEH

Webservice and have used the Environment Agency Monthly water situation report (environment agency, 2020[1]) and hydrological summary for the UK in August 2020 (UKCEH,2020[2]) for context.

The evidence supports the anecdotal reports that the storms were very localised and the depths experience throughout the Borough of Havering varied. The radar data shows the areas of highest intensity tracked across the borough from the north east and east to the west and south west, with the highest intensity area falling over the Havering-atte-Bower gauge mostly missing the Gascoigne gauge. The Having Bower rain gauge was the gauge nearest the locations affected by flooding that captured the most representative rainfall depths.

Analysis of the rainfall depths for both the most intense rainfall period and a 36 hour duration indicates return periods for 14th-16th August 2020 varying between 7.8 to 12 years (13% and 8% AEP respectively).

The data supports the statement that a months rainfall fell in the 36 hours around the 16th August.

[1] Environment Agency, 2020. Monthly Situation Report, August 2020, www.gov.uk/environment-agency
[2] UKCEH, 2020. Hydrological Summary for the United Kingdom, http://nrfa.ceh.ac.uk/monthly-hydrological-summary-uk