Hertfordshire County Council Section 19 Flood Investigation Report

Northwood

Northwood in 2010
Aerial Photography © GeoPerspectives.co.uk

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Hertfordshire County Council
Northwood Flood Investigation Report

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Version 2

Rev	Date	Details	Author	Checked and Approved by
1	13/10/17	For internal FRM team consultation	James Lester, Flood Risk Management Project Officer	Andy Hardstaff, Flood Risk Management Team Leader
2	23/10/17	Final draft for distribution to Risk Management Authorities and residents	John Rumble, Head of Environmental Resource Planning Andy Hardstaff, Flood Risk Management Team Leader	Matthew King, Head of Waste Management & Environmental Resource Planning

Explanation of Acronyms and Terms

Acronym / Term	Explanation
FWMA 2010	Flood and Water Management Act 2010 – Legislation that was developed and enacted as a result of the review into the serious flooding in 2007. It brings new powers and duties to local authorities and other regulatory bodies.
HCC	Hertfordshire County Council
LDA 1991	Land Drainage Act 1991 – Legislation that sets out a range of roles and responsibilities relating to flood risk management. It is also the legislation that gives powers to local authorities to manage flood risk and highlights the role of the landowner to manage watercourses on their land to maintain the flow of water.
LLFA	Lead Local Flood Authority – This is the role assigned to the unitary or county council for an area with a range of duties and powers to support the management of local flood risk.
RMAs	Risk Management Authorities – Bodies identified in the FWMA 2010 with roles and powers to manage flood risk. In Hertfordshire this includes the County Council as Lead Local Flood Authority and Highway Authority, district councils, Highways England, the Environment Agency, the Bedfordshire and River Ivel Internal Drainage Board, Thames Water Utilities Limited and Anglian Water Services Limited.
Adopted Highway	The term has been used in this report to include all highways maintainable at public expense. This includes historic highways as well as those formally adopted through section 38 of the Highways Act 1980 and preceding powers.
Antecedent conditions	Antecedent conditions is a term used to describe the relative wetness or dryness of a catchment, which changes continuously and can have a very significant effect on surface water flows during wet weather. Antecedent moisture conditions are high when there has been a lot of recent rainfall and the ground is moist. Antecedent moisture conditions are low when there has been little rainfall and the ground becomes dry.
Attenuation	The processes of water retention on site slowly being released to a surface water/combined drain or watercourse.
Storage	An area or structure where surface water flows are retained.
TfL	Transport for London
TWUL	Thames Water Utilities Limited
Riparian Owner	A riparian owner refers to a person who owns land bounding upon a river, lake, or other watercourse.
EA	Environment Agency

Executive Summary

During the late afternoon of 23rd June 2016, Northwood was affected by flooding. It was one of a number of areas in Hertfordshire where flooding occurred as a result of exceptionally intense rainfall.

In the areas covered by this investigation, there was confirmed flooding to 24 properties with 15 being flooded internally and a further 9 properties flooding externally. This flooding was from mainly surface water with contributions from the Moor Park Stream in the vicinity of St Mary's Avenue. In addition, the volume of water contained within the Moor Park Stream is likely to have inhibited the discharge of the Thames Water Utilities Limited surface water sewer network and contributed towards surcharging of the highway gullies in the investigation area.

In Northwood there was reported surcharging along the sewer pipe line which goes between St Mary's Avenue and the Moor Park Stream up to Ardross Avenue. Floodwater is reported to have flowed down Batchworth Lane, flowing where it can from the road into the topographical depression lying parallel to the south. Flood water which got into this depression followed from east to west through properties and gardens.

Hertfordshire County Council (HCC) in its role as Lead Local Flood Authority, on becoming aware of a flooding issue, has the responsibility to begin an investigation.

The main findings of this investigation are:

- The rainfall event on the 23rd June 2016 was intense, with there being a 3% chance of rainfall this severe or worse happening in any given year.
- The intensity of the rainfall on the 23rd June overwhelmed the local surface water sewer network which was not designed for rainfall events of this magnitude. The fast overland flows due to the topography of the area would have made it difficult for gullies to capture water; instead water would have flowed over gullies.
- Flooding would have been influenced by factors affecting the Moor Park Stream (watercourse). This includes fluvial flooding to the back-gardens of properties on St Mary's Avenue.
- The security screen and associated debris restricting access to Transport for London land spanning the river would have held back water in the channel instead of letting it discharge at normally
- High water in the watercourse is likely to have submerged the surface water sewer outfall pipes, which would have reduced the rate at which water collected from houses and the highway could discharge away from the investigation area.

The recommendations from this investigation for reducing the risk of flooding from surface water are:

- Individual property owners review the flood risk to their property and consider steps they could take to reduce the probability of flooding together with the benefits of installing property level flood resilience.

- An initial assessment is carried out into the viability of the creation of an area of surface water storage in the upper part of the catchment adjacent to Batchworth Lane.
- Riparian owners of the Moor Park Stream are made aware of their responsibilities in relation to the management of this watercourse.
- Local residents are made aware of who to contact if there is an issue with the watercourse.
- The security grill in the railway fence and screen at the entrance to the culvert in railway land are reviewed with a view to redesigning them so that they function better in times of flood and are also easier to access and maintain.
- The highway authority reviews the road drainage network in this area to identify and rectify any damage and determine if it would be beneficial to identify any of the gullies for inclusion on the vulnerable gully programme.
- Thames Water investigates the surface water sewer network. This should include a survey to accurately record the asset dimensions. In addition the performance of the surface water sewer network should be reviewed to determine if any repair work is needed or if improvements should be carried out.

1. Introduction

1.1 LLFA investigation

Under Section 19 of the Flood and Water Management Act (FWMA) 2010 HCC as Lead Local Flood Authority (LLFA), on becoming aware of a flood in its area, must, to the extent that it considers it necessary or appropriate:

- Investigate the incident;
- Identify the Risk Management Authorities (RMAs) with relevant flood risk management functions;
- Establish if the relevant RMAs have responded to the flood event or are proposing to respond;
- Publish its findings; and
- Inform the relevant RMAs of its findings.

An RMA (as defined under Section 6, subsection 13 of the FWMA 2010), has certain powers to manage, regulate, assess and mitigate flood risk. The activities of the following RMAs have been examined as part of this Section 19 flood investigation for Northwood:

- HCC as LLFA
- HCC as the highway authority
- Thames Water

Following the flood event experienced in Northwood on the 23rd June 2016, it was determined that this incident met the criteria in Policy 2 of HCC's Local Flood Risk Management Strategy for a detailed Section 19 Investigation to be undertaken because more than five properties flooded internally.

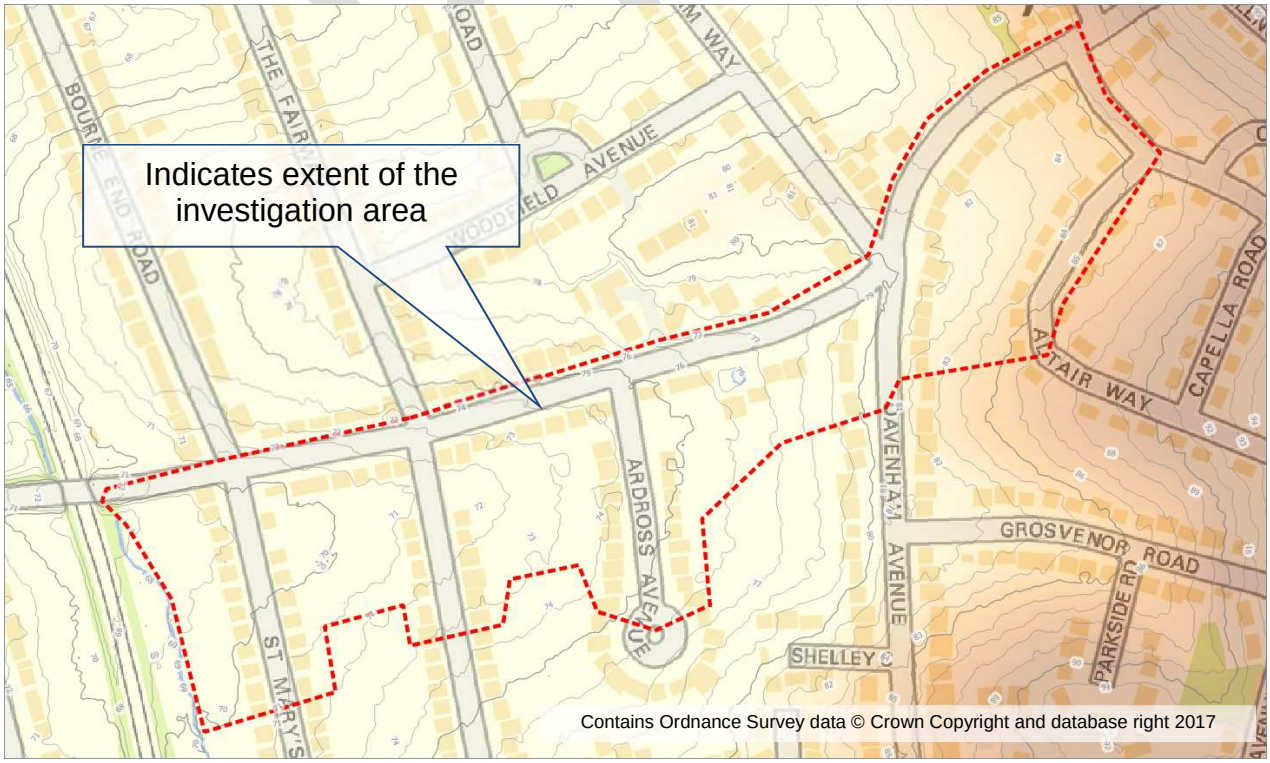
1.2 Location of the investigation area and description

The flood incident occurred in the Eastbury area of Northwood in the Three Rivers District of Hertfordshire, see figure Figure 1. The extent of the Section 19 Flood Investigation area has been defined following analysis of the results of the HCC questionnaire survey conducted following the 23rd June 2016 flood event. The following streets are included within the investigation area: Altair Way, Davenham Avenue, Ardross Avenue, Eastbury Road, Batchworth Lane, and St Mary's Avenue. The questionnaire responses confirmed that there was internal flooding to properties on each of these streets. The extent of the investigation area can be seen in figure Figure 2.

The technical assessment to support this Section 19 Flood Investigation examined the extent of the contributing catchment for this flood incident and this can be found in figure Figure 3. This shows the area within which any rain that falls will flow towards St Mary's Avenue.

Figure 1 Location map for Northwood, Hertfordshire

Figure 2 Map of investigation area extent

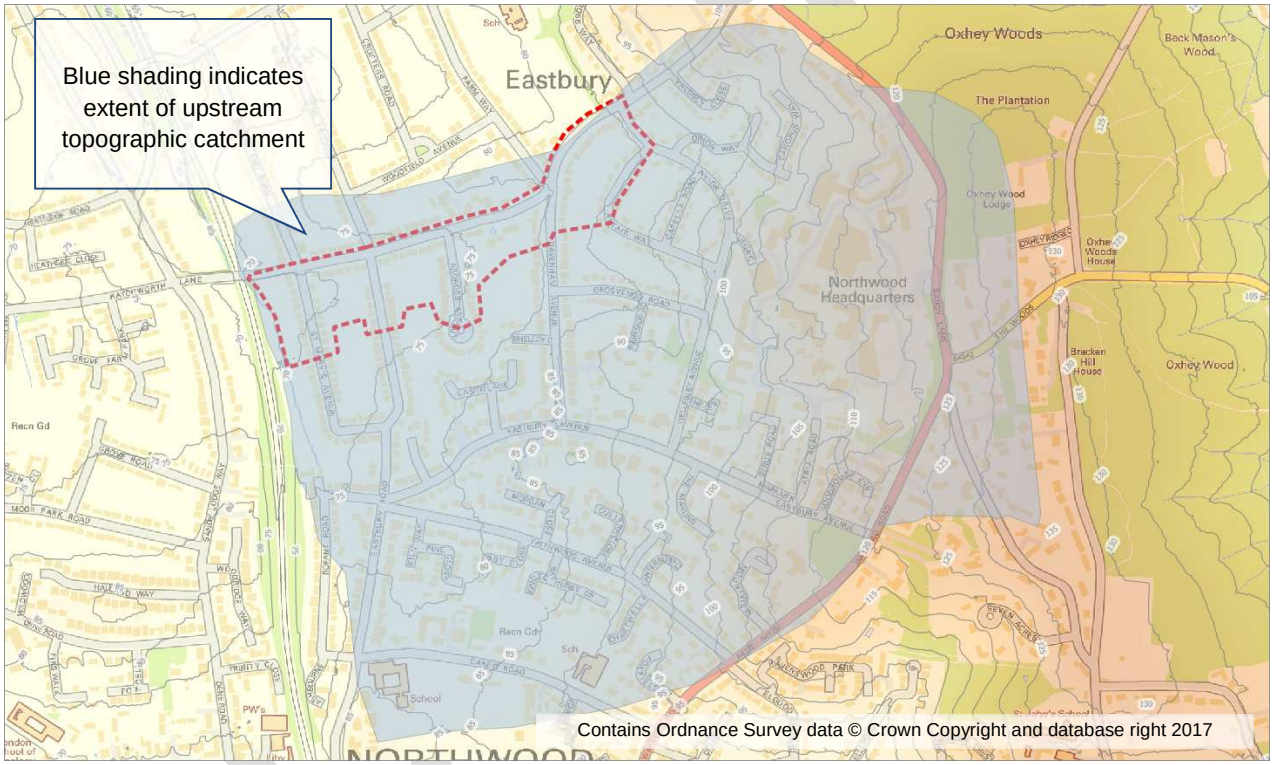


1.3 Key features and structures

The majority of the catchment is comprised of residential dwellings and associated access roads. Green space is generally limited to gardens with some tree cover to the east of Sandy Lane. The investigation area encompasses a depression in the land which runs downhill from Altair Way parallel to Batchworth Lane and down to the Moor Park Stream, which is designated Main River. There is a change in height of 18 metres from the top to the bottom of the investigation area.

The contributing surface water catchment, as shown in figure Figure 3, has its southern extent located in the London Borough of Hillingdon with the boundary running from east to west between Eastbury Avenue and Frithwood Avenue.

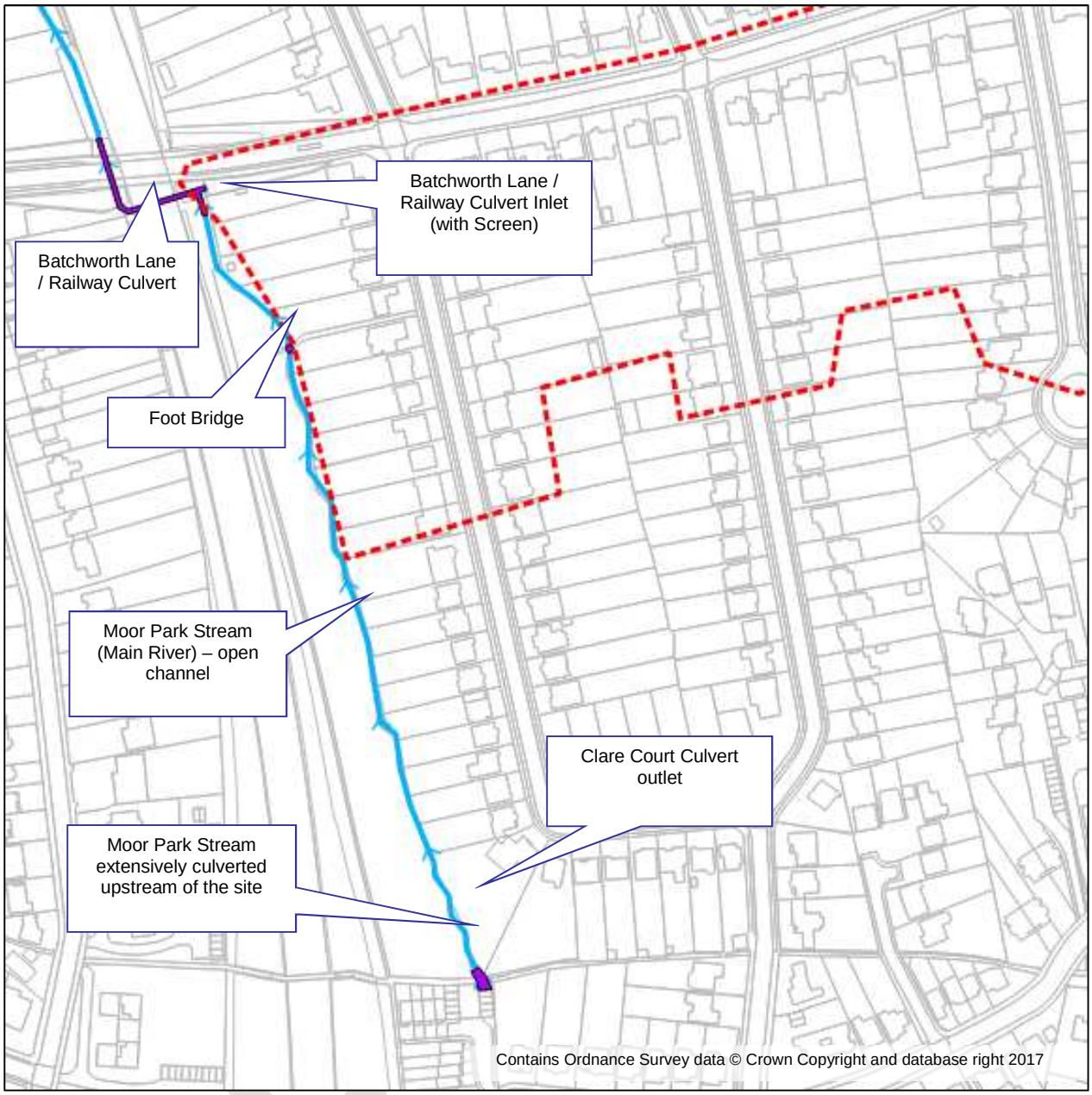
Figure 3 Upstream catchment boundary map



The Moor Park Stream flows from south to north along the western boundary of the catchment. This watercourse runs alongside the Metropolitan Tube Line and passes through a culvert beneath the rail line at the crossing with Batchworth Lane. The Moor Park Stream is culverted for a section within the bounds of the investigation area and takes the Moor Park Stream under Batchworth Lane. The Batchworth Lane culvert is managed by Transport for London (TfL) and is fitted with an inlet screen to prevent access to the culvert and to stop large debris blocking the culvert.

Maintenance of the Batchworth Lane culvert and channel within lands under control of Transport for London is understood to be their responsibility. Outside of these areas, watercourse maintenance is the responsibility of the riparian owners. The watercourse and associated structures are shown in figure Figure 4.

Figure 4 Watercourse map (identifying structures along the watercourse)



2. Background and History of Flooding

2.1 Previous flood events

There have been no historical reports to the LLFA of flooding in the investigation area listed in table Table 1. The LLFA has only been recording flood events since 2010; therefore the LLFA will be unaware of any flood events prior to that date. Flood events prior to 2010 identified by residents as part of this investigation will be added to the LLFA Flood Incident Record.

Hertfordshire County Council in its capacity as the Highway Authority keeps records of

all highway faults made by members of the public, which includes flooding to and from adopted Highways. Previous to this flood event, there have been 4 recorded incidents of historical flooding of the highway and the footpath within the investigation area.

The latest Strategic Flood Risk Assessment (SFRA) covering this area was undertaken in 2007 and published jointly by Three Rivers District Council, Dacorum Borough Council and St Albans City and District Council. Flood maps included in the SFRA indicate that the area is not at risk from river (fluvial) flooding and there are no historic records of fluvial flooding in the investigation area. The SFRA also states how in the ten years prior to the SFRA being produced, sewer flooding records identify that 33 properties flooded from sewers in the vicinity of the investigation area.

3. Assessment of the 23rd June 2016 flood event

3.1 Summary of 23rd June 2016 event for Hertfordshire

On the afternoon of 23rd June 2016, torrential rain and thunderstorms caused flash flooding across the south east of England. In Hertfordshire, a corridor of severe rainfall swept across the county starting in Northwood and heading north-east, affecting Bushey, Carpenders Park, South Oxhey, Radlett, London Colney, Hatfield and Welwyn Garden City. There was also localised flooding in Hitchin, Baldock, Stevenage and Royston.

3.2 Observations

In Northwood there was reported surcharging along the sewer pipe line which goes between St Mary's Avenue and the Moor Park Stream up to Ardross Avenue. Floodwater is reported to have flowed down Batchworth Lane, flowing where it can from the road into the topographical depression lying parallel to the south. Flood water which got into this depression followed from east to west through properties and gardens.

Reports of flooding to Hertfordshire Fire and Rescue for the catchment is summarised below:

- Eastbury Avenue – Flooding (localised) at 18:04 on 23rd June 2016.
- Ardross Avenue (and few houses on street) – Flooding inside at 18:18 on 23rd June 2016.
- Eastbury Road – Flooding outside (Low Risk) at 18:19 on 23rd June 2016.
- St Mary's Avenue – Flooding inside (Low Risk) at 18:40 on 23rd June 2016.

All Hertfordshire Fire and Rescue records of flooding in the area took place in the early evening of 23rd June 2016 during the flood event for this investigation.

A questionnaire survey was sent out to all residents in Hertfordshire who may have been impacted by the 23rd June 2016 flood event. This was conducted by HCC as the LLFA. The purpose of the questionnaire was to establish the extent of the flood event,

the number of properties impacted and an indication of the mechanisms that caused flooding to property or critical infrastructure.

In Northwood, questionnaires were sent to 69 properties, of which 30 were completed and returned. The table below identifies the known details and facts that were derived from the questionnaire analysis:

Table 1 Flood survey summary

Road/Street	Responses	Flooding Confirmed (internal)	Reported flooding mechanism	Additional notes
Altair Way	3	3 (1)	Surcharging Drains	Flooding from drains and runoff from higher areas
Batchworth Lane	7	7 (3)	Surface Water	Flooding from road onto driveways
Davenham Avenue	4	3 (1)	Surface Water	Flooding from drains and runoff from higher areas
Ardross Avenue	4	3 (3)	Surcharging Drains Surface Water	Flooding from road due to blocked / backing up drains
Crofters Road	1	1 (1)	Foul Water	Crofters Road was flooded from a different flowpath and therefore will be investigated in a separate Section 19 Investigation
Eastbury Avenue	3	0 (0)	N/A	No flooding reported
Eastbury Road	1	1 (1)	Surcharging Drains Surface Water	Flooding from Eastbury Road and Batchworth Lane
St Mary's Avenue	7	6 (5)	Surcharging Drains Surface Water Fluvial	Flooding reported from adjacent properties / road, surface water sewer network and watercourse

Six survey responses indicated that no flooding was experienced during the flood event these included:

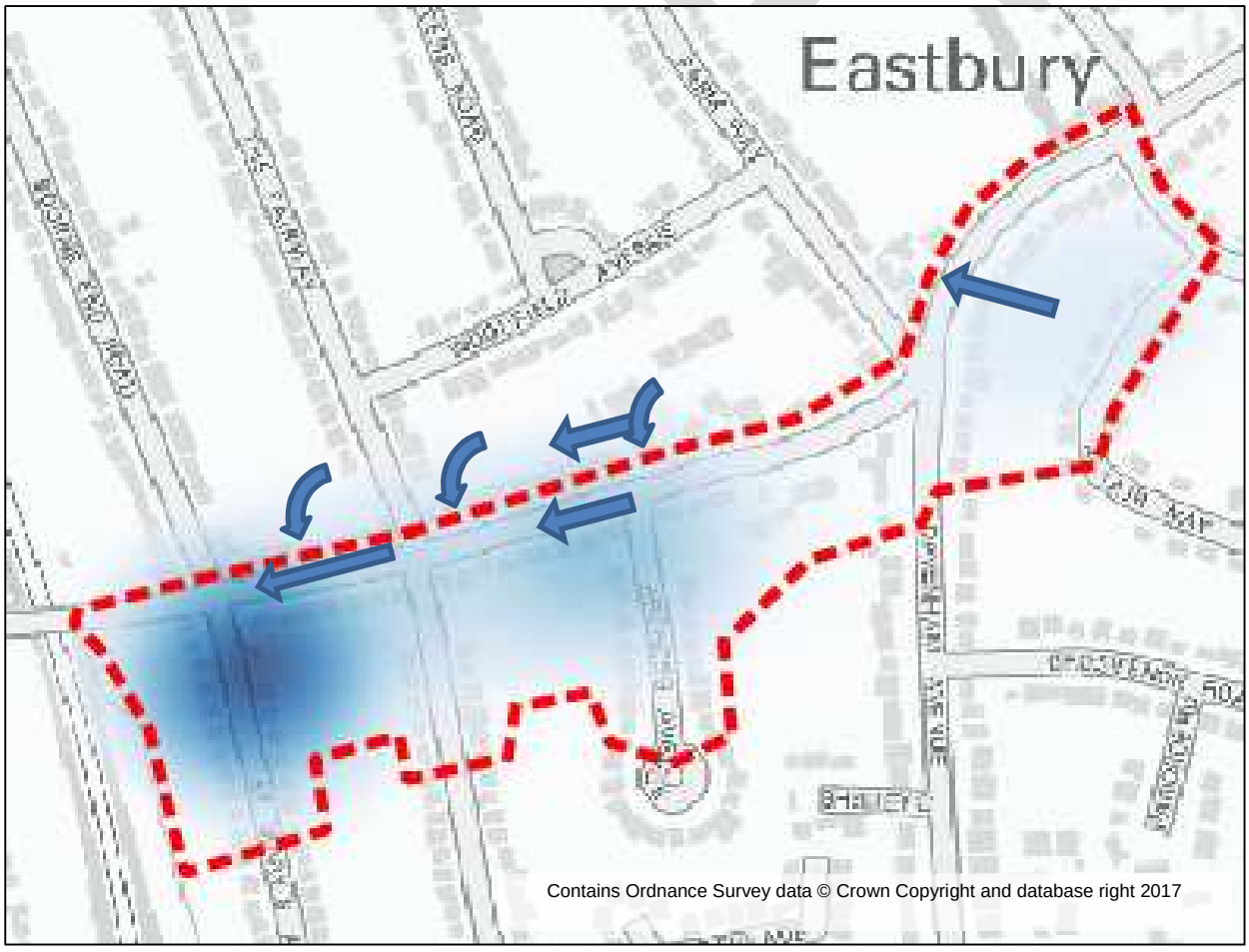
- 3 properties on Eastbury Avenue
- 1 property on St Mary's Avenue
- 1 property on Ardross Avenue (but noted that adjacent drains were blocked)
- 1 property on Davenham Avenue

Further relevant details taken from the Flood Incident Questionnaires is summarised below:

- Properties to the lower lying, western extent of the catchment recorded the biggest impact from flooding.
- Residents along St Mary's Avenue were the worst affected and reported flood depths of up to 1m internally and externally.
- Ardross Avenue residents reported significant depths of flooding and mentioned blocked gullies as contributing to the problem.
- The majority of responses indicated that flooding flowed from adjacent properties or roads at a higher elevation.
- Flooding in 1984 and 1993 was mentioned in a number of responses.

The flood depths and flow directions reported via the flood incident questionnaires are displayed in Figure 5 in the form of a heatmap (with the most severe a darker colour). This shows the flood depths with the arrows representing the flow direction and the darker areas showing the greater depth of flood water. Flood depths were deepest at St Mary's Avenue, at the lower extent of the investigation area; this was closely followed by the area in the vicinity of the junction between Ardross Avenue and Batchworth Lane.

Figure 5 Flood incident questionnaire results heat map



3.3 Rainfall and antecedent conditions

The Met Office issued Amber Severe Weather Warnings of heavy rain for London, South East England and the East of England for the 23rd June 2016. Amber Warnings suggest that travel could be disrupted and localised flooding of low-lying areas and property could occur. However warnings are general for county areas and are not location specific.

The storm tracked north-easterly across the south east of England. It was raining across most of Hertfordshire at the time of the flooding; however as can be seen from the rainfall radar in figure Figure 6, the areas of most intense rainfall (grey areas) were localised and moving along a narrow band within the storm. The red circle shows the approximate location of Northwood.

Figure 6 Hertfordshire Rainfall Radar map at 18:00hrs on 23/06/16

Rainfall data for the site has been taken from both the Met Office and from third party Personal Weather Stations (PWS). The Met Office rainfall used was from the following locations:

- Batchworth Lane, Northwood (509095, 192411) – hourly radar (predicted, site-specific) rainfall
- Northolt Weather Station (509866, 184494) – minute rate rainfall (approx. 9km from Northwood)

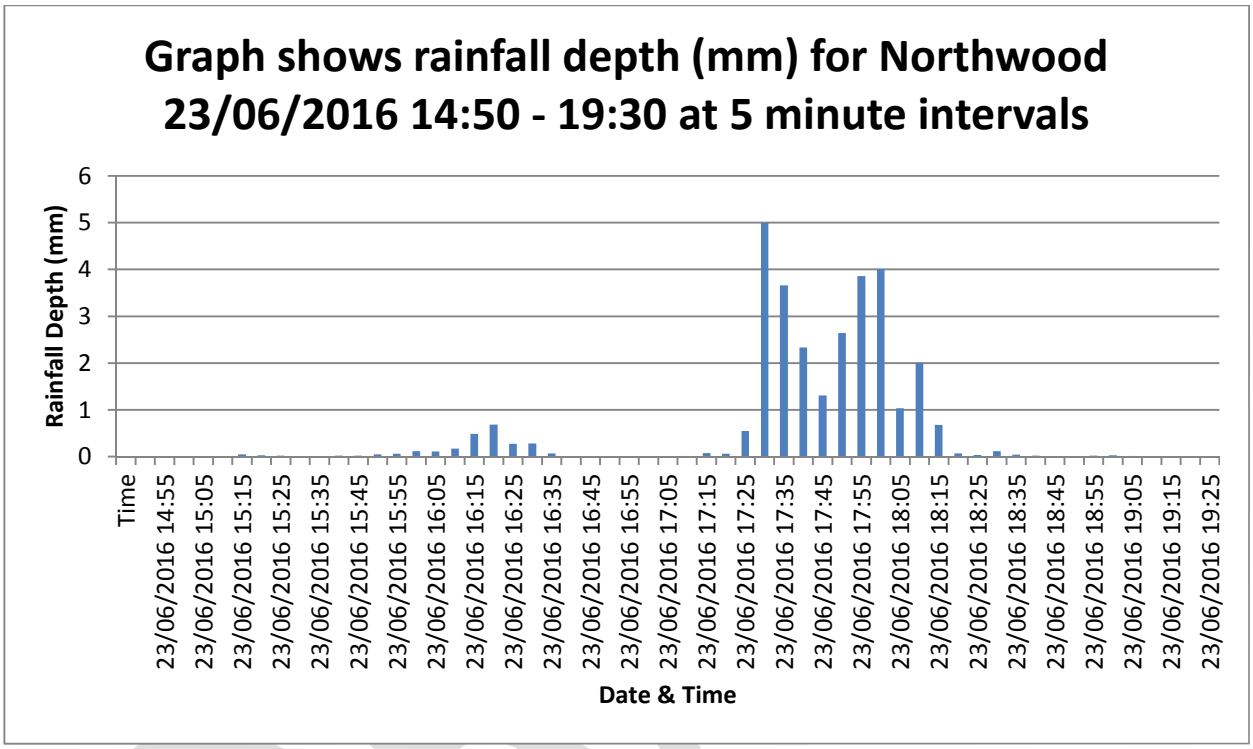
Third party unverified rainfall data has been gathered from a number of Personal Weather Stations for an approximate radius of 10 km around the investigation area.

The data, in combination, tends to indicate that the most extreme rainfall experienced was in a relatively confined area in the vicinity of the site. Rainfall was heaviest between 17:00 and 19:00 (see figure Figure 7) which correlates with flood reports and Hertfordshire Fire and Rescue call-out records. The maximum rainfall rate (rainfall

intensity) over any 15-minute period (c. 36mm/hr) equates to a return period of between 30 and 35 years.

Substantial rainfall on 8th and 20th June 2016 was recorded in Northwood; however it is unlikely that this caused surrounding land to be fully saturated when the 23rd June 2016 rainfall event occurred.

Figure 7 Rainfall depth graph taken from Radar for the rainfall event experienced in Northwood

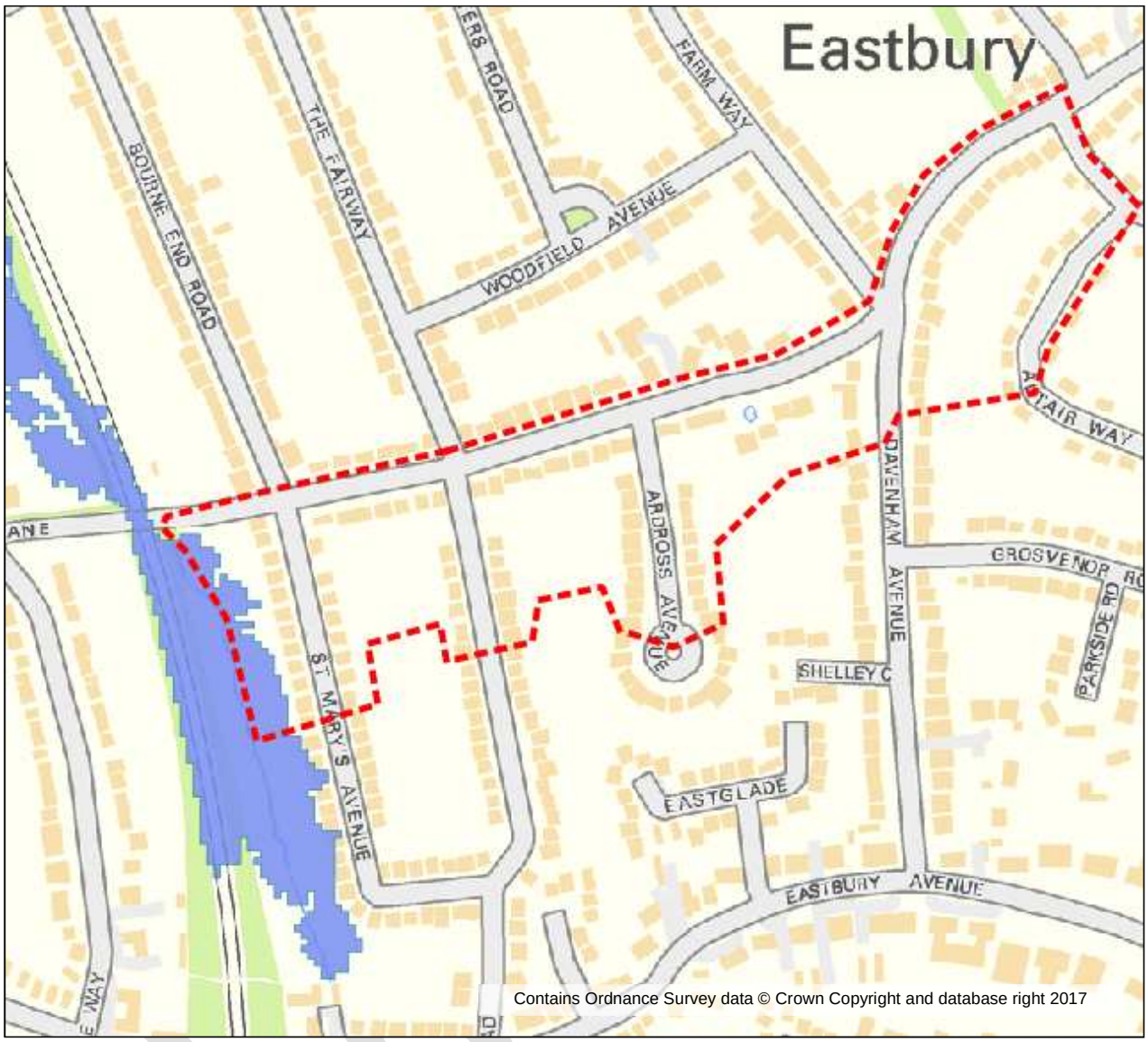


3.4 Rivers and watercourses

The Moor Park Stream forms the western boundary of the investigation area, see figure Figure 4. As Moor Park Stream is designated Main River it is under the responsibilities of the Environment Agency. Main rivers are usually larger rivers and streams. The Environment Agency carries out maintenance, improvement or construction work on main rivers to manage flood risk.

Environment Agency (EA) indicative fluvial flood mapping indicates that there is the potential for fluvial flooding from Moor Park Stream to coincide with areas within the scope of this Section 19 Flood Investigation. Figure Figure 8 shows the extent of Flood Zone 3 (area of land with a 1% Annual Exceedance Probability (AEP) of flooding from rivers, a 1% chance of flooding within any given year) in the Eastbury area. As can be seen in figure Figure 8, fluvial flooding is predicted along the western boundary of the investigation area, coinciding with the rear gardens of houses along the west of St Mary's Avenue for a 1% AEP magnitude event.

Figure 8 Environment Agency Flood Map for Planning (Rivers and Seas) – Flood Zone 3 (1% AEP)



3.4.1 The effect of culverts

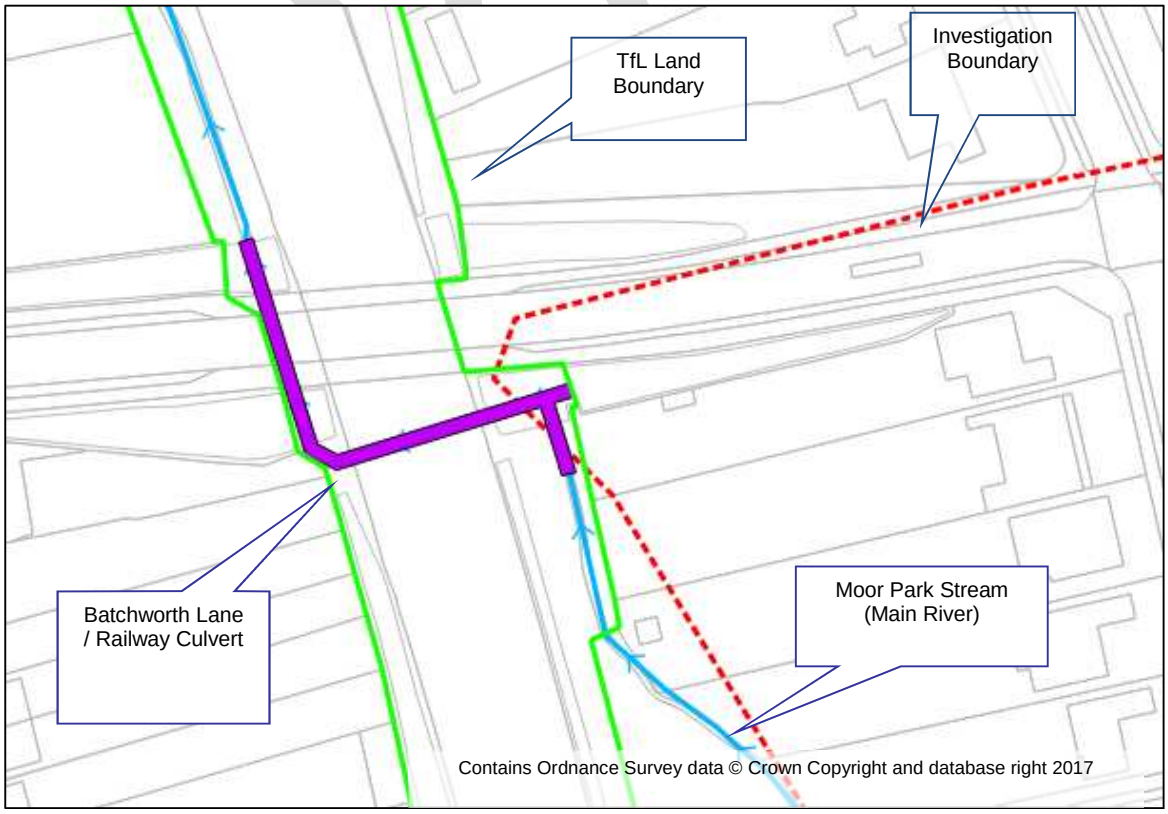
In order to better understand the likely fluvial flood scenario experienced in June 2016, consideration has to be given to a number of structures which alter the flow of water. Inflows to, and outflows from the Moor Park Stream near the investigation area have potential to be significantly influenced by a number of culverts adjacent to the site, see figure Figure 4, these include:

- ***Clare Court Culvert -*** Moor Park Stream emerges from a 750mm diameter culvert of unknown length to the north of Clare Court, south east of St Mary's Avenue. This culvert essentially controls inflows to the open channel section adjacent to the investigation area. A continuous impermeable property boundary exists adjacent to (and upstream of) the culvert outlet, and as such any flows in the upper catchment in excess of the culvert capacity would be retained upstream.

- ***St Mary's Avenue Culvert -*** A pedestrian access footbridge with an associated culvert is located to the rear (east) of properties along St Mary's Avenue. The culvert is 400mm diameter and has a shallow deck structure. During flood events, water would tend to flow over the top of the crossing and flow into the downstream channel at a level that is lower than adjacent properties. Therefore, the culvert is not considered to be a significant source of flood risk at the site.
- ***Batchworth Lane Culvert -*** Moor Park Stream passes through a culvert beneath Batchworth Lane/Metropolitan Tube Line. The culvert inlet is located to the south east of the road/railway crossing and discharges to the north-west. The culvert dimension varies along its length and capacity would be limited by the smallest opening size. The culvert would not have had capacity to pass the full flow reaching that location; this assessment excludes the throttling effect of the upstream Clare Court culvert. It is likely that a significant proportion of the water in the catchment to that point enters the watercourse via direct surface water flooding and sewer inflows downstream of the culvert outlet.

- **Watercourse blockage –** The Moor Park Stream flows into Transport for London (TfL) lands associated with the Metropolitan Tube Line immediately west of the site. TfL has provided information on key drainage assets within its land holding, as shown on figure Figure 9. Resident feedback indicated that the screen on the culvert inlet, coinciding with the TfL landholding boundary was blocked during the flood event and floodwater was observed to build up behind the screen.

Figure 9 Transport for London watercourse / drainage assets



3.5 Urban drainage

The surface water and foul water sewer network in Northwood is the responsibility of Thames water Utilities Ltd (TWUL). In this catchment, the sewer networks for foul water and surface water are separate. Hertfordshire County Council in its capacity as the Highway Authority is responsible for draining the rainfall which falls on the highway and this is achieved via a network of gullies. These gullies are connected to the surface water sewer system operated by TWUL.

The TWUL surface water network serving the investigation area discharges to the Moor Park Stream at the bottom of the catchment. Three points of discharge are upstream of the Batchworth Lane culvert and hence these outfalls could be impeded by raised water levels at that point.

TWUL's networks must operate within a regulatory boundary laid out by the economic regulator of the water sector in England and Wales (OfWAT). Most surface water sewer networks are only designed for managing small and lower magnitude rainfall events. Flood frequency can be defined in terms of annual exceedance probability (AEP). This allows better understanding of the volumes of water a drainage asset can cope with until it becomes full and water surcharges from the pipe. It is likely that the TWUL surface water network would have been running at design capacity, which would in any case have limited the potential for gullies to discharge water to the wider drainage network.

Most surface water sewer networks are only designed for managing a defined level of rainfall. Thames Water estimates that the rain that fell on 23rd June 2016 was roughly the same volume of water as the maximum capacity that their surface water sewer can manage, which is a storm estimated at a 3.33% chance of happening in any one year.

A review of TWUL surveys and maintenance records in 2016 following the flood on 23rd June 2016 indicates that root penetration was identified in a small section of pipe within the investigation site. However, considering the volume of rainfall recorded, it is very unlikely to have been a significant contributing factor to the flooding experienced.

Analysis completed as part of the technical assessment for this report indicates that a number of key assets would have been unable to convey the runoff that would have been drained by the drainage network within the investigation area. The analysis of runoff and pipe capacities indicates that for 5 out of 6 key junctions, the capacity of storm water drainage pipes were below the capacity required to adequately drain the surface water that would have been created by the rainfall event on 23rd June 2016.

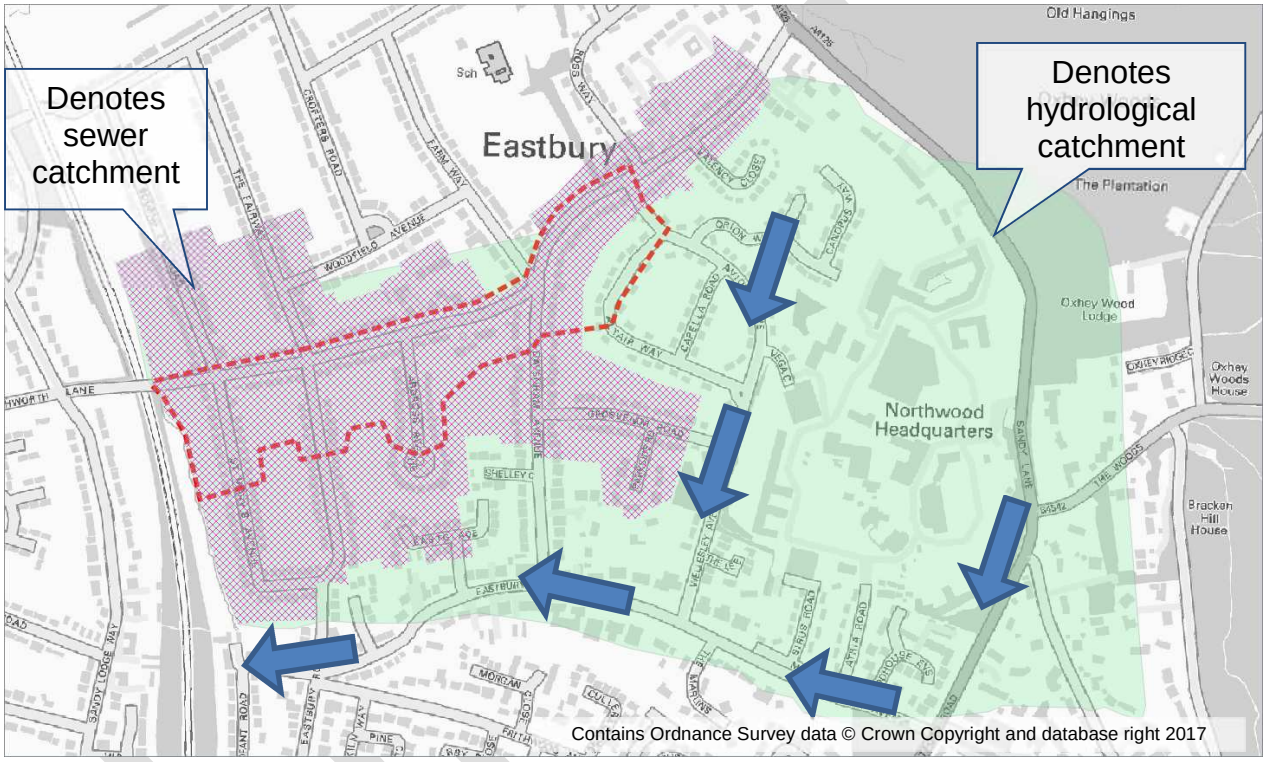
Highway gullies are designed to capture and drain moderate rainfall from the highway. Their ability to drain water is affected by the volume and velocity of water running over the gullies. Even where gullies are placed to receive large volumes of water, the volume that they can discharge is limited by the outlet pipe sizes and the available capacity in the downstream network. Overland flow that enters the highway from adjacent land adds to the volumes of water that the gully network is required to drain away.

The rainfall was likely to have been equivalent to or greater than the normally designed

capacity of adoptable or highways drainage networks. All the gullies within the investigation area are on the 18-month cyclical gully clean programme.

Additional rainfall falling elsewhere within the catchment, in excess of sewer capacity in those areas, is likely to have flowed overland into the investigation area and exacerbated sewer limitations in the catchment there. The TWUL surface water sewer catchment includes lands outside the natural topographic / hydrological catchment in the immediate vicinity of the investigation area, and this will tend to bring water from outside catchments toward the site, as shown in Figure 10.

Figure 10 Wider storm sewerage hydrological catchment

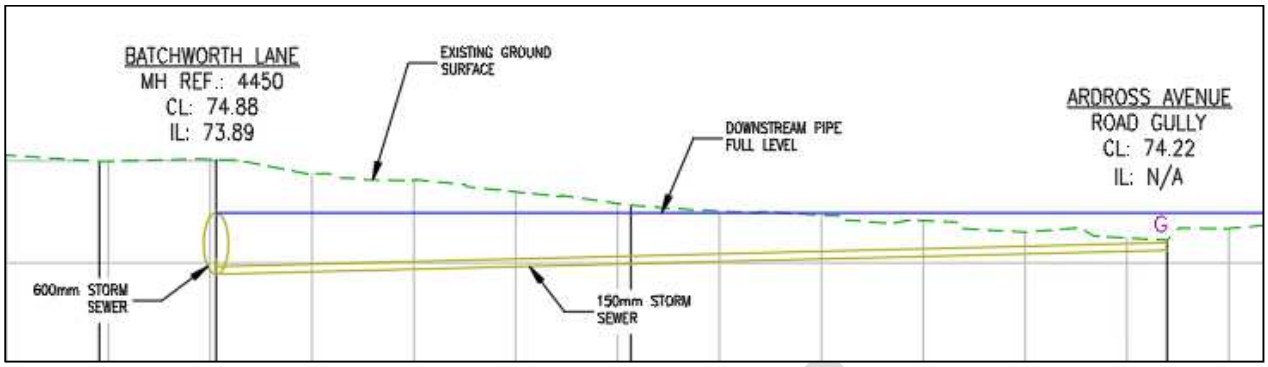


The surface water sewer beneath Batchworth Lane would have been under-capacity for the rainfall event experienced on 23rd June 2016. Sewers are therefore likely to have been surcharged. The potential exists for surcharged sewer water levels to have caused flooding on lower lying lands at Ardross Avenue by causing backflows into connecting sewers serving those roads, with flows emerging via gullies or manhole covers.

Figure 11 demonstrates how the surcharged surface water sewer flowing at full capacity on Batchworth Lane would have the potential to cause out of sewer flooding at Ardross Avenue[1]. Flooding emerging on Ardross Avenue via this mechanism would tend to follow the overland flow path indicated by the EA Risk of Flooding from Surface Water (RoFfSW) map, as shown in figure Figure 12.

[1] Levels are as per topographic survey data commissioned by HCC for this investigation

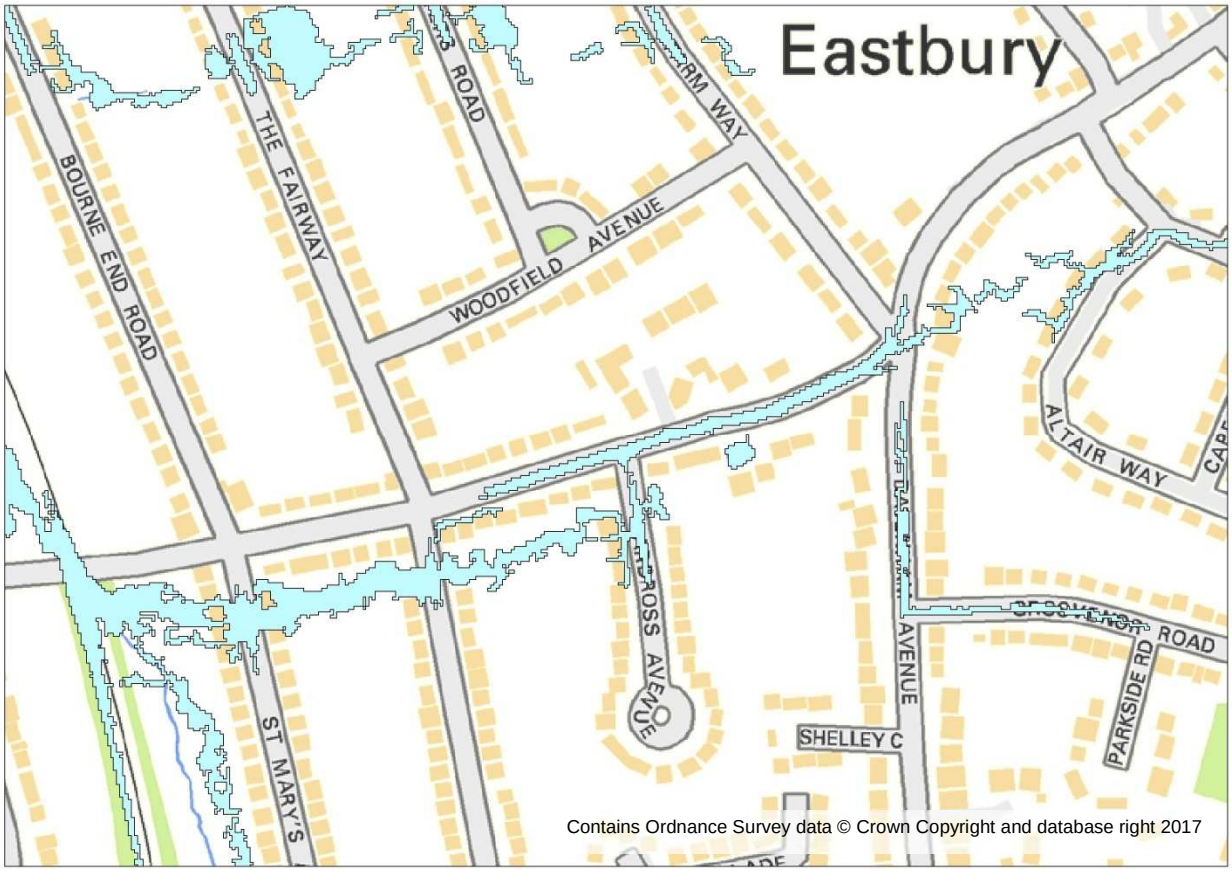
Figure 11 Storm sewer surcharge at Ardross Avenue



3.6 Surface water runoff (pluvial)

Surface water runoff was the main mechanism by which flooding occurred in the area of this Section 19 Flood Investigation. The topographical drainage routes correspond with the properties that reported flooding. The reported observed flooding and the Risk of Flooding from Surface Water Map correlate with each other, see **Error! Reference source not found.**which shows the risk of flooding from surface water for the 3.3% AEP event, taken from the EA's mapping.

Figure 12 EA's Risk of Flooding from Surface Water Map (RoFfSW) (3.3% AEP)



Surface water flooding following flow routes are likely to have been locally exacerbated by obstructions to flow paths, such as fences and walls between buildings, which would have caused water to be held back, causing locally raised water levels.

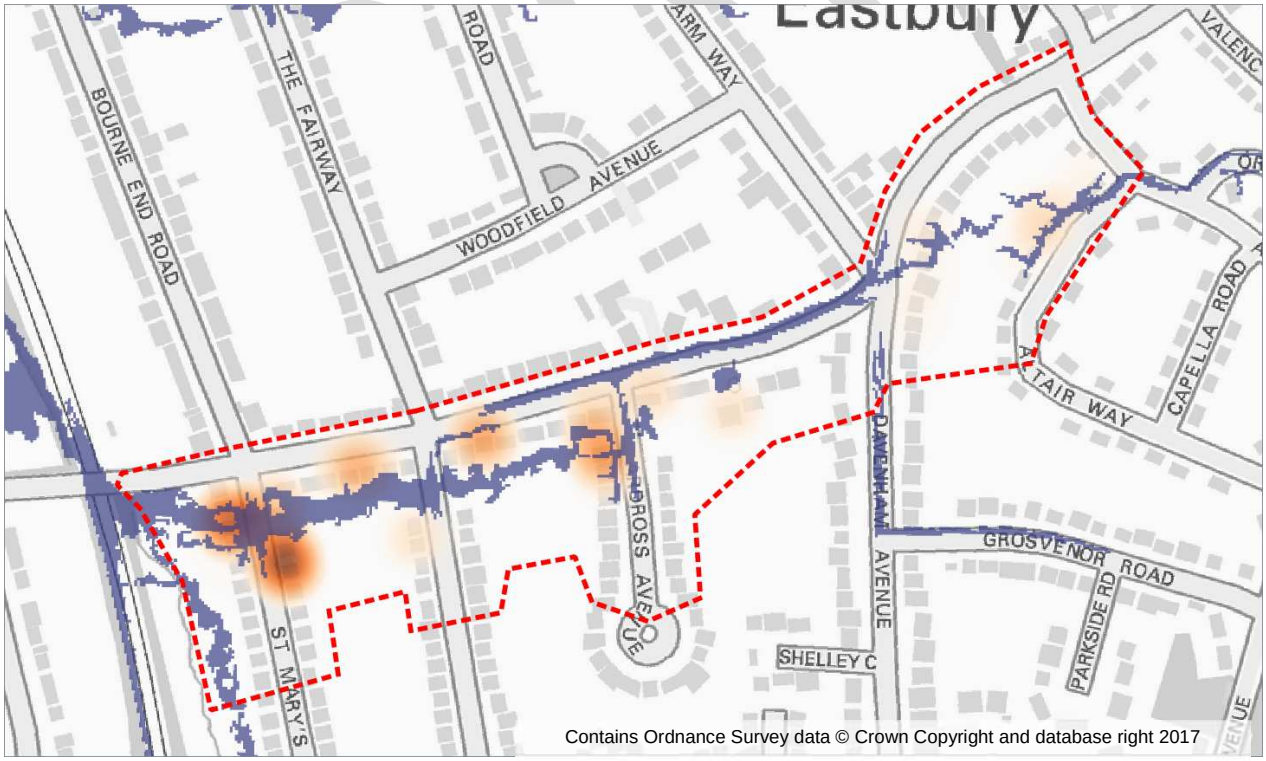
Where drainage system surcharging occurred, emerging water or water which would otherwise have been captured would have contributed to surface water runoff. Runoff in excess of sewer capacity would have followed the flow routes indicated by the EA surface water flood map (Figure 12).

Consideration of the low permeability of soil in the investigation area suggests that the catchment is likely to naturally have a rapid response to rainfall events. This also indicates that natural drainage in the catchment is likely to be predominantly dependent on discharge to watercourses rather than infiltration to groundwater.

3.7 Causes of flooding

Considering the estimated return periods of the recorded rainfall, a surface water flood event similar to that shown on EA's 3.3% AEP surface water mapping would have occurred on 23rd June 2016. Figure 13 shows the EA predicted surface water flood extent resulting from a rainfall event with a 3.3% AEP in any one year overlain with the 'heatmap' of observed flood depths.

Figure 13 EA's Risk of Flooding from Surface Water Map (3.3% AEP) vs. Observed Flooding (heatmap)



Given the strong correlation between the recorded rainfall, observed flooding, and associated surface water flood extent mapping, it can be reasonably concluded that surface water flooding was a significant contributing factor to flooding experienced on 23rd June 2016.

The local surface water sewer network was not designed for rainfall events of this magnitude. Flooding would also have been influenced by factors affecting the Moor Park Stream, including the fluvial flooding to the back-gardens of properties on St Mary's Avenue, the backing up of water alongside the boundary fence to Transport for London's land and the discharge of TWUL surface water sewer network may have been inhibited by the fluvial flooding.

4. Responsible authorities and landowners

Part of the role of HCC as the LLFA in accordance with Section 19 of the FWMA 2010 is to identify the risk management authorities (RMAs) that have flood risk management functions relevant to the flooding in the St Mary's Avenue / Batchworth Lane area of Northwood. Those RMAs and their relevant powers and functions are set out below.

4.1 Hertfordshire County Council as Lead Local Flood Authority

HCC as the LLFA for Hertfordshire has fulfilled its responsibility to carry out a Flood Investigation under Section 19 of the FWMA 2010, to;

1. Identify the relevant RMAs and;
2. Establish if those authorities intend to utilise their own powers and to what extent. The actions that the relevant RMAs have agreed to take are set out in Section 6.

In order to achieve the responsibilities under Section 19, HCC as LLFA must first establish the cause and impacts of the flooding and then, where possible, identify actions to reduce flood risk.

HCC as the LLFA for Hertfordshire has powers to carry out flood risk management works, in accordance with the Local Flood Risk Management Strategy for Hertfordshire, for flooding from surface runoff and groundwater.

The LLFA is also required to maintain a register of structures and features that have a significant effect on local flood risk.

This Flood Investigation has been commissioned by Hertfordshire County Council as the areas reported as being affected by flooding are fully within their jurisdiction as Lead Local Flood Authority (LLFA).

4.2 Hertfordshire County Council as the Highway Authority

HCC are the responsible authority to maintain and manage adopted highways including associated drainage infrastructure such as gullies, drainage pipes, and soakaways etc. which have been provided for the sole purpose of draining the public highway.

St Mary's Avenue, Batchworth Lane, Ardross Avenue, Altair Way, Eastbury Road and Davenham Avenue are highway maintainable at public expense and are impacted by the flooding.

HCC as the Highway Authority have powers to manage water falling on the public highway under the Highways Act 1980, however where this water originates from third party land and not from runoff from the highway these powers are limited.

HCC as the Highway Authority is required, as far as is reasonably practicable, to keep highways open and usable by the public.

In extreme flood events the majority of excess surface water will eventually flow onto the highway as roads act as manmade conduits for such water.

4.3 Thames Water

TWUL manages the public surface water and foul water sewer networks; it therefore has been identified as a relevant RMA. TWUL manages flooding from their network in line with their business plan approved by OfWAT.

TWUL, like all water companies, are required to keep a register of all instances of internal and external flooding of properties, this is referred to as the DG5 register. This register is used as the evidence to justify improvements to the surface water network.

Only TWUL has the authority to alter the surface water sewer and to manage the flood risk associated with it.

4.4 Environment Agency

The Environment Agency holds discretionary powers to manage flood risk from watercourses which are designated as Main River. It is also the regulatory body for approval of work within 8m of the centreline of such watercourses.

As part of this work the Environment Agency issues flood alerts and warnings to residents in areas that have been identified as being at risk of flooding from main rivers. Moor Park Stream is a main river.

Although in this case there were no properties which flooded as a direct result of water leaving the watercourses the ability of the surface water sewers may have been impacted by raised water levels which in turn would have been affected a number of structures on the watercourse.

4.5 Transport for London and other Riparian Landowners

Riparian landowners, who include Transport for London, are responsible for the maintenance of Moor Park Stream and any associated structures. This is to ensure that water is not impeded from flowing through the watercourse channel.

5. Conclusions, potential mitigation options and recommendations

5.1 Conclusion

The main cause of flooding was surface water resulting from an intense 30 minute rainfall event. Overall the pattern of flooding was broadly as predicted in the Environment Agency Risk of Flooding from Surface Water (RoFfSW) maps. Direct surface water runoff is the principle mechanism causing flooding with some contribution from water emerging from surcharged drains and sewers. This surcharging will have been a consequence of inflows from higher up the catchment combining to exceed the design capacity of the drainage system in the lower part of the catchment.

Drainage in the area would have been overwhelmed due to the intensity of the rainfall. There would have been some localised effects due to blockages in the highway and surface water systems but this would not have had a significant impact on the overall probability of property flooding. It may also have been due in part to raised water levels in the watercourse (Moor Park Stream) restricting the ability of the surface water sewers to discharge. The raised levels will have been a result of restrictions on flow due to the culvert under Batchworth Lane and obstruction to the screen on TfL's boundary fence.

The potential to mitigate the flood risk is limited as the upper parts of the catchment are predominately residential with little open space other than roads and one area of amenity space adjacent to Batchworth Lane. There is no single action that would significantly reduce flood risk in the area. The strategy should be to carry out a range of measures to reduce the impact of heavy rainfall in the area; this will need to include work to improve the flood resilience of individual properties.

A collaborative approach between the relevant Risk Management Authorities HCC as LLFA, HCC as highway authority, Thames Water and the Environment Agency working with TfL and other stakeholders will be needed to manage flood risk most effectively in the area.

5.2 Potential mitigation options

The technical assessment report suggested a range of actions to be considered to contribute to the overall reduction of flood risk in the area.

Actions suggested by the technical assessment report	Comments	Take forward as a recommended action?
a. Target improved public awareness of property level protection options and registration for the EA flood warning service.	1. There will always be a level of flood risk to some properties in the area. Property owners should be made aware of the risk and the actions that they can take to reduce the probability of properties flooding internally. 2. The EA flood warning service covers flooding from watercourses and rivers rather than surface water. It has limited availability in the area as the risk of property flooding from the watercourse is low.	Yes **Recommendation 1** With qualification **Recommendation 1**
b. Target improved public awareness of obligations in relation to riparian maintenance of watercourses and culverts to applicable properties and occupants adjacent to Moor Park Stream.	3. There needs to be a general awareness of key assets. 4. Riparian owners need to be aware of their responsibilities. 5. A means of raising and resolving issues relating to the watercourse need to be identified.	Yes **Recommendation 3**
c. Increased frequency of maintenance to the inlet screen at and culvert at Moor Park Stream in and adjacent to TfL lands.	6. The structure in the boundary fence needs reviewing. The vertical bars and poor access mean that it will trap debris and is also difficult to clear especially when the area is already flooding. Any proposals will be subject to environmental permitting regulation by the Environment Agency.	Yes **Recommendation 4**
d. Identification of existing key local storm water drainage assets, in particular, critical gullies on low lying roads at Ardross Avenue, Eastbury	7. Gullies have a very limited impact during storm events, especially where they discharge to networks that may be already surcharged. 8. However they can assist with drain down of an area to	Yes

Actions suggested by the technical assessment report	Comments	Take forward as a recommended action?
Road, and St Marys Avenue.	reduce the duration of flooding and to manage the impact of flooding of the highway during less extreme events.	**Recommendation 5**
e. Undertake a review of Thames Water asset information in order to verify or correct potentially spurious asset information which tends to indicate large diameter sewers flowing into small diameter sewers in a number of areas. A further qualitative or detailed modelling review of the verified Thames Water network may identify areas of particular need, discussed subsequently.	9. Some inconsistency was found in the records of the surface water infrastructure this needs to be resolved before any further assessment can take place. 10. Thames Water have procedures agreed with OfWAT to review the performance of the public surface water sewers based on reports of property flooding from customers.	Yes **Recommendation 6**
f. Highlight to local property owners whose sites are affected the predicted surface water flow paths the consequences of infill development and impermeable boundaries that would tend to impound floodwater, with the intention of advocating replacement with porous boundaries.	11. There is little scope in the catchment to significantly reduce the volume of surface water flow so this will remain as a risk. 12. The risk of surface water flooding is increased where water is impounded adjacent to properties. Modifying boundary features can help to reduce water depths and direct water away from properties.	Yes **Recommendation 1**
g. Improve preparedness for flooding by implementing a community flood plan, with subsequent actions such as assembling stocks of sandbags, formalising arrangement of distribution of sandbags and warning schemes, and improved coordination	13. Individual and community flood plans are good way of understanding flood risk in an area an the most effective action to take during an event 14. Warning services for surface water flood risk are not reliable for relatively small surface water catchment. This has implications for preparation and response to flood events.	Partly **Recommendation 1**

Actions suggested by the technical assessment report	Comments	Take forward as a recommended action?
with emergency services.	15. There are better alternatives to sand bags at a property and neighbourhood level.	
Additional potential measures to seek to alleviate flooding, likely to involve funding and considered capital works, have been identified as follows:		
h. Potential for further investigation of pinch points and deficiencies in the Thames Water storm sewerage network, to seek to ensure a design horizon for the network. In particular, works to the Thames Water network may be viable in order to prevent potential for backflow from sewers in Batchworth Lane to connected sewers and gullies in low lying areas to the south of that road.	16. Thames Water has procedures agreed with OfWAT to review the performance of the public surface water sewers based on reports of property flooding from customers.	Yes **Recommendation 6**
i. Improvements to the Batchworth Lane / TfL culvert and screen to increase flood capacity and enhance provision for access to maintain the existing culvert inlet screen or a replacement improved screen to current design standards.	17. The culvert screen and grille in the boundary fence need to be reviewed. 18. The culvert screen could be better designed to reduce the probability of blocking and to make routine maintenance easier. 19. The structure in the boundary fence needs modification. The vertical bars and poor access mean that it will trap debris and is also difficult to clear especially when the area is already flooding. Any proposals will be subject to environmental permitting regulation by the Environment Agency.	Yes **Recommendation 4**
j. Potential for further investigation of a catchment management / surface water interception scheme in the upper hydrological catchment, with a	20. There is limited scope but an initial appraisal of the opportunities is worthwhile. 21. In order to have the best chance of securing funding this needs to be considered as part as a package of measures	Yes

Actions suggested by the technical assessment report	Comments	Take forward as a recommended action?
view to seeking to reduce pressure on the downstream drainage network.	as it will need to be demonstrated that flood risk to properties is significantly reduced.	**Recommendation 2**

5.3 Recommendations

A. Identify relevant stakeholders, Risk Management Authorities, and Landowners, and as may be appropriate seek to implement flood management measures; including in particular increased public awareness, uptake of Property Level Protection, and identification of key drainage asset maintenance needs.

B. Investigate potential flood alleviation options. Any flood alleviation option(s) selected will require a technical assessment by the relevant authority and / or landowner and approval (if required) prior to any implementation on site.

No.	Recommendation	Comments	RMAs and other parties involved
1	Individual property owners review the flood risk to their property and consider steps they could take to reduce the probability of flooding together with the benefits of installing property level flood resilience. (5.2a above)	Whatever other steps are taken there will always be a residual level of flood risk. In some cases there may be relatively simple actions such as modification to boundary features that will reduce the probability of flooding. Even if found to be viable proposals such as in (6.2 j above) will not eliminate flood risk and would be medium term actions 5 – 10 years. Flood plans for individual properties can help guide actions that will reduce the impact of flooding and promote recovery.	Individual property owners supported by HCC as LLFA
2	An initial assessment is carried out into the viability of the creation of an area of surface water storage in the upper part of the catchment adjacent to Batchworth Lane.	Funding will be an issue. Conventional sources would require the flood risk benefit of the scheme to be demonstrated and this balanced against the cost. National grant contributions will be linked to demonstrating that properties have been moved from one designated flood risk band to a lower one. Also assumes that a flood risk scheme will be acceptable to the relevant landowners.	HCC as LLFA, HCC as highway authority, Thames Water, land owners.
3	Riparian owners of the Moor Park Stream are made aware of their responsibilities.	Riparian ownership needs to be established and contact made to highlight the importance of the watercourse being maintained.	HCC as LLFA and the Environment Agency.

No.	Recommendation	Comments	RMAs and other parties involved
	Local residents are made aware of who to contact if there is an issue with the watercourse	Contacts to be included in the final version of this report	HCC as LLFA and the Environment Agency. TfL and Environment Agency
4	The security grille in the railway fence and screen at the entrance to the culvert in railway land are reviewed with a view to redesigning them so that they function better in times of flood and are also easier to maintain.	The woodland surroundings for these areas present a higher risk of blockage from debris building up over time and acutely during a flood event. Raised water levels will have an impact on the operation of the surface water drainage and potentially contribute to property flooding.	Riparian owners which includes TfL
5	The highway authority reviews the road drainage network in this area to identify and rectify any damage and determine if it would be beneficial to identify any of the gullies for inclusion on the vulnerable gully programme.	The highway network does not have a significant impact on flood risk and is not designed as a general surface water network for the area. Nonetheless it can make a worthwhile contribution to managing surface water.	HCC as the local highway authority
6	Thames Water investigates the surface water sewer network. This should include a survey to accurately record the asset. In addition the performance of the surface water sewer network should be reviewed to determine if any repair work is needed or if improvements can be carried out.	The operational network needs to be understood before any further decisions can be taken. Any necessary maintenance and repair work should be carried out. Upgrades of the network to alleviate flooding will need to be assessed in line with OfWAT approved procedures.	Thames Water

6. Actions Undertaken by RMA's

The following sections set out the actions that are completed or are in progress by the relevant risk management authorities in relation to the 23rd June 2016 flooding in Northwood.

6.1 Hertfordshire County Council as the Lead Local Flood Authority

- Have carried out an investigation using their powers under Section 19 of the FWMA 2010.
- The extent of the flooding was confirmed through resident questionnaires and consultants were engaged to carry out a technical assessment of the area.

6.2 Thames Water Utilities Ltd

- Have carried out maintenance operations in the area and have also conducted a modelling exercise to understand the operation of the surface water sewer network in the area.

6.3 Hertfordshire County Council as the Highway Authority

- Have reviewed the operation of the highway drainage in the area.

6.4 Environment Agency

- Have carried out a visual inspection of the structures on the main river and reviewed the information on their asset database.

6.5 Transport for London

- Have conducted routine maintenance of the security screen and culverts within their riparian responsibility.
- Requested assistance from the Environment Agency to help redesign the security screen as well as improving access to the watercourse through their land.

7. Next Steps and Actions

7.1 Hertfordshire County Council as Risk Management Authority

The following are agreed actions to be undertaken by HCC in its capacity as LLFA;

1. Shares this draft report with residents in the areas of flood risk and the relevant RMAs and other parties
2. Arranges a public meeting to discuss the investigation findings and this report
3. Finalises this report and arranges for it to be published and distributed to the relevant RMAs
4. Carries out an initial assessment of the viability of creating an area of surface water storage adjacent to Batchworth Lane.
5. Includes this area in a proposed bid for grant aid to help with the installation of property level resilience measures.
6. Works with the Environment Agency to distribute information about riparian responsibilities and identify relevant contacts.
7. Assesses if any of the drainage in the area should be included on the s21 register of structures and features which have a significant impact on local flood risk.

7.2 Hertfordshire County Council as Highway Authority

The following are recommended actions to be undertaken by HCC in its capacity as Highways Authority;

1. Reviews the area to determine if changing the frequency of gully cleansing would be beneficial.
2. Programmes remedial action for any blocked or damaged gullies
3. Continues to monitor reported faults through the highway reporting system.

8. Disclaimer

This report has been prepared as part of Hertfordshire County Council's responsibilities under the Flood and Water Management Act 2010. It is intended to provide context and information to support the delivery of the local flood risk management strategy and should not be used for any other purpose.

The findings of the report are based on a subjective assessment of the information available by those undertaking the investigation and therefore may not include all relevant information. As such it should not be considered as a definitive assessment of all factors that may have triggered or contributed to the flood event. HCC expressly disclaims responsibility for any error in, or omission from, this report arising from or in connection with any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the time of preparation and HCC

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