PREPARED FOR

Roxeth Critical Drainage Area

Feasibility Study Report

LONDON BOROUGH OF HARROW

Authored by: Claudia Button
Reviewed by: Catherine Grutsch
Approved by: Valentina Aleotti

Date: April 2025
Version: 3.0

Metis Consultants Ltd.
2 Sheen Road, Richmond
London, TW9 1AE
United Kingdom
t. 020 8948 0249
e. info@metisconsultants.co.uk
w. metisconsultants.co.uk

Revision History

Version	Date	Description	Reviewed	Prepared	Approved
1.0	March 2025	Draft for Client Review	CG	CB	VA
2.0	April 2025	Updated Version	CG	CB	VA
3.0	April 2025	Final Version	VA	CB	VA

Limitations

Metis Consultants Limited (Metis) have prepared this Report for the sole use of the Client. No other warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by Metis. This Report is confidential and may not be disclosed by the Client nor relied upon by any other party without the prior and express written agreement of Metis.

The conclusions and recommendations contained in this Report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by Metis has not been independently verified by Metis, unless otherwise stated in the Report.

The work described in this Report is based on the conditions encountered and the information available during the period of production. The scope of this Report and the services are accordingly factually limited by these circumstances.

Metis disclaim any undertaking or obligation to advise any person of any change in any matter affecting the Report, which may come or be brought to Metis' attention after the date of the Report.

Certain statements made in the Report that are not historical facts may constitute estimates, projections or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the Report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. Metis specifically does not guarantee or warrant any estimate or projections contained in this Report.

The Client should take appropriate professional legal advice prior to implementing any recommendations made within this Report that may impact on the legal exposure of the Client.

Copyright

Executive Summary

Metis Consultants Ltd has been commissioned by the London Borough of Harrow to conduct a feasibility study and identify opportunities to alleviate flood risk within the Roxeth Catchment. The catchment experienced a significant flood event, approximated to be a 1% annual exceedance probability (AEP) event, that occurred on 23 September 2024. Internal property flooding was experienced at 35 properties in the low point of the catchment where flood waters collected during the storm and due to a surcharging manhole. This study reviewed the catchment to identify opportunities to alleviate flood risk to properties.

An initial longlist of potential solutions to address flooding in the study area was developed through a desk-based analysis of catchment characteristics and a site visit. The site visit was conducted to gather additional information to evaluate the feasibility of proposed schemes and understand local conditions and constraints that could affect implementation. Following the site visit, the longlist was refined, and the most suitable options were selected for the shortlist refer *Table 1-1*.

Table 1-1: Roxeth Catchment Shortlisted Options

Option No.	Description
1	On-Site Surface Water Management in Schools within the Catchment
4	Dry Basin Option 2, Alexandra Park
5	Additional Box Culvert, Alexandra Park
6	Underground Storage, Harrow Football Club
7	Property Level Protection, Walton Avenue to Fields End Road

The catchment area for the study area is 135 ha. This is a significant catchment size which consequently has large volumes of surface water runoff during storm events. Where surface waters collect in the natural low point in the topography, there are no opportunities to introduce a scheme that could relieve these properties of flooding as it is all residential. Consideration was given to the wider catchment for opportunities where storage could be achieved. Infiltration to ground was not an option in this catchment due to the clay soil type.

Pending detailed hydraulic modelling, it is unclear whether the options identified could alleviate the catchment of the flooding issues experienced during high return period events, due to the lack of available space to store flood waters in critical areas and high investment requirements. The options shortlisted comprise of two SuDS-based solution and three hard engineering solutions. Discussions with key stakeholders and further investigations into existing infrastructure will benefit the development of Options 1, 4, 5 and 6. Option 7 could be presented to property owners who were impacted by internal flooding as this option will provide a short-term solution to internal flooding until another option can be progressed.

The Hadleigh Close development was reviewed to understand if the development increased flood risk to properties on Somervell Road. According to planning application data submitted to Harrow Council, the development at Hadleigh Close was required to mitigate their surface water runoff from impermeable areas for up to a 1% AEP storm event.

Contents

Figures and Tables

Acronyms and Abbreviations

Abbreviation	Definition
AEP	Annual Exceedance Probability
AMP	Asset Management Plan
BGL	Below Ground Level
BGS	British Geological Survey
CDA	Critical Drainage Area
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
Ealing	London Borough of Ealing
FAS	Flood Alleviation Scheme
FCERM GiA	Flood and Coastal Erosion Risk Management Grant in Aid
GIS	Geographic Information System
Harrow	London Borough of Harrow
Hillingdon	London Borough of Hillingdon
IUD	Integrated Urban Drainage
LFRZ	Local Flood Risk Zone
mAOD	Metres Above Ordnance Datum
Metis	Metis Consultants Ltd
OBC	Outline Business Case
RoFSW	Risk of Flooding from Surface Water
SINC	Sites of Importance for Nature Conservation
SPZs	Source Protection Zones
SSSI	Sites of Special Scientific Interest
SuDS	Sustainable Drainage Systems
SW	Surface Water
TWUL	Thames Water Utilities Limited
UXO	Unexploded Ordnance

1 Introduction

1.1 Background

The London Borough of Harrow (Harrow) has commissioned Metis Consultants Ltd (Metis) to conduct a feasibility study to identify opportunities for a Flood Alleviation Scheme (FAS) or Sustainable Drainage (SuDS) interventions within the Roxeth Catchment, shown in *Figure 1-1*.

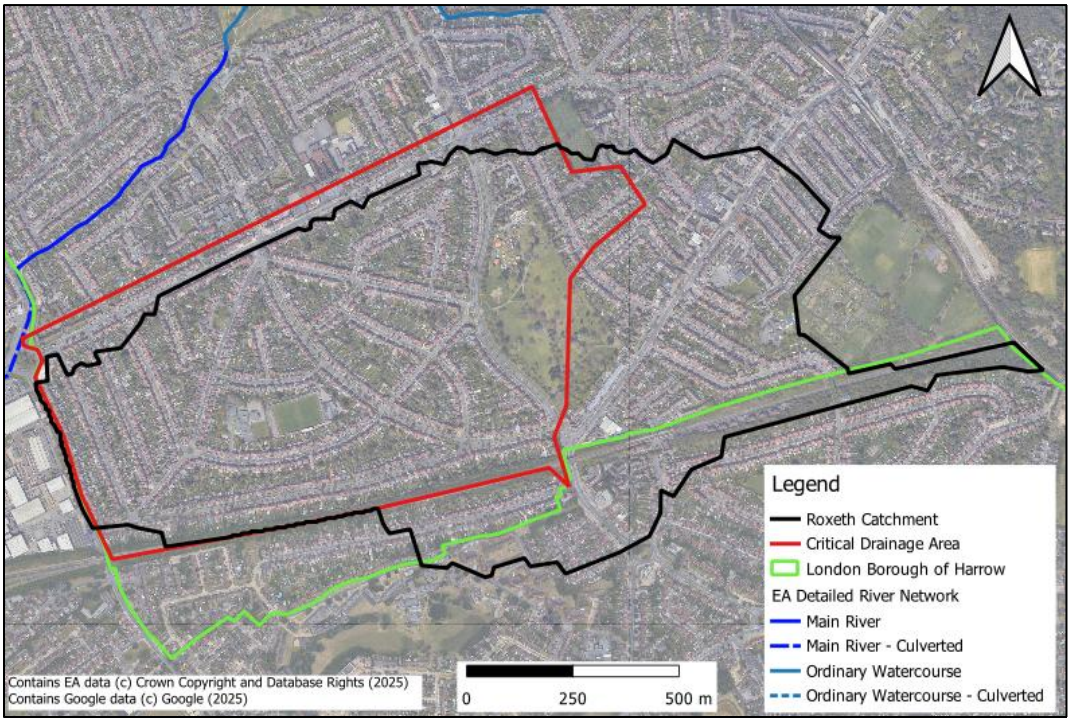

Figure 1-1: Overview of Catchment

The Roxeth catchment (the catchment) is situated in the southwest corner of Harrow, bordering the London Borough of Ealing (Ealing) and the London Borough of Hillingdon (Hillingdon). The catchment area is 135 ha. The Roxbourne River runs to the north of the catchment in the adjacent catchment. The Roxbourne River is open in Harrow before becoming culverted in Hillingdon, directly southwest of the catchment. The Roxeth catchment's surface water sewer network discharges into the culverted Roxbourne River. The land use in the catchment is primarily urban residential, with Alexandra Park to the east of the catchment, and Earlsmead Primary School and Harrow Football Club in the centre of the catchment.

A major storm event on the 23rd September 2024 caused significant flooding in the catchment, including internal flooding to 35 properties in the low point of the catchment and approximately 130 flood related service requests to Harrow. Some properties that experienced internal flooding had also experienced previous flooding incidents in storm events in 2014 and 2016, that whilst reported to Thames Water they were not reported to Harrow.

According to Met Office rainfall radar data and using the Flood Estimation Handbook (FEH) method, the September storm event was approximated to be a 1% annual exceedance probability (AEP) storm event or equivalent to one month's rainfall within a five-hour period. This means that throughout any year, the probability of storm event of this size happening is 1%. AEP's are used to estimate the likelihood of a storm event of a certain magnitude happening within any given year and are based on historical rainfall data.

During the September event, the River Roxbourne was flowing at maximum capacity, according to freely available river level data. This limited the ability for surface water to be discharged from the surface sewer network because it was unable to freely discharge into the culverted river, exacerbating the flooding issues experienced during the storm event.

1.2 Objectives

The objectives of this feasibility study are to:

- Complete an assessment of the flood risk within the Critical Drainage Area (CDA), refining the catchment boundaries hydrologically where necessary.
- Map flooding locations and data from the 23 September 2024 storm event.
- Assess flood mechanisms and potential options to reduce flood risk to properties identified as at risk on the Environment Agency's (EA) Risk of Flooding from Surface Water (RoFSW) mapping and the data from the 23 September 2024 event.
- Review the existing Thames Water Utilities Limited (TWUL) flood alleviation infrastructure information and drainage asset data within the catchment.
- Identify options and recommendations to mitigate the flood risk or mitigate the consequences of flood events within the CDA.
- Investigate if the Hadleigh Close development could have increased flooding to properties along Somerville Road.

2 Study Area

2.1 Desktop Assessment

2.1.1 General Considerations

	Findings	Source
Topography	High point: Northolt Road (Eastern side of the study area) Low point: Roundabout at Field End Road and Eastcote Lane intersection (Western side of the study area)	DEFRA, refer Figure 2-4
Geology	Bedrock Geology: Thames Group – Clay, Silt, Sand and Gravel. Combined Geology: Claygate Member. Clay type soils limit the ability for surface water runoff to be infiltrated to ground, which restricts the surface water management options available to the catchment.	BGS, refer Appendix A Figure 6-1 and Figure 6-2
Groundwater	Unproductive: areas comprised of rocks that have negligible significance for water supply or baseflow to rivers.	DEFRA Magic Map, refer Appendix B Figure 6-3 and Appendix C Figure 6-4 and Figure 6-5
Unexploded Ordnance (UXO)	Low Risk, no strategic target, military establishment, airfield or bombing decoy in the vicinity of the CDA.	Zetica, refer Appendix G Figure 6-15
Conservation	No conservation areas in the catchment	DEFRA Magic Map
Historic Landfill	None	DEFRA Magic Map
Listed Buildings	None	DEFRA Magic Map, refer Appendix D Figure 6-6, Figure 6-7, Figure 6-8 and Figure 6-9
Tree Protection Order (TPO)	There is one tree in the catchment protection order, on the north side of Earlsmead	Harrow, refer Appendix Figure 6-14
Habitats and Species	Priority Habitat – Deciduous Woodland, in the south-eastern corner of the catchment. Species – Lapwig are known to be in the area	DEFRA Magic Map, refer Appendix E Figure 6-11, Figure 6-12 and Figure 6-13

2.2 Roxbourne River Level

The Roxbourne River was flowing at significant capacity during the September 2024 storm event. Data sourced from Department of Environment Food & Rural Affairs (DEFRA) Hydrology Data Explorer for the Thistledene Avenue station conveys the spike in water levels levels from between 0 m and 0.3 m to approximately 1.1 m on 23 September 2024, refer to *Figure 2-1*.

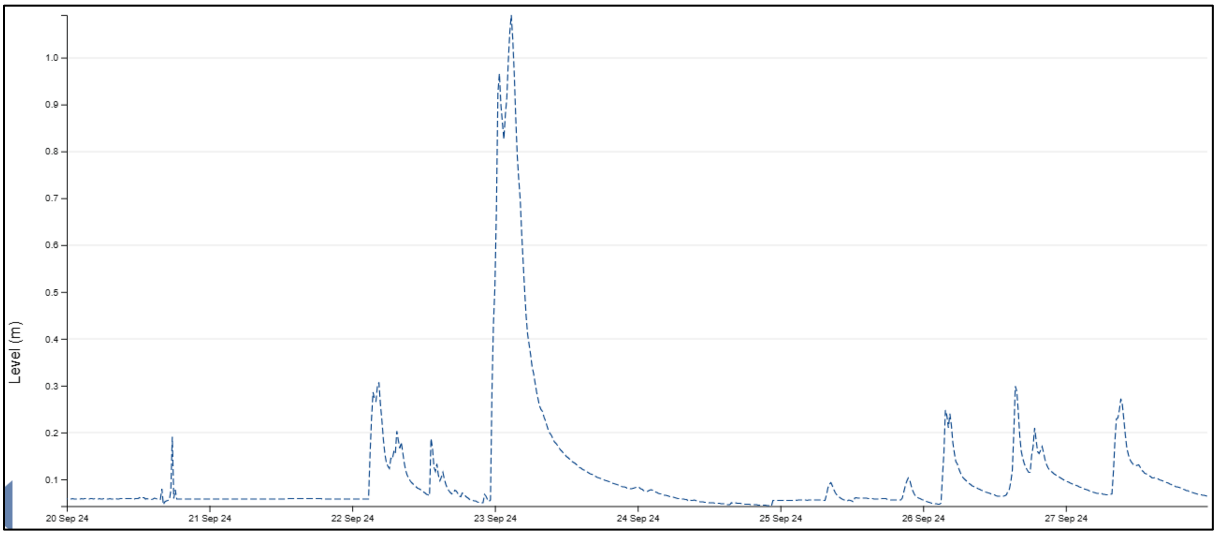

Figure 2-1: Roxbourne River Levels 20 September 2024 to 27 September 2024[1]

This data demonstrates how high the water levels in the Roxbourne River were during the storm and how this would impact the surface water sewer's ability to discharge into the river.

2.3 Thames Water Response During the Storm Event

Thames Water Utilities Limited (TWUL) consider the September 2024 storm event an "extreme hydraulic event"[2] and reported that the Yeading Brook and Roxbourne River were full, and in some locations breaching their banks. If the TWUL outfalls were submerged, the network would be unable to operate and discharge into rivers as they typically would.

Immediately after the September 2024 storm, TWUL commissioned a survey of their assets that connect or lead to the large culvert and trunk sewer at the Eastcote Lane and Victoria Road roundabout. The survey reported no underlying issues, blockages or defects and minimal debris and silt throughout the survey area.

Harrow have an asset management programme approach to gulley cleaning which shows the gulleys were last cleaned on the 6th September which should not have prevented flood water

[1] Department for Environment Food and Rural Affairs. Hydrology Data Explorer - Thistledene Avenue Station. https://environment.data.gov.uk/hydrology/station/2a1ebeb2-18ec-4d98-baee-7cfd650b9ed3 (accessed 13 March 2025)

[2] N Levy, Personal Communication, 21 October 2024

from draining freely into the sewer network when the storm abated. However the Harrow engineer on site on the following morning noted that many gulley grates were covered with leaves and litter debris preventing them from draining.

Harrow have reported that they clean the gullies in this catchment two to three times per year as this catchment is known to have high risk of flooding. Gullies are cleaned to remove any leaf litter and debris build up that has accumulated since the last clean which may inhibit flow into the surface water sewer network.

2.4 Flood Risk

The EA's RoFSW dataset, shown in *Figure 2-2*, indicates that the surface water flood risk in the 3.33% and 1% AEP storm events are concentrated through the mid-western portion of the catchment from Corfe Avenue to Fields End Road. These areas of higher predicted surface water flood risk align with the flooding locations identified during the September 2024 flood event.

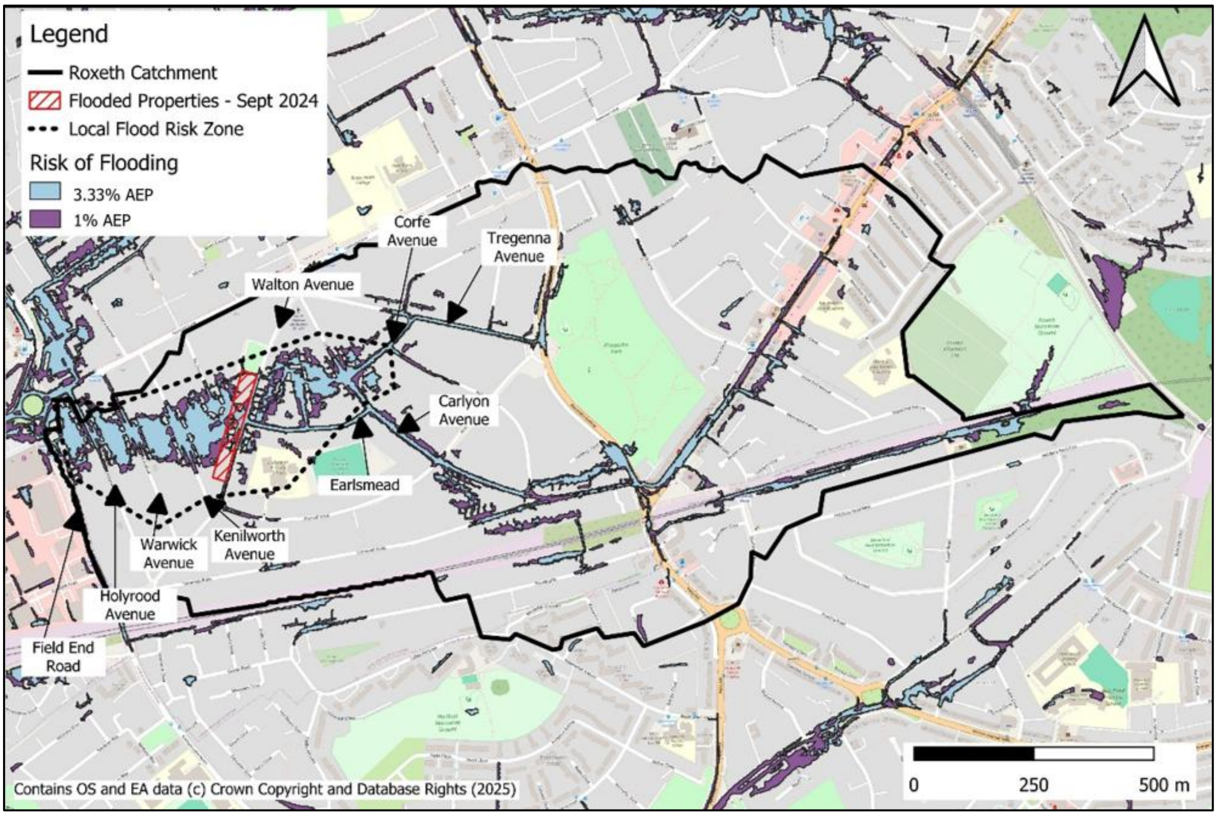

Figure 2-2: Risk of Flooding in the Roxeth Catchment

The total surface area and volumes of flooding across the catchment are shown in *Table 2-1,* these volumes are high-level and are estimated based on the RoFSW dataset.

Table 2-1: Catchment Flooding Characteristics

Storm Event	Surface Area (ha)	Volume (m^3)
3.33% AEP	7.5	24,400
1% AEP	14	49,800

As shown above, the volume of flooding from the catchment is significant during 3.33% and 1% AEP storms. *Table 2-2* below shows the flooding characteristics of the Local Flood Risk Zone (LFRZ) as shown in *Figure 2-2*.

Table 2-2: LFRZ Flooding Characteristics

Storm Event	Surface Area (ha)	Volume (m^3)
3.33% AEP	4.3	15,300
1% AEP	6.8	29,000

In comparison with the entire catchment, the LFRZ in a 3.33% AEP storm has 63% of the flood volume and 57% of the flooded surface area. In a 1% AEP storm the LFRZ has 58% of the volume of flooding and 49% of the flooded surface area. This data conveys the magnitude of flooding experienced in this small area which is only 12% of the total catchment size. The concentration of flood waters in this residential area is a significant challenge for this catchment as there are no large storage opportunities in this key area or immediately upstream where effective surface water management could be undertaken.

The major flow paths for the catchment area can be seen in *Figure 2-2*. Flows from the east and south of the catchment collect at the southern end of Alexandra Park. From here it flows along Somervell and Carlyon Avenue, down to the Earlsmead intersection. Due to the topography, the worst flood risk is predicted through the residential properties between Carlyton, Walton, Kenilworth, Warwick, Holyrood Avenues and Field End Road.

The flooding worsens across these streets as they are the natural low point of the catchment. Most of the catchment residential, with surface cover consisting of impermeable hardstanding of buildings, driveways, paved garden areas and roads, resulting in minimal opportunities for the water to soakaway to ground and the surface sewer network being the primary collection point for rainfall runoff. When the sewer infrastructure capacity is exceeded as it was in the September storm event, the flood waters use the secondary overland flow path which follows the natural fall of the land and collects in these low points.

Clay soils in the catchment area add further challenges to the management of surface water runoff due to the limited ability to infiltrate water to ground, increasing dependency on the surface water sewer and secondary flow path. With all factors combined, the management of surface water flooding in this catchment is incredibly challenging.

2.5 Drainage Asset Information

TWUL is responsible for drainage assets in the catchment, which consists mainly of a separated drainage network. The surface water sewer network follows the natural topography of the catchment depicted in *Figure 2-4.* There are some surface water sewers outside of the Roxeth catchment boundary line that contribute to the flows within the catchment.

Within the catchment, it is predominately separated surface water and foul water piped networks. Combined sewers are sparsely located across the catchment, although these appear to be connected to individual properties before feeding into a foul water sewer.

According to the TWUL sewer asset data, the Earlsmead and Walton Avenue intersection is where 89% of the catchment's surface water sewer network converges to, see *Figure 2-3*.

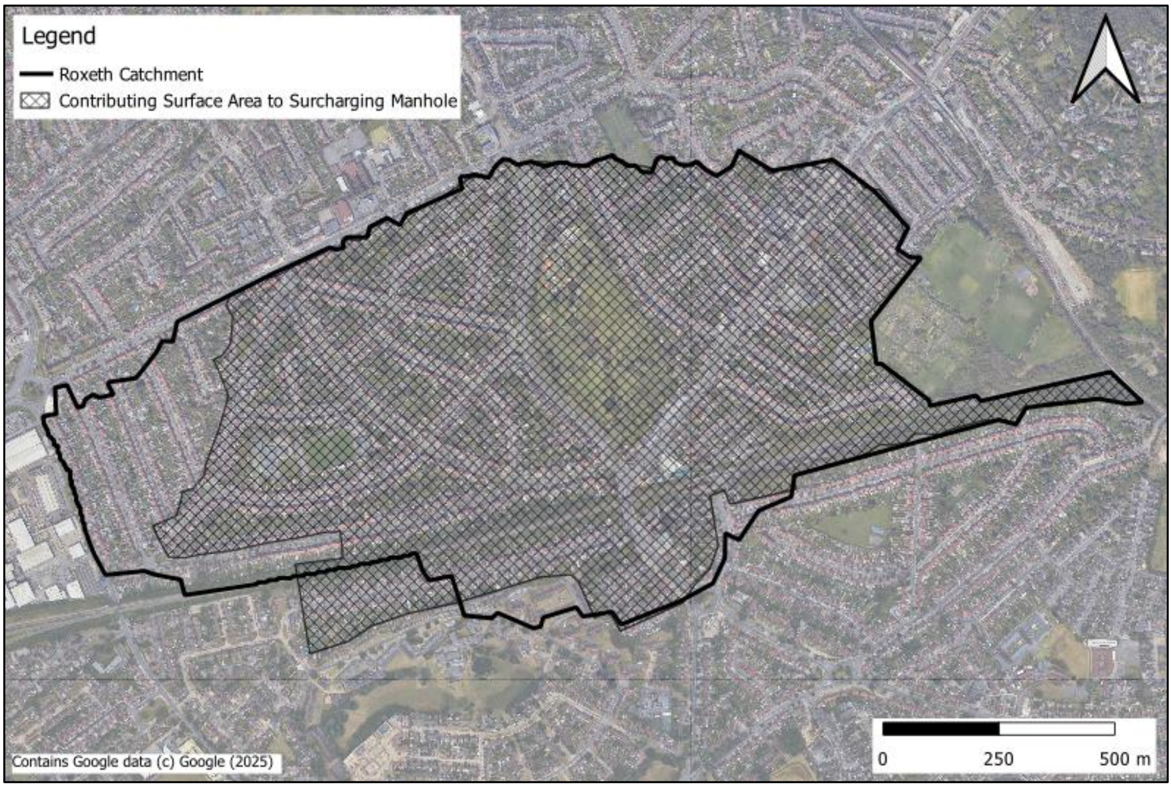

Figure 2-3: Catchment Area for Surcharging Manhole at the Earlsmead and Walton Avenue Intersection

The Walton Avenue and Earlsmead intersection was where major flooding was experienced during the September 2024 event, which included the surcharging of one of the surface water manholes. According to TWUL records, the surcharging manhole is where two large 1.0 m diameter pipes converge. There is no information to indicate where this manhole discharges to, whether it be to the 762 mm, an unmapped culvert or nowhere. It is likely it does connect to an outlet however this has not been captured in the asset data. Internal flooding was an issue for properties along the western side of Walton Avenue as video evidence of the surcharging manhole was captured from this area.

A surface water pump shed is located at the park area on Walton Avenue, upstream from the intersection. The 2016 TWUL data indicates that the surface water pump station may be pumping towards the Earlsmead / Walton Avenue intersection. No further information on this pump shed was available at the time of writing this report.

From the intersection, the primary outlet is a 762 mm surface water sewer pipeline which runs underneath a dwelling on Walton Avenue, and continues through multiple private properties between Walton Avenue, Kenworth Avenue, Warwick Avenue, Holyrood Avenue and Field End Road. This is the low point of the catchment where significant flooding is experienced during flood events, see Section 2.4 above. The surface water outlet from the catchment ultimately discharges into the culverted section of the Roxbourne River near the intersection of Eastcote Lane and Field End Road.

2.6 Flood Defence Asset Review

A review of existing flood defence assets in the catchment was undertaken. There are two large underground storage assets in Alexandra Park. The box culvert located to the north of the park area stores an estimated 800 m^3. According to TWUL records this was managed by Harrow for TWUL from 1991 to 1997, although TWUL paid for the scheme's development. It is unclear who undertook the cost of maintenance. The asset mapping was completed based on information sent to TWUL from Harrow.

The asset information for the box culvert to the south of the park does not include the height of the chamber and the cover, therefore an estimate of storage volume was not developed. The culvert stores flows from the surface water network on Northolt Road and the catchment draining into Northolt Road to the northeast of the park.

2.7 Hydrological Catchment

The Roxeth CDA (in red in *Figure 1-1*) was identified in the 2011 Roxeth Surface Water Management Plan (SWMP). The hydrological catchment was updated using current topographical data for this study, using the Geographic Information System (GIS) "Watershed" tool to delineate the Roxeth catchment based on topographical high points (in black in *Figure 1-1*).

The watershed catchment area extents include Eastcote Lane to the north, Northolt Road, between Corbins Lane and Eastcote Lane to the east, Newmarket Avenue in the south and Field End Road in the west. The total catchment area is 135 ha.

The map of the 5 m elevation intervals shown in *Figure 2-4* demonstrates the direction of flow across the catchment. With the highest point in the southeast corner of the catchment, and lowest point in the northwest.

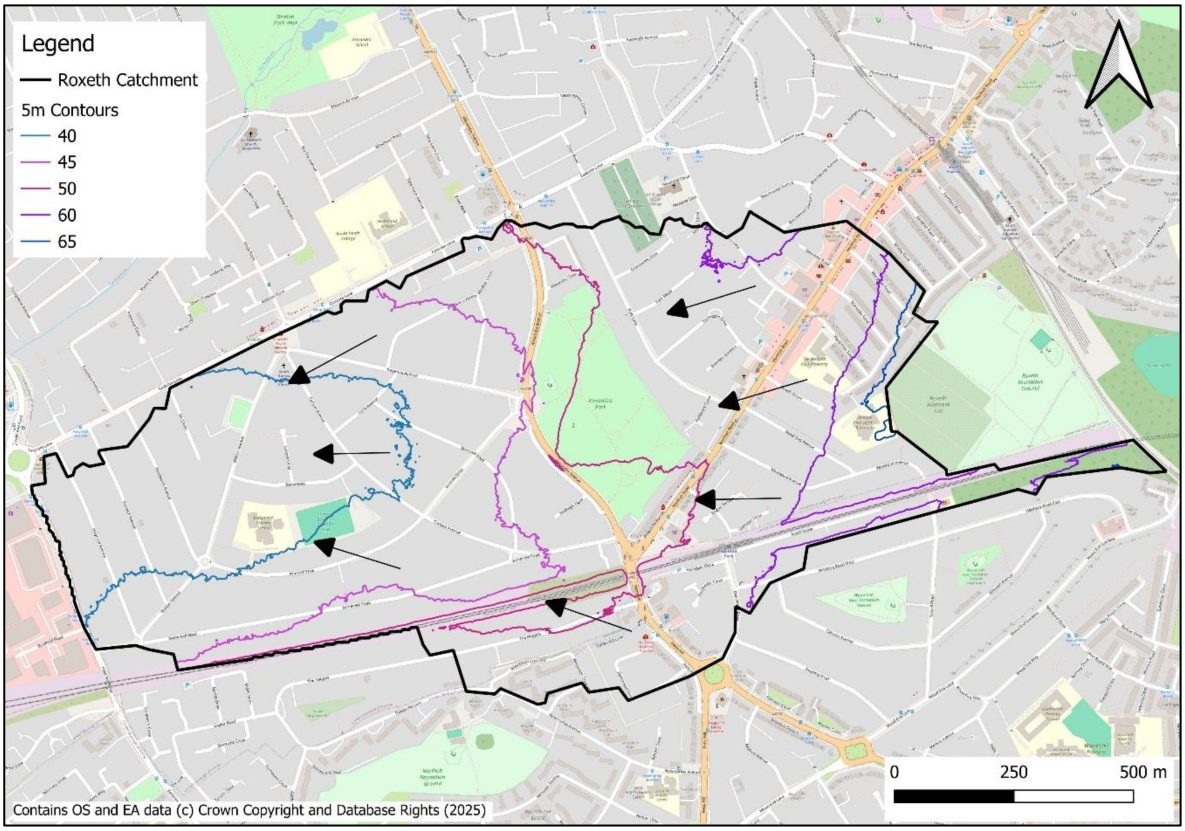

Figure 2-4: 5 m Contours

2.8 Site Visit

Metis conducted a site visit of the Roxeth Catchment on Wednesday 22nd January 2025. On the day, the longlist options were explored, and notes were taken to inform the shortlist based on topography, size, buildability, wider benefits, and local constraints. Photographic evidence captured throughout the visit are provided in Appendix H**.**

3 Option Appraisal

3.1 Longlist

An initial longlist of potential options to address flooding within the Roxeth Catchment was developed using a desk-based study of the characteristics of the study area and a site visit. Options were developed using the 'source – pathway – receptor' model described in DEFRA's SWMP Technical Guidance (2010).

Source options aim to reduce the volume of water entering the conveyance systems. This may be through a change in surface type from impermeable paving to gardens or grasses, provision of vegetation that helps to take up water, or through slow infiltration and storage to delay flow to downstream areas. These options have been pursued where possible, however often represent a higher cost to storage ratio. They generally provide good water quality, biodiversity, and amenity benefits but lower water quantity benefits. Due to the urban characteristics of the catchment, source options were solely available for schools in the catchment due their large impervious footprint and greenspace available for storage purposes. Source type solutions at a property level would be beneficial to the catchment, however would entail significant buy in from property owners across the catchment, of which majority will not be directly impacted by the flooding and likely hesitant to implement any changes at their property.

Runoff pathways offer greater opportunity for water storage through de-culverting of pipe networks, channel widening or diversion to temporary storage. These features aim to hold back water and free up downstream conveyance capacity, allowing more water to enter the drainage network and reduce the likelihood of surface flooding due to network overflow or insufficient capacity. These features often provide a good storage for the cost of work and are most effective in the upper to mid-catchment reaches. They can also provide biodiversity and amenity benefits, and some improved water quality. In this catchment, pathway solutions were challenging to implement in key locations due to the flood flow path being in residential properties and along roads. Improvements to existing infrastructure where storage has been implemented has been suggested where possible.

Intervention at flood receptors is generally a last resort option for flood alleviation. These options are often focused completely on flood mitigation and do not necessarily address water quantity, water quality, biodiversity, and amenity (the four pillars of Sustainable Drainage Systems (SuDS)). They may be related to building works, flood barriers or other property level protection. These options are generally most effective protecting large areas at risk. Intervention type options will be useful for properties in the low point of the catchment as they will provide immediate relief to internal flooding.

The aim for this feasibility study was to target key locations where surface water flooding could be managed to provide relief to properties prone to flooding in the low point of the catchment. Benefits and major risks were reviewed for each longlisted option identified. Each longlisted option was evaluated for flood risk benefits, feasibility, and wider benefits to meet the project objectives listed in *Section 1.2.* The appraisal is qualitative and based on best available information.

Table 3-1 describes the appraisal criteria applied to each option.

Table 3-1: Appraisal Criteria

Appraisal Criteria	Description
Flood Benefits	Is the scheme near a major flow path or sewer? Can the scheme reduce flooding to residential properties? Can the scheme reduce flooding to non-residential properties / major assets? Can the scheme provide flood relief to properties in the low point of the catchment?
Environmental and Social Benefits	Will the scheme have a positive impact on biodiversity, water quality or other environmental benefits? Will the scheme provide educational benefits? Will the scheme provide aesthetic benefits? Will the scheme be accepted by stakeholders?
Technical Feasibility/Risks	Are there major construction risks? Are there major health and safety risks (for the lifetime of the scheme)? Are there space constraints? Could there be legal issues?
Cost	How much is the scheme likely to cost? Is the scheme likely to access public funding?
Shortlisted?	The purpose of this report is to assess the impact proposed schemes will have on properties identified as at risk on the EA's RoFSW mapping and who experienced flooding during the September 2024 flood event.

The longlist of FAS proposed for the Roxeth Catchment are listed in *Table 3-2***.** Due to challenging terrain, limited greenspace throughout the catchment and the large catchment area resulting in large volumes of surface water runoff, there is no singular option to ultimately resolve the flooding within the catchment. The storm experienced in September 2024 was approximated to be a 1% AEP storm event which is an extraordinary storm exacerbated by the Roxbourne River being at full capacity. Options listed below will improve flooding, unfortunately none may completely relieve the flooding experienced in the catchment in large storm events.

Table 3-2. Long-list Options

No.	Option	Shortlist	Reason
1	**On-Site Surface Water Management – Earlsmead Primary School and Welldon Park Academy and Infants & Nursery**	**Yes**	**The schools within the catchment have large areas of impervious surfaces due to their large buildings and sealed surfaces for outside activities. These schools have got some greenspace on-site where they could implement SuDS to manage some of their surface water run-off on site. The Earlsmead Primary School is directly upstream from the catchments critical intersection where flooding occurs. Managing stormwater on-site would benefit the downstream receiving environment.**
2	Highway SuDS – Walton Avenue	No	The upstream catchment area from the basin is minor, compared to other pathways that could be more beneficial. Additionally, the surface water pumping station located at the park could already be servicing this area.
3	Dry Basin Option 1 – Alexandra Park	No	There is already a large 800 m^3 underground storage chamber here servicing the upstream area to the north of the catchment. The existing chamber is not located along the major flow paths of the catchment and upsizing this chamber may not be targeting a key location.
4	**Dry Basin Option 2 – Alexandra Park**	**Yes**	**Constructing an attenuation basin at the low point of the park and constructing bunding along the park perimeter to intercept overland flows from the park and capture flows upstream of where the flooding is experienced.**
5	**Additional Box Culvert – Alexandra Park**	**Yes**	**An additional box culvert in parallel to the existing box culvert could double the storage in this area. By adding another box culvert, some of the catchment's runoff can be captured upstream of where the flooding is experienced.**
6	**Underground Storage – Harrow Football Club**	**Yes**	**The Harrow Football Club is a large open space directly upstream of the Earlsmead and Walton Avenue intersection. The club is on Earlsmead where surface water runoff flows during large storm events. Intercepting a major flooding route upstream of the critical location could make a difference to the flooding at the Earlsmead and Walton Avenue intersection.**
7	**Property Level Protection – Walton Avenue to Fields End Road**	**Yes**	**Due to the limited options available for improving flooding in the catchment, flood prone properties should consider investing in physical barriers to prevent internal flooding.**

No.	Option	Shortlist	Reason
8	Private Property Stormwater Management – Catchment Wide	TBC	As this option relies on residents implementing changes at their properties, it is heavily dependant on stakeholder engagement. Harrow cannot implement this option without the support of the local property owners. The properties that would have the greatest impact are upstream of the locations with major flooding. There would be significant stakeholder engagement required for this option and residents would be unlikely to contribute to costs if not directly impacted by flooding. If the stakeholder engagement is successful, this could be hugely beneficial to the flooding in the catchment.

Refer to *Figure 3-1* for the locations of the longlisted options across the catchment.

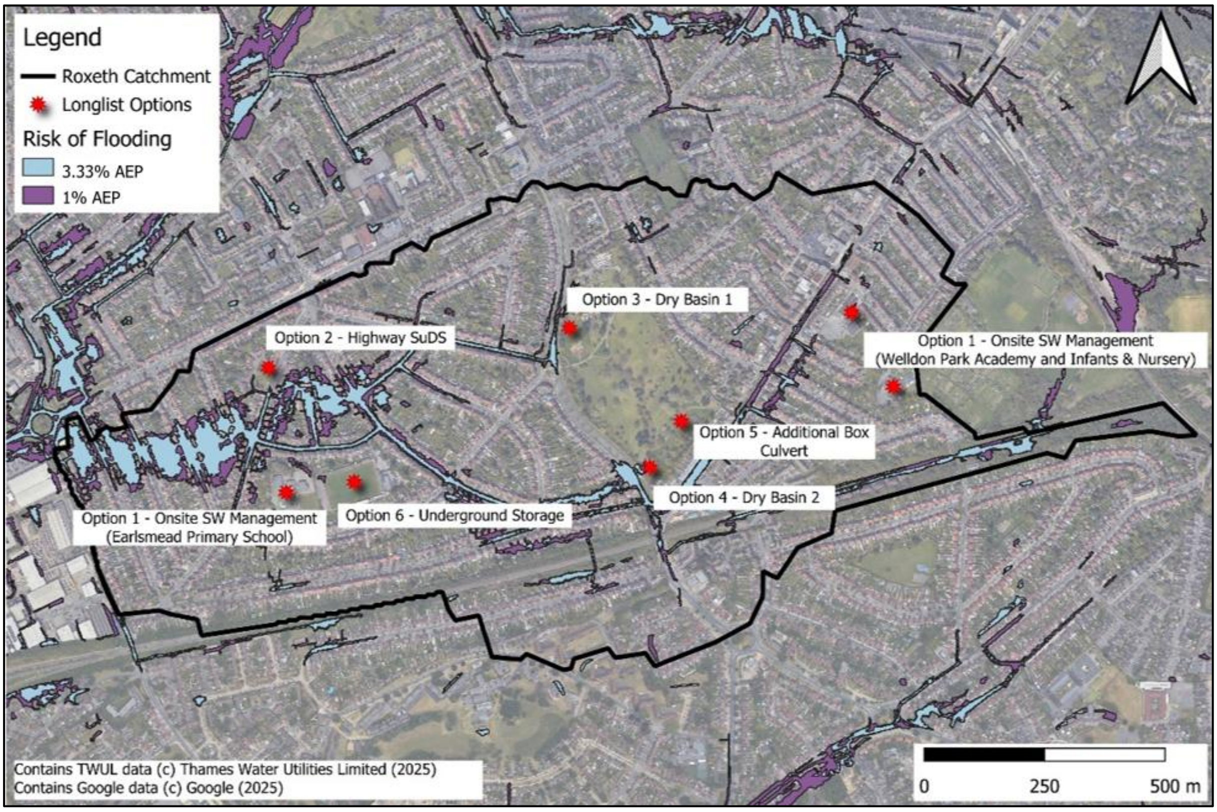

Figure 3-1: Roxeth Longlist Option Locations

4 Short List

The options assessed to best meet the project objectives including flood benefit and wider environmental benefits were carried forward to the shortlist. The options were appraised in greater detail and a high-level concept design and risk assessment was developed for each. The concept designs are preliminary, and it is anticipated that it will be refined as further work is undertaken.

4.1 Option 1 – Onsite SW Management, Earlsmead Primary School and Welldon Park Academy and Infants & Nursery

4.1.1 General

Onsite surface water (SW) management at the local schools within the catchment is a great way to reduce the volume of downstream flooding by utilising their greenspaces with SuDS to minimise their SW runoff. This option falls under the "Source" type solution. Schools typically have large impervious areas due to large buildings and surfaces for outdoor activities. By utilising greenspace and managing their school's run-off on-site, the downstream environment will receive less surface runoff from a main contributor.

Onsite SW management options could include:

- Detention basins
- Rain gardens
- Roof water storage
- Underground storage
- Permeable Pavement

In addition to flood risk benefits, there are other benefits associated with this option. Firstly, by having surface water management tools constructed onsite will provide pupils with the opportunity to learn about climate change and the water cycle, and what can be done to reduce the impacts this has on the environment and local community. Secondly, SuDS often have wider benefits by improving the water quality through natural processes such as filtration via plants and microbiological processes.

4.1.2 Risks

The location and design of this option should not prevent school pupils from having greenspace to play and do activities on. SuDS can be incorporated into the environment to maximise the available space for such activities.

To minimise risks during construction, working collaboratively with the schools will be essential. Ideally construction should take place during summer holidays to reduce disruption to learning.

4.1.3 Earlsmead Primary School

Earlsmead Primary School is located on Arundel Drive, refer *Figure 4-1*. The figure shows roof areas, impervious areas and where storage could potentially be integrated into the school site.

Figure 4-1: Earlsmead Primary School

According to TWUL's data, there is only one outlet pipe from the school which traverses adjacently to a property on Earlsmead, before discharging into the main network metres from the critical Earlsmead / Walton Avenue intersection described above. Managing stormwater directly upstream from where major flooding is experienced will help reduce the volume of flooding downstream by attenuating the runoff for a period of time.

The estimated hardstanding surface areas at the school are shown in *Table 4-1*.

Table 4-1. Hardstanding Surface Area at Earlsmead Primary School

Impervious Surfaces (m^2)	Roof Area (m^2)
3,664	2,540

Based on rainfall data in the area for a 60 minute storm, the resulting volumes of runoff from the roof areas for a range of annual return periods are shown in *Table 4-2*.

Table 4-2. Surface Water Runoff Volumes at Earlsmead Primary School for 60 minute Storm

Storm Event	Roof Volume (m^3)	Impervious Surfaces Volume (m^3)
100% AEP	38	54
20% AEP	52	75
10% AEP	59	85
3.33% AEP	62	89
1% AEP	88	128

The runoff volumes shown in *Table 4-2* demonstrate how much surface water can be generated from hardstanding areas during storm events.

Impervious areas at the school could be converted into pervious depending on their use and requirements.

4.1.4 Welldon Park Academy and Infants & Nursery

This school has two sites: The Welldon Park Academy and Welldon Park Infants & Nursery, refer *Figure 4-2*. They are located on Wyvenhoe Road and Kingsley Road, respectively, in the upper reaches of the catchment.

Figure 4-2: Welldon Park Academy and Infants & Nursey SuDS Opportunities

The figure shows roof areas, impervious areas and where storage could potentially be integrated into the two school sites. The estimated hardstanding surface areas at the school sites are shown in *Table 4-3* and *Table 4-4.*

Table 4-3. Hardstanding Surface Areas at Welldon Park Academy

Impervious Surfaces (m^2)	Roof Area (m^2)
3,917	1,657

Table 4-4. Hardstanding Surface Area at Welldon Infants & Nursery

Impervious Surfaces (m^2)	Roof Area (m^2)
2,729	1,868

Based on rainfall data in the area, the resulting volumes of runoff from the hardstanding areas are shown in *Table 4-5* and *Table 4-6* for Welldon Park Academy and Infants & Nursery, respectively.

Table 4-5. Surface Water Runoff Volumes for Welldon Park Academy for 60 minute Storm

Storm Event	Roof Volume (m^3)	Impervious Surfaces Volume (m^3)
1% AEP	25	58
20% AEP	34	80
10% AEP	38	91
3.33% AEP	40	95
1% AEP	58	136

Table 4-6. Surface Water Runoff Volumes for Welldon Infants and Nursery for 60 minute Storm

Storm Event	Roof Volume (m^3)	Impervious Surfaces Volume (m^3)
1% AEP	29	40
20% AEP	40	56
10% AEP	46	63
3.33% AEP	48	66
1% AEP	68	95

The volume of surface water runoff from the hardstanding areas at the schools demonstrate the impact having on-site surface water storage could make to the downstream environment.

Impervious areas at the school could be converted into pervious surfaces, depending on what their purpose is.

The Welldon Park Infants and Nursery faction is located upstream of Welldon Park Academy. Based on contours, surface water discharges towards the driveway out to Kingsley Road. The Academy has a large greenspace area upstream of its main buildings and sealed surfaces. Consideration could be given to storing run-off from the Infants and Nursery in this greenspace area at the Academy to relieve some downstream flooding. The Infants and Nursery have some potential greenspace onsite which could also be used to store surface water, as this greenspace is adjacent to the driveway.

4.1.5 Recommendations

Stakeholder acceptance and funding would be required to progress the SuDS in schools options. We recommend the following to progress the options:

- Engagement with the schools to gauge their interest in implementing SuDS on-site and acquire the school drainage plans to determine whether all surface water runoff discharges through the sewer networks indicated on TWUL data.

- Understand whether the schools have had previous flood incidents on site, which would increase their eligibility for Department for Education (DfE) flood defence funding.
- If the schools are interested in developing their SuDS on site, detailed hydraulic modelling would be required to understand their flood mitigation benefits and potential for funding through FCERM GiA.
- Survey the size and invert levels of Earlsmead Primary Schools outlet infrastructure to determine capacity and elevations.

4.2 Option 4 - Dry Basin Option 2, Alexandra Park

In Alexandra Park, the overland flow is directed to the southwestern corner and flows out through the park gates onto Alexandra Avenue where there is high risk of flooding. Video evidence submitted to Harrow during the September 2024 event shows there is significant flow exiting from the park.

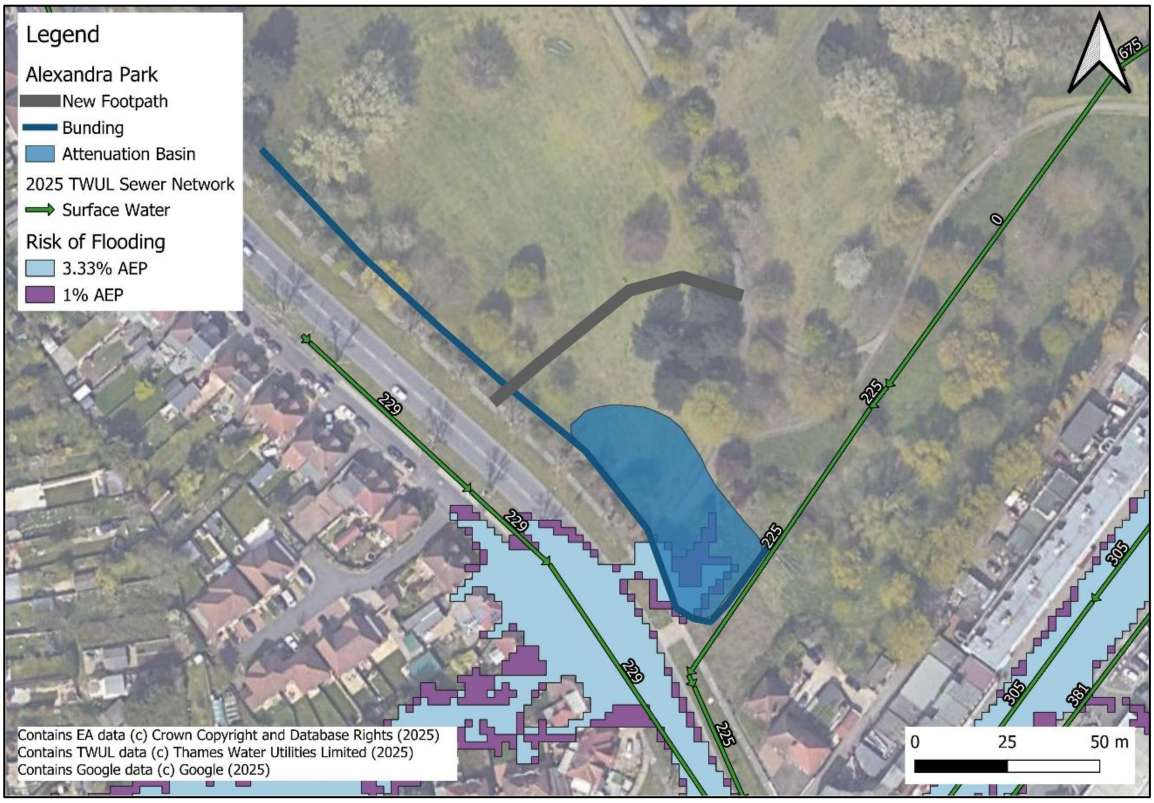

Figure 4-3: Alexandra Park Dry Basin Option 2

This option provides an attenuation basin in the low point of the park. This would require relocating the entrance to the park and footpath in this area to maximise the storage potential in the corner. Due to the TWUL surface water sewer, the entire area adjacent to the path may be unable be utilised.

In addition to the basin, bunding along the edge of the park could be constructed to intercept the overland flows off Alexandra Park and redirect them into the basin.

4.2.1 Risks

This option requires ground excavations to take place. Investigations into other utility services in the area is essential to determine if any require re-locating or if the area is unfeasible.

The works will be close to established trees, tree surveys would be required to determine the extent of tree root protection zones.

To ensure continuity with the bunding at the new entrance, the footpath will need to go over the top of the bunding. Gradients and widths need to be designed to ensure the park is accessible to people with disabilities.

4.2.2 Recommendations

To progress Option 4 would require significant investment and confirmation of flood mitigation benefits. The scheme could cost approximately £550k for a basin of 650 m^3, based on high-level, in-house costing tools. In order to progress the scheme, we recommend the following:

- Site surveys be undertaken to determine site constraints including utilities and trees.
- Further design development and detailed hydraulic modelling to develop a detailed understanding of flood mitigation benefits of the scheme, construction costs and potential for FCERM GiA funding.

4.3 Option 5 – Additional Box Culvert, Alexandra Park

In Alexandra Park there is a large underground box culvert. This box culvert services the upper reaches of the catchment, helping reduce flooding in the low point downstream. Consideration was given to increasing the underground storage capacity in this area to further help relieve flooding downstream, refer *Figure 4-4*. This option falls under the "Pathway" option type.

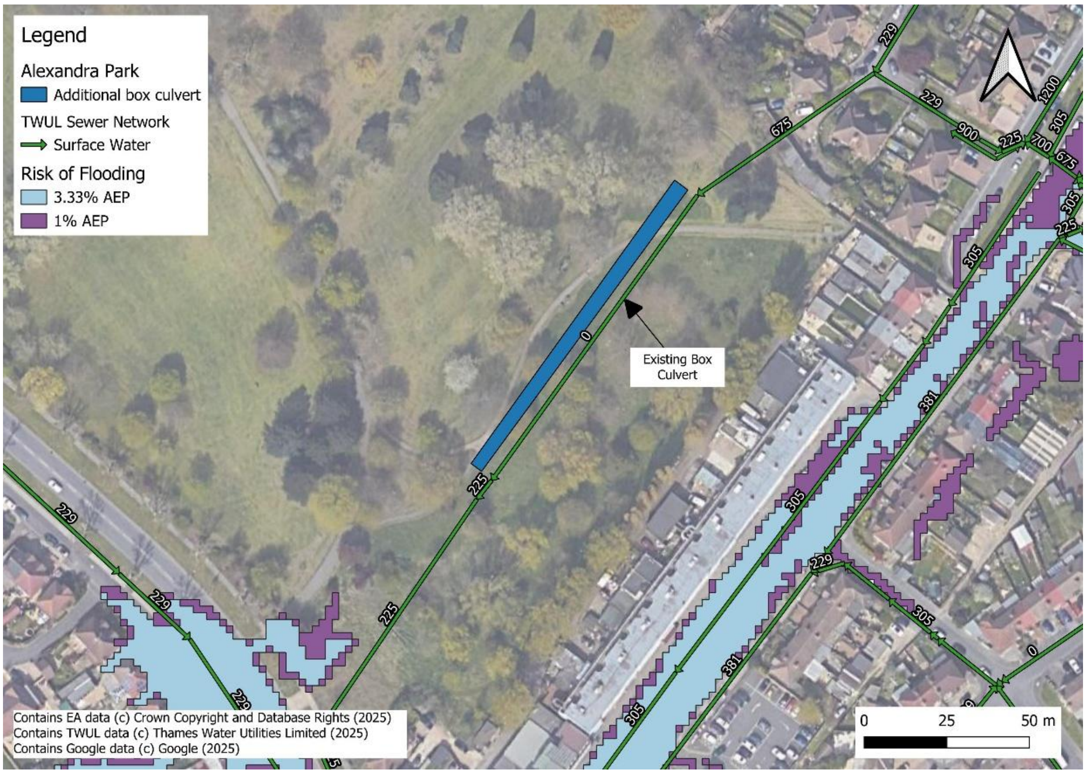

Figure 4-4: Alexandra Park Additional Box Culvert

An additional box culvert could be constructed adjacent to the existing box culvert to potentially double the storage capacity in this area. The inflow from the upstream network may need to be upsized to capture significant flows in the option.

4.3.1 Risks

This option is constrained by other utilities infrastructure located in the park. If there are services along the pathway adjacent to the box culvert, significant work may be required to relocate the utilities and approvals would be required.

As the existing box culvert is a TWUL asset, gaining their approval to modify and work in close proximity to their assets will be required.

The site has multiple established trees scattered across it. To construct a sizeable box culvert to improve downstream flooding, tree felling will be required.

4.3.2 Recommendations

To progress Option 5 would require significant investment, stakeholder acceptance and confirmation of flood mitigation benefits. A high-level cost estimate was undertaken for the scheme, using in-house costing tools that were based upon similar schemes in the London region. The project is estimated to cost between £500k to £1million, based on the depth and size of the potential pipe installation. Further design development is required to develop a more detailed cost assessment. To progress the option, we recommend the following:

- Engagement with TWUL to better understand their asset and seek permission to investigate the area further.
- Site surveys of existing infrastructure, utilities and trees to understand how additional storage can be integrated into the system to maximise the potential storage volume in this area.
- Further design development and detailed hydraulic modelling to understand the flood mitigation benefits of the option and whether it could be eligible for FCERM GiA funding.

4.4 Option 6 – Underground Storage, Harrow Football Club

The Harrow Football Club (HFC) is a large greenspace area near the major flood flow path along Earlsmead and is located directly upstream from where the major flooding occurs at the Earlsmead / Walton Avenue intersection, refer *Figure 4-5*.

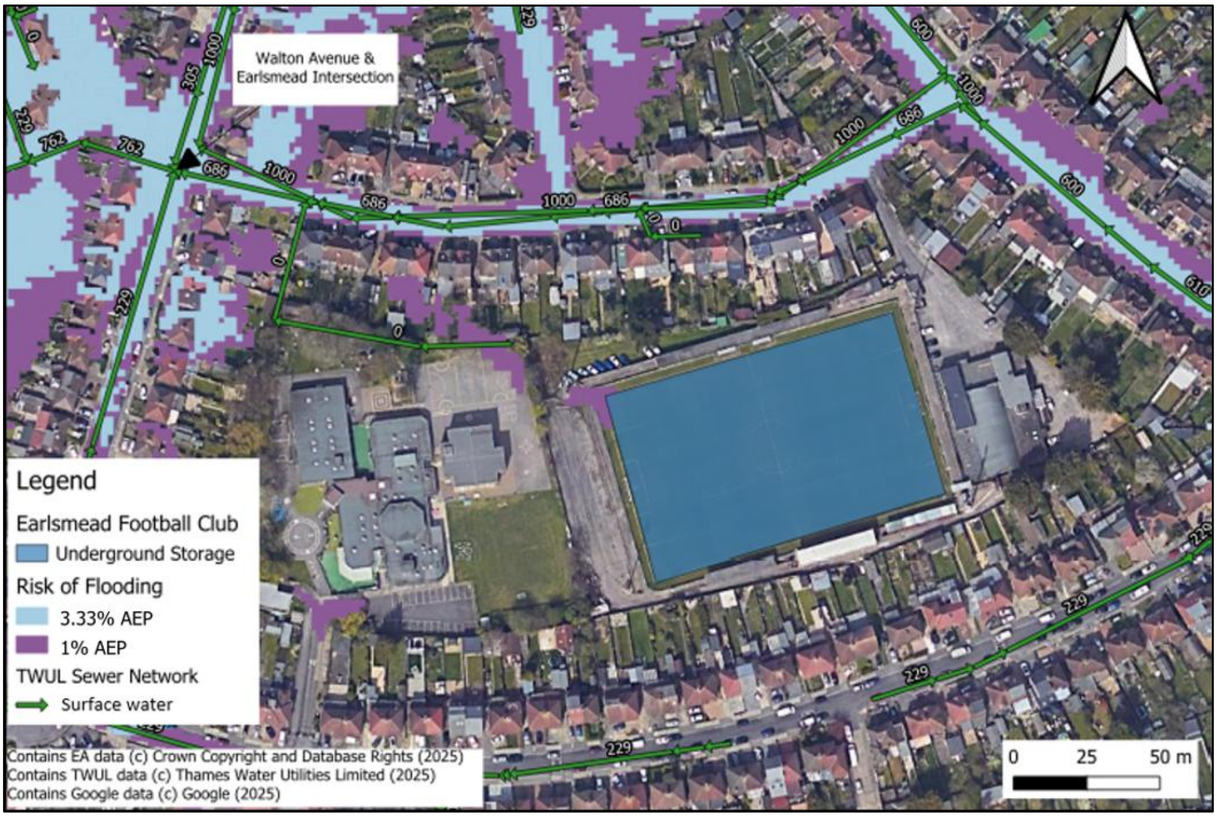

Figure 4-5: Harrow Football Club

Geo-cellular units or Hydro-Rock could be installed beneath the pitch to store large volumes of surface water during flood events. The available footprint / pitch area is 0.67 ha. Depending on how many layers of geo-cellular units are used, the potential storage beneath the pitch could be between 2,000 m^3 and 4,000 m^3, assuming a depth of 0.3 m per unit. This amount of storage and the convenient location upstream of the surcharging manhole has the potential to make a significant impact to the flooding downstream.

A possibility for an outlet to the storage units is the surface water outlet pipe from Earlsmead Primary School to the west of the football club.

4.4.1 Risks

Elevation levels are not favourable to a gravity run system to the surface water sewer located on Earlsmead. Due to the depth of the storage units being below Earlsmead, a pumping system would be required to empty the storage unit back into the TWUL network. The football club could also consider using the water stored as irrigation for the pitch. Due to the proximity to the Earlsmead Primary School, consideration could be given to them using it as an irrigation system too.

A significant challenge for this scheme is the buy-in from the football club. They are a well-established club with events on throughout the year. Constructing storage beneath their pitch will cause major disruption to their programme.

4.4.2 Recommendations

To progress Option 6 would require significant investment, stakeholder acceptance and confirmation of flood mitigation benefits. Due to the large quantity of earthworks required and the large surface area for storage, this scheme would have significantly high costs. A high-level cost estimate of the scheme, based on in-house costing tools, resulted in an estimate of approximately £4 million to £5 million. To progress the option, we recommend the following:

- Engagement with the Football Club to establish if they would consider this scheme at their site.
- A topographical survey of the site should be carried out to confirm the ground elevations across the site and, as described in *Section 4.1*, survey the drainage outlet to determine the size and invert levels at Earlsmead Primary School. Buy in from Earlsmead Primary School will be required for this scheme.
- Further design development and detailed hydraulic modelling to develop a detailed understanding of flood mitigation benefits of the scheme, construction costs and potential for FCERM GiA funding.

4.5 Option 7 – Property Level Protection, Walton Avenue to Fields End Road

Property level protection at individual properties is an intervention at the flood receptor. Due to the significant challenges this catchment faces as described previously in the report, few of the options listed above will be able to solve the flooding issues in the low point of the catchment.

To protect dwellings from internal flooding a watertight physical barrier to prevent surface water entering the property is recommended at all properties who experienced flooding during storm events and / or are in the low point of the catchment.

The physical barrier can be installed by an independent company / contractor. The contractor will secure bracing at entry points to the building, where boards or similar can be placed when high levels of rainfall is expected. The boards can either be placed manually by the homeowner, or some systems will drop boards from above – depending on the type installed. Barriers can be installed at doorways, garages or even at the gate depending on the fence type. If installing physical barriers at the fence line, consideration should be given to ensuring the sides and back of the property are also watertight, as water could backflow.

The cost of this option would depend on the type of barrier required and contractor used. A summary of a cost estimate from Flood Protection Solutions for a 1.5 m wide doorway is included in *Table 4-7*. Please note: the cost estimate is indicative only. The cost will vary depending on a range of factors including and not limited to door size, concrete base, shipping, packing, centre posts and installation.

Table 4-7: Flood Protection Solutions Quote

	600 mm	1000 mm*
Reveal Fix Barrier	£649 +VAT	£878 +VAT
Face Fix Barrier	£853 +VAT	£1,182 +VAT

* Properties requiring a flood barrier higher than 600mm must have engineering approval to install a barrier at such a height due to the force of water which may compromise the structural integrity of the barrier.

Alternatively, for a Floodstop 600mm high barrier refer to *Table 4-8* for cost estimates provided for a range of door sizes. Please note all prices do not include installation, delivery, packers or powder-coating.

Table 4-8: Floodstop Quote

Door Width	600 mm
762mm	£860 +VAT
900 mm	£900 +VAT
1500	£1,100 +VAT

This option will have most impact on affected properties in the fastest timeframe. Property owners can organise contractors to price and install the barriers. Whereas other options require negotiation and further investigations to confirm their viability, before having budget set for construction in future years to come.

4.5.1 Risks

As the barriers prevent flooding entering properties, the flooding will be displaced and will flow elsewhere. This may introduce increased flood risk to the wider area.

The implementation and maintenance of these barriers will be managed by homeowners / tenants. If they are not managed as per manufacturers specifications, internal flooding may still occur during flood events.

4.5.2 Recommendations

To develop this option, we recommend the following:

- Engagement with residents to understand their appetite for property level protection and ability for implementation.
- Determination of whether the residential properties could qualify for joint funding through the EA's FCERM GiA outline business case for property level resilience. An initial property survey and analysis of properties at risk would be required to determine eligibility.

5 Hadleigh Close Development

According to Council documents, the planning permissions for the development were originally applied for in 2004 with 14 2-story houses, however the application was declined. In May 2005 a development of 12 2-storey houses was re-applied for and declined by Harrow Council the following July. The developers appealed the decision, to which planning permission was granted by the Secretary of State for Communities and Local Government in June 2006[3]. The Hadleigh Close development was constructed in 2011 / 2012, based on aerial imagery. Neighbours along Somervell Road have raised concerns about the impact the development has had on flooding at their properties.

Hadleigh Close is a private road, thus TWUL is not required to obtain detailed asset records of the site and the Harrow gully data does not extend into the Close. *Figure 5-1* shows the surface water sewer for the surrounding area and the EA's RoFSW for the 3.33% and 1% AEP storm events, *Figure 5-2* shows a closer view of all TWUL sewers and Harrow gully data available.

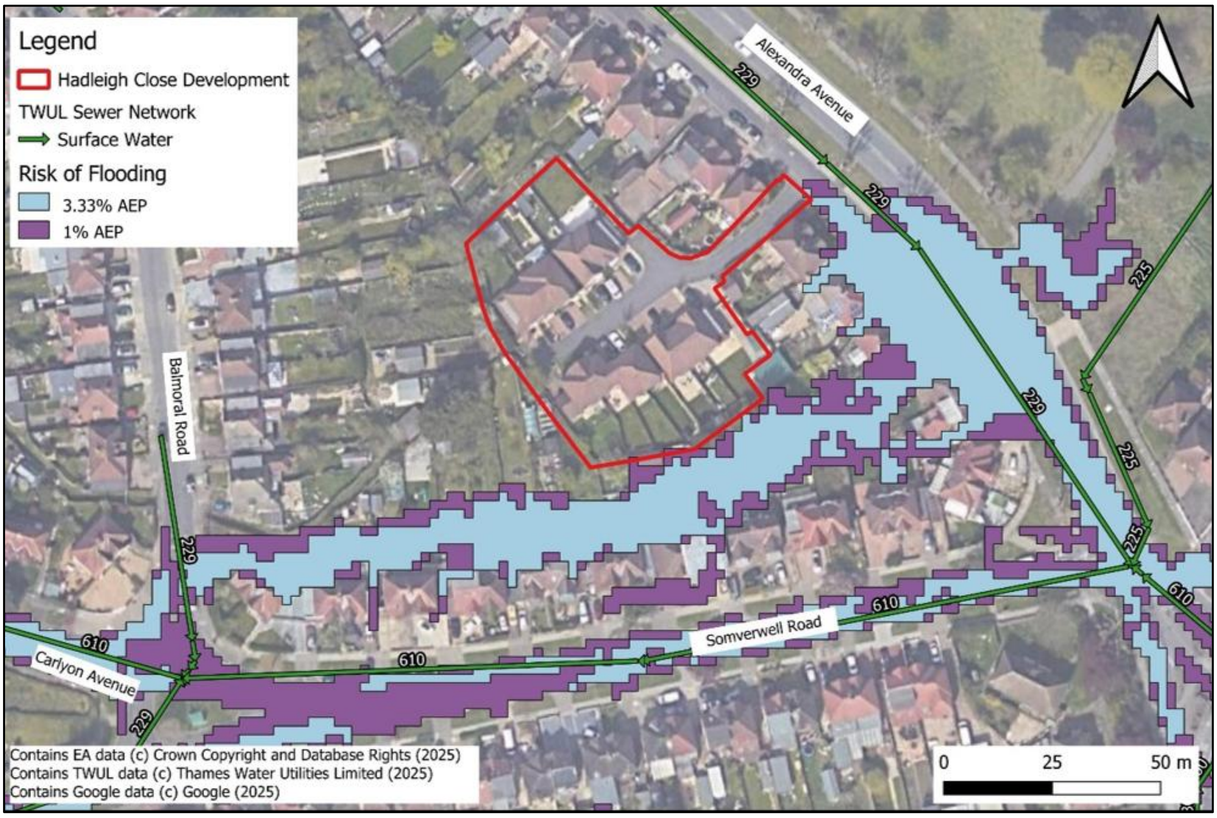

Figure 5-1: Hadleigh Close and Somervell Road RoFSW and TWUL Surface Water Sewer

[3] Secretary of State for Communities and Local Government. (2006, June 29). Appeal Decision.

Figure 5-2: TWUL data for Hadleigh Close

TWUL data shows privately owned surface water and foul water sewers. In TWUL datasets this means that the asset is not owned by TWUL. The data shows a misconnection with a private foul sewer connecting into a private surface water sewer, prior to discharging into the TWUL surface water sewer. The TWUL foul water sewer in Hadleigh Close is perpendicular to the presumed correct direction of flow.

The development drainage plans submitted during the planning process were reviewed to evaluate their impact on Somervell Road. The drainage plan demonstrates the surface water drains to the east towards Alexandra Avenue. There is a 50 m^3 storage tank at the downstream end where surface water collects prior to being pumped into Alexandra Avenue. This storage tank has been designed to store impervious surface runoff for a 60 minute 1% AEP storm event based on calculations submitted during the planning process. The gully's indicated on the drainage plan have been confirmed to be in-situ via the gully plan provided by Harrow which was based on aerial imagery.

Figure 5-1 shows the properties along Somervell Road were in a pre-existing surface water flow path based on the EA's RoFSW mapping. This was confirmed in the appeal decision letter for the development, where the inspector states "I am told that houses have been flooded in the past. Flood relief works carried out in 1992 resulted in considerable improvements, but rainwater accumulates in gardens in the area and heavy rain continues to result in localised flooding."[3] This information suggests that flooding has been an issue in this area for some time.

Based on planning application drainage designs provided, the development should have been designed to attenuate the surface water runoff for the impermeable areas of the development for up to and including a 60 minute 1% AEP storm on-site. No as-built information has been provided to confirm the site was constructed as designed.

6 Conclusions and Recommendations

Following the approximated 1% AEP storm event in September 2024, the Roxeth CDA catchment experienced widespread flooding, where 35 properties experienced internal water damage because of the high flood waters. Following a hydrological investigation, it was found that the catchment area is significant, with an area of 135 ha. Further analysis found that 89% of the catchment's sewer collects at the Walton Avenue and Earlsmead intersection, which was a key area of flooding during the September 2024 event.

A 1% AEP storm exceeds the design standard requirements for surface water infrastructure. The extreme storm event inundated the surface water sewers and highway infrastructure which caused flooding at ground level and for excess water to flow to the natural low points in the topography. In addition to this, the primary outlet for the surface water sewer, the Roxbourne River, was flowing a maximum capacity which limited the surface water sewers ability to discharge into it.

Prior to the event, Harrow confirmed the gullies on and around Walton Avenue and Earlsmead were cleaned as per their 2-3 times per year priority gully cleansing regime. The gullies in this area are cleaned often as the area is known to have high risk of flooding. Following the event TWUL carried out investigations and confirmed the surface water sewer was clear of debris and silt following the event, and that there were no blockages impacting the sewer.

During the September 2024 event, it is estimated that flooded volume could have reached up to 50,000 m^3 across the catchment, based on the EA's high-level 1% AEP RoFSW mapping.

The catchment is predominately residential which limits the available greenspace for collecting and storing the large volumes of flood waters. Where greenspace exists, it is in the upstream portion of the catchment and not directly on the major flow paths. The catchment's low points are located throughout residential properties which limits the storage capacity solutions available to the catchment.

Metis have undertaken an assessment of opportunities for flood alleviation schemes across the catchment. The short-listed options are:

- Option 1 – On-site Surface Water Management, Earlsmead Primary School and Welldon Park Academy and Infants & Nursery
- Option 4 – Dry Basin 2, Alexandra Park
- Option 5 – Additional Box Culvert, Alexandra Park
- Option 6 – Underground Storage, Harrow Football Club
- Option 7 – Property Level Protection, Walton Avenue to Field Ends Road

Due to the large volumes of surface water runoff from the catchment, implementation of multiple options described above would be required to alleviate the receiving environment where internal flooding is experienced during significant storm events. Options 1, 4, 5 and 6 require further investigations to be undertaken, depend on key stakeholders buying into the scheme and require significant investment. Option 7 would provide immediate protection to impacted residents who experience internal flooding during major storm events, however will not mitigate flood events.

TWUL have advised that they need to prioritise flooding across the entire Thames Water catchment. Currently this catchment is not due for consideration within the upcoming Asset Management Period (AMP) 2025-2030. This means that TWUL is unlikely to be able to assist with any of the recommendations within this report until the next AMP period.

To develop the options further, the following next steps are recommended:

Wider Catchment:

- Drainage survey of the surface water infrastructure at the Walton Avenue and Earlsmead intersection to understand the drainage network in this area and fill current data gaps. Clarifying the infrastructure in this area will help Harrow and TWUL's understanding of how this critical area functions during storm events and whether any upgrades or connections are required to improve efficiencies in this area.

Option 1 - On-site Surface Water Management, Earlsmead Primary School and Welldon Park Academy and Infants & Nursery:

- Engagement with the schools to gauge their interest in implementing SuDS on-site and acquire the school drainage plans to determine whether all surface water runoff discharges through the sewer networks indicated on TWUL data.
- Understand whether the schools have had previous flood incidents on site, which would increase their eligibility for Department for Education (DfE) flood defence funding.
- If the schools are interested in developing their SuDS on site, detailed hydraulic modelling would be required to understand their flood mitigation benefits and potential for funding through FCERM GiA.
- Survey the size and invert levels of Earlsmead Primary Schools outlet infrastructure to determine capacity and elevations.

Option 4 – Dry Basin Option 2, Alexandra Park

- Site surveys be undertaken to determine site constraints including utilities and trees.
- Further design development and detailed hydraulic modelling to develop a detailed understanding of flood mitigation benefits of the scheme, construction costs and potential for FCERM GiA funding.

Option 5 – Additional Box Culvert, Alexandra Park:

- Engagement with TWUL to better understand their asset and seek permission to investigate the area further.

- Site surveys of existing infrastructure, utilities and trees to understand how additional storage can be integrated into the system to maximise the potential storage volume in this area.
- Further design development and detailed hydraulic modelling to understand the flood mitigation benefits of the option and whether it could be eligible for FCERM GiA funding.

Option 6 – Underground Storage, Harrow Football Club:

- Engagement with Harrow Football Club to establish if they would consider this scheme at their site.
- A topographical survey of the site should be carried out to confirm the ground elevations across the site and, as described in *Section 4.1*, survey the drainage outlet to determine the size and invert levels at Earlsmead Primary School. Buy in from Earlsmead Primary School will be required for this scheme.
- Further design development and detailed hydraulic modelling to develop a detailed understanding of flood mitigation benefits of the scheme, construction costs and potential for FCERM GiA funding.

Option 7 – Property Level Protection, Walton Avenue to Fields End Road:

- Engagement with residents to understand their appetite for property level protection and ability for implementation.
- Determination of whether the residential properties could qualify for joint funding through the EA's FCERM GiA outline business case for property level resilience. An initial property survey and analysis of properties at risk would be required to determine eligibility.

Appendix A – Bedrock Geology

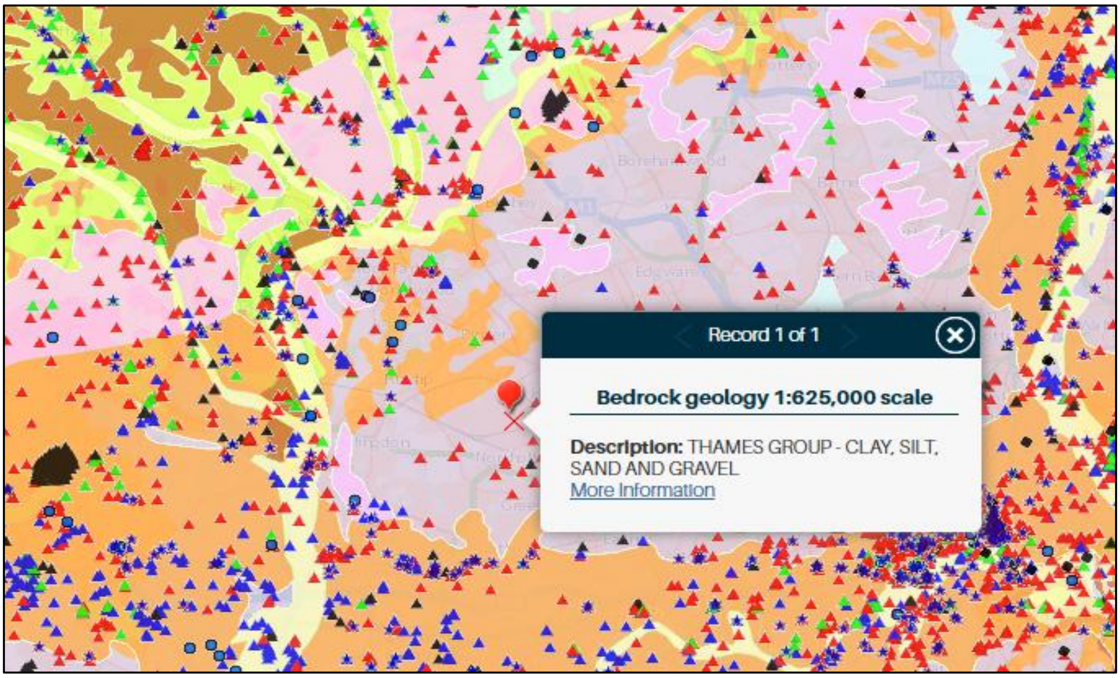

Figure 6-1: Bedrock Geology for the Roxeth

Figure 6-2: Combined Geology

Appendix B – Groundwater Vulnerability

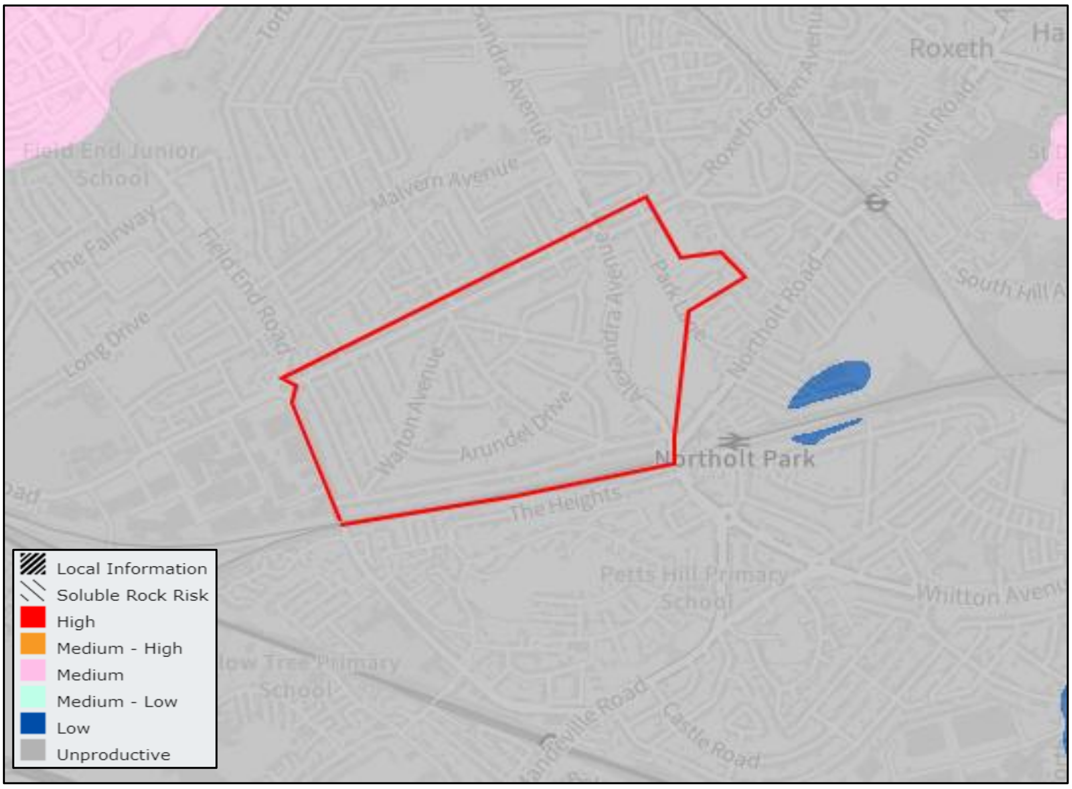

Figure 6-3: Groundwater Vulnerability Map

Appendix C – Aquifers

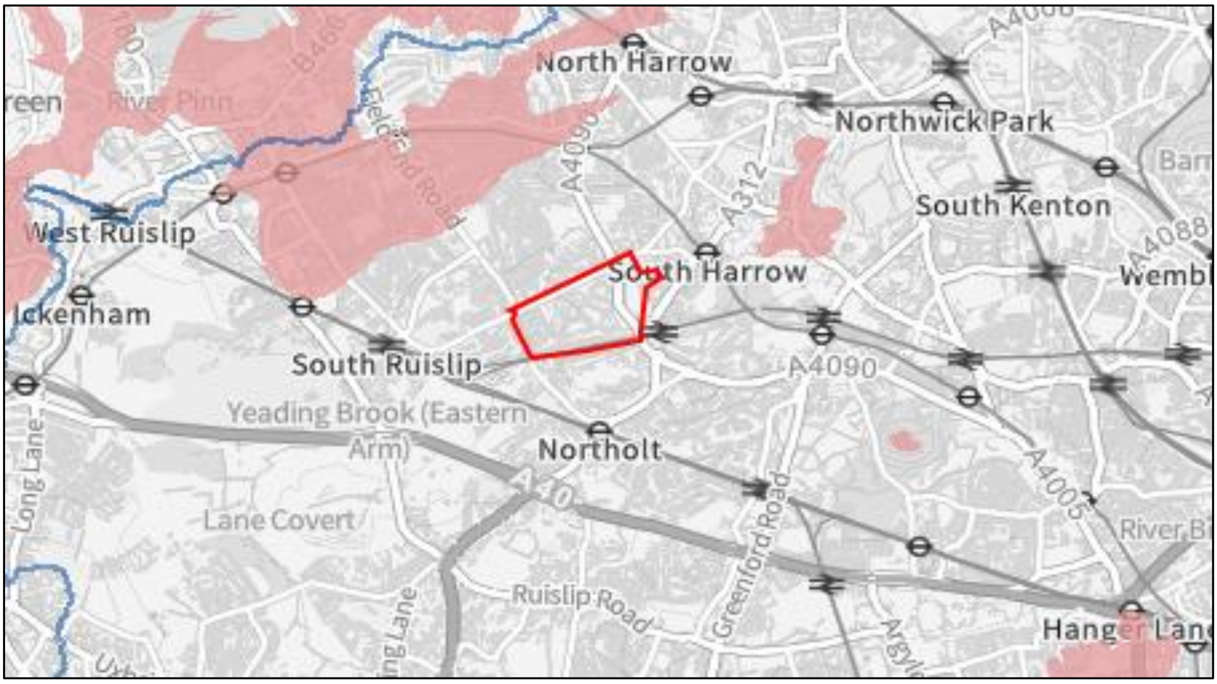

Figure 6-4: Aquifer Designation (Bedrock)

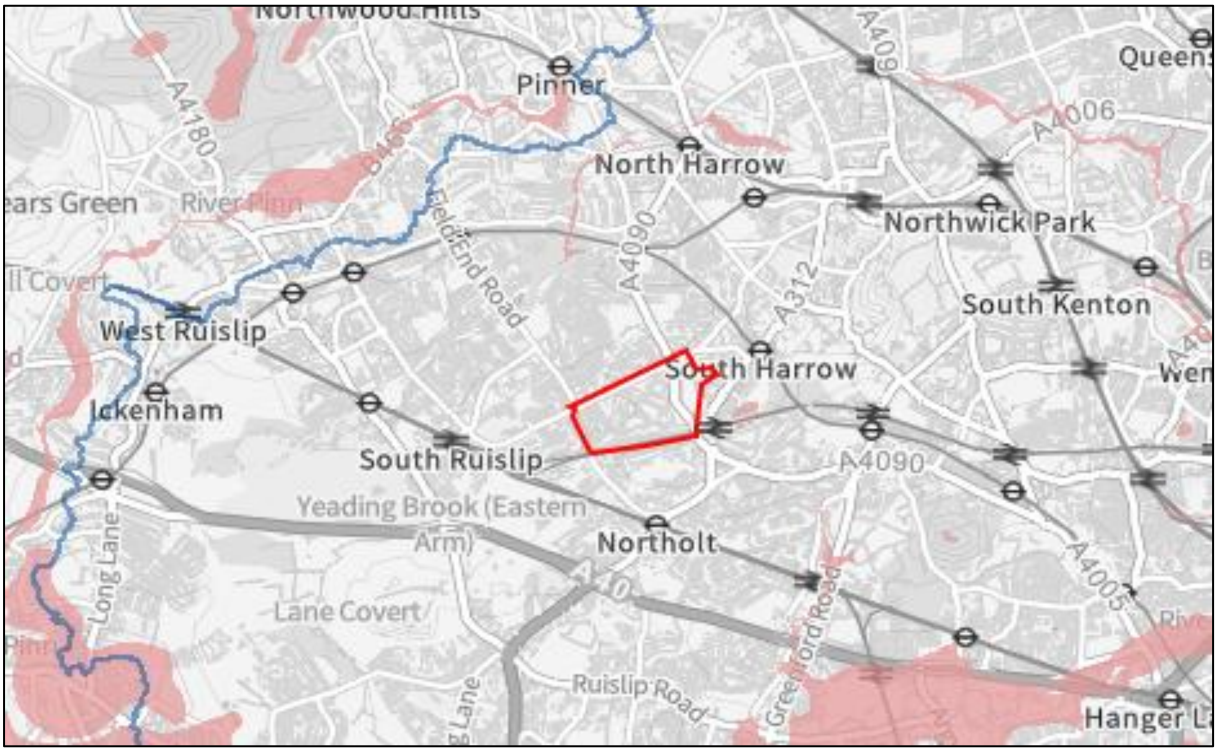

Figure 6-5: Aquifer Designation (Superficial Drift)

Appendix D – Other Land Designations

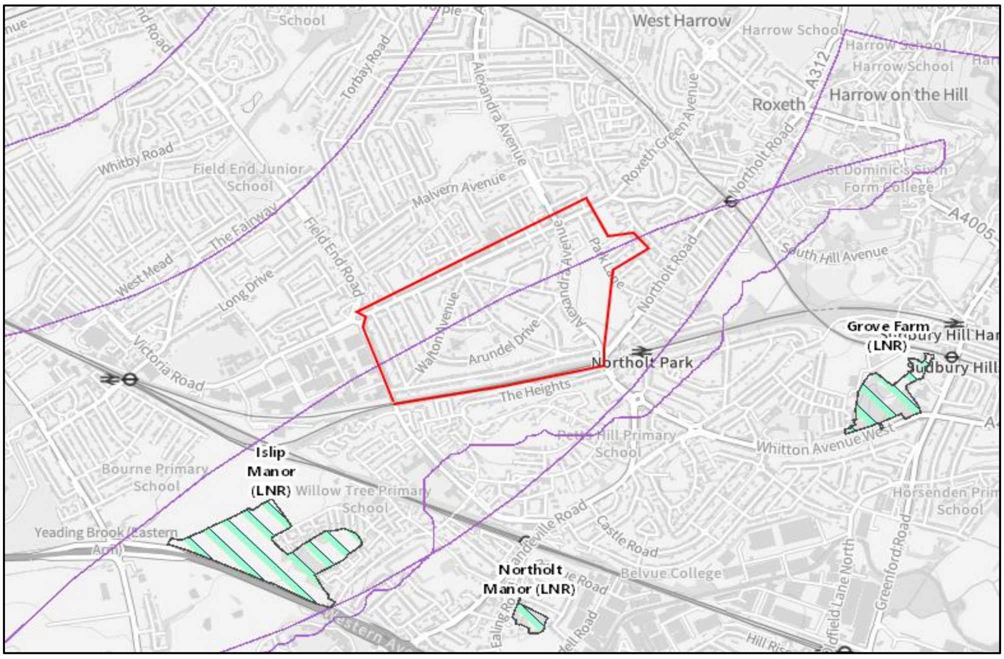

Figure 6-6: Statutory Land Designations

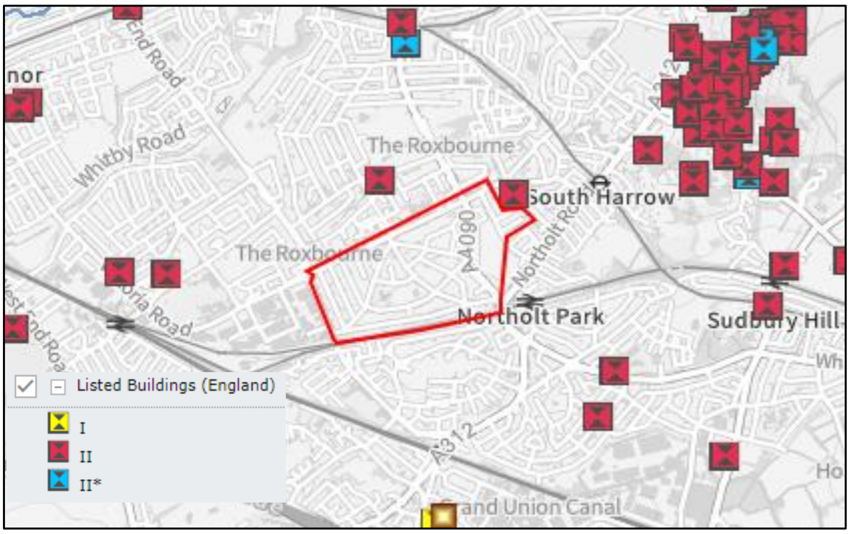

Figure 6-7: Historic Statutory Land Designations

Figure 6-8: Historic Non-Statutory Land Designations

Figure 6-9: Non-Statutory Land Designations

Appendix E – Habitats & Species

Figure 6-10: Living England Habitat Map

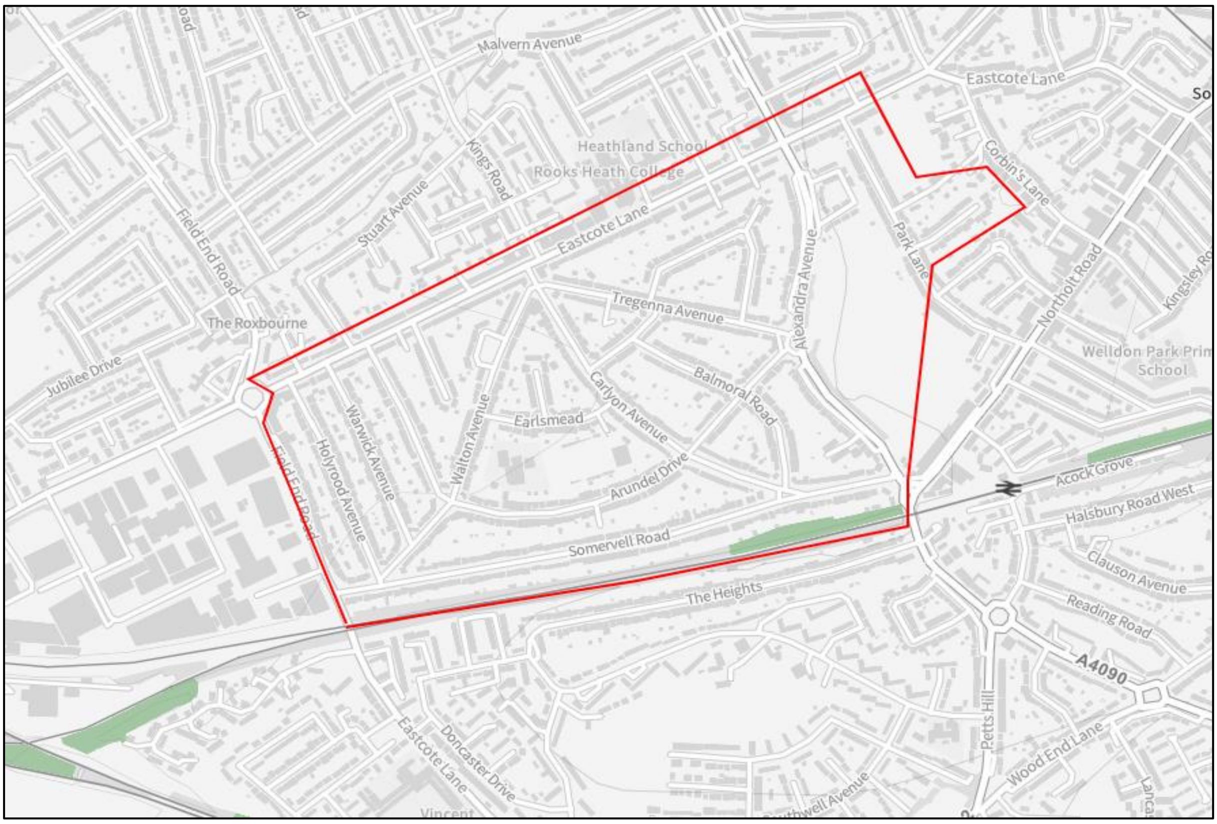

Figure 6-11: Priority Habitat - deciduous woodland

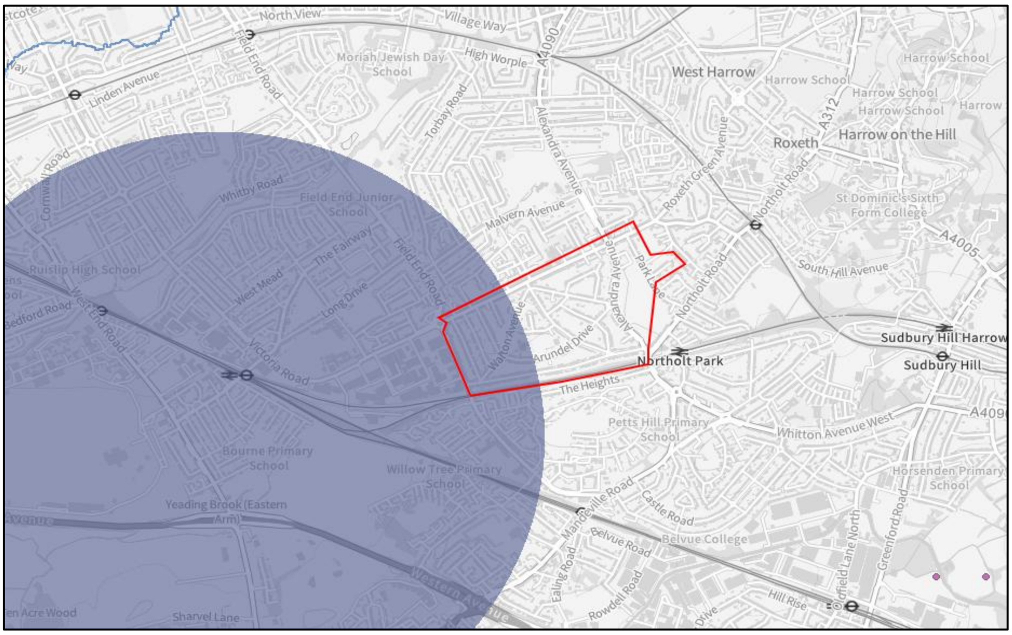

Figure 6-12: Species (Indicating grassland assemblage farmland bird, lapwing, turtle dove species)

Figure 6-13: Species (Indicating Lapwig for Priority Species for CS Targeting)

Appendix F – Tree Preservation Orders

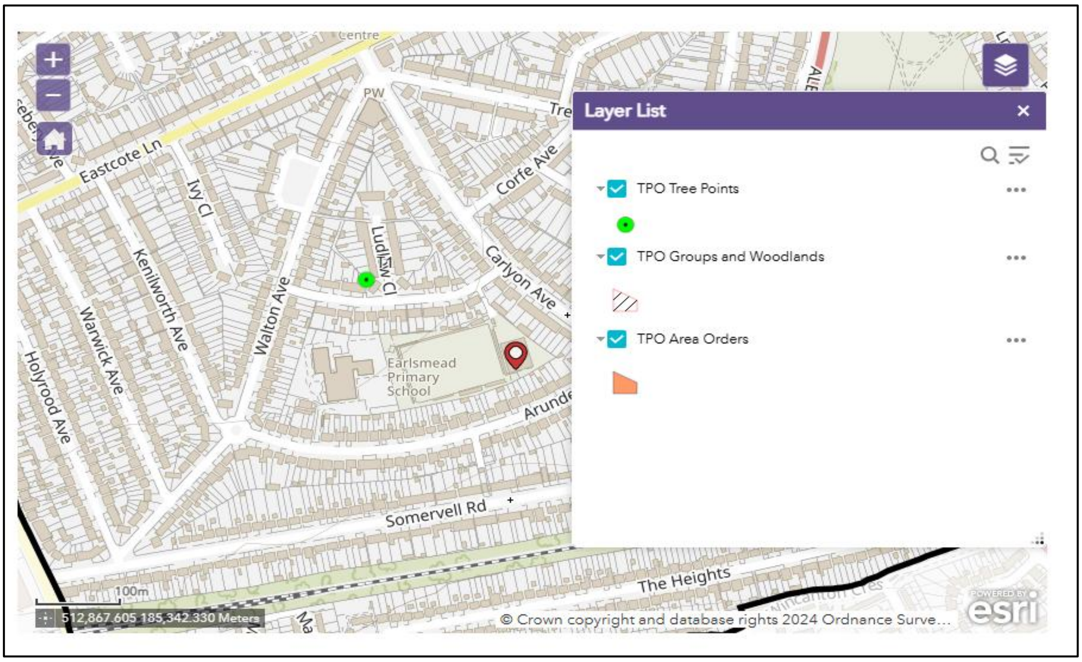

Figure 6-14: Tree Preservation Orders

Appendix G – Unexploded Ordinance

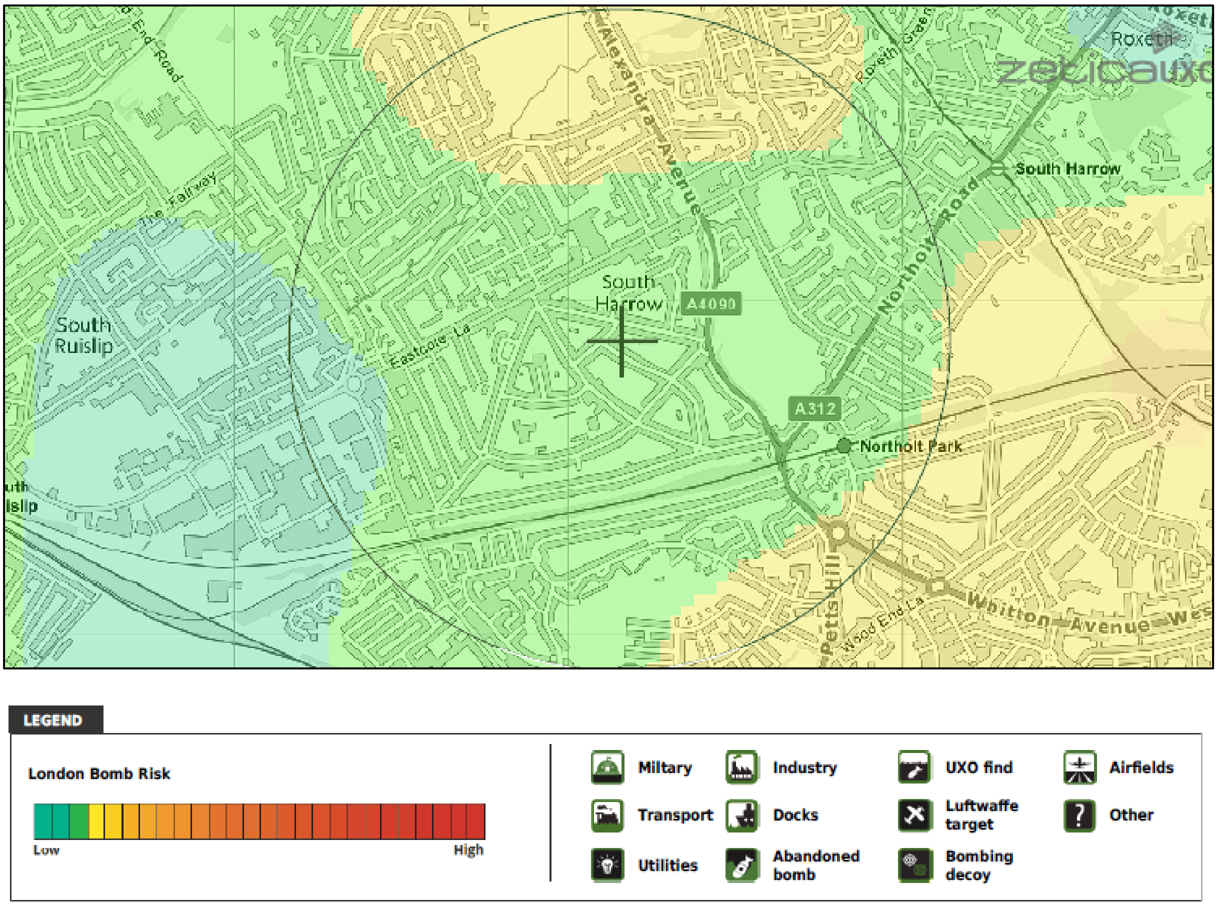

Figure 6-15: Unexploded Ordinance Map

Appendix H – Longlist Analysis