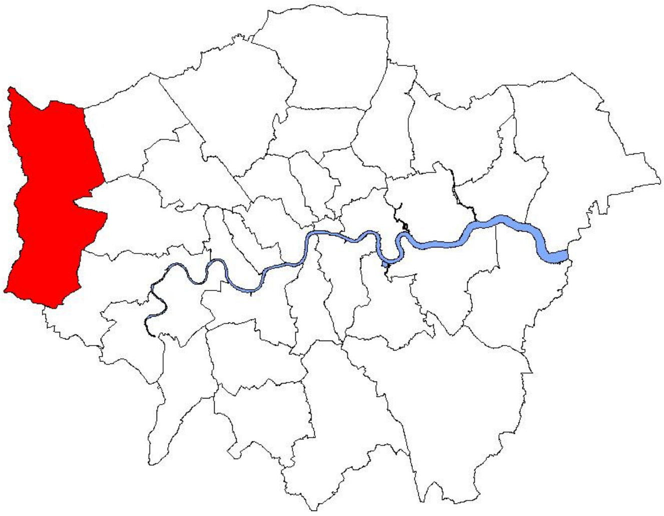
SURFACE WATER MANAGEMENT PLAN

Evidence Base

DRAIN LONDON



LONDON BOROUGH OF HILLINGDON

GREATER LONDON AUTHORITY

Thames Water

LONDON COUNCILS

Environment Agency

HILLINGDON LONDON

Acknowledgements

A number of people and organisations outside Hillingdon Council have contributed to this Surface Water Management Plan. Their assistance is greatly appreciated, and in particularly inputs and information provided by:

- The British Geological Survey;
- British Waterways;
- Drain London Group 1 Boroughs:
    - London Borough of Hounslow;
    - London Borough of Ealing; and
    - London Borough of Hillingdon.
- The Environment Agency;
- The Greater London Authority;
- London Councils;
- The London Fire Brigade;
- Network Rail;
- Thames Water;
- Highways Agency; and
- Transport for London and London Underground.

Executive Summary

This document forms the first part of the Surface Water Management Plan (SWMP) for the London Borough of Hillingdon which has been delivered as part of the Tier 2 package of works of the Drain London Project. This document is the evidence base for a plan which will outline the preferred surface water management strategy the London Borough (LB) of Hillingdon and includes consideration of flooding from sewers, drains, groundwater and runoff from land, small watercourses and ditches that could occur as a result of heavy rainfall.

The SWMP builds upon previous work undertaken at part of the Drain London Tier 1 package of works and has been undertaken following a four phase approach in line with Defras SWMP technical guidance documentation (2010). These are;

- Phase 1 – Preparation;
- Phase 2 – Risk Assessment;
- Phase 3 – Options; and
- Phase 4 – Implementation and Review.

This document forms Phases 1 and 2 of the SWMP.

Phase 1 Preparation

Phase 1 builds upon work undertaken during Tier 1 of the Drain London Project. The Tier 1 work involved the collection and review of surface water data from key stakeholders and the building of partnerships between key stakeholders responsible for local flood risk management. It was also decided that London would be delineated into 8 working groups. The LB of Hillingdon forms part of Group 1 along with the LB's of Ealing and Hounslow.

The LB of Hillingdon has begun to establish a broader partnership with the Boroughs located within Group 2 (the LB of Barnet, Brent and Harrow), through the establishment of the North West London Strategic Flood Group, in order for these local authorities to determine best practice and resources to enable each authority to discharge their responsibilities as Lead Local Flood Authority (LLFA) under the Flood and Water Management Act (FWMA) 2010.

Phase 2 Risk Assessment

As part of Phase 2 Risk Assessment, direct rainfall modelling has been undertaken across the entire Borough for five specified return periods. The results of this modelling have been used to identify Local Flood Risk Zones (LFRZs) where flooding affects houses, businesses and/or infrastructure. Those areas identified to be at more significant risk have been delineated into Critical Drainage Areas (CDAs) representing one or several LFRZs as well as the contributing catchment area and features that influence the predicted flood extent.

Within the LB of Hillingdon, 17 CDAs have been identified; these are shown in Figure i (overleaf) – Figure 1 within Appendix D provides this image a t a larger resolution. The principal mechanisms for flooding in the LB of Hillingdon can be broadly divided into the following categories:

- River Valleys (current and historical) - Across the study area, the areas particularly susceptible to overland flow are formed by narrow corridors associated with topographical valleys which represent the routes of the 'lost' watercourses within London;
- Topographical Low Lying Areas - areas such as underpasses, subways and lowered roads beneath railway lines are more susceptible to surface water flooding;

- Railway Embankments - discrete surface water flooding locations along the up-stream side of the raised network rail embankment (running roughly west to east through the South of the Borough);
- Topographical Low Points – areas which are at topographical low points throughout the Borough which result in small, discrete areas of deep surface water ponding; and
- Sewer Flood Risk – areas where extensive and deep surface water flooding is likely to be the influence of sewer flooding mechanisms alongside pluvial and groundwater sources.

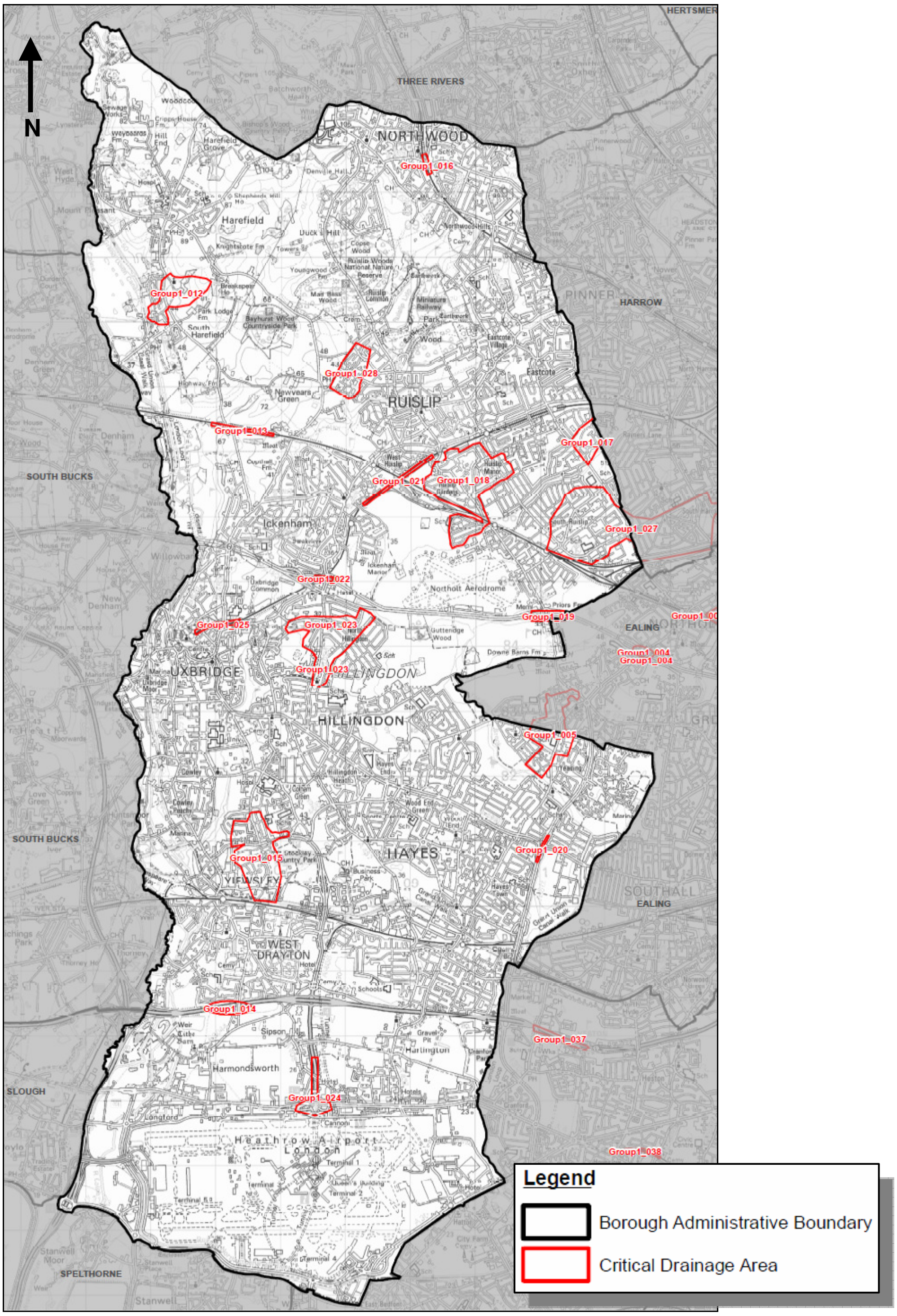


Figure i. Critical Drainage Areas within the London Borough of Hillingdon.

Analysis of the number of properties at risk of flooding has been undertaken for the rainfall event with a 1 in 100 probability of occurrence in any given year. A review of the results demonstrate that 29,300 residential properties and 1,300 non-residential properties in the LB of Hillingdon could be at risk of surface water flooding of greater than 0.03m depth (above an assumed 0.1m building threshold) during a 1 in 100 year rainfall event.

A review of these statistics coupled with local knowledge of the study area identifies that the following CDAs, located within Table i, are at greatest risk of flooding in terms of the number of receptors at risk

Table i Critical Drainage Areas at greatest risk in London Borough of Hillingdon

CDA ID	Infrastructure		Households		Commercial / Industrial	
	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep
Group1_027	4	1	1290	4	13	0
Group1_018	3	1	921	1	16	0
Group1_015	3	0	593	19	14	0
Group1_005	6	0	565	0	1	0
Group1_023	2	0	376	0	7	0
Group1_028	1	0	353	5	1	0

The majority of surface water flooding within the Borough is as a result of topographical low areas and obstructions to natural overland flowpaths, along with runoff within historical river valleys. Several rail lines are predicted to be at risk due to the elevations of the finished track being lower than the surrounding areas and within cuttings.

Three (3) CDAs have been identified as being cross boundary/borough, these are: CDA 005 which is cross boundary with the LB of Ealing and CDA's 017 and 0027 with the LB of Harrow.

Phase 3 Options Assessment

There are a number of opportunities for measures to be implemented across the Borough to reduce the impact of surface water flooding. Ongoing maintenance of the drainage network and small scale improvements are already undertaken as part of the operations of the Borough. In addition, opportunities to raise community awareness of the risks and responsibilities for residents should be sought, and LB of Hillingdon may wish to consider the implementation of a Communication Plan to assist with this.

It is important to recognise that flooding within the Borough is not confined to just the CDAs, and therefore, throughout the borough there are opportunities for generic measures to be implemented through the establishment of a policy position on issues including the widespread use of water conservation measures such as water butts and rainwater harvesting technology, use of soakaways, permeable paving, bioretention car park pods and green roofs. In addition, there are borough-wide opportunities to raise community awareness.

For each of the CDAs identified within the borough, site-specific measures will be identified that could be considered to help alleviate surface water flooding. Work on clarifying the risks in priority areas has been started to allow options assessment, however as it is ongoing, these have not been included within this document.

Pluvial modelling undertaken as part of the SWMP has identified that flooding within the LB of Hillingdon is heavily influenced by existing and historic river valleys, and impacts a number of regionally important infrastructure assets.

There are a number of options that will be considered including:

- Engage with residents regarding the flood risk in the Borough, to make them aware of their responsibilities for property drainage (especially in the CDAs) and steps that can be taken to improve flood resilience;
- Provide an 'Information Portal' via the LB of Hillingdon website, for local flood risk information and measures that can be taken by residents to mitigate surface water flooding to/around their property;
- Prepare a Communication Plan to effectively communicate and raise awareness of surface water flood risk to different audiences using a clearly defined process for internal and external communication with stakeholders and the public; and
- Improve maintenance regimes, and target those areas identified to regular flood or known to have blocked gullies.

Phase 4 Implementation & Review

- Phase 4 will establish a long-term Action Plan for LB of Hillingdon to assist in their role under the FWMA 2010 to lead in the management of surface water flood risk across the borough.

The SWMP Action Plan is a 'living' document, and as such, should be reviewed and updated regularly (recommended annually or greater), particularly following the occurrence of a surface water flood event, when additional data or modelling becomes available, following the outcome of investment decisions by partners and following any additional major development or changes in the catchment which may influence the surface water flood risk within the borough.

Glossary

Term	Definition
Aquifer	A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water.
AMP	Asset Management Plan, see below
Asset Management Plan	A plan for managing water and sewerage company (WaSC) infrastructure and other assets in order to deliver an agreed standard of service.
AStSWF	Areas Susceptible to Surface Water Flooding. A national data set held by the Environment Agency and based on high level modelling which shows areas potentially at risk of surface water flooding.
Bank Full	The flow stage of a watercourse in which the stream completely fills its channel and the elevation of the water surface coincides with the top of the watercourses banks.
Catchment Flood Management Plan (CFMP)	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
CDA	Critical Drainage Area, see below.
Critical Drainage Area	A discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure.
CFMP	Catchment Flood Management Plan, see entry above
CIRIA	Construction Industry Research and Information Association
Civil Contingencies Act	This UK Parliamentary Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums have a duty to put into place emergency plans for a range of circumstances including flooding.
CLG	Government Department for Communities and Local Government
Climate Change	Long term variations in global temperature and weather patterns caused by natural and human actions.
Culvert	A channel or pipe that carries water below the level of the ground.
Defra	Government Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model: a topographic model consisting of terrain elevations for ground positions at regularly spaced horizontal intervals. DEM is often used as a global term to describe DSMs (Digital Surface Model) and DTMs (Digital Terrain Models).
Dendritic	Irregular stream branching, with tributaries joining the main stream at all angles. e.g. drainage networks converge into larger trunk sewers and finally one outfall.
DG5 Register	A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 20 years.
DSM	Digital Surface Model: a topographic model of the bare earth/underlying terrain of the earth's surface including objects such as vegetation and buildings.
DTM	Digital Terrain Model: a topographic model of the bare earth/underlying terrain of the earth's surface excluding objects such as vegetation and buildings. DTMs are usually derived from DSMs.
EA	Environment Agency, Government Agency reporting to DEFRA charged with protecting the Environment and managing flood risk in England.
Indicative Flood Risk Areas	Areas determined by the Environment Agency as potentially having a significant flood risk, based on guidance published by Defra and WAG and the use of certain national datasets. These indicative areas are intended to provide a starting point for the determination of Flood Risk Areas by LLFAs.

Term	Definition
FCERM	Flood and Coastal Erosion Risk Management Strategy. Prepared by the Environment Agency in partnership with Defra. The strategy is required under the Flood and Water Management Act 2010 and will describe what needs to be done by all involved in flood and coastal risk management to reduce the risk of flooding and coastal erosion, and to manage its consequences.
FMfSW	Flood Map for Surface Water. A national data set held by the Environment Agency showing areas where surface water would be expected to flow or pond, as a result of two different chances of rainfall event, the 1 in 30yr and 1 in 200yr events.
Flood defence	Infrastructure used to protect an area against floods such as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Flood Risk Area	See entry under Indicative Flood Risk Areas.
Flood Risk Regulations	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.
Floods and Water Management Act	An Act of Parliament which forms part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England. The Act was passed in 2010 and is currently being enacted.
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a watercourse (river or stream). In this report the term Fluvial Flooding generally refers to flooding from Main Rivers (see later definition).
FRR	Flood Risk Regulations, see above.
IDB	Internal Drainage Board. An independent body with powers and duties for land drainage and flood control within a specific geographical area, usually and area reliant on active pumping of water for it's drainage.
iPEG	Increased Potential Elevated Groundwater (iPEG) maps. The iPEG mapping shows those areas within the borough where there is an increased potential for groundwater to rise sufficiently to interact with the ground surface or be within 2 m of the ground surface. The mapping was carried out on a London-wide scale by Jacobs/JBA in March 2011.
IUD	Integrated Urban Drainage, a concept which aims to integrate different methods and techniques, including sustainable drainage, to effectively manage surface water within the urban environment.
LB	London Borough, e.g. LB Hillingdon, London Borough of Hillingdon
LDF	Local Development Framework, is the spatial planning strategy introduced in England and Wales by the Planning and Compulsory Purchase Act 2004 and given detail in Planning Policy Statements 12. These documents typically set out a framework for future development and redevelopment within a local planning authority.
LFRZ	Local Flood Risk Zone, see below.
Local Flood Risk Zone	Local Flood Risk Zones are defined as discrete areas of flooding that do not exceed the national criteria for a 'Flood Risk Area' but still affect houses, businesses or infrastructure. A LFRZ is defined as the actual spatial extent of predicted flooding in a single location
Lead Local Flood Authority	Local Authority responsible for taking the lead on local flood risk management. The duties of LLFAs are set out in the Floods and Water Management Act.
LiDAR	Light Detection and Ranging, a technique to measure ground and building levels remotely from the air, LiDAR data is used to develop DTMs and DEMs (see definitions above).
LLFA	Lead Local Flood Authority, see above.

Term	Definition
Local Resilience Forum	A multi-agency forum, bringing together all the organisations that have a duty to cooperate under the Civil Contingencies Act, and those involved in responding to emergencies. They prepare emergency plans in a co-ordinated manner and respond in an emergency. Roles and Responsibilities are defined under the Civil Contingencies Act.
LPA	Local Planning Authority, see below.
Local Planning Authority	The local authority or Council that is empowered by law to exercise planning functions for a particular area. This is typically the local Borough or district Council.
LRF	Local Resilience Forum, see above.
Main River	Main rivers are a statutory type of watercourse in England and Wales, usually larger streams and rivers, but also include some smaller watercourses. A main river is defined as a watercourse marked as such on a main river map, and can include any structure or appliance for controlling or regulating the flow of water in, into or out of a main river. The Environment Agency's powers to carry out flood defence works apply to main rivers only.
NRD	National Receptor Dataset – a collection of risk receptors produced by the Environment Agency. A receptor could include essential infrastructure such as power infrastructure and vulnerable property such as schools and health clinics.
Ordinary Watercourse	All watercourses that are not designated Main River, and which are the responsibility of Local Authorities or, where they exist, IDBs are termed Ordinary Watercourses.
PA	Policy Area, see below.
Partner	A person or organisation with responsibility for the decision or actions that need to be taken.
PFRA	Preliminary Flood Risk Assessment, see below.
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.
Pluvial Flooding	Flooding from water flowing over the surface of the ground; often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow.
Policy Area	One or more Critical Drainage Areas linked together to provide a planning policy tool for the end users. Primarily defined on a hydrological basis, but can also accommodate geological concerns where these significantly influence the implementation of SuDS
PPS25	Planning and Policy Statement 25: Development and Flood Risk
Preliminary Flood Risk Assesment	Assessment required by the EU Floods Directive which summarises flood risk in a geographical area. Led LLFAs.
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, combined with the consequence of the flood.
Risk Management Authority	As defined by the Floods and Water Management Act. These can be (a) the Environment Agency,(b) a lead local flood authority, (c) a district council for an area for which there is no unitary authority, (d) an internal drainage board,(e) a water company, and (f) a highway authority.
RMA	Risk Management Authority, see above
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
SFRA	Strategic Flood Risk Assessment, see below

Term	Definition
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
Strategic Flood Risk Assessment	SFRAs (SFCAs in Wales) are prepared by local planning authorities (in consultation with us) to help guide local planning. They allow them to understand the local risk of flooding from all sources (including surface water and groundwater). They include analysis and maps of the impact of climate change on the extent of future floods. You can find these documents on the website of your local planning authority.
SuDS	Sustainable Drainage Systems, see below.
Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques. Includes swales, wetlands, bioretention devices and ponds.
Surface water	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.
SWMP	Surface Water Management Plan
TE2100	The Thames Estuary 2100 Project. Led by the Environment Agency, the project was established in 2002 with the aim of developing a long-term tidal flood risk management plan for London and the Thames estuary.
TfL	Transport for London
TWUL	Thames Water Utilities Ltd
UKCIP	The UK Climate Impacts Programme. Established in 1997 to assist in the co-ordination of research into the impacts of climate change. UKCIP publishes climate change information on behalf of the UK Government and is largely funded by Defra.
WaSC	Water and Sewerage Company

Table of Contents

TABLES

FIGURES

1 Introduction

1.1 What is a Surface Water Management Plan?

1.1.1 A Surface Water Management Plan (SWMP) is a plan produced by the Lead Local Flood Authority (in this case London Borough of Hillingdon) which outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small water courses and ditches that occurs as a result of heavy rainfall.

1.1.2 This SWMP study has been undertaken as part of the Drain London Project in consultation with key local partners who are responsible for surface water management and drainage in the London area – including Thames Water, the Environment Agency and Transport for London. The Partners have worked together to understand the causes and effects of surface water flooding and agree the most cost effective way of managing surface water flood risk for the long term.

1.1.3 The finalised SWMP will establish a long-term action plan to manage surface water and will influence future capital investment, maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

1.2 Background

1.2.1 In May 2007 the Mayor of London consulted on a draft Regional Flood Risk Appraisal (RFRA). One of the key conclusions was that the threat of surface water flooding in London was poorly understood. This was primarily because there were relatively few records of surface water flooding and those that did exist were neither comprehensive nor consistent. Furthermore the responsibility for managing flood risk in London is split between Boroughs and other organisations such as Transport for London, London Underground, Network Rail and relationships with the Environment Agency and Thames Water and the responsibility for managing sources of flood risk were unclear. To give the issue even greater urgency it is widely expected that heavy storms with the potential to cause flooding will increase in frequency with climate change.

1.2.2 The Greater London Authority, London Councils, Environment Agency and Thames Water commissioned a scoping study to test these findings and found that this was an accurate reflection of the situation. The conclusions were brought into sharp focus later in the summer of 2007 when heavy rainfall resulted in extensive surface water flooding in parts of the UK such as Gloucestershire, Sheffield and Hull causing considerable damage and disruption. It was clear that a similar rainfall event in London would have resulted in major disruption. The Pitt Review examined the flooding of 2007 and made a range of recommendations for future flood management, most of these have been enacted through the Flood and Water Management Act 2010 (FWMA).

1.2.3 The Department for Environment, Food and Rural Affairs (Defra) recognised the importance of addressing surface water flooding in London and fully funded the Drain London project. The Drain London project is being delivered through 3 'Tiers' as shown in Figure 1-1 and described in Table 1-1. This SWMP form part of Tier 2 package of works.

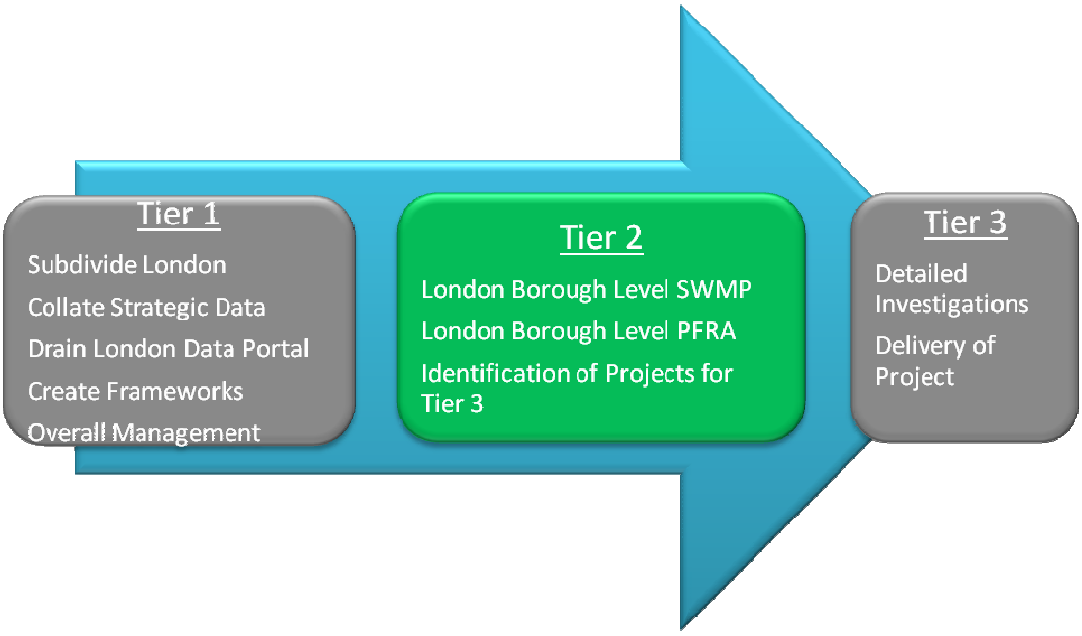


Figure 1-1 Drain London Project 'Tier' Structure

1.2.4 Figure 1-1 provides a summary of the work undertaken within each Tier (phase) of the Drain London Project.

Table 1-1 Summary of Drain London Project 'Tier' Structure

Phase	Summary of works
Tier 1	a) A high level strategic investigation to group the 33 separate boroughs into a smaller number of more manageable units for further study under Tiers 2 and 3. b) Collection and collation of relevant information across all London Boroughs and strategic stakeholders including the Environment Agency, Thames Water and Transport for London. c) Development of a web based 'Portal' to provide data management, data storage and access to the various data sets and information across the 'Drain London Forum' (DLF) participants and to consultants engaged to deliver Tiers 2 and 3. d) Develop technical framework documents and prioritisation tools to guide delivery of Tiers 2 and 3.
Tier 2	a) Delivery of 33 Borough-level intermediate Surface Water Management Plans (SWMPs) within the management groups to define and map Local Flood Risk Zones, Critical Drainage Areas and flood policy areas and produce an Action Plan for each borough. b) Delivery of 33 Borough-level Preliminary Flood Risk Assessments to comply with the Flood Risk Regulations 2009 requirements for Lead Local Flood Authorities (LLFAs). c) Define a list of prioritised Critical Drainage Areas for potential further study or capital works in Tier 3, using the prioritisation tool developed in Tier 1.
Tier 3	a) Further investigations into high priority Local Flood Risk Zones/Critical Drainage Areas to further develop and prioritise mitigation options. b) Delivery of demonstration projects of surface water flood mitigation solutions identified in Tier 2 SWMPs. c) Funding or co-funding within the London area for green roofs and other types of sustainable urban drainage (SUDS). d) Set up of at least 2 community flood plans in local communities at risk from flooding

1.2.5 As described in Table 1-1, Tier 2 of the Drain London project involves the preparation of SWMPs for each London Borough (LB). Through the subsequent enactment of the FWMA Boroughs are also required to produce Preliminary Flood Risk Assessments (PFRA). The Drain London project has been extended to deliver both a PFRA and a SWMP for each London Borough. This will be a major step in meeting Borough requirements as set out in the F&WM Act. Another key aspect of the Act is to ensure that Boroughs work in partnership with other Local Risk Authorities. Drain London assists this by creating sub-regional partnerships as identified within Figure 1-2 below.

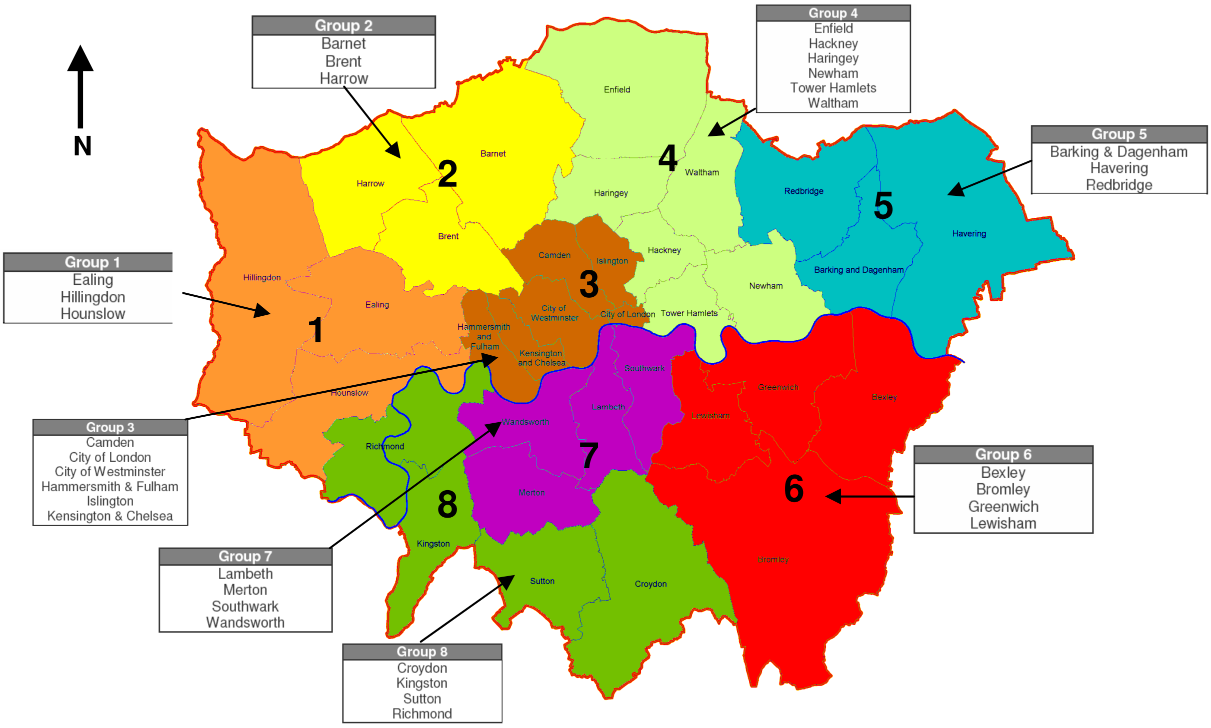


Figure 1-2 Drain London Sub-regional Partnerships

1.3 SWMP Process

1.3.1 The Defra SWMP Technical Guidance (2010) provides the framework for preparing SWMPs. This report has been prepared to reflect the four principal stages identified by the guidance (refer Figure 1-3, overleaf):

- **Preparation**; Identify the need for a SWMP, establish a partnership with the relevant stakeholders and scope SWMP (refer to Section 2);
- **Risk Assessment**; Identify which level of detail is required for the SWMP – a Level 2 Intermediate assessment was selected for this study (refer to Section3);
- **Options**: Identify options/measures (with stakeholder engagement) which seek to alleviate the surface water flood risk within the study area (refer to Section 4); and
- **Implementation and Review**: Prepare Action Plan and implement the monitoring and review process for these actions (refer to Section 5).

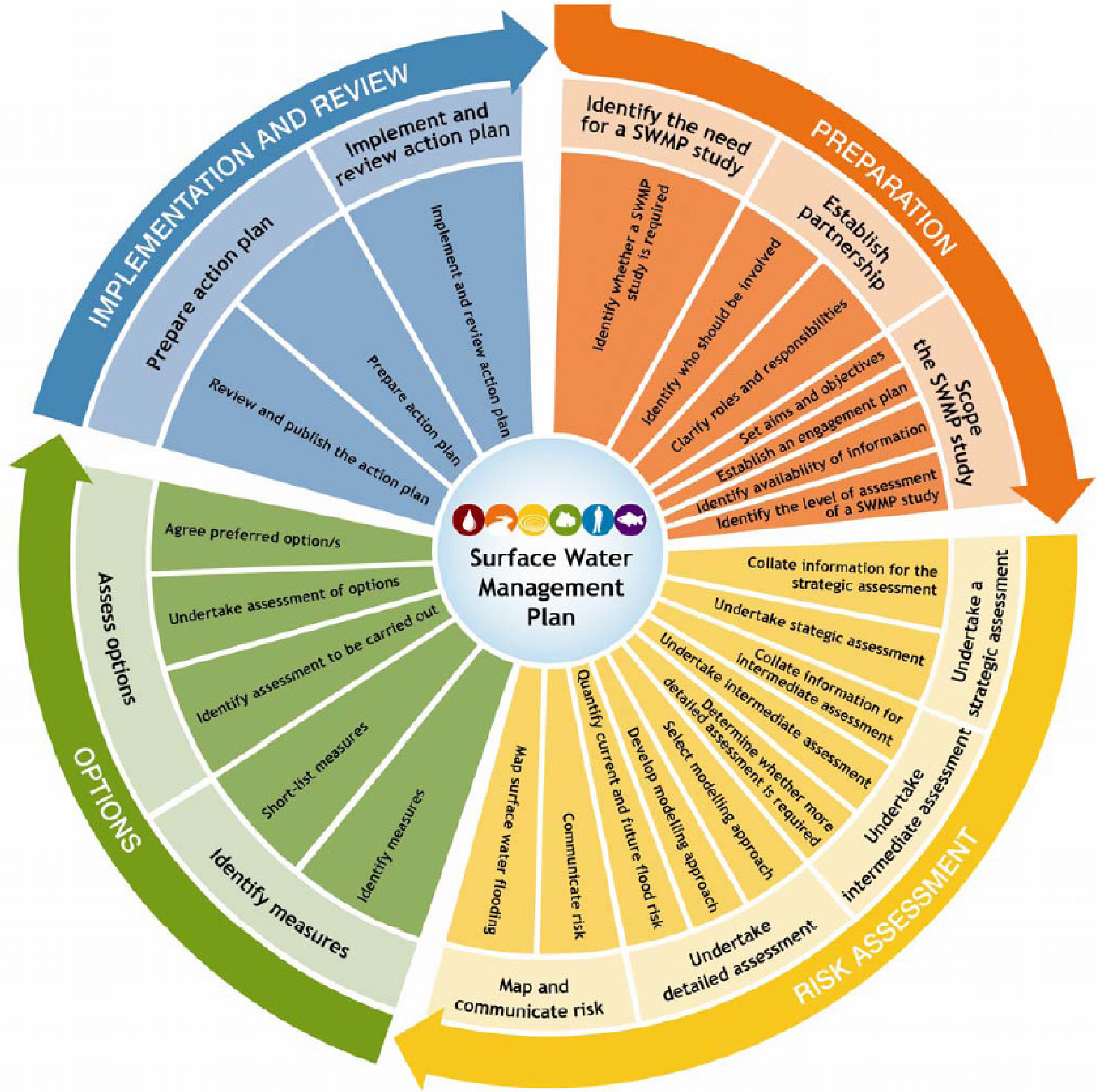


Figure 1-3 Recommended Defra SWMP Process (Source Defra 2010)

1.3.2 The scope of the Tier 2 work (refer to Table 1-1) falls mainly within Phase 2 (Risk Assessment) providing the evidence base. Phase 3 (Options) and Phase 4 (Implementation and Review) will be provided in the second part of the plan.

1.4 Objectives

1.4.1 The objectives of the whole SWMP process are to:

1.4.2 Phase 1

- Establish and consolidate partnerships between key drainage stakeholders to facilitate a collaborative culture of data, skills, resource and learning sharing and exchange, and closer coordination to utilise cross boundary working opportunities;

1.4.3 Phase 2

- Develop a robust understanding of surface water flood risk in and around the study area, taking into account the challenges of climate change, population and demographic change and increasing urbanisation in London;

- Identify, define and prioritise Critical Drainage Areas, including further definition of existing local flood risk zones and mapping new areas of potential flood risk;

- Borough specific aims and objectives identified included :
- Identify surface water flood risk areas to assist with spatial planning and future development;
- Identify surface water flood risk areas to assist with emergency planning within the Borough;
- Provision of mapping which is suitable for public distribution;

Undertake engagement with stakeholders to raise awareness of surface water flooding, identify flood risks and assets

1.4.4 Phase 3

- Facilitate discussions and report implications relating to wider issues falling outside the remit of this Tier 2 work, but deemed important by partners and stakeholders for effectively fulfilling their responsibilities and delivering future aspects of flood risk management.

- Make holistic and multifunctional recommendations for surface water management which improve emergency and land use planning, and enable better flood risk and drainage infrastructure investments;

- *Determine (if possible) options to alleviate flood risk within the identified Critical Drainage Areas;*

1.4.5 Phase 4

- Deliver outputs to enable a real change on the ground whereby partners and stakeholders take ownership of their flood risk and commit to delivery and maintenance of the recommended measures and actions;

- Provide a clear Action Plan which the Council can implement (and/or areas to investigate) to assist in the further understanding of pluvial and groundwater flooding within the Borough.

1.5 Study Area

Location and Characteristics

1.5.1 The London Borough (LB) of Hillingdon is located in west London. The Borough borders the London Boroughs of Ealing and Harrow to the east, Hounslow to the south-east, Richmond upon Thames to the south. South Bucks District Council is located along the majority of the Boroughs western boundary whilst Three Rivers District Council is located along the northern boundary and Slough District Council along the southwest.

1.5.2 The Borough boundary encompasses an area of 11,530ha (115.3km^2) and contains a mixture of urban and open space landuses. The borough has a distinctive character with its combination of suburban streets and shopping centre's, industrial land, major office developments and large areas of open land, historic woodland and inland waterways including 4,960 hectares of Green Belt. The majority of the urban extent is located within the north east and central portions of the borough. Figure 1-4 (and Figure 3, within Appendix D), overleaf, provides an overview of the landuses within Hillingdon.

1.5.3 The Borough contains the following significant infrastructure:

- Heathrow Airport is located within the south of the Borough;
- Network Rail and London underground rail lines along with tube/rail stations and rail assets and infrastructure;
- Five hospitals; and
- Two (2) motorways and thirteen (13) arterial roads.

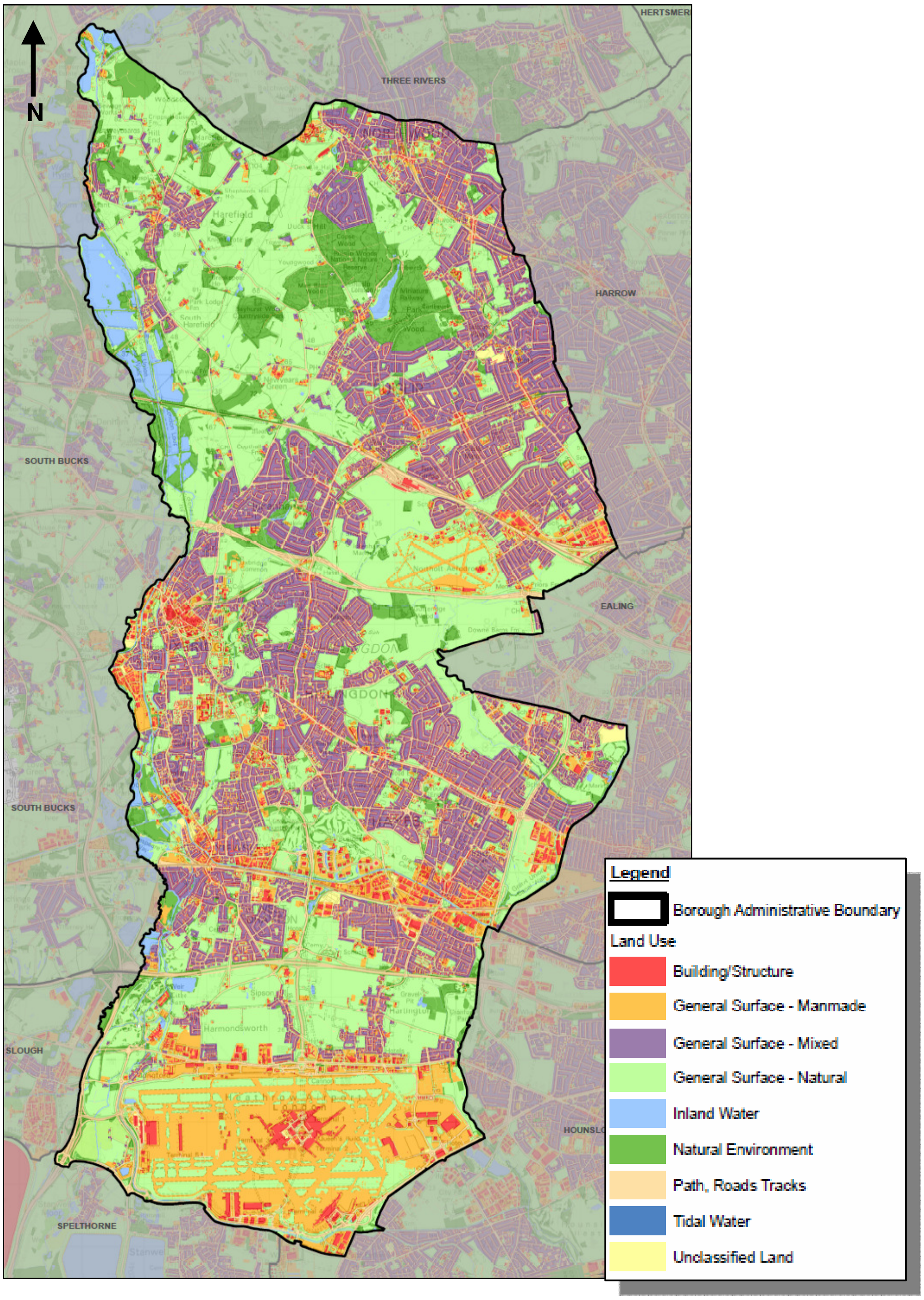


Figure 1-4 Land Uses within the London Borough of Hillingdon

Major Rivers and Waterways within the Borough

1.1.1 The following watercourse are located within the boundaries of the Borough:

- River Colne (including the tributaries of the Frays River and New Years Greene Bourne);
- River Crane (including the Yeading Brook);
- River Pinn;
- Duke of Northumberland River & Longford River;
- Grand Union Canal;

River Colne

1.1.2 The River Colne is one of the major rivers in the Borough. The River Colne forms the western boundary in the north of the Borough. The Colne is often referred to in two sections; the Upper Colne and the Lower Colne system differentiated by Denham Weir. The Upper Colne is predominantly rural land use and the Lower Colne can be considered urban. The Colne is a very complex river system with large reservoirs used to store potable supply water for Greater London. The Frays River and the River Pinn form some of the major tributaries into the River Colne.

Yeading Brook

1.1.3 The Yeading Brook flows into the Borough of Hillingdon from the east through two principle branches the east and west arm.

1.1.4 The Yeading Brook East arm enters Hillingdon through a long culvert at Field End Road (National Grid Reference 512340, 185690) before surfacing again to the southwest of Victoria Retail Park (National Grid Reference 511721, 185382). The Eastern arm flows in a south-westerly direction for 3.6km through South Ruislip and then west along the southern boundary of Northolt Aerodrome before its confluence with the West arm (at National Grid Reference 549950, 184190).

1.1.5 The Yeading Brook West arm enters Hillingdon through Ruislip recreation ground and flows in parallel with the East arm in a south-westerly direction for 5km, until its confluence with the Ickenham Stream to the south. The West arm then flows for 1.7km through rural pasture before its confluence with the East arm at National Grid Reference 509950, 184190. The Yeading Brook main branch then flows south for 7.6km passing through green open space to the southeast of Yeading and the easterly edge of Hayes. Of this 7.6km length the Yeading Brook travels in parallel with the Grand Union Canal for 2.5km before flowing under an Aqueduct becoming the River Crane at Craneford Park.

River Crane

1.1.6 The Yeading Brook changes its name to the River Crane at Hayes, north of the M4 to the south of the Grand Union Canal and before flowing under the M4 into Cranford Park. The River Crane continues to flow through green open space in a southerly direction for 2km before it is joined by the small tributary Frog's Ditch. The Crane then flows for 1.7km into the Heathrow Airport grounds before flowing out into the neighbouring Borough of Hounslow.

Duke of Northumberland River & Longford River

1.1.7 The Duke of Northumberland River and Longford River are two channels that split from the River Colne at Harmondsworth (National Grid Reference 505350, 178160). The Duke of Northumberland River is an artificial channel and is one of the main tributaries of the River Crane. It consists of two sections; the Harmondsworth or Western Section and the Mogden or Eastern Section. The Duke of Northumberland River flows in a southerly direction before turning in an easterly direction to form the southern border of the Borough along the perimeter of Heathrow airport before flowing into the Borough of Hounslow, running in parallel to the Longford River. As part of the Terminal 5 development this watercourse has been slightly diverted.

The Grand Union Canal

1.1.8 The Grand Union Canal enters the Borough near (NGR 515940, 178720) and travels in a southerly direction through the Borough before connecting to the River Thames at Brentford via the Thames Lock and Brentford Dock (NGR 517840, 177290). The Grand Union Canal has two branches within the Borough of Hillingdon to the east and west. The westerly branch of the Grand Union Canal runs from the north of the Borough in parallel with the Upper Colne, through the Borough to Yiewsley, before turning east and travelling across the Borough through Hayes and on to Bull's Bridge. Here it joins with the easterly branch, known as the Paddington Branch.

1.1.9 It is recommended that the reader refers to the LB Hillingdon Strategic Flood Risk Assessment (available from the planning section of the council website) for additional information relating to these watercourse

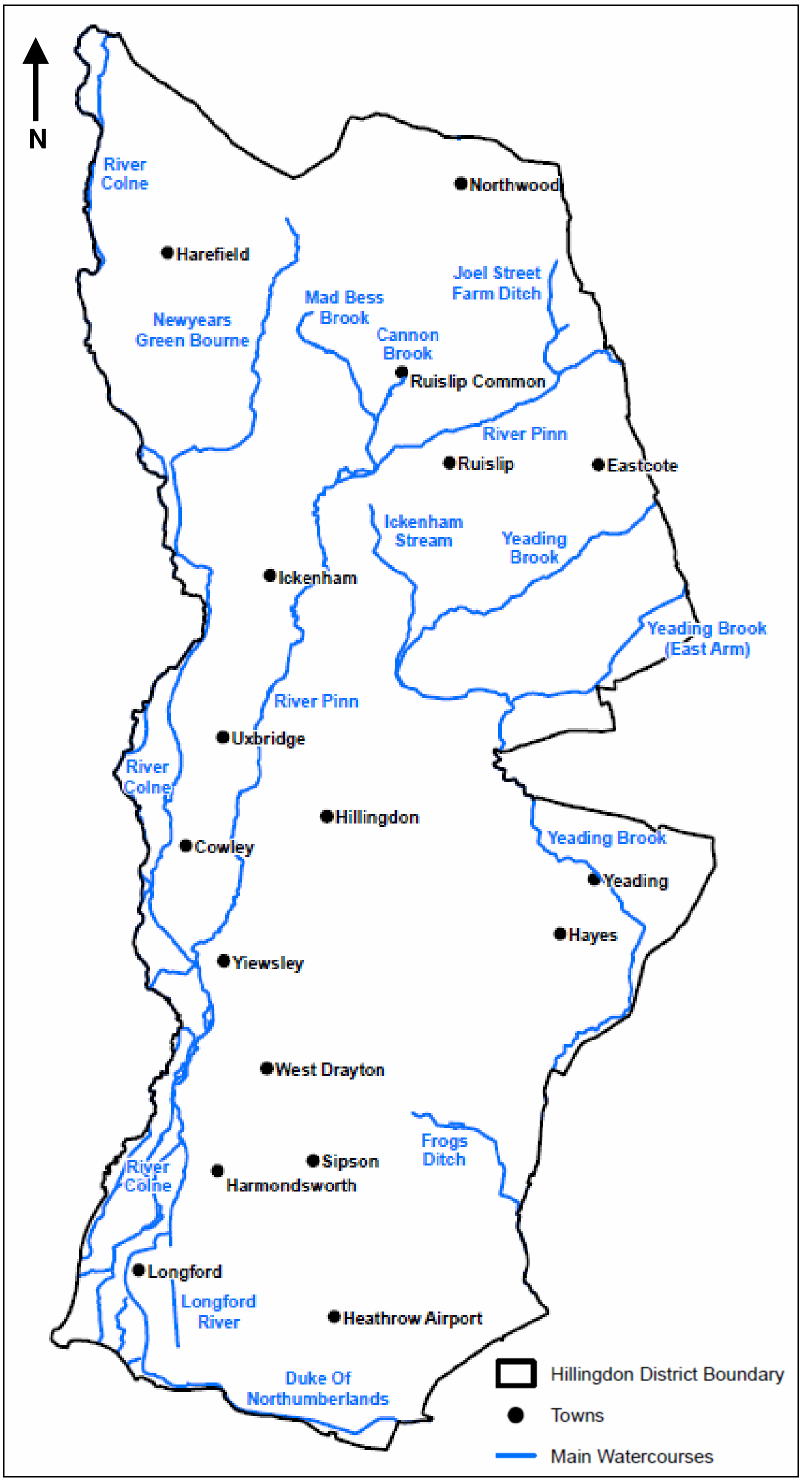


Figure 1-5 Main Watercourses within Hillingdon (source: Scott Wilson 2008, London Borough of Hillingdon SFRA)

Topography and Geology

1.5.4 Figure 1-6 (below) identifies the general elevations within the Borough.

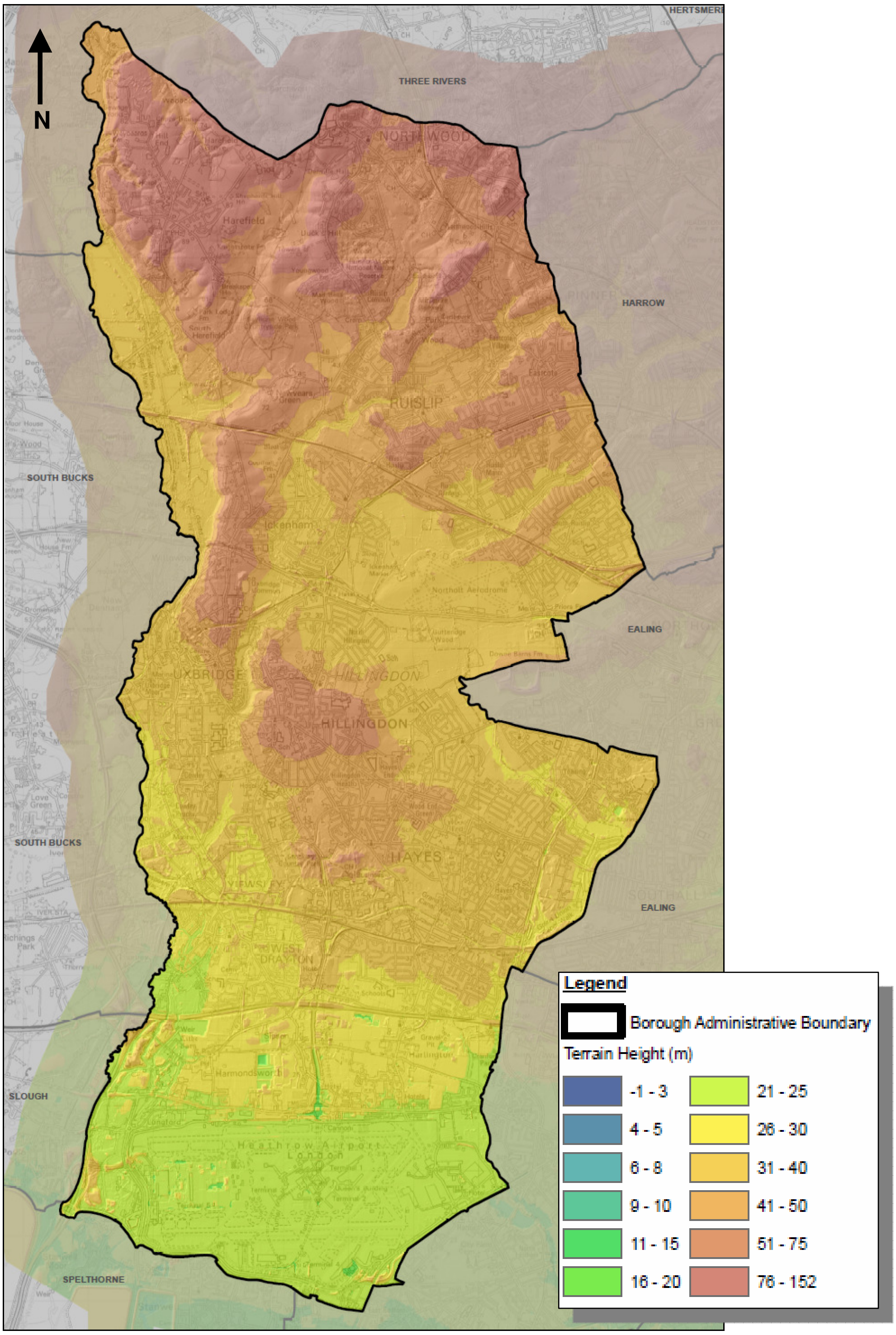


Figure 1-6 LiDAR Representation of the Topography within Hillingdon

1.5.5 Figure 1-6 indicates that the highest elevations within the Borough are in the north of the Borough, between Harefield, Ruislip and North Wood with areas of high ground located near Hillingdon. Figure whilst the lowest elevations can be located in the south of the borough near Heathrow Airport.

1.5.6 The dominant solid geology for the LB of Hillingdon is the London Clay Formation. Outcrops of the Lambeth group are located within river valleys near the north of the borough (around Ruislip and Northwood). Along the western boundary of the borough some areas of Chalk are located near the River Colne.

1.5.7 Drift deposits overlying the solid geology in the southern area of the district consist of pockets of Langley Silt (sandy clay and silt 'brick earth') overlying the River Terraced Deposits (mainly gravels), which have been locally excavated creating lakes and reservoirs where they have not been backfilled and areas of in-filled ground where they have.

1.5.8 Within the vicinity of West Drayton, Langley silt is found to extensively overlie the gravels. In the northern part of the district (Hillingdon and further north) drift deposits are limited to pockets of Glacial Sand and Gravel, which includes undifferentiated head (the glacial deposits will consist mainly of sands and gravels and the head deposits of sandy clay and silt). Along the line of river channels, alluvial deposits are located and in some areas the underlying solid formation has been exposed.

1.5.9 Figure 12, within Appendix D, provides an overview of the geology within the borough.

Significant future development plans

1.5.10 The Local Development Framework (LDF) for the London Borough of Hillingdon identifies a number of growth areas with a focus on: Uxbridge, Yeading, West Drayton, Hayes and the Heathrow Opportunity Area

1.5.11 It is recommended that the Borough utilise the SWMP, PFRA and the SFRA to develop the most suitable locations for future development. These assessments will also be used in the decision making process for new development proposals.

Interactions with neighbouring Boroughs / County Councils

1.5.12 The Environment Agency has proposed Strategic Flood Risk Management Boards within Greater London to coordinate Flood Risk Management. The Council is member of a partnership for flood risk management with the following London Boroughs:

- Ealing;
- Hounslow;
- Harrow;
- Brent; and
- Barnet.

1.5.13 Figure 1-7 identifies the boundary of the West London Flood Risk Management Board, which include the LB of Hillingdon.

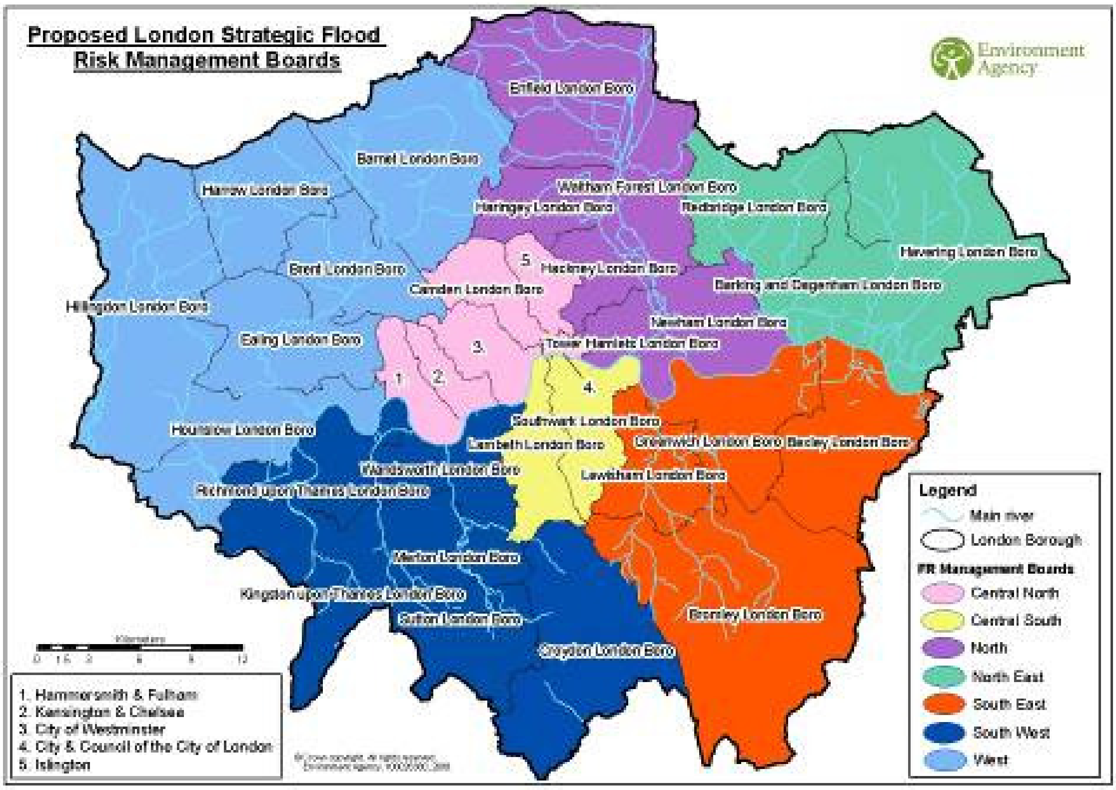


Figure 1-7 Proposed Strategic Flood Risk Management Boards

1.5.14 The group is is currently developing a Terms of Reference but in summary the purpose of this partnership to;

- Understand flood risk within the group Boroughs;
- Share best practise management between the Councils; and
- Create a forum to address cross Borough drainage issues.

1.6 Flooding Interactions

1.6.1 The SWMP technical guidance (Defra 2010) identifies four primary sources of surface water flooding that should be considered within a SWMP as described below:

- **Pluvial flooding**; high intensity storms (often with a short duration) are sometimes unable to infiltrate into the ground or be drained by formal drainage systems since the capacity of the collection systems is not large enough to convey runoff to the underground pipe systems (which in turn might already be surcharging). The pathway for pluvial flooding can include blockage, restriction of flows (elevated grounds), overflows of the drainage system and failure of sluice outfalls and pump systems.

- **Sewer flooding**; flooding which occurs when the capacity of the underground drainage network is exceeded, resulting the surcharging of water into the nearby environment (or within internal and external building drainage networks). The discharge of the drainage network into waterways and rivers can also be affected if high water levels in receiving waters obstruct the drainage network outfalls.

- **Ordinary Watercourses**: flooding from small open channels and culverted urban watercourses (which receive most of their flow from the urban areas) can either exceed their capacity and cause localised flooding of an area or can be obstructed (through debris or illegal obstruction) and cause localised out of bank flooding of nearby low lying areas.

- **Groundwater flooding** occurs when the water level within the groundwater aquifer rises to the surface. In very wet winters these rising water levels may lead to flooding of areas that are normally dry. This can also lead to streams that only flow for part of the year being reactivated. These intermittent streams are typically known as bournes. Water levels below the ground can rise during winter (dependant on rainfall) and fall during drier summer months as water discharges from the saturated ground into nearby watercourses.

1.6.2 Figure 1-8 provides an illustration of these flood sources. Each of these sources of flood risk a futher explained within Section 2.

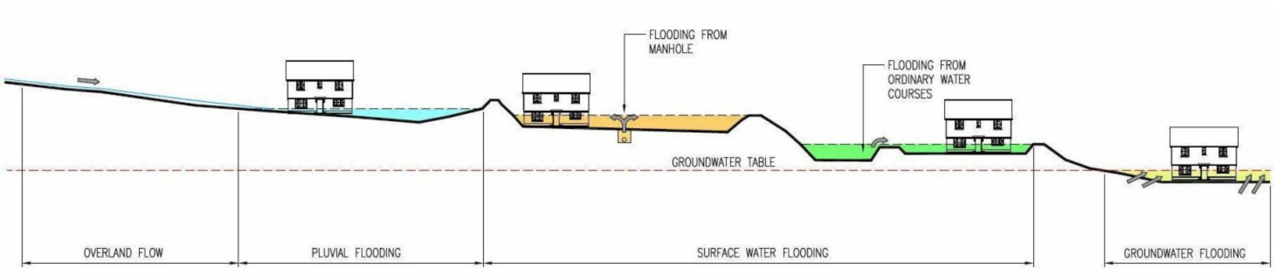


Figure 1-8 Illustration of Flood Sources (source: WSP, 2010).

1.7 Linkages with Other Plans

1.7.1 The increased focus on flood risk over recent years is an important element of adaptation to climate change. The clarification of the role of London Boroughs as Lead Local Flood Authorities (LLFA) is welcomed. The creation of a number of new documents can at times be confusing. Drain London links into all of these:

Regional Flood Risk Appraisal (RFRA)

1.7.2 The RFRA is produced by the Greater London Authority and gives a regional overview of flooding from all sources. The RFRA will be updated in 2012 to reflect the additional information on local sources of flood risk (surface water, groundwater and Ordinary Watercourses) from Drain London. This may also generate new policies that would be incorporated into the London Plan when it is reviewed.

Thames Catchment Flood Management Plan (CFMP)

1.7.3 The Thames Catchment Flood Management Plan (CFMP) was published in 2008 by the Environment Agency and sets out policies for the sustainable management of flood risk across the whole of the Thames catchment over the long-term (50 to 100 years) taking climate change into account. More detailed flood risk management strategies for individual rivers or sections of river may sit under these.

1.7.4 The CFMP emphasises the role of the floodplain as an important asset for the management of flood risk, the crucial opportunities provided by new development and regeneration to manage risk, and the need to re-create river corridors so that rivers can flow and flood more naturally.

1.7.5 This CFMP will be periodically reviewed, approximately five years from when it was published, to ensure that it continues to reflect any changes in the catchment. There are links to Drain London where there are known interactions between surface water and fluvial flooding

Preliminary Flood Risk Assessment (PFRA)

1.7.6 These are required as part of the Flood Risk Regulations which implement the requirements of the European Floods Directive. Drain London is producing one of these for each London Borough (each of which is a Lead Local Flood Authority), to give an overview of all local sources of flood risk. In London the PFRA process is greatly assisted by the new data and information relating to surface water which comes from the Drain London SWMPs. Boroughs must review these PFRAs every 6 years.

Surface Water Management Plans (SWMP)

1.7.7 Drain London is producing one of these for each London Borough. They provide detailed information on the potential for surface water flooding, based on probabilistic 2-dimensional modelling. This information improves greatly on data which has previously been provided at a national scale by the Environment Agency. In addition each SWMP contains an Action Plan that has been developed in conjunction with both the Borough and relevant other Risk Management Authorities. This data and actions and associated policy interventions will feed directly into the operational level of the Borough across many departments, in particular into spatial and emergency planning policies and designations and into the management of local authority controlled land.

Strategic Flood Risk Assessments (SFRA)

1.7.8 Each local planning authority is required to produce a SFRA under Planning Policy Statement 25 (PPS25). This provides an important tool to guide planning policies and land use decisions. Current SFRAs have a strong emphasis on flooding from main rivers and the sea and are relatively weak (due to past priorities and a lack of data) in evaluating flooding from other local sources including surface water, groundwater and Ordinary Watercourses. The information from Drain London will improve this understanding.

1.7.9 Currently a Level 1 SFRA has been produced for the Borough. This was completed in November 2011 with the intention that it will be updated periodically to reflect the latest flood risk information. This document can be obtained from the LB of Hillingdon website.

Local Development Documents (LDD)

1.7.10 LDDs including the Core Strategy and relevant Area Action Plans (AAPs) will need to reflect the results from Drain London. This may include policies for the whole Borough or for specific parts of Boroughs, for example Critical Drainage Areas. There may also be a need to review Area Action Plans where surface water flood risk is a particular issue. The updated SFRA will assist with this as will the reviewed RFRA and any updated London Plan policies. In producing Opportunity Area Planning Frameworks, the GLA and Boroughs will also examine surface water flood risk more closely.

Local Flood Risk Management Strategies

1.7.11 The Flood and Water Management Act 2010 (FWMA) requires each LLFA to produce a Local Flood Risk Management Strategy by December 2012. Whilst Drain London will not directly deliver a LFRMP, the SWMPs, PFRAs and their associated risk maps will provide the necessary evidence base to support the development of LFRMS and it is anticipated that no, or limited new modelling will be necessary to produce these strategies.

1.7.12 The schematic diagram (Figure 1-9 below) illustrates how the CFMP, PFRA, SWMP and SFRA link to and underpin the development of a Local Flood Risk Management Strategy.

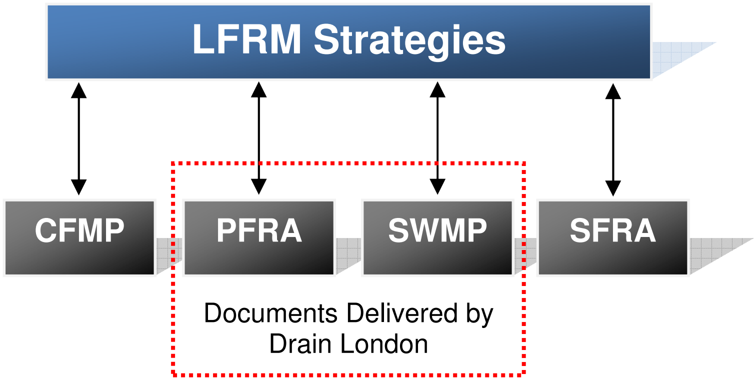


Figure 1-9 Linkages of LFRM Strategy Reports

1.8 Existing Legislation

1.8.1 The Flood and Water Management Act 2010 (FWMA) presents a number of challenges for policy makers and the flood and coastal risk management authorities identified to co-ordinate and deliver local flood risk management (surface water, groundwater and flooding from ordinary water courses). 'Upper Tier' local authorities have been empowered to manage local flood risk through new responsibilities for flooding from surface and groundwater.

1.8.2 The FWMA reinforces the need to manage flooding holistically and in a sustainable manner. This has grown from the key principles within Making Space for Water (Defra, 2005) and was further reinforced by the summer 2007 floods and the Pitt Review (Cabinet Office, 2008). It implements several key recommendations of Sir Michael Pitt's Review of the Summer 2007 floods, whilst also protecting water supplies to consumers and protecting community groups from excessive charges for surface water drainage.

1.8.3 The FWMA must also be considered in the context of the EU Floods Directive, which was transposed into law by the Flood Risk Regulations 2009 (the Regulations) on 10 December 2009. The Regulations requires three main types of assessment / plan to be produced:

a) Preliminary Flood Risk Assessments (maps and reports for Sea, Main River and Reservoir flooding) to be completed by Lead Local Flood Authorities and the Environment Agency by the 22 December 2011. Flood Risk Areas, at potentially significant risk of flooding, will also be identified. Maps and management plans will be developed on the basis of these flood risk areas.

b) Flood Hazard Maps and Flood Risk Maps. The Environment Agency and Lead Local Flood Authorities are required to produce Hazard and Risk maps for Sea, Main River and Reservoir flooding as well as 'other' relevant sources by 22 December 2013.

c) Flood Risk Management Plans. The Environment Agency and Lead Local Flood Authorities are required to produce Flood Risk Management Plans for Sea, Main River and Reservoir flooding as well as 'other' relevant sources by 22 December 2015.

1.8.4 Figure 1-10, overleaf, illustrates how this SWMP fits into the delivery of local flood and coastal risk management, and where the responsibilities for this lie.

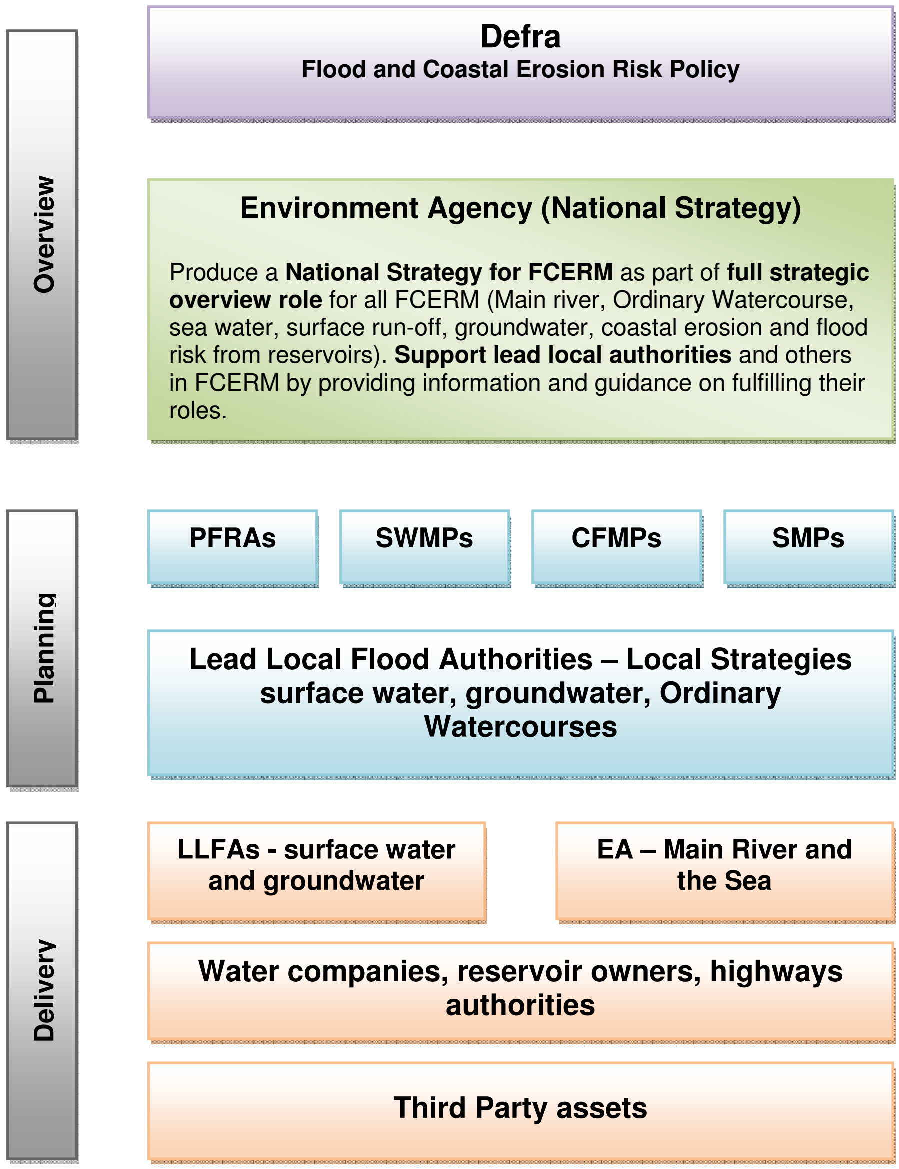


Figure 1-10 Where the SWMP is located within the delivery of local flood and coastal risk management

1.9 Peer Review.

1.9.1 It is essential for the Drain London Project that SWMPs are consistent and comparable across Greater London. This is to facilitate:

- Fair, transparent and rapid allocation of funds to identified high priority flood risk areas within London;
- Collaborative working practices between stakeholders; and

- Building of local capability (Council officers and consultants doing work in the future will be able to make use of outputs regardless of who produced them for each Borough).

1.9.2 To ensure consistency and comparability between London Borough SWMPs produced, a Peer Review process has been used. The process involved the four consultant teams who are working on the Drain London SWMPs independently reviewing each others work. This has ensured that all outputs result from a consistent technical approach, are of a high technical quality and are communicated in the specified formats. The peer review report for this SWMP is included in Appendix E.

1.10 LLFA Responsibilities

1.1.10 Aside from forming partnerships and coordinating and leading on local flood management, there are a number of other key responsibilities that have arisen for Local Lead Flood Authorities from the Flood & Water Management Act 2010, and the Flood Risk Regulations 2009. These responsibilities include:

- **Investigating flood incidents** – LLFAs have a duty to investigate and record details of significant flood events within their area. This duty includes identifying which authorities have flood risk management functions and what they have done or intend to do with respect to the incident, notifying risk management authorities where necessary and publishing the results of any investigations carried out. .
- **Asset Register** – LLFAs also have a duty to maintain a register of structures or features which are considered to have an effect on flood risk, including details on ownership and condition as a minimum. The register must be available for inspection and the Secretary of State will be able to make regulations about the content of the register and records.
- **SuDS Approving Body** – LLFAs are designated the SuDS Approving Body (SAB) for any new drainage system, and therefore must approve, adopt and maintain any new sustainable drainage systems (SuDS) within their area. This responsibility is anticipated to commence from April 2012.
- **Flood risk management strategies** – LLFAs are required to develop, maintain, apply and monitor a strategy for local flood risk management in its area. The local strategy will build upon information such as national risk assessments and will use consistent risk based approaches across different local authority areas and catchments.
- **Works powers** – LLFAs have powers to undertake works to manage flood risk from surface runoff and groundwater, consistent with the local flood risk management strategy for the area.
- **Designation powers** – LLFAs, as well as district councils and the Environment Agency have powers to designate structures and features that affect flooding in order to safeguard assets that are relied upon for flood risk management.

1.10.1 These LLFA requirements have been considered in the production of this document. The SWMP will assist the LLFA in providing evidence for points 1, 2 and 3.

2 Phase 1: Preparation

2.1 Partnership

2.1.1 The Flood and Water Management Act 2010 defines the Lead Local Flood Authority (LLFA) for an area as the unitary authority for the area, in this case the LB of Hillingdon. As such, the LB of Hillingdon is responsible for leading local flood risk management including establishing effective partnerships with stakeholders such as the Environment Agency, Thames Water Utilities Ltd, Transport for London, Network Rail and London Underground as well as others. Ideally these working arrangements should be formalised to ensure clear lines of communication, mutual co-operation and management through the provision of Level of Service Agreements (LoSA) or Memorandums of Understanding (MoU). It is recommended that the partnerships created as part of the Drain London Tier 1 work are maintained into perpetuity.

2.1.2 The LB of Hillingdon forms part of the Drain London 'Group 1' group of Boroughs, established as part of the Drain London programme, formed to assist delivery of Drain London, but also to establish an ongoing working partnership for managing local flood risk in the area. Drain London Group 1 includes the London Boroughs of Hillingdon, Ealing and Hounslow.

2.1.3 Currently Group 1 are represented on the Thames Regional Flood Defence Committee (RFDC) by the councillor from the LB of Hounslow.

2.1.4 At a Borough level, Hillingdon has set up a Flood Working Group in response to the Flood and Water Management Act, which includes departmental representatives from strategic planning, emergency planning, drainage and highways, in recognition of the cross-department input require on managing local flood risk.

2.1.5 Members of the public also have valuable information to contribute to the SWMP and to an improved understanding and management of local flood risk within the Borough. Public engagement can afford significant benefits to local flood risk management by gaining access to additional local knowledge, building trust, and increasing the chances of stakeholder acceptance of options and decisions proposed in future flood risk management plans.

2.2 Data Collection

2.2.1 The collection and collation of strategic level data was undertaken as part of the Drain London Tier 1 work and disseminated to Tier 2 consultants by the GLA. Data was collected from each of the following organisations:

- London Borough of Hillingdon;
- British Airports Authority;
- British Geological Survey;
- British Waterways; Network Rail;
- Thames Water.
- Environment Agency;
- Greater London Authority;
- Highways Agency;
- London Underground;
- Transport for London.

2.2.2 A comprehensive data set was provided to the Tier 2 consultants. Where available, additional supplemental data was provided by individual organisations (e.g. BAA Heathrow Airport).

2.2.3 Table 2-1 provides a summary of the data sources held by partner organisations and provides a description of each dataset, and how the data was used in preparing the SWMP. This data was collated centrally by the Greater London Authority through the Drain London project, including centralising relevant data sharing agreements and licensing. This data was then disseminated to consultants Capita Symonds with Scott Wilson for the preparation of the LB of Hillingdon SWMP.

Table 2-1 Data Sources and Use

	Dataset	Description	Use in this SWMP
Environment Agency	Main River centre line	GIS dataset identifying the location of Main Rivers across London	To define waterway locations within the Borough.
	Environment Agency Flood Map (Flood Zones)	Shows extent of flooding from rivers during a 1 in 100yr flood and 1 in 1000yr return period flood. Shows extent of flooding from the sea during 1 in 200yr and 1 in 1000yr flood events. Ignores the presence of defences.	To identify the fluvial and tidal flood risk within the Borough and areas benefiting from fluvial and tidal defences.
	Areas Susceptible to Surface Water Flooding	A national outline of surface water flooding held by the EA and developed in response to Pitt Review recommendations.	To assist with the verification of the pluvial modelling
	Flood Map for Surface Water	A second generation of surface water flood mapping which was released at the end of 2010.	To assist with the verification of the pluvial modelling
	Groundwater Flooding Incidents	Records of historic incidents of groundwater flooding as recorded by the Environment Agency.	To identify recorded groundwater flood risk – assist with verifying groundwater flood risk
	National Receptors Dataset	A nationally consistent dataset of social, economic, environmental and cultural receptors including residential properties, schools, hospitals, transport infrastructure and electricity substations.	Utilised for property/infrastructure flood counts and to determine CDA's.
	Indicative Flood Risk Areas	National mapping highlighting key flood risk areas, based on the definition of 'significant' flood risk agreed with Defra and WAG.	Initial review to determine national view on flood risk areas within the Borough.
	Historic Flood Outline	Attributed spatial flood extent data for flooding from all sources.	Used to assist with the verification of modelling results and CDA locations (where available)
	Rainfall Data	15 minute and daily rainfall gauge records from approximately 1990 – 2010 for gauge sites across London.	Used in the initial stages of rainfall modelling to determine appropriate model durations and hyetographs.

	Dataset	Description	Use in this SWMP
	Source protection zones	Show zones around important groundwater sources which may be impacted by contamination that might cause pollution in the area. The maps show three main zones (inner, outer and total catchment).	Within the assessment of groundwater flooding to determine permeable geology
	Asset data	Details on the location and extent of flood defences across Group 1 as well as system asset management plans.	To determine asset locations within the pluvial modelling process.
London Borough	Strategic Flood Risk Assessments (SFRA)	SFRAs may contain useful information on historic flooding, including local sources of flooding from surface water, groundwater and flooding from canals.	Provide a background to the flood risk in the Borough.
London Borough	Historical flooding records	Historical records of flooding from surface water, groundwater and Ordinary Watercourses.	Where available used to assist with the verification of modelling results and CDA locations.
London Borough	Anecdotal information relating to local flood history and flood risk areas	Anecdotal information from authority members regarding areas known to be susceptible to flooding from excessive surface water, groundwater or flooding from Ordinary Watercourses.	Assist with CDA confirmation but not necessarily used as verification evidence.
London Borough	Highways Flooding Reports	Highways Flooding Reports, including analysis of the flood risk at each location.	Verification of pluvial model results.
London Borough	Core Strategy Development Plans	Local Development Scheme, details on Area Action Plans,	Understanding of areas of future development.
Thames Water	DG5 Register for Thames Water Utilities areas	DG5 Register logs and records of sewer flooding incidents in each area.	Mapping sewer flooding incidents.
Thames Water	Sewer pipe network	GIS dataset providing the georeferenced location of surface water, foul and combined sewers across Group 1. Includes pipe size and some information on invert levels.	Verifying CDA locations and Phase 3:Options Assessment
Thames Water	Basements	GIS dataset showing Thames Water Utilities recording of basement locations.	Defining CDAs and utilised within the property count information
British Waterways	British Waterway's canal network	Detailed GIS information on the British Waterway's canal network, including the location of canal centrelines, sluices, locks, culverts, etc.	Centrelines have been incorporated within modelling to define canal locations
British Geological Society	Geological datasets	Licenced GIS datasets including: Geological indicators of flooding; Susceptibility to groundwater flooding; Permeability; Bedrock and superficial geology.	Understanding the geology of the Borough

	Dataset	Description	Use in this SWMP
GLA	Deprived Areas	Index of Multiple Deprivation, ranking all London Ward's.	Used within the prioritisation matrix and for property counts
	Administrative boundaries	Greater London Borough boundaries	Providing study boundaries
	Ordnanace Survey Mapping, MasterMap	Vector mapping of the London area	Utilised within the pluvial modelling to determine "roughness" within the Borough
London Fire Brigade	Historic flooding records	London Fire Brigade call outs to incidents of flooding between January 2000-December 2009. Does not specify the source of flooding.	Understanding of possible flood locations within the Borough – records do not indicate what type of flooding occurred at each location.
London Underground and Network Rail	Historic flooding records	Recorded incidents of flooding to London Underground and National Rail infrastructure	Verification of pluvial modelling results and CDA designations
Transport for London	Pump Station Locations	Pdf mapping identifying the location of road underpass pump stations owned and maintained by TfL.	Understanding which assets include pumping stations and to assist in the verification of pluvial outputs and the optioneering exercise
Infoterra	LiDAR topographical data	High resolution elevation data derived from airborne sources – at a 1m grid. A laser is used to measure the distance between the aircraft and ground and between the aircraft and the vegetation canopy or building tops. Typical (unfiltered) accuracy ranges are +/- 0.15m.	Filtered LiDAR was utilised within the creation of the pluvial models to define the ground surface of the catchment and to understand the general topography of the catchment and wider Borough.

2.3 Data Review

2.3.1 The most significant data gap across the LB of Hillingdon relates to records of past 'local' flooding incidents. This is a common issue across the UK as record keeping of past floods has historically focussed on flooding from rivers or the sea. Records of past incidents of surface water, sewer, groundwater or Ordinary Watercourse flooding has been sporadic.

2.3.2 Thames Water have provided postcode linked data on records of sewer flooding, (known as the DG5 register) however more detailed data on the location and cause of sewer flooding is not currently available.

2.3.3 Some incidents have been digitised into GIS from hard copy maps by LB of Hillingdon, however there is very little information on the probability, hazard or consequence of flooding.

2.3.4 Similarly, the London Fire Brigade have recorded incidents of call outs relates to flooding, however there is no information on the source of flooding (e.g. pipe bursts or rainfall), or probability, hazard or consequence of the flooding. Due to this limitation, these records were not used in the model verification process.

Future Groundwater Flooding

2.3.5 Groundwater flooding is dependent on local variations in topography, geology and soils. The causes of groundwater flooding are generally understood however it is difficult to predict the actual location, timing and extent of groundwater flooding without comprehensive datasets.

2.3.6 There is a lack of reliable measured datasets to undertake flood frequency analysis and even with datasets this analysis is complicated. Surface water flooding incidents are sometimes mistaken for groundwater flooding incidents, e.g. where runoff via infiltration seeps from an embankment, rather than locally high groundwater levels. Drain London have commissioned specific groundwater emergence maps, known as increased Potential for Elevated Groundwater (iPEG) maps, to assist in determining the areas within Greater London that are possibly at risk of groundwater flooding.

Future Surface Water Flooding

2.3.7 The Environment Agency data sets 'Areas Susceptible to Surface Water Flooding' and second generation 'Flood Map for Surface Water' are national scale assessments suitable for broadly identifying surface water flood risk. The datasets are of a resolution suitable for assessments such as the PFRA, however are limited in their use in addressing the next stages of the Flood Risk Regulations (2009), e.g. Hazard Maps and in producing SWMPs and useful Action Plans The outputs from Drain London will assist in addressing this data limitation. These EA data sets were utilised in the model validation phase.

Flooding Consequences

2.3.8 The National Receptors Database (NRD), version 1.0 data set, was provided for all London Boroughs in December 2010. This data set was provided to allow property counts to be undertaken for all SWMPs. Version 1.1 of the NRD has subsequently been issued and contains modifications and corrections since version 1.0. However, in order to avoid repetition of work, and ensure consistency between the SWMP, PFRA and the EA Pluvial flooding (Areas Susceptible to Surface Water Flooding and Flood Map for Surface Water), it was decided to complete the SWMP using NRD version 1.0.

2.4 Security, Licensing and Use Restrictions

2.4.1 A number of datasets used in the preparation of this SWMP are subject to licensing agreements and use restrictions.

2.4.2 The following national datasets provided by the Environment Agency are available to lead local flood authorities for local decision making:

- EA Flood Zone Map;
- Areas Susceptible to Surface Water Flooding;
- Flood Map for Surface Water; and

- National Receptor Database.

2.4.3 A number of the data sources used are publicly available documents, such as:

- Strategic Flood Risk Assessment;
- Catchment Flood Management Plan; and
- Preliminary Flood Risk Assessment.

2.4.4 The use of some of the datasets made available for this SWMP has been restricted. These include:

- Records of property flooding held by the Council and by Thames Water Utilities Ltd;
- British Geological Society geology datasets;
- London Fire Brigade call outs for flooding; and
- Index of Multiple Deprivation.

2.4.5 Necessary precautions must be taken to ensure that all restricted information given to third parties is treated as confidential. The information must not be used for anything other than the purpose stated in the agreement. No information may be copied, reproduced or reduced to writing, other than what is necessary for the purpose stated in the agreement.

2.5 LLFA Asset Register Requirements

2.5.1 As indicated in Section 2.5, the FWMA requires that the LLFA maintains an asset register which records information about structures and features that are likely to have a significant impact on flood risk within the LLFAs jurisdictional boundary.

2.5.2 As of the 6th April 2011, all LLFAs will need to maintain a register. Defra have determined the legal characteristics of the register and records, this is provided in Table 2-1 (below).

Table 2-2 Asset Register (source: Defra, 2011 Lead Local Flood Authority Duty to Maintain a Register)

	Register	Record
a.	Must be made available for inspection at all reasonable times.	Up to the LLFA to decide if they wish to make it available for inspection
b.	Must contain a list of structures or features which in the opinion of the authority, are likely to have a significant effect on a local flood risk.	For each structure or feature listed on the register, the record must contain information about its ownership and state of repair.
c.	s.21 (2) of the Act allows for further regulations to be made about the content of the register and record. There is currently no plan to provide such regulations therefore their content should be decided on by the LLFA depending on what information will be useful to them.	
d.	There is no legal requirement to have a separate register and record although as indicated above, only the register needs to be made available for public inspection.	

2.5.3 A template and guidance documentation were provided to the LLFAs in March 2011. Although these templates were not designed to be a working tool, they do demonstrate what information could be contained within the register and how it could be structured.

2.5.4 The creation of the asset register was not within the scope of the Drain London project and is the responsibility of the LLFA. It is recommended that the LLFAs utilise a risk-based approach when creating the asset register, and begin recording structures or features which are considered the have the greatest influence on flooding first.

2.6 Review of Asset Management Systems

2.6.1 As part of the SWMP, LB of Hillingdon existing asset management system has been reviewed against the following criteria (as specified by the Drain London board):

- Level 1 – The Borough knows where their assets are, what they look like and what condition they are in. Register system may take the form of a spreadsheet or hard copy records.
- Level 2 – The Borough is aware of the 'Local Authority Flood Risk Asset Tool' currently being produced by the EA / Defra. Their register is GIS based (basic proprietary system only) or uses a highways based asset management system database. Their register captures information generally aligned with guidance provide by the Tool and the EA NFCDD system where practical. They know where their assets are and carry out reactive maintenance of significant structures as required.
- Level 3 – The Borough has a detailed understanding of Asset Registers as required by the Flood and Water Management Act. Their register system accurately replicates the 'Local Authority Flood Risk Asset Tool' data standards and related NFCDD structures to an attribute level. Their register is GIS based (advanced proprietary or bespoke system) or is completely integrated with an existing asset management system. They know where their assets are and carry out periodic maintenance on the structures using a risk based priority system.

2.6.2 LB Hillingdon provided limited asset information as part of the Drain London Tier 1 'data collection' exercise and based on the current review of the asset register appears to be Level 1.

2.6.3 Appendix B provides additional information (and recommendations) for the actions required to meet a full level 3 status (as defined above).

3 Phase 2: Risk Assessment

3.1 Intermediate Assessment

Aims

3.1.1 The aim of the Phase 2 Intermediate Risk Assessment is to *identify the sources and mechanisms of surface water flooding across the study area* which will be achieved through an intermediate assessment of pluvial flooding, sewer flooding, groundwater flooding and flooding from Ordinary Watercourses along with the interactions with main rivers and the sea. The modelling outputs will then be mapped using GIS software.

3.1.2 SWMPs can function at different geographical scales and therefore necessarily at differing scales of detail. Table 3-1 defines the potential levels of assessment within a SWMP. This SWMP has been prepared at the 'Borough' scale and fulfils the objectives of a second level 'Intermediate Assessment'.

Table 3-1: SWMP Study Levels of Assessment [Defra 2010]

Level of Assessment	Appropriate Scale	Outputs
1. Strategic Assessment	Greater London	Broad understanding of locations that are more vulnerable to surface water flooding. Prioritised list for further assessment. Outline maps to inform spatial and emergency planning.
2. Intermediate Assessment	Borough wide	Identify flood hotspots which might require further analysis through detailed assessment. Identify immediate mitigation measures which can be implemented. Inform spatial and emergency planning.
3. Detailed Assessment	Known flooding hotspots	Detailed assessment of cause and consequences of flooding. Use to understand the mechanisms and test mitigation measures, through modelling of surface and sub-surface drainage systems.

3.1.3 As shown in Table 3-1 above, the intermediate assessment is applicable across a large town, city or Borough. In the light of extensive and severe historical flooding and the results from the over-arching national pluvial modelling suggesting that there are 38,300 properties at risk across the Borough during a 1 in 200 year return period rainfall event, it is appropriate to adopt this level of assessment to further quantify the risks.

3.1.4 The purpose of this intermediate assessment is to further identify those parts of the Borough that are likely to be at greater risk of surface water flooding and require more detailed assessment. The methodology used for this SWMP is summarised below. Further detail of the methodology is provided in Appendix C.

- A Direct Rainfall modelling approach using TuFLOW software has been selected whereby rainfall events of known probability are applied directly to the ground surface and water is routed by the model over a representation of the ground surface to provide an indication of potential flow path directions and velocities and areas where surface water may pond.

- The direct rainfall modelling has been supported by hydraulic field visits and have been undertaken in consultation with the LB of Hillingdon staff and EA staff. The outputs from the pluvial modelling have been verified (where possible) against historic surface water flood records.

3.2 Risk Overview

3.2.1 The following sources of flooding have been assessed and are discussed in detail in the following sections of this report:

- Pluvial flooding: runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or a watercourse. Figure 13 to 22 in Appendix D, present mapped results of the surface water modelling for all modelled rainfall events;
- Sewer flooding; flooding which occurs when the capacity of the underground drainage network is exceeded, resulting in flooding inside and outside of buildings. Normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters as a result of wet weather or tidal conditions;
- Flooding from Ordinary Watercourses: flooding which occurs as a result of the capacity of the watercourse being exceeded resulting in out of bank flow (water coming back out of rivers and streams); and
- Flooding from groundwater sources: occurs when the water level within the groundwater aquifer rises to the surface.

3.2.2 The identification of areas at risk of flooding has been dominated by the assessment of surface water and Ordinary Watercourse flooding as these sources are expected to result in the greater consequence (risk to life and damage to property), as well as the quality of the information available for informing the assessment.

Mapping Limitations

3.2.3 The mapping shown within this report is suitable to identify broad areas which are more likely to be vulnerable to surface water flooding. This allows the LB of Hillingdon and its partners to undertake more detailed analysis in areas which are most vulnerable to surface water flooding.

3.2.4 In addition, the maps can also be used as an evidence base to support spatial planning. This will ensure that surface water flooding is appropriately considered when allocating land for future development. The maps can be used to assist emergency planners in preparing their Multi-Agency response plans.

3.2.5 Please note that these maps only show the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall in urban areas) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses. Individual properties therefore may not always face the same chance of flooding as the areas that surround them.

3.2.6 There may also be particular occasions when flooding occurs and the observed pattern of flooding does not in reality match the predicted patterns shown on these maps. We have done all we can to ensure that the maps reflect all the data available to us and have applied our expert knowledge to create conclusions that are as reliable as possible. It is essential that anyone using these maps fully understands the complexity of the data utilised in production of the maps, is aware of the limitations and does not use the maps in isolation.

3.2.7 We will not be liable if the maps are misused or misunderstood. The maps will not always be completely accurate or up to date. We are also not liable for any future flooding that is not highlighted in this report.

3.3 Surface Water Flooding

Description

3.3.1 Surface water flooding is the term used to describe flooding which occurs when intense, often short duration rainfall is unable to soak/infiltrate into the ground or is above the capacity of the drainage systems and therefore runs over the surface of the land causing flooding.. It is most likely to occur when soils are saturated so that they cannot infiltrate any additional water or in urban areas where buildings tarmac and concrete prevent water infiltrating into the ground. The excess water can pond (collect) in low points, and result in the development of flow pathways often along roads but also through built up areas and open spaces. . This type of flooding is usually short lived and associated with heavy downpours of rain.

3.3.2 The potential volume of surface runoff in catchments is directly related to the size and shape of the catchment to that point. The amount of runoff is also a function of geology, slope, climate, rainfall, saturation, soil type, urbanisation and vegetation.

Causes and classifications

3.3.3 Surface water flooding can occur in rural and urban areas, but usually causes more damage and disruption in the latter. Flood pathways include the land and water features over which floodwater flows. These pathways can include drainage channels, rail and road cuttings. Developments that include significant impermeable surfaces, such as roads and car parks may increase the volume and rate of surface water runoff.

3.3.4 Urban areas which are close to artificial drainage systems, or located at the bottom of hillsides, in valley bottoms and hollows, may be more prone to surface water flooding. This may especially be the case in areas that are down slope of land that has a high runoff potential including impermeable areas and compacted ground.

Impacts of surface water flooding

3.3.5 Surface water flooding can affect all forms of the built environment, including:

- Residential, commercial and industrial properties;
- Infrastructure, such as roads and railways, telecommunication systems and sewer systems;

It can also impact on:

- Agriculture; and
- Amenity and recreation facilities.

3.3.6 Flooding from land is usually short-lived and may only last as long as the rainfall event. However occasionally flooding may persist in low-lying areas where ponding occurs. Due to the typically short duration, flooding from land tends not to have as serious consequences as other forms of flooding, such as flooding from rivers or the sea however it can still cause significant damage and disruption on a local scale.

Historic Records – Surface Water Flooding

3.3.7 Past records of surface water flooding within Hillingdon have been gathered from sources such as the Environment Agency, London Underground as well as the LB of Hillingdon. These incidents have been mapped as part of the SWMP and are identified in Figure 5 (Appendix D). Table 3-2 provides a summary of the previous records of flooding attributed to surface water in the LB of Hillingdon.

Table 3-2: Records of Surface Water Flooding

Date	Location	Recorded Impacts
Unknown	Ruislip Manor Tube Station, Victoria Road	Flooding to station entrance during periods of heavy rainfall
Unknown	Ruislip Tube Station, A4180	Flooding to station entrance during periods of heavy rainfall
Unknown	West Ruislip Station	Heavy rain left standing water in the middle of roads in Eastcote and Ruislip and seeping in through front doors of properties
Unknown	Hillingdon underground station	Flooding throughout flood warning area
Unknown	Civic Centre	Civic centre canteen and underground car park flooded, cars left with water levels up to window sills
July 2006	Heathrow Airport	Heavy rain causing disruption to flights

3.3.8 There are limited records of surface water flooding in the London Borough of Hillingdon that can be used to verify the modelling results, however discussions with Council staff at Hillingdon has provided anecdotal support for several of the locations identified as being susceptible.

Methodology for Surface Water Flooding

3.3.9 Several 2-dimensional (2D) direct rainfall models were created, using the TUFLOW software, to determine the causes and consequences of surface water flooding within the LB of Hillingdon. The results of the models provide an indication of key flowpaths, velocities and areas where water is likely to pond.

3.3.10 As the extents of the models have been based upon catchment boundaries, and not Borough boundaries, several models were required to cover the area occupied by the LB of Hillingdon. This was carried out to appropriately represent cross-boundary interaction and allow for Drain London Tier 2 consultants to undertake a collaborative modelling approach. Figure 3-1 below indicates the extent of the models utilised within the assessment of the LB of Hillingdon.

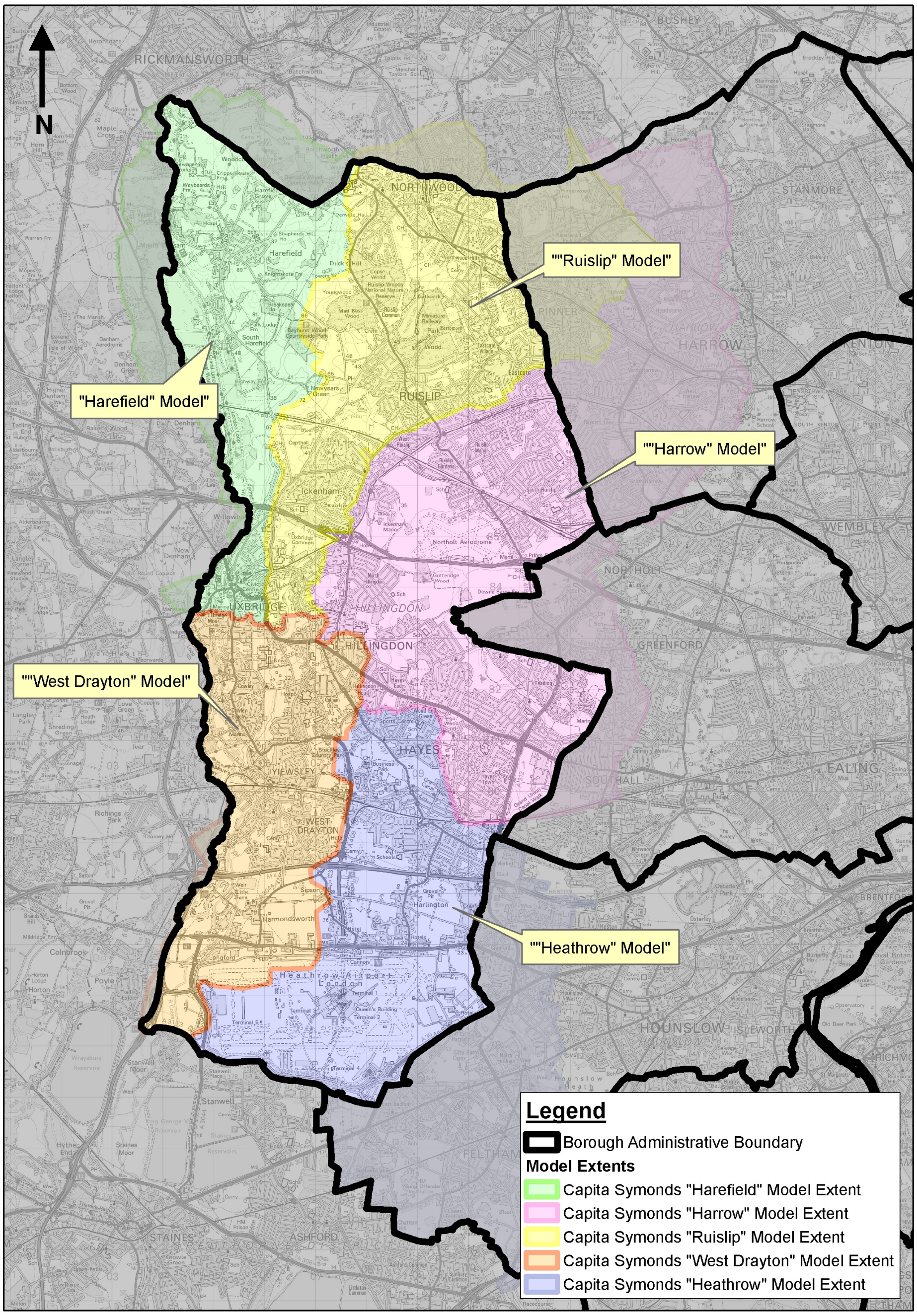


Figure 3-1: Model coverage for the London Borough of Hillingdon

3.3.11 The hydraulic models were run for the following return periods:

- 1 in 30 year event;
- 1 in 75 year event;
- 1 in 100 year event;
- 1 in 100 year event with allowance for climate change (30% increase in rainfall); and
- 1 in 200 year event

3.3.12 As part of this study, maps of maximum water depth and hazard for each of the return periods above have been prepared and are presented in Appendix D of this report. When viewing the maps, it is important that the limitations of the modelling are considered. The key assumptions include the use of a continuous loss (6.5mm/hr) to represent the presence of the underground drainage network. The model does not take into account any capacity issues associated with the drainage network such as surcharging of manholes leading to backing up of surface water, blocked outfalls etc.

3.3.13 Refer to Appendix C1 for a detailed discussion on the hydraulic modelling methodology.

3.3.14 As part of the SWMP process hydraulic modelling has been undertaken which indicates the areas potentially at risk from surface water flooding now and in the future. The model indicates that water is predicted to pond over a number of roads and residential properties (refer to surface water flood depth maps located in Appendix D). These generally occur at topographical low points, or where water is constricted behind an obstruction or embankment. Railway lines with 'cuttings' may also be particularly susceptible, e.g. east of Denham Rail station and north of Ruislip Gardens tube station.

3.3.15 The results of the assessment have been used to identify 'Local Flood Risk Zones' (LFRZs) and 'Critical Drainage Areas' (CDAs) across the LB of Hillingdon. These CDAs are identified in Figures 1.1 and 1.2 of Appendix D. Section 3.1 provides a short summary of the risk of flooding within each CDA.

Uncertainty in flood risk assessment – Surface Water Modelling

3.3.16 The surface water modelling provides the most detailed information to date on the mechanisms, extent and hazard which may result from high intensity rainfall across the LB of Hillingdon. However, due to the strategic nature of this study and the limitations of some data sets, there are limitations and uncertainties in the assessment approach that the reader should be aware of.

3.3.17 There is a lack of reliable measured datasets and the estimation of the return period (probability) for flood events is therefore difficult to verify. The broad scale mapping provides an initial guide to areas that may be at risk, however there are a number of limitations to using the information:

- The mapping does not include underground sewerage and drainage systems;
- The mapping should not be used in a scale to identify individual properties at risk of surface water flooding. It can be used as a general indication of areas potentially at risk.
- Whilst modelled rainfall inputs has been modified to reflect the possible impacts of climate change it should be acknowledged that this type of flooding scenario is uncertain and likely to be very site specific. More intense short duration rainfall and higher more prolonged winter rainfall are likely to exacerbate flooding in the future.

3.4 Ordinary Watercourse Flooding

Description

3.4.1 All watercourses in England and Wales are classified as either 'Main Rivers' or 'Ordinary Watercourses'. The difference between the two classifications is based largely on the perceived importance of a watercourse, ad in particular it's potential to cause significant and widespread flooding.

3.4.2 However this is not to say watercourses classified as Ordinary Watercourses cannot cause localised flooding. The Water Resources Act (1991) defines a 'Main River' as "a watercourse shown as such on a Main River Map". The Environment Agency keep and maintain information on the spatial extent of the Main River designations. The Floods and Water Management Act (2010) defines any watercourse that is not a Main River an Ordinary Watercourse – including ditches, dykes, rivers, streams and drains (but not public sewers).

3.4.3 The Environment Agency have duties and powers in relation to Main Rivers. Local Authorities, or in some cases Internal Drainage Boards, have powers and duties in relation to Ordinary Watercourses.

3.4.4 Flooding from Ordinary Watercourses occurs when water levels in the stream or river channel rise beyond the capacity of the channel, causing floodwater to spill over the banks of the watercourse and into the adjacent land . The main reasons for water levels rising in Ordinary Watercourses are:

- Intense or prolonged rainfall causing flow to increase in watercourses, exceeding the capacity of the channel. This can be exacerbated by wet antecedent (the preceding time period) conditions and where there are significant contributions of groundwater;
- Constrictions/obstructions within the channel causing flood water to backup;
- Blockage/obstructions of structures causing flood water to backup and overtop the banks; and
- High water levels preventing discharge at the outlet of the Ordinary Watercourse (often into a Main River).

3.4.5 Table 3-3, overleaf, summaries the watercourses present in the Borough and the classification.

Table 3-3: Watercourses in the London Borough of Hillingdon

Watercourse	Classification	Responsibility under the FWMA
River Colne	Main River	EA
Newyears Green Bourne	Main River	
Mad Bess Brook	Main River	
Cannon Brook	Main River	
Joel Street Farm Ditch	Main River	
Ickenham Stream	Main River	
Yeading Brook	Main River	
River Crane	Main River	
Frogs Ditch	Main River	
Longford River	Main River	
River Pinn	Main River	
Duke of Northumberland River	Main River	
Grand Union Canal	Ordinary Watercourse	British Waterways

Impacts of Flooding from Ordinary Watercourse

3.4.6 The consequence of Ordinary Watercourse flooding is dependent upon the degree of hazard generated by the flood water (as specified within the DEFRA/Environment Agency research on Flood Risks to People - FD2321/TR2) and what the receptor is (e.g. the consequence of a hospital flooding is greater than that of a commercial retailer). The hazard Ordinary Watercourses pose is a relationship between the depth and velocity of water, which, in Ordinary Watercourses, depends on:

- Constrictions in the channel causing flood water to backup;
- The magnitude of flood flows;
- The size, shape and slope of the channel;
- The width and roughness of the adjacent floodplain; and
- The types of structures that span the channel.

3.4.7 The hazard posed by floodwater is proportional to the depth of water, the velocity of flow and the speed of onset of flooding. Hazardous flows can pose a significant risk to exposed people, property and infrastructure.

3.4.8 Whilst low hazard flows are less of a risk to life (shallow, slow moving/still water), they can disrupt communities, require significant post-flood clean-up and can cause costly and possibly permanent structural damage to property.

Historic Records – Ordinary Watercourse Flooding

3.4.9 There were no historical records of flooding from Ordinary Watercourses available from the LB of Hillingdon. This is not to say that no such incidents have occurred or that there is no future flood risk to the Borough from Ordinary Watercourses.

Methodology for Assessing Ordinary Watercourses

3.4.10 Ordinary watercourses have been included in the surface water flood modelling. Watercourses have been defined by digitising “breaklines” along the centre line of each watercourse. Elevations of watercourses have been determined from LiDAR to represent a “bank full” scenario.

3.4.11 Structures along the watercourse have been modelled as either 1D or 2D elements, depending on the length and location of the structure. The dimensions of structures have been determined from asset information obtained in the data collection stage where available or inferred from site visits or LiDAR data.

3.4.12 The assessment of flood risk from Ordinary Watercourses in Hillingdon has been based on outputs from the Drain London surface water modelling described in Appendix C and presented in Figures 13, 15, 17 and 19 of Appendix D. The figures indicate that LB of Hillingdon is at a low risk of flooding from Ordinary Watercourses with little to no standing water observed in the floodplain. This is found to be consistent with the Environment Agency Flood Zone Maps and increases confidence in the outputs of the surface water model.

3.4.13 Please note that the risk of flooding from fluvial (including Main River) and tidal sources are covered within the SFRA for the London Borough of Hillingdon dated November 2008 and prepared by Scott Wilson consulting (the SFRA can be obtained from the LB of Hillingdon website).

Uncertainties and Limitations – Ordinary Watercourse Modelling

3.4.14 As with any hydraulic model, these models have been based on a number of assumptions which may introduce uncertainties into the assessment of risk. The assumptions within the models should be noted and understood such that informed decisions can be made when using model results.

3.4.15 The modelling of structure has been based on site investigation and photographic interpretation. It is recommended that any detailed modelling obtain survey data to represent the structure.

3.4.16 Channel capacity has been based on LiDAR information and not specific site surveys. It is recommended that a site survey of key channel areas is recommended in locations know to flood.

3.4.17 One storm duration has been utilised for the study and it is recommended that additional durations are investigated in future detailed modelling.

3.4.18 Taking these uncertainties and constraints into consideration, the estimation of risk of flooding from rivers presented in this report is considered robust for the level of assessment required in the SWMP.

3.5 Groundwater Flooding

Description

3.5.1 Groundwater flooding is caused by the emergence of water originating from sub-surface permeable strata. In short, groundwater flooding is water which emerges from the ground from either a specific point (such as a spring) or over a wide diffuse location. A groundwater flood event results from a rise in groundwater level sufficient for the water table to intersect the ground surface and inundate low lying land. Groundwater floods tend to be long in duration developing over weeks or months and prevailing for days or weeks.

3.5.2 There are many mechanisms associated with groundwater flooding, which are linked to high groundwater levels, and can be broadly classified as:

- Direct contribution to channel flow.
- Springs erupting at the surface.
- Inundation of drainage infrastructure.
- Inundation of low-lying property (basements).

Impacts of Groundwater Flooding

3.5.3 The main impacts of groundwater flooding are:

- Flooding of basements of buildings below ground level – in the mildest case this may involve seepage of small volumes of water through walls, temporary loss of services etc. In more extreme cases larger volumes may lead to the catastrophic loss of stored items and failure of structural integrity;
- Overflowing of sewers and drains – surcharging of drainage networks can lead to overland flows causing significant but localised damage to property. Sewer surcharging

can lead to inundation of property by polluted water. Note: it is complex to separate this flooding from other sources, notably surface water or sewer flooding;

- Flooding of buried services or other assets below ground level – prolonged inundation of buried services can lead to interruption and disruption of supply;
- Inundation of roads, commercial, residential and amenity areas – inundation of grassed areas can be inconvenient; however the inundation of hard-standing areas can lead to structural damage and the disruption of commercial activity. Inundation of agricultural land for long durations can have financial consequences; and
- Flooding of ground floors of buildings above ground level – can be disruptive, and may result in structural damage. The long duration of flooding can outweigh the lead time which would otherwise reduce the overall level of damages.

3.5.4 In general terms groundwater flooding rarely poses a risk to life.

Historical Records

3.5.5 Table 3-4 provides a summary of the previous records of flooding attributed to of groundwater in the LB of Hillingdon. Figure 10 in Appendix D shows the geographical locations on these incidents within the Borough.

Table 3-4: Records of Groundwater Flooding

Date	Location	Recorded Impacts
06/11/2006	Northwood Cricket Ground	Unknown
31/05/2007	Property on Links Way, Northwood	Waterlogged
22/11/2002	Crosier Way, Ruislip Manor	Standing Water
18/11/2004	Winsor Avenue next to recreation ground,North Hillingdon	Standing Water
21/11/2002	Hoppner Road, Hillingdon	Standing Water
08/02/2010	Beacon Close, Willowbank	Slow Flowing Water

3.5.6 The areas with increased potential of elevated groundwater in the LB of Hillingdon are shown in Figure 10 of Appendix D together with historic records of flooding which have been identified as related to groundwater. The figures show that areas along the western Borough boundary and the south around Heathrow Airport have the greatest potential within the Borough.

Methodology used for Groundwater Mapping

3.5.7 As part of the Drain London project Drain London Tier 1 consultants commissioned a dataset referred to as the Increased Potential Elevated Groundwater (iPEG) maps. The iPEG mapping assists in identifying areas which have an increased potential to experience groundwater flooding. The iPEG map shows those areas within the borough where there is an increased potential for groundwater to rise sufficiently to interact with the ground surface or be within 2 m of the ground surface. The assessment was carried out at a Greater London scale.

3.5.8 The four data sources listed below have been utilised to produce the 'increased Potential for Elevated Groundwater' (iPEG) map:

- British Geological Survey (BGS) Groundwater Flood Susceptibility Map;
- Jacobs Groundwater Emergence Maps (GEMs);
- Jeremy Benn Associates (JBA) Groundwater Flood Map; and

- Environment Agency/Jacobs Thames Estuary 2100 (TE2100) groundwater hazard maps.

3.5.9 More information on the production of the iPEG map is discussed in Appendix C.

3.5.10 The iPEG mapping is presented in Figure 5 of Appendix D together with historic records of flooding which have been identified as related to groundwater. The mapping indicates an increased potential for ground water to rise most noticeably within the river valleys. A majority of the historical incidents correlate well with the iPEG mapping however there are historic records of groundwater incidents which are located outside of the identified emergence zones. The discrepancy between recorded historic incidents and potential areas of future incidents may be attributed to the following:

- Past incidents may be a result of localised flooding mechanisms (or other flooding mechanisms) which have not been assessed as part of the production of the iPEG mapping.
- The iPEG mapping does not represent local geological features and artificial influences (e.g. structures or conduits) which have the potential to heavily influence the local rise of groundwater.
- The iPEG map only shows areas that have the greatest potential for elevated groundwater and does not necessarily include all areas that are underlain with permeable geology.
- The flood source attributed to some past incidents may not be accurate.

Uncertainties and Limitations – Groundwater Flooding

3.5.11 Not all areas underlain by permeable geology are shown on the iPEG maps. Only where there is the highest degree of confidence in the assessment are the areas delineated as areas where groundwater may be an issue. This ensures resources are focused on the most susceptible areas. In all areas underlain by permeable substrate, groundwater should still be considered in planning developments.

3.5.12 Within the areas delineated, the local rise of groundwater will be heavily controlled by local geological features and artificial influences (e.g. structures or conduits) which cannot currently be represented. This localised nature of groundwater flooding compared with, say, fluvial flooding suggests that interpretation of the map should similarly be different. The map shows the area within which groundwater has the potential to emerge but it is unlikely to emerge uniformly or in sufficient volume to fill the topography to the implied level. Instead, groundwater emerging at the surface may simply runoff to pond in lower areas.

3.5.13 For this reason within iPEG areas, locations shown to be at risk of surface water flooding are also likely to be most at risk of runoff/ponding caused by groundwater flooding. Therefore the iPEG map should not be used as a “flood outline” within which properties at risk can be counted. Rather it is provided, in conjunction with the surface water mapping, to identify those areas where groundwater may emerge and if so what would be the major flow pathways that water would take.

3.5.14 It should be noted that this assessment is broad scale and does not provided a detailed analysis of groundwater, it only aims to provide an indication of where more detailed consideration of the risks may be required.

3.5.15 The causes of groundwater flooding are generally understood. However groundwater flooding is dependent on local variations in topography, geology and soils. It is difficult to predict the actual location, timing and extent of groundwater flooding without comprehensive datasets.

3.5.16 There is a lack of reliable measured datasets to undertake flood frequency analysis on groundwater flooding and even with datasets this analysis is complicated due to the non-independence of groundwater level data. Studies therefore tend to analyse historic flooding which means that it is difficult to assign a level of certainty.

3.5.17 The impact of climate change on groundwater levels is highly uncertain. More winter rainfall may increase the frequency of groundwater flooding incidents, but drier summers and lower recharge of aquifers may counteract this effect.

3.6 Sewers

Description

3.6.1 Flooding from foul and combined sewers occurs when rainfall exceeds the capacity of networks or when there is an infrastructure failure. In the LB of Hillingdon the sewer network is a largely separated foul and surface water system with some areas still utilising a combined system (in a combined system foul sewage and rain water are drained using the same pipes).

Causes of sewer flooding

3.6.2 The main causes of sewer flooding are:

- Lack of capacity in the sewer drainage networks due to original under-design;
- Lack of capacity in sewer drainage networks due to an increase in flow (such as climate change and/or new developments connecting to the network);
- Exceeded capacity in sewer drainage networks due to events larger than the system designed event;
- Loss of capacity in sewer drainage networks when a watercourse has been fully culverted and diverted or incorporated into the formal drainage network (lost watercourses);
- Lack of maintenance or failure of sewer networks which leads to a reduction in capacity and can sometimes lead to total sewer blockage;
- Failure of sewerage infrastructure such as pump stations or flap valves leading to surface water or combined foul/surface water flooding;
- Groundwater infiltration into poorly maintained or damaged pipe networks; and
- Restricted outflow from the sewer systems due to high water or tide levels in receiving watercourses (‘tide locking’).

Impacts of Sewer Flooding

3.6.3 The impact of sewer flooding is usually confined to relatively small localised areas but flooding is associated with blockage or failure of the sewer network, flooding can be rapid and unpredictable. Flood waters from this source are also often contaminated with raw sewage and pose a health risk. The spreading of illness and disease can be a concern to the local population if this form of flooding occurs on a regular basis.

3.6.4 Drainage systems often rely on gravity assisted dendritic systems, which convey water in trunk sewers located at the lower end of the catchment. Failure of these trunk sewers can have serious consequences, which are often exacerbated by topography, as water from surcharged manholes will flow into low-lying urban areas.

3.6.5 The diversion of "natural" watercourses into culverted or piped structures is a historic feature of the London drainage network. Where it has occurred, deliberately or accidentally it can result in a reduced available capacity in the network during rainfall events when the sewers drain the watercourses catchment as well as the formal network. Excess water from these watercourses may flow along unexpected routes at the surface (usually dry and often developed) as its original channel is no longer present and the formal drainage system cannot absorb it.

Historic Records – Sewer Flooding

3.6.6 There are no historic records of flooding attributed to the sewerage network in the LB of Hillingdon.

3.6.7 The risk of flooding from sewers is increasing due to the increasing urbanisation of areas and rising rainfall intensities. Several recent flood events across the country have been attributed to the inability of the drainage network to contain runoff during severe storm events and the occurrence of events which exceed the design capacity of the drainage network may be increasing.

3.6.8 The data provided by Thames Water for use in this SWMP shows postcodes where properties are known to have experienced sewer flooding prior to June 2010. Figure 9 in Appendix D displays this data along with other known records of sewer flooding. The data provides a broad overview of flood incidents in the Borough as it is not property specific, instead providing information in postcode sectors (a four digit postcode). As some of these sectors extend into other London Boroughs, it is not possible to determine the exact number of properties that have experienced a sewer flooding incident. The Thames Water dataset is summarised for the LB of Hillingdon in Table 3-5.

3.6.9 The majority of the incidents of sewer flooding are clustered in North Hillingdon and along the west side of the Borough – post codes HA6 1, HA4 6, UB109, UB8 2, UB8 1 and UB7 7.. These areas are located in areas of low elevation and the large number of recorded sewer flooding incidents may be attributed to "locking" of surface water sewer outfalls to the River Thames or because of a shallow-gradient drainage network.

Table 3-5: Number of Thames Water sewer flood records within the London Borough of Hillingdon

Post Code Sector	2 in 10 external	2 in 10 internal	1 in 10 external	1 in 10 internal	1 in 20 external	1 in 20 internal	Severe	Total Properties
HA2 9	0	0	0	0	3	3	0	6
HA4 0	1	0	1	0	4	0	1	7
HA4 6	1	0	6	2	15	4	7	35
HA4 7	0	0	1	0	2	16	0	19
HA4 8	0	0	0	0	5	1	3	9
HA4 9	1	0	2	0	8	0	1	12
HA5 1	0	0	0	0	0	3	4	7
HA5 2	0	0	1	0	0	8	5	14
HA5 3	0	0	0	0	2	3	0	5
HA6 1	1	0	7	0	6	8	3	25
HA6 2	0	0	0	0	4	7	0	11
HA6 3	0	0	0	0	2	3	0	5

Post Code Sector	2 in 10 external	2 in 10 internal	1 in 10 external	1 in 10 internal	1 in 20 external	1 in 20 internal	Severe	Total Properties
UB100	0	0	1	0	2	2	8	13
UB108	1	0	5	0	2	5	0	13
UB109	0	1	5	3	8	11	0	28
UB3 2	0	0	0	0	2	4	0	6
UB3 3	0	0	0	0	1	0	0	1
UB4 8	0	0	0	0	3	1	0	4
UB4 9	0	0	0	0	1	0	0	1
UB7 7	0	0	0	0	10	11	0	21
UB7 8	0	0	0	0	3	3	0	6
UB7 9	0	0	1	0	3	1	0	5
UB8 1	1	2	3	6	0	0	0	12
UB8 2	1	0	2	0	13	4	1	21
UB8 3	0	0	0	0	10	2	0	12
UB9 6	0	0	1	0	0	3	0	4
Total	7	3	36	11	109	103	33	302

Methodology for Drainage Network Modelling

3.6.10 Consultation with Thames Water determined that the sewer system across London could be assumed to have an approximate capacity of 6.5mm/hr. This was represented in the surface water modelling by removing 6.5mm/hr from the rainfall totals for the duration of the model.

3.6.11 The sewer system was not modelled explicitly hence interaction between the sewer system and surface water modelling is not investigated. This was beyond the scope of the Borough wide study but in specific areas where the sewer network has been identified to be of particular relevance to flood risk more detailed integrated modelling may be required at a later date..

Uncertainties in Flood Risk Assessment – Sewer Flooding

3.6.12 Assessing the risk of sewer flooding over a wide area is limited by the lack of data and the quality of data that is available. Furthermore, flood events may be a combination of surface water, groundwater and sewer flooding.

3.6.13 An integrated modelling approach is required to assess and identify the potential for sewer flooding but these models are complex and require detailed information. Obtaining this information can be problematic as datasets held by stakeholders are often confidential, contain varying levels of detail and may not be complete. Sewer flood models require a greater number of parameters to be input and this increases the uncertainty of the model predictions.

3.6.14 Existing sewer models are generally not capable of predicting flood routing (flood pathways and receptors) in the above ground network of flow routes - streams, dry valleys, highways etc.

3.6.15 Use of historic data to estimate the probability of sewer flooding is the most practical approach, however does not take account of possible future changes due to climate change or future development. Nor does it account for improvements to the network, including clearance of blockages, which may have occurred

3.7 Other Factors Effecting Flooding

3.7.1 Interactions between surface water and tidal/fluvial flooding are generally a result of watercourses unable to store excess surface water runoff. Where the watercourse in question is defended, surface water can pond behind defences. This may be exacerbated in situations where high water levels in the watercourse prevent discharge via flap valves through defence walls.

3.7.2 Main rivers have been considered in the surface water modelling by assuming a 'bank full' condition, in the same way that Ordinary Watercourses have been modelled. Structures such as weirs, locks and gates along watercourses have not been explicitly modelled. Tidal flooding does affect the London Borough of Hillingdon.

3.7.3 The River Colne enters Hillingdon at the northern perimeter before flowing in a southerly direction forming the western border in the north of the Borough. Frays River and the River Pin form some of the major tributaries into the River Colne. The Yeading Brook enters the borough from the east before flowing south, becoming the River Crane at Hayes. The River Crane has a history of flooding in its lower reaches.

3.7.4 The Duke of Northumberland River and Longford River are artificial channels both with off-take gates restricting flow from the River Colne. As such no flooding from either of these artifical rivers is anticipated. The Grand Union Canal has two branches; the westerly branch runs from the north in parallel with the Upper Colne before turning east and travelling onto Bull's Bridge where it joins the easterly branch. The Grand Union Canal interacts with the River Colne at Denham Weir, Willowbank and the Confluence between Shire Ditch, River Colne and the Grand Union Canal.

3.7.5 Further information on fluvial and tidal flooding can be found in the Level 1 LB of Hillingdon SFRA (prepared by Scott Wilson, 2008).

3.8 Critical Drainage Areas

3.8.1 A critical drainage area as defined by the Drain London Tier 2 Technical Specification is *"a discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer and/or river) often cause flooding in a Flood Risk Area during severe weather thereby affecting people, property or local infrastructure."*

3.8.2 Within these CDAs, Local Flood Risk Zones have been identified. These are defined as *"the actual spatial extent of predicted flooding in a single location. LFRZs are discrete areas of flooding that do not exceed the national criteria for a 'Flood Risk Area' but still affect houses, businesses or infrastructure."* Local Flood Risk Zones (LFRZs) across the LB of Hillingdon have been identified based on both the probability and consequence of flooding from the above 'local' sources.

3.8.3 The approach taken has therefore considered the local circumstances in defining and agreeing with each Borough it's LFRZs, whilst seeking to maintain consistency in the overall level of risk to people and property.

3.8.4 Figure 3-2 (below) provides an example of a CDA and LFRZ. Note that the LFRZ has not been delineated with a boundary. This has been undertaken to prevent implying properties not shown at risk to be within a flood risk "zone". This approach has been adopted across the whole of the Drain London study area.

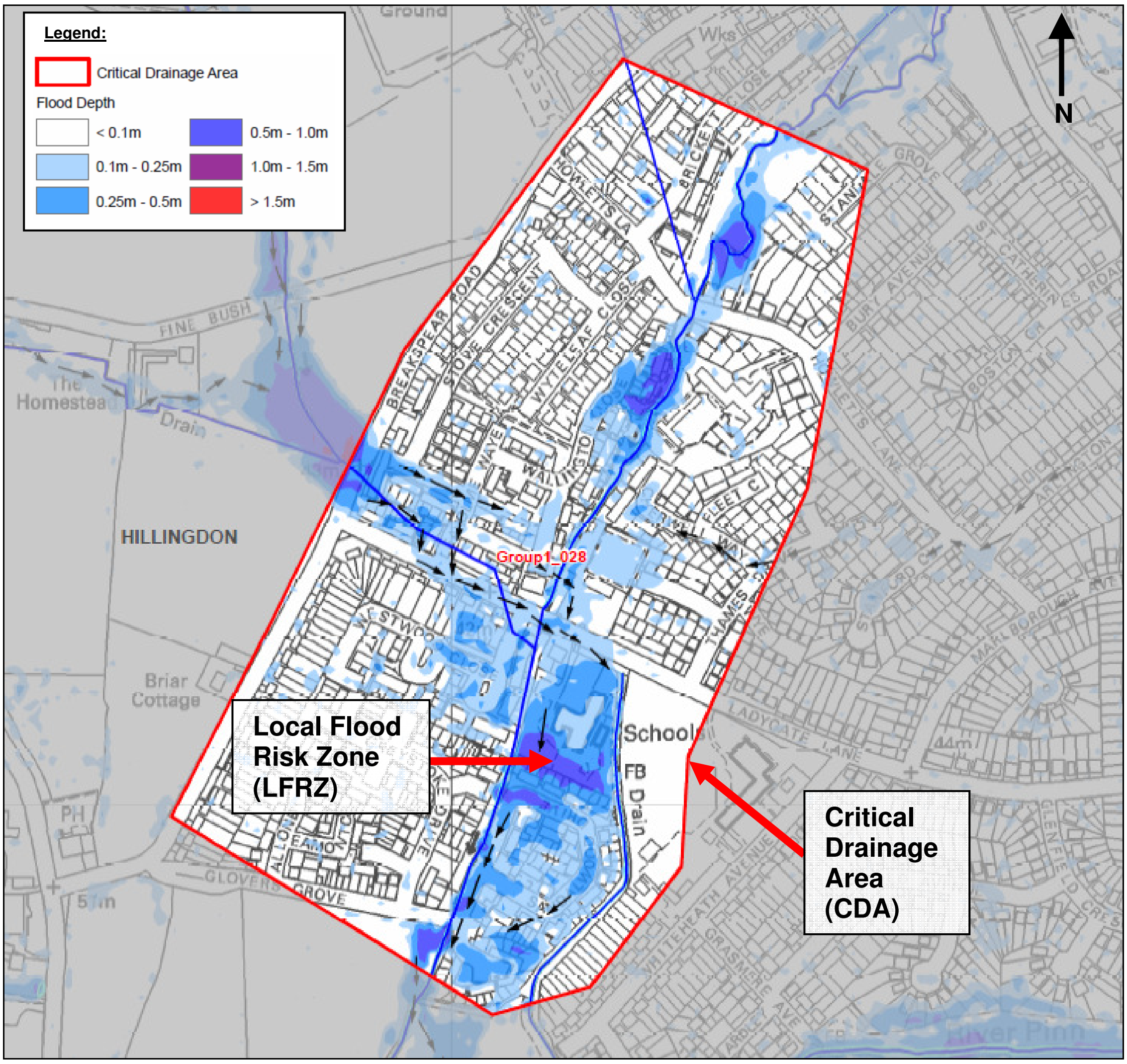


Figure 3-2 Example Critical Drainage Area (CDA) and Local Flood Risk Zone (LFRZ)

3.8.5 41 CDAs have been identified across Group 1, including 17 within the LB of Hillingdon. The following sections of the report provide a summary of the location, probability, consequences and mechanisms of flooding in each CDA in the LB of Hillingdon. Figures 13 to 22, in Appendix D, indicate the flood depth and flood hazard in each critical drainage area for the 1 in 100 year rainfall event – a summary image can be located within Figure 3-3 (overleaf). Detailed hazard and flood depth figures can be located within Figures 23 – 24 of Appendix D.

3.8.6 Due to the complexities of surface water flooding within the LB of Hillingdon, it has been agreed that the policy application areas (refer to Section 4.3) should be defined as the boundaries of the LB of Hillingdon, covering the entire administrative area and thus not omitting communities outside of any identified CDA or surface water catchment boundaries.

Figure 3-3 Critical Drainage Areas Locations within Hillingdon

3.8.7 Guidance on the depths and velocities (hazard) of floodwater that can be a risk to people is shown within Figure 3-4 (overleaf). These are typically classified as caution (very low hazard), moderate (danger for some), significant (danger for most), extreme (danger for all).

d * (v+0.5) + DF

Velocity \ Depth	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
0.00	0.13	0.25	0.38	0.50	0.63	0.75	0.88	1.00	1.13	1.25
0.50	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
1.00	0.38	0.75	1.13	1.50	1.88	2.25	2.63	3.00	3.38	3.75
1.50	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
2.00	0.63	1.25	1.88	2.50	3.13	3.75	4.38	5.00	5.63	6.25
2.50	0.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50
3.00	0.88	1.75	2.63	3.50	4.38	5.25	6.13	7.00	7.88	8.75
3.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
4.00	1.13	2.25	3.38	4.50	5.63	6.75	7.88	9.00	10.13	11.25
4.50	1.25	2.50	3.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50
5.00	1.38	2.75	4.13	5.50	6.88	8.25	9.63	11.00	12.38	13.75

Categories of flood hazard:

	From	To	
Class 1	0.75	1.50	Danger for some
Class 2	1.50	2.50	Danger for most
Class 3	2.50	20.00	Danger for all

Note: The table gives values of flood hazard (= d*(v+0.5) +DF)

Figure 3-4 Combinations of flood depth and velocity that cause danger to people (Source: DEFRA/Environment Agency research on Flood Risks to People - FD2321/TR2)

3.8.8 This information has been converted into a hazard rating (defined within Table 3-6) which can be seen within all hazard related figures within Appendix D figures 14, 16, 18, 20 and 22.

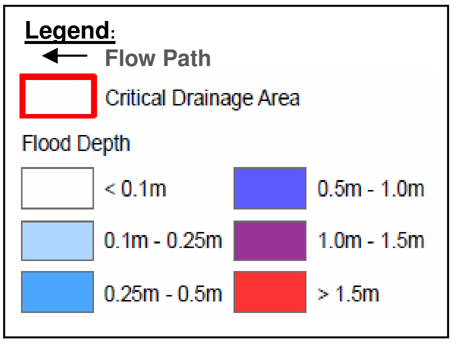
Table 3-6 Legend for Hazard Rating Figures

Degree of Flood Hazard	Hazard Rating (HR)		Description
Low	<0.75	Caution	Flood zone with shallow flowing water or deep standing water
Moderate	0.75b – 1.25	Dangerous for some (i.e. children)	Danger: Flood zone with deep or fast flowing water
Significant	1.25 -2.5	Dangerous for most people	Danger: Flood zone with deep fast flowing water
Extreme	>2.5	Dangerous for all	Extreme danger: Flood zone with deep fast flowing water

3.8.9 The following commentary on the indentified CDAs within the LB of Hillingdon are based on the results of the 1 in 100 year rainfall event.

3.8.10 Please note that the identified CDAs may not be in a standard numerical order as the numbering format has been assigned at a group and not Borough level.

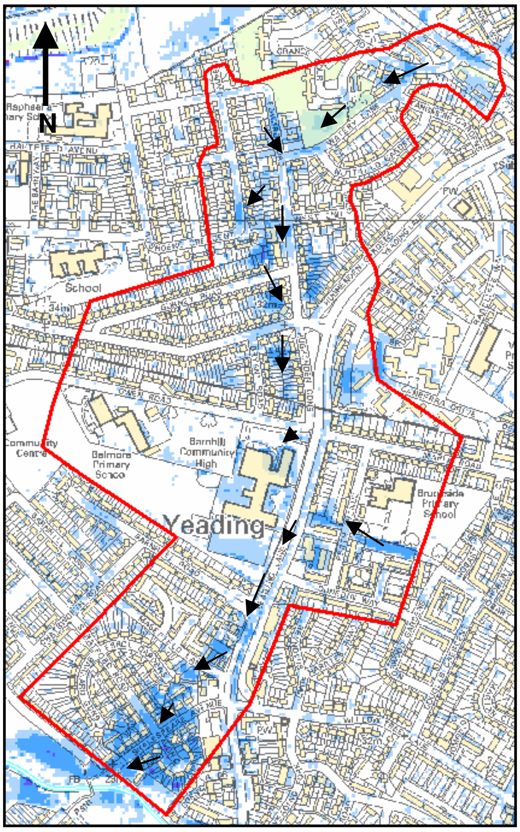
3.8.11 The following legend applies to all of the CDA images.



CDA: Group1_005

Location: Edward Road/Yeading Lane/Shakespeare Avenue, Southall (below right)

Description: the hydraulic model predicts that runoff will flow down Edward Road. Runoff is then predicted to flow through properties adjacent to Hughenden Gardens, around the Barnhill Community High School and past Yeading Lane and Shakespeare Street with the final outfall being the Yeading Brook. The model predicts that water will pond within topographical low points (along the flow path). In order to manage the flood risk within the cross boundary CDA, a cooperative flood risk management effort from both boroughs is essential for managing the flood risk within the CDA.

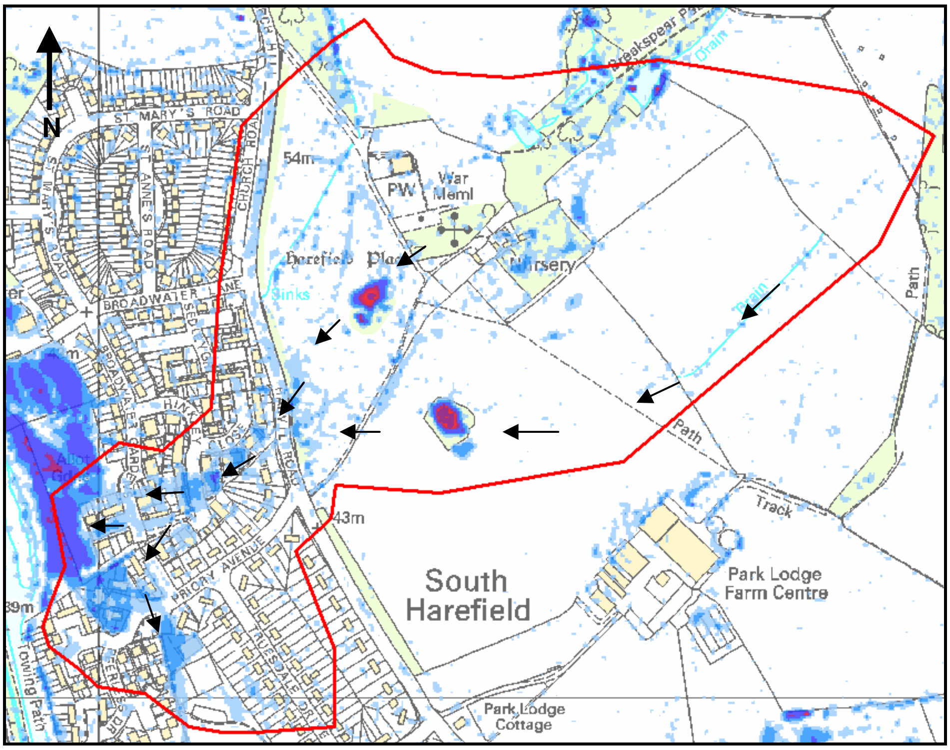


The predicted modelled hazard results indicate that the majority of the CDA is within a low flood hazard. However this increases to moderate (with some areas being significant) within the overland flow paths and areas of ponding.

Validation: There is a good correlation between the modelling results and the Areas Susceptible to Surface Water Flooding (AStSWF) maps for both the 1 in 30 year and 1 in 200 year rainfall events.

CDA: Group1_012

Location: Hinkley Close and Priory Avenue, South Harefield (below)

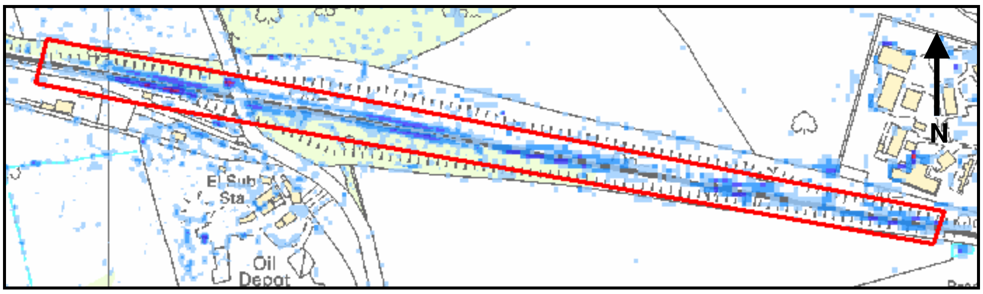


Description: The hydraulic model predicts an overland flow path (from the open space) will be generated within the north east of the CDA, which will convey runoff into the allotment gardens west of Broadwater Gardens (the topographical low point within the CDA). Surface water runoff is also predicted to flow in a southerly direction along Priory Avenue, resulting in the possible flooding of several residential properties. Flooded depths near the residential properties flood event are predicted to be approximately 0.3-0.6m for the 1 in 100 year rainfall event. Peak depths within the allotment gardens are predicted to be between 0.7-1.1m for the 1 in 100 year rainfall event.

Validation: The modelled results correlate well with the EA AStSWF maps for both the 1 in 30 year and 1 in 200 year rainfall events. The EA maps show slightly larger flood extents around Harvil Road which could be a result of the cut-off depth used in the Drain London model results.

CDA: Group1_013

Location: Rail Line near Copthall Covert (Skip Lane), New Years Green (below)

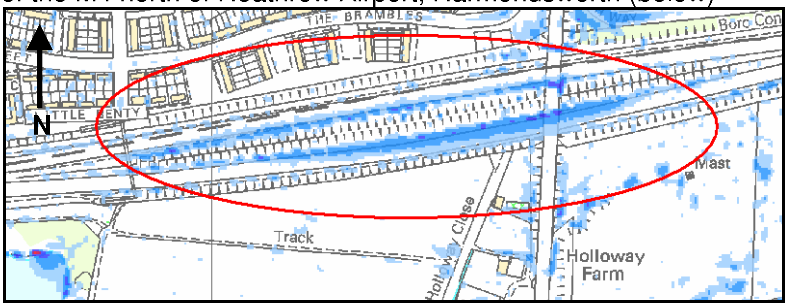


Description: This section of rail line is located in a cutting and can be considered the topographical low point within its catchment. Modelling results indicate that the area is prone to flooding due to the overland runoff within the local catchment converging on the low elevations within the CDA. This section of railway track is considered critical transport infrastructure of national importance. It is important to note that the actual drainage infrastructure in this area is unknown and has not been included within the model.

Validation: Drain London modelling shows larger flood depths in comparison to the EA AStSWF, however the extents are similar. This difference is likely to a result of the model in this area representing the railway corridor as a continuous flow path whereas the EA model does not include structures and therefore may have trapped water upstream of this area.

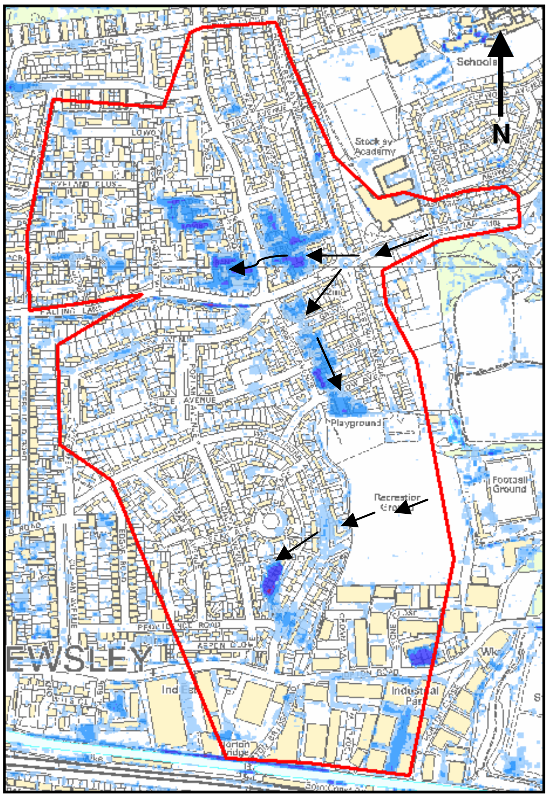
CDA: Group1_014

Location: Section of the M4 north of Heathrow Airport, Harmondsworth (below)



Description: This section of the motorway is at a topographical low point and runoff is predicted to pond beneath the Harmondsworth Road overpass. The M4 is considered critical transport infrastructure of national significance due to its transport links within and outside of London. As no drainage infrastructure (for the any motorway) was provided for this study, it is not known if any current mitigation measure (pumps storage areas etc) are located within the CDA.

Validation: There is good correlation between the modelling results and the EA AStSWF maps for both 1 in 30 year rainfall and 1 in 200 year rainfall events. There are no recorded incidents of flooding at this location.



CDA: Group1_015

Location: Willow Lane, Cherry Tree Avenue and Frankswood Avenue, Yiewsley (right)

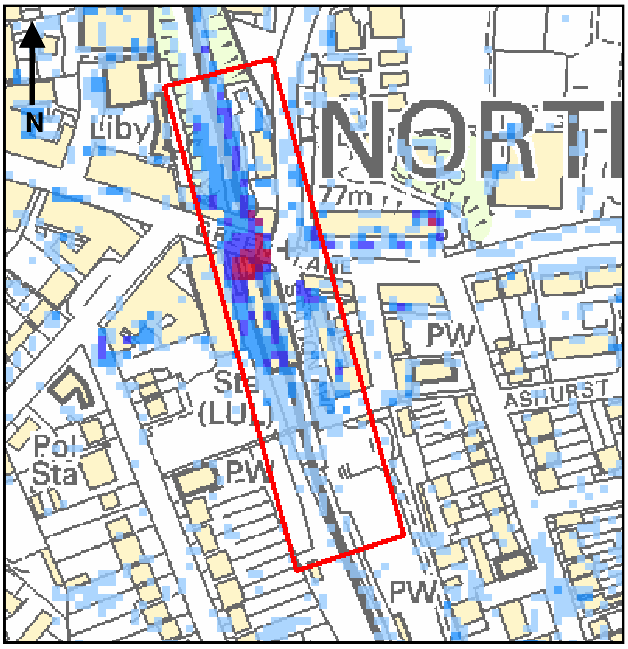
Description: The hydraulic model predicts that surface water runoff will flow down Park View Lane and then on to Falling Lane before ponding behind higher ground. Once this low lying area reaches its storage capacity, it overtops the discharges flow in a western direction and floods properties near Frankswood Avenue (which also receives runoff from northwest areas of the catchment).

Runoff from Park View Lane also travels south at the Chestnut Avenue roundabout (Apple Tree Roundabout) and flows in a southerly direction where it converges with flow from the higher open space in the east and is forced to pond due to the raised open space creating an obstruction to the flow.

The predicted hazard is generally of a low risk, however in areas near the flooded properties, and within the overland flow paths, this risk increases to moderate due to the depth of water, and is significant in small isolated areas, due to both the depth and velocity of the flood water.

Validation: There is good correlation with the modelling results and the EA AStSWF maps for areas with deep flooding however shallow extents in the EA model are considerably larger than those predicted in the model.

CDA: Group1_016



Location: Northwood Station and London Underground/National Rail tracks (left)

Description: The station is located in a topographical low point. The predicted model results indicates that the local catchment will drain to this area and pond. As no drainage infrastructure (for the any rail line or station) was provided for this study, it is not known if any current mitigation measure (pumps storage areas etc) are located within the CDA.

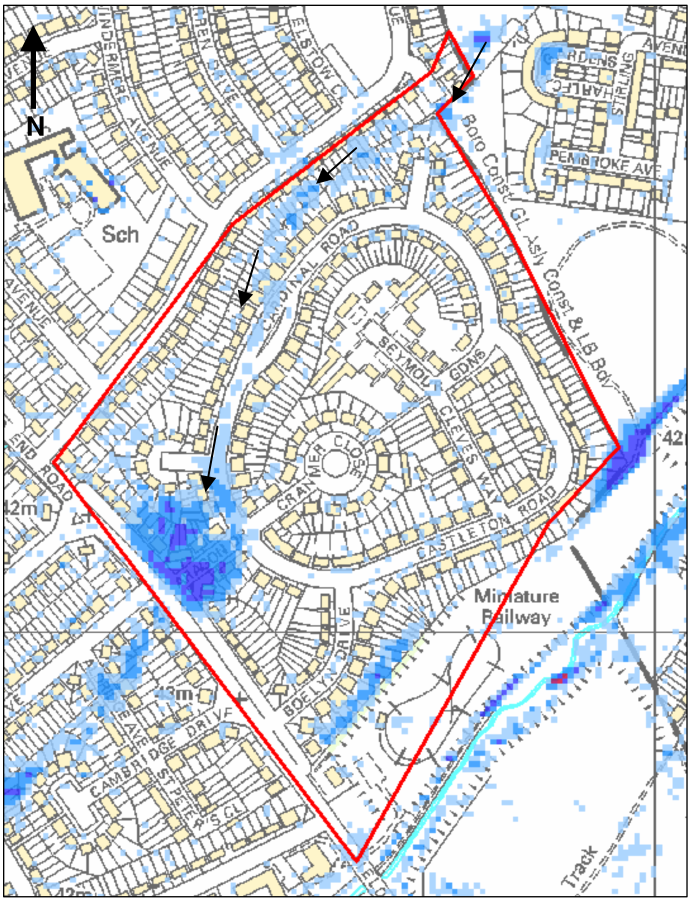
Validation: There is a good correlation between the modelling results and the EA AStSWF maps.

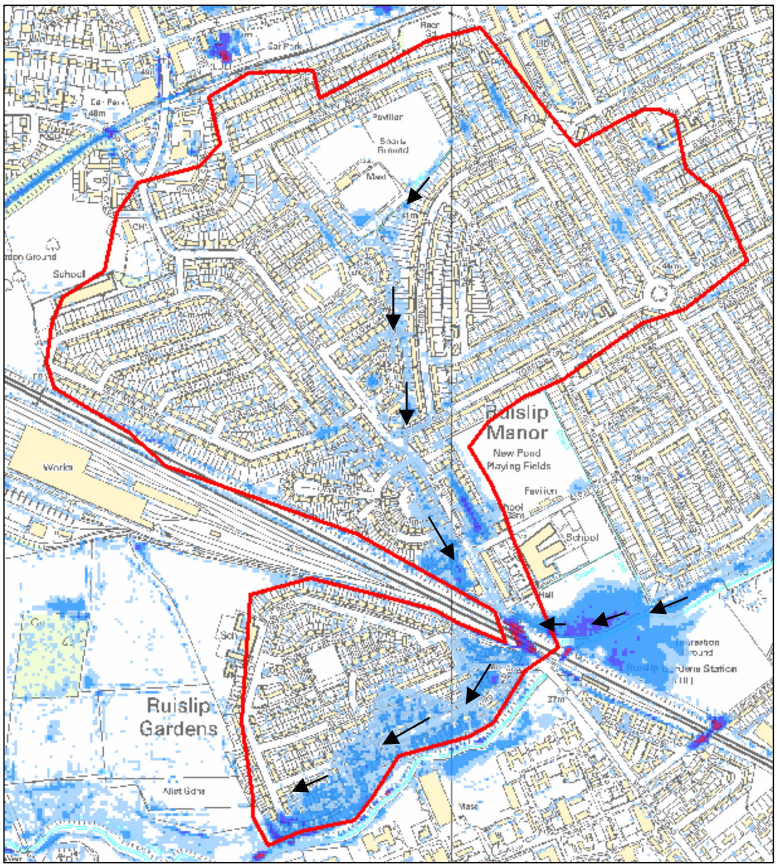
CDA: Group1_017
Location: Aragon Drive, Ruislip (right)

Description: Surface water runoff is predicted to flow from the north (down Warren Drive and into Cardinal Road) and the east (from the open space east of Woodlands Avenue – within the LB of Harrow). This overland flow appears to collect in Aragon Drive which is the local low point and obstructed by Field End Road which is located at a higher elevation.

The hazard risk is predicted to be generally considered low, however in areas near the topographical low point the risk increased to moderate, due to the depth of water and is significant in small isolated areas, due to both the depth and velocity of the flood water.

Validation: The model extents generally correlate with the EA AStSWF map extents.





CDA: Group1_018

Location: Clyfford Road/West End Road (A4180)/Berkley Close/Lea Crescent, Ruislip (left)

Description: Overland flow travels to the catchment low point which is near the A1480 underpass and the Clyfford Road area. The surface water is predicted to back up behind the railway embankment and drains towards the underpass.

The model also predicts that the Yeading Brook could back up behind the culverts (located under the railway embankment), and overtop the banks and open space area which could create an overland flow path that flows into the A1480 underpass.

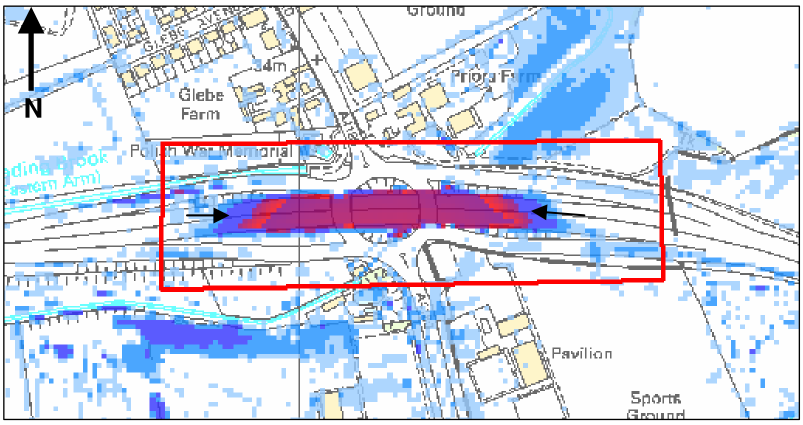
These flows appear to pond within the underpass which then creates and overland flow path which could flood properties north of the Yeading Brook.

The hazard is predicted to be generally low, however in areas near the flooded properties and within the flow paths, this risk rises to moderate due to the depth of water and is significant in small isolated areas, due to both the depth and velocity of the flood water (in particular within the A4180).

Validation: The extents produced by the hydraulic model generally correlate with the EA AStSWF mapping however the modelled results indicate greater areas of flooding near Clyfford Road. Anecdotal evidence from Hillingdon Council indicates that the Clyfford Gardens area has historically flooded.

CDA: Group1_019

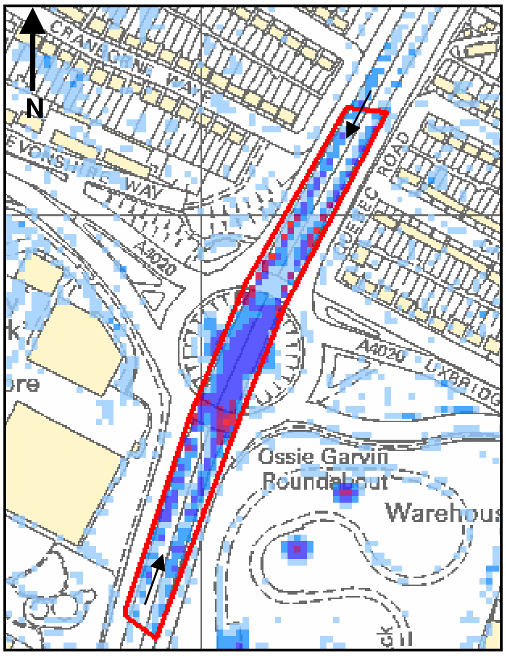
Location: A40 underpass at A4180 flyover, South Ruislip (below)



Description: Surface water is predicted to converge at this low point within the A40 (beneath A4180 roundabout). There is no Thames Water drainage in the vicinity of the A40 in this location and therefore it is unclear how this location drains.

There is a TFL pump station located in this area which would suggest that this area is identified to be an area susceptible to flooding by TfL.
This drainage network was not provided to the Drain London study, and therefore any benefits from mitigation/ managements measures cannot be determine at this stage.. This section of the A40 is considered critical transport infrastructure of national significance as this route is part of the access road north through Hillingdon.

Validation: There is a good correlation between the EA AStSWF Maps for both 1 in 30 year and 1 in 200 year rainfall events. There are no recorded incidents of flooding at this location.



CDA: Group1_020

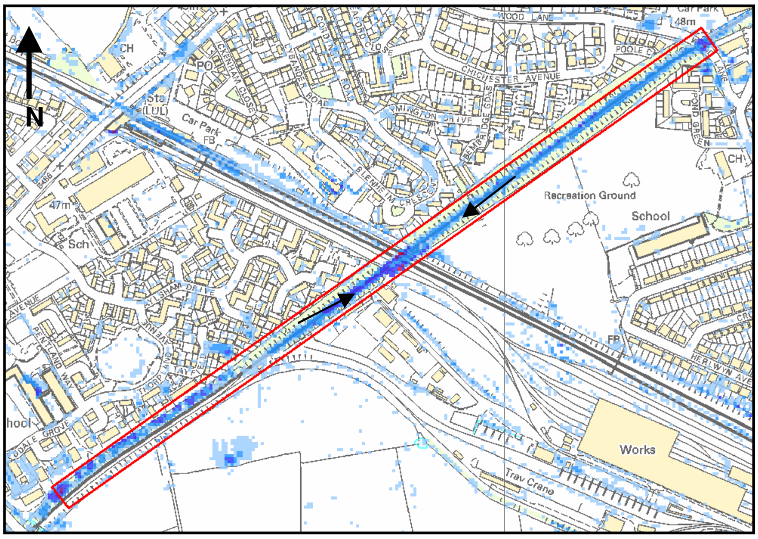
Location: A312 underpass at A4020 flyover, Hayes (left)

Description: Surface water is predicted to pond at an topographical low point within the A31 (beneath the A4020 roundabout). There is no Thames Water drainage in this section of the A40 in this location and therefore it is unclear how this location drains. There is a TFL pump station located in this area which would suggest that this area is identified to be an area susceptible to flooding by TfL. This drainage network was not provided to the Drain London study, and therefore any benefits from mitigation/ managements measures cannot be determine at this stage.

Validation: There is a good correlation between the EA AStSWF Maps for both 1 in 30 year and 1 in 200 year rainfall events.

CDA: Group1_021

Location: London Underground rail Line between Ickenham and Ruislip Stations (below)



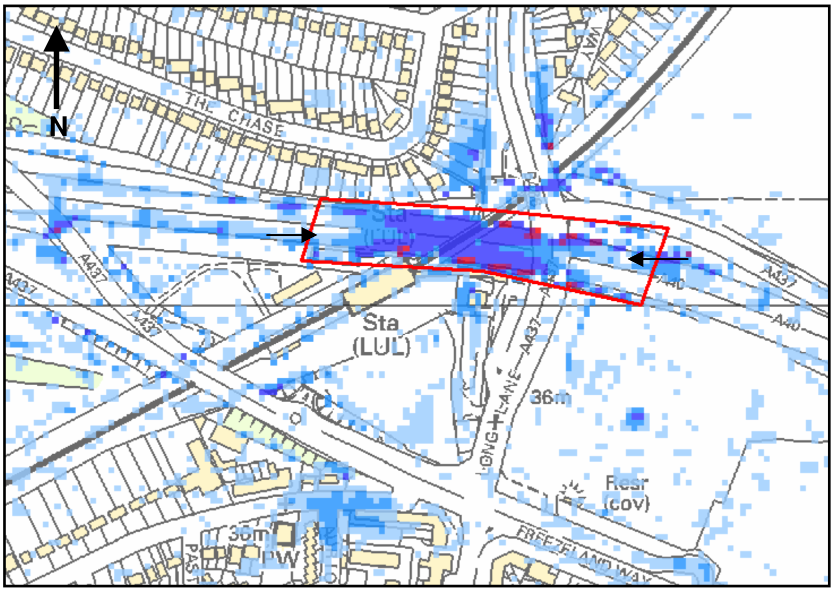
Description: This section of rail line is located in a cutting and is therefore a topographical low point within the catchment. Runoff from higher ground is predicted to drain towards the rail line and pond. No drainage infrastructure information was provided for the study and therefore it is not known if any flood management measures (flood storage, pumps etc) are in place for the rail line. . Drainage from a northern Thames Water drainage catchment appears to discharge to an existing drainage ditch running parallel to the railway (along its southern boundary).

This railway line has been considered as critical transport infrastructure considered regionally important as it includes the London underground Metropolitan and Piccadilly Lines westward out of London.

Validation The Drain London modelling results show increased flood depths compared to the EA AStSWF maps, however the extents appear similar. This may be a result of the Drain London modelling in this area modelling a continuous flow path along the railway corridor, whereas the EA model may have trapped water upstream of this area as no structures were included in their model.

CDA: Group1_022

Location: A40 (Western Avenue) underpass beneath the London Underground Hillingdon Station and track and A437 (Long Lane) overpass (below).



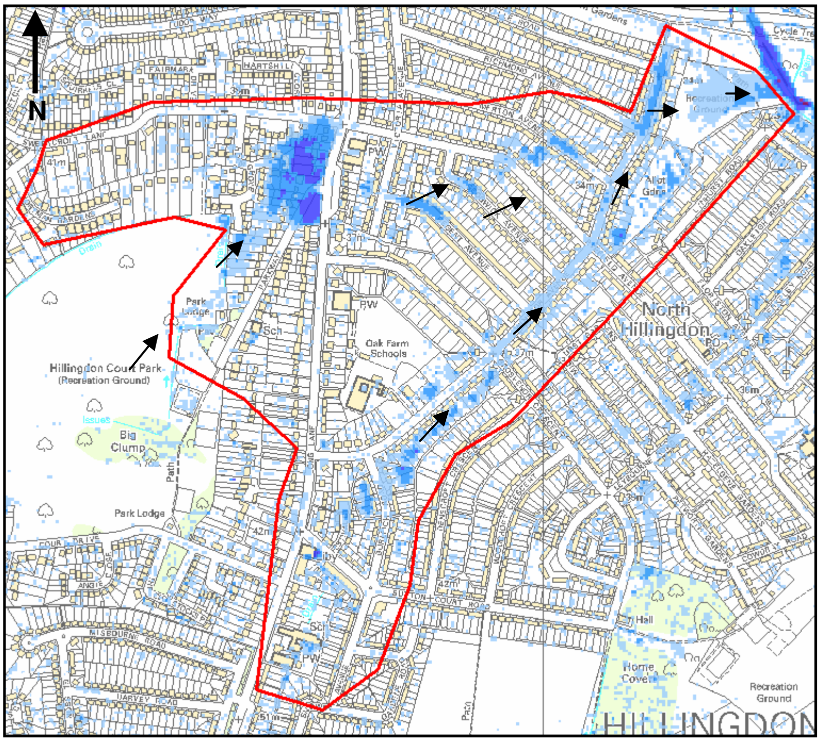
Description: Surface water is predicted to ponds in the local topographical low point located within this section of the A40 below the A437 overpass. There is no Thames Water drainage in the section of the A40 in this location and therefore it is unclear how this location drains.

As no drainage network was provided to the Drain London study from TfL, and therefore any benefits from mitigation/ managements measures cannot be determine at this stage. Hazards ratings vary between moderate and extreme due to the predicted flood depths within the CDA.

Validation: There is a good correlation between the EA AStSWF Maps for both 1 in 30 year and 1 in 200 year rainfall events.

CDA: Group1_023

Location: Parkway/Sweetcroft Lane, North Hillingdon (below)

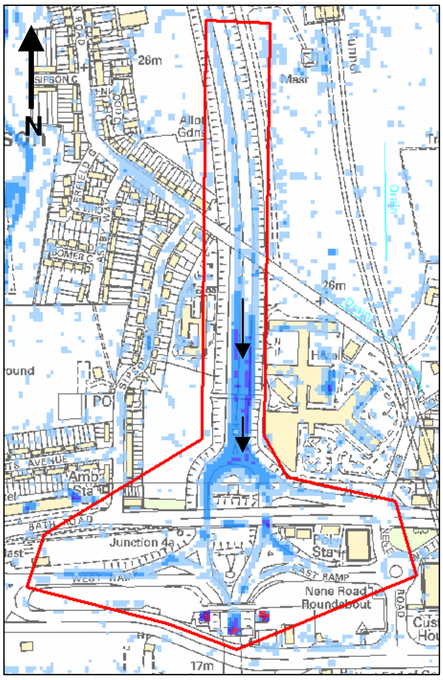


Description: Surface water runoff from the Hillingdon Court Park area is predicted to flow towards the intersection of Parkway and Sweetcroft Lanes. Elevations along Long Lane are greater than the flooded areas, preventing water from propagate further. Ponding occurs in the Windsor Avenue/Granville Road area due to topography.

Depths of water surrounding residential properties are between 0.3m and 0.8m for the 100 year flood event. At these depths of water, there is a notable risk to human life. Depths of water along Parkway reach 0.6m. Under these conditions, the road is likely to be impassable to vehicles.

The EA AStSWF mapping has a good correlation with the model results. Hillingdon Council advise that this area is prone to flooding when the drain is blocked.

CDA: Group1_024



Location: M4, Heathrow Airport (right)

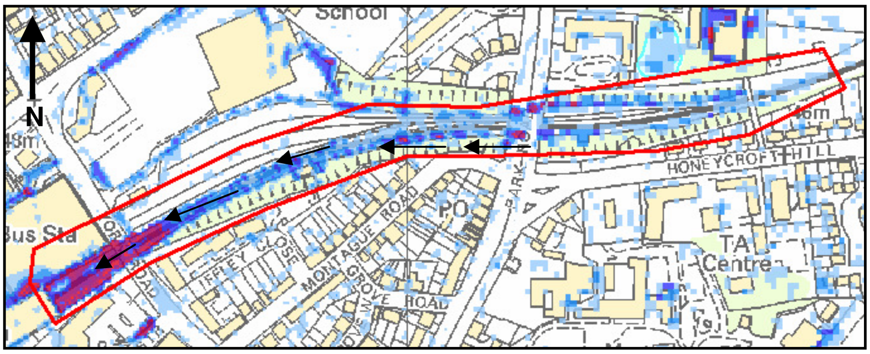
Description: Surface water ponds in the low point on the M4, just north of the underpass. No Thames Water drainage is located within this section of the M4 and it is assumed that this is managed by the Highways Agency – no drainage plans were provided as part of this study. . This motorway is considered critical transport infrastructure of national significance, as this route is part of the access road to Heathrow Airport.

The hazard is predicted to range between moderate and significant as a result of the depth of ponding within the CDA.

Validation: There is good correlation between the extents and depths of the EA AStSWF Maps and the predicted Drain London model results.

CDA: Group1_025

Location: Uxbridge Station and London Underground Line (below)

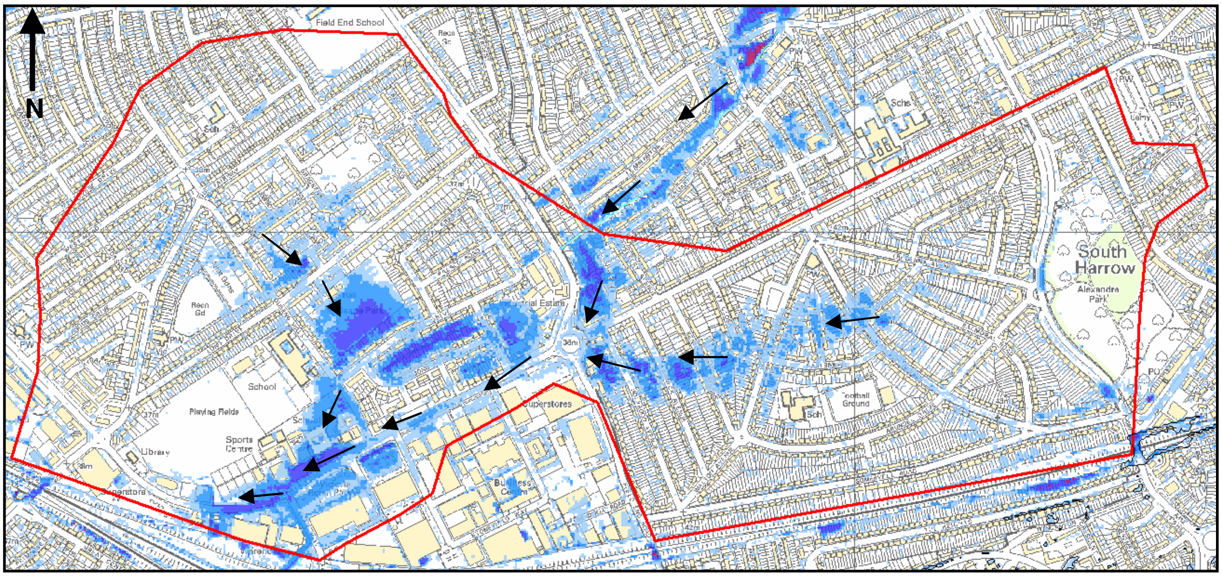


Description: The station is located in an area of ground which is lower than the surrounding area – the model results indicate the flood waters may be obstructed by higher ground levels neat the platforms and station. The current surface water drainage infrastructure is unknown as it has not been provided by TfL for this site. This section of railway is considered critical transport infrastructure of regional significance. The hazard is predicted to vary between significant to extreme depending on the predicted flood depths.

The Drain London modelling results show a larger flood extent and depth compared to the EA AStSWF maps. This may be a result of the Drain London modelling including a continuous flow path to the station, whereas the EA model may have trapped water upstream of this area as the model does not include any structures. There are no supporting records of historic flooding.

CDA: Group1_027

Location: Properties located along Diamond Road and Jubilee Drive, the Victoria Road Retail Park, and the Industrial Estate along Princes Way (below).



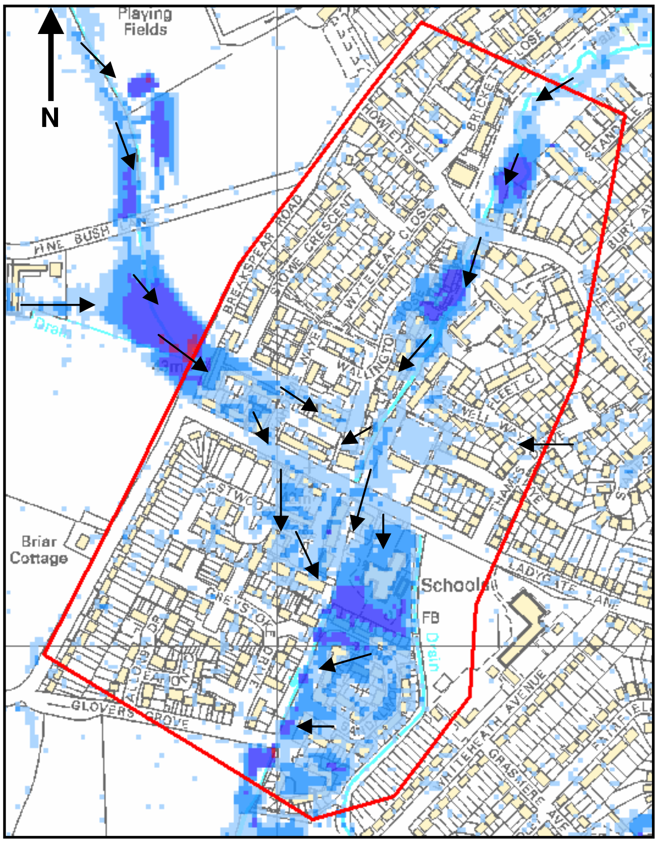
Description: The industrial estate on Princes Way and the residential properties along Diamond Road and Jubilee Drive, are flooded as a result of overland flow from Harrow Borough to the east. Surface water is observed to flow along two natural valley/lost waterways (one is the culverted Yeading Brook [East Arm]) in Harrow before overtopping Field End Road. The Victoria Retail Park and Queensmead School on Victoria Road are also flooded as a result of this flowpath as well as from contributing overland flow from the north, through Deane Park.

Depths of water along Victoria Road reach up to 0.7m in the 1 in 100 year rainfall event. The road is unlikely to be passable to traffic at these depths. The rear gardens of several properties along Diamond Road and Jubilee Drive are predicted to flood between 0.5 – 0.8m. The majority of the CDA will have a low hazard however, along the overland flow path and areas of ponding it is predicted that the flood hazard will vary between moderate to significant.

Validation: The modelled results correlate reasonably well with the EA AStSWF maps for both the 1 in 30 year and 1 in 200 year events.

CDA: Group1_028

Location: Lady Gate Lane, Ruislip (below)



Description: Overland flow accumulates near the intersection of Ladygate Lane and Breakspear Road (from runoff channels through the Mad Bess Brook and an unnamed drain), it ponds until the road level is reached and then overtops the road and flows in an easterly direction. The runoff flows down Ladygate Lane before flooding properties to the south. Flooding may also occur due to the culvert backing up on the upstream face of the Cannon Brook and forming an obstruction to flow which then overtops Ladygate Lane and contributes the predicted flooding of properties around Sandalwood Drive.

The predicted modelled hazards results indicate that the majority of the CDA is within a low flood hazard. However, this increases to a moderate and significant hazard within the overland flow paths and areas of ponding.

Validation: There is good correlation between the modelling results and the EA AStSWF maps for 1 in 200 year event. 1 in 30 year event also shows good correlation with deep areas with some discrepancies within the shallow extents – as these are predicted to be larger within the Drain London. During a model validation meeting with the LB of Hillingdon, this area was identified as a CDA which has previously flooded.

3.9 Summary of Risk

3.9.1 Table 3-1 (below) identifies the surface water flood risk to infrastructure, households and commercial/industrial receptions. The table is a summary of the information submitted to the Drain London Board in the Prioritisation Matrices for each CDA.

Table 3-1: Summary of Surface Water Flood Risk in CDAs in the London Borough of Hillingdon

CDA ID	Scheme Location	Moderation		Infrastructure						Households								Commercial / Industrial				Validation
				Essential		Highly Vulnerable		More Vulnerable		Non-Deprived (All)		Non-Deprived (Basements)		Deprived (All)		Deprived (Basements)		All		Basements Only		
		Primary	Secondary	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	
Group1_005	Yeading Lane, Southall	Environmental	Health and Safety	1	0	1	0	4	0	452	0	0	0	113	0	0	0	1	0	0	0	Validated
Group1_012	Hinkley Close, South Harefield	Environmental	Health and Safety	1	0	1	0	0	0	107	0	0	0	0	0	0	0	0	0	0	0	Validated
Group1_013	Railway line near Copthall Covert (Skip Lane)	Nationally / strategically important infrastructure	Health and Safety	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Validated
Group1_014	Section of the M4 north of Heathrow Airport	Nationally / strategically important infrastructure	Health and Safety	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Validated
Group1_015	Kingston Avenue, Yiewsley	Environmental	Health and Safety	2	0	1	0	0	0	593	19	0	0	0	0	0	0	14	0	0	0	Validated
Group1_016	Northwood Station	Nationally / strategically important infrastructure	Deliverability	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Validated
Group1_017	Aragon Drive, Ruislip	Environmental		0	0	0	0	0	0	172	1	0	0	0	0	0	0	1	0	0	0	Validated
Group1_018	Clyfford Road, Ruislip	Health and Safety		2	1	0	0	1	0	921	1	0	0	0	0	0	0	16	0	0	0	Validated
Group1_019	A40 South Ruislip	Regionally Important Infrastructure	Health and Safety	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Validated
Group1_020	A312 underpass at A4020 flyover	Regionally Important Infrastructure	Health and Safety	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Validated
Group1_021	London Underground rail Line east of Ickenham Stations	Regionally Important Infrastructure	Environmental	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Validated
Group1_022	A40 (Western Avenue) underpass Hillingdon LUL track and A437 (Long Lane)	Regionally Important Infrastructure		1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Validated
Group1_023	Parkway, North Hillingdon	Health and Safety	Environmental	0	0	0	0	2	0	376	0	0	0	0	0	0	0	7	0	0	0	Validated
Group1_024	Section of the M4 leading to Heathrow Airport	Nationally / strategically important infrastructure	Health and Safety	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Validated
Group1_025	Uxbridge Station London Underground Line	Regionally Important Infrastructure	Health and Safety	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Validated
Group1_027	Victoria Retail Park, Ruislip	Health and Safety	Environmental	1	1	1	0	2	0	1290	4	0	0	0	0	0	0	13	0	0	0	Validated
Group1_028	Lady Gate Lane, Ruislip	Health and Safety	Environmental	0	0	0	0	1	0	353	5	0	0	0	0	0	0	1	0	0	0	Validated

4 Phase 3: Options

4.1 Objectives

4.1.1 The purpose of Phase 3 is to identify a range of structural and non-structural measures (options) with the potential to alleviate flood risk and to then assess each option in order to eliminate those that are not feasible or do not make economic sense. The remaining options will then be developed and tested against their relative effectiveness, benefits and costs. The target level of flood protection from surface water flooding has been set at 1 in 75 years. This aligns with the likely level of flood protection necessary to enable commercial insurance cover to be provided to the general public.

4.1.2 The option identification will take place on an area-by-area (site-by-site) basis following the process established in Phase 2. The options assessment will assess measures for each CDA in turn..

4.1.3 Further detailed analysis may occur for high priority CDAs, as defined by the Prioritisation Matrix, within the next Tier (Tier 3) of the Drain London project.

4.2 Measures

4.2.1 Surface water flooding is often highly localised and complex. Its management is therefore highly dependent upon the characteristics of the critical drainage area and there are few solutions which will provide benefits in all locations. This section outlines potential measures which have been considered for mitigating the surface water flood risk within LB of Hillingdon.

4.2.2 The SWMP Plan Technical Guidance (Defra 2010) identifies the concept of Source, Pathway and Receptor as an appropriate basis for understanding and managing flood risk. Figure 4-1 identifies the relationship between these different components, and how some components could be considered within more than one category.

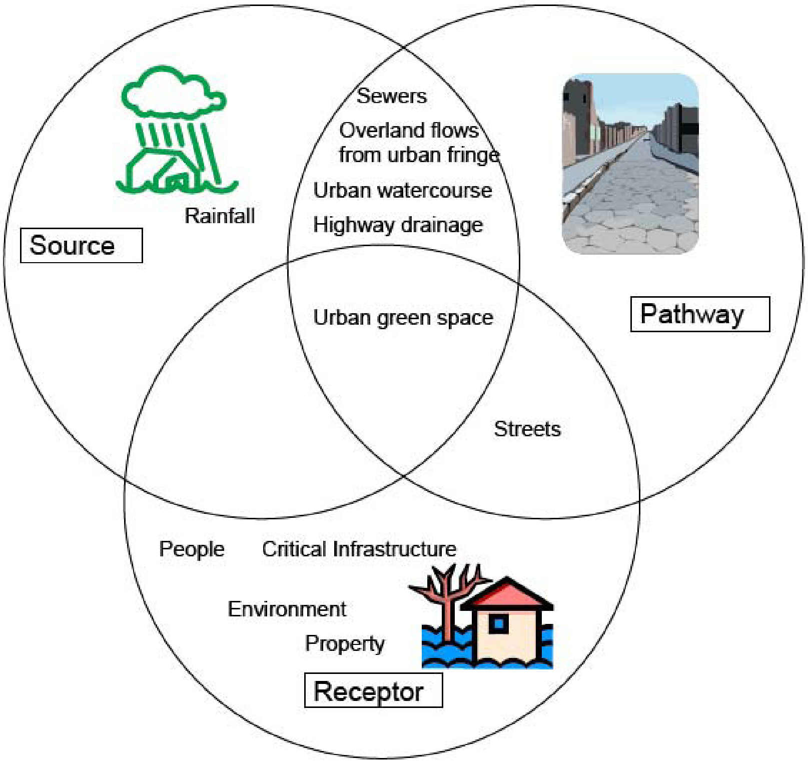


Figure 4-1 Illustration of Sources, Pathways & Receptors (extracted from SWMP Technical Guidance, Defra 2010)

4.2.3 When identifying potential measures it is useful to consider the source, pathway, receptor approach (refer to Figure 4-1and Figure 4-2). Both structural and non-structural measures will be considered in for the identified CDAs.

Structural measures can be considered as those which require fixed or permanent assets to mitigate flood risk (such as a detention basin, increased capacity pipe networks).

Non-structural measures may not involve fixed or permanent facilities, and the benefits to of flood risk reduction is likely to occur through influencing behaviour (education of flood risk and possible flood resilience measures, understanding the benefits of incorporating rainwater reuse within a property, planning policies etc).

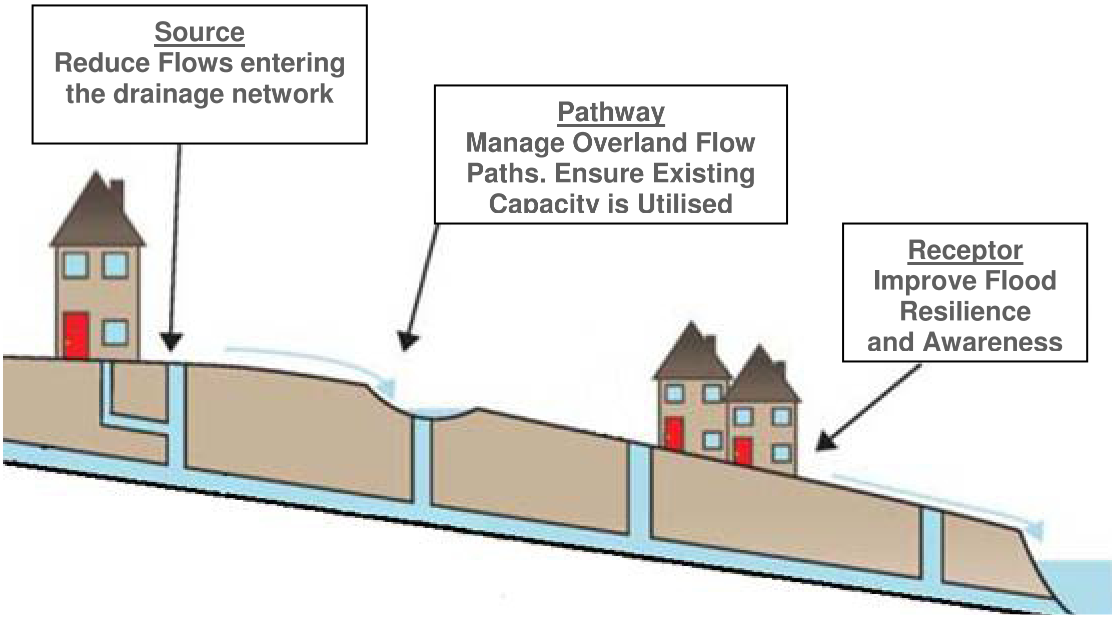


Figure 4-2 Source, Pathway and Receptor Model (adapted from Defra SWMP Technical Guidance, 2010)

Methods for managing surface water flooding can be divided into methods which influence either the Source, Pathway or Receptor, as described below, (refer to Table 4-1, overleaf.):

- Source Control: Source control measures aim to reduce the rate and volume of surface water runoff through increasing infiltration or storage, and hence reduce the impact on receiving drainage systems. Examples include retrofitting SuDS (e.g Bioretention basins, wetlands, green roofs etc) and other methods for reducing flow rates and volume.

- Pathway Management: These measures seek to manage the overland and underground flow pathways of water in the urban environment, and include: increasing capacity in drainage systems; separation of foul and surface water sewers etc.

- Receptor Management: This is considered to be changes to communities, property and the environment that are affected by flooding. Mitigation measures to reduce the impact of flood risk on receptors may include improved warning and education or flood resilience measures.

Table 4-1 Typical Surface Water Flood Risk Management Measures

	Generic measures	Site specific measures
	• Do Nothing (do not continue maintenance) • Do Minimum (continue current maintenance)	
Source control	• Bioretention carpark pods • Soakaways, water butts and rainwater harvesting • Green roofs • Permeable paving • Underground storage; • Other 'source' measures	• Swales • Detention basins • Bioretention basins; • Bioretention carpark pods; • Bioretention street planting; • Ponds and wetlands
Pathway Management	• Improved maintenance regimes • Increase gulley assets	• Increase capacity in drainage system • Separation of foul & surface water sewers • Managing overland flows • Land Management practices • Other 'pathway' measures
Receptor Management	• Improved weather warning • Planning policies to influence development • Social change, education and awareness • Improved resilience and resistance measures • Raising Doorway/Access Thresholds' • Other 'receptor' measures	• Temporary or demountable flood defences - collective measure

4.3 Proposed Surface Water Drainage Policy

4.3.1 It should be acknowledged that the CDAs only account for a small portion of the areas that could be affected by surface water flooding. The CDAs are the areas where the impact of surface water flooding is expected to be greatest but it is recommended that the Council implement policies which will reduce the flood risk from surface water flooding throughout the borough and promote Best Management Practises to the implementations of SuDS and the reduction of runoff volumes.

4.3.2 The SWMP Action Plan (discussed in Section 5) will recommend a number of policies that will be included in the Local Development Framework to help reduce the flood risk within the Borough:

5 Phase 4: Implementation and Review

5.1 Action Plan

5.1.1 An Action Plan will be created for each LLFA within the Drain London area. The Action Plan is a summary spreadsheet that has been formulated by reviewing the previous phases of the SWMP in order to create a useful set of actions relating to the management and investigation of surface water flooding going forward. The Action Plan will be a live document, maintained and regularly updated by the Borough, as actions are progressed and investigated.

5.1.2 Table 5-1 (overleaf) outlines the Action Types that will be used to categorise actions in the Action Plan and a summary of their status.

Table 5-1 Summary of Actions within the Action Plan

Action Type	Description	Status
Flood and Water Management Act / Flood Risk Regulations	Duties and actions as required by the FRR and FWMA - Refer to Appendix A of the LGG 'Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management' (February 2011) for minimum requirements.	LB Hillingdon is currently progressing its responsibilities with regards to the FWMA and FRR, and is in the process of drafting a Strategy
Policy Action	Spatial planning or development control actions.	LB Hillingdon is currently ensuring that all recommendations in the SWMP are taken forward into the next stages of its Local Development Framework
Communication / Partnerships	Actions to communicate risk internally or externally to LLFA or create / improve flood risk related partnerships	LB Hillingdon is working with the North West London Flood Risk Partnership to share resources, As a first stage to improve communication is currently drafting flood risk information to publish to the public the first part of which is the publishing of this document.
Financial / Resourcing	Actions to secure funding internally / externally to support works or additional resources to deliver actions	LB Hillingdon is working hard to secure funding to deliver flood risk works for a number of key schemes identified within the borough.
Investigation / Feasibility / Design	Further investigation / feasibility study / Design of mitigation	LB Hillingdon is in the process of further investigation to establish appropriate future mitigation works.
Flooding Mitigation Action	Maintenance or capital works undertaken to mitigate flood risk	LB Hillingdon is currently progressing works to mitigate flooding

5.1.3 For clarity it is noted that the FWMA places immediate or in some cases imminent new responsibilities on Lead Local Flood Authorities, of which LB Hillingdon is one. The main actions required are contained in the Action Plan but are also summarised below:

- Develop, maintain, apply and monitor a Strategy for local flood risk management of the area.
- Duty to maintain a local flood risk asset register.
- Investigate flood incidents and record in a consistent manner.
- Establish a SuDS Approval Body (SAB).
- Contribute towards achievement of sustainable development.
- On-going responsibility to co-operate with other authorities through sharing of data and expertise.

- Preparation of flood risk management plans.

5.2 Review Timeframe and Responsibilities

5.2.1 Following the production of this first part of the SWMP and evidence base the Council will prepare an action plan. The proposed actions will be classified into the following categories:

- Short term; Actions to be undertaken within the next six months
- Medium term: Actions to be undertaken within the next year.
- Long term. Actions to be undertaken beyond the first year of implementation.

5.2.2 The Action Plan identifies the relevant internal departments and external partnerships that should be consulted and asked to participate when addressing an action. After an action has been addressed, it is recommended that the responsible department (responsible for completing the action) review the Action Plan and update it to reflect any issues (communication or stakeholder participation) which arose during the completion of an action and whether or not additional actions are required.

- It is recommended that the Action Plan is reviewed and updated on a quarterly basis to reflect any necessary amendments. In order to capture the works undertaken by the Council and other stakeholders, it is recommended that the Action Plan review should not be greater than an annual basis.

5.3 Ongoing Monitoring

5.3.1 The partnership arrangements established as part of the SWMP process (e.g., LB of Hillingdon, neighbouring Boroughs, EA and TWUL, etc, working in collaboration) should continue beyond the completion of the SWMP in order to discuss the implementation of the proposed actions, review opportunities for operational efficiency and to review any legislative changes.

5.3.2 In addition, maintaining the working partnership between the 'Group 1' group of Boroughs is recommended in order to gain an understanding of flood risk across the boroughs and to share best practice management procedures.

5.3.3 The SWMP Action Plan should be reviewed and updated annually as a minimum, but there may be circumstances which might trigger a review and/or an update of the Action Plan in the interim,in fact Action Plan updates may be as frequent as every few months. Examples of something which would be likely to trigger an Action Plan review include::

- Occurrence of a surface water flood event;
- Additional data or modelling becoming available, **which may alter the understanding of risk within the study area**;
- Outcome of investment decisions by partners is different to the preferred option, which may require a revision to the action plan, and;
- Additional (**major**) development or other changes in the catchment which may affect the surface water flood risk.

5.3.4 It is in the interest of LB of Hillingdon that the SWMP Action Plan remains current and up-to-date. To help facilitate this, it would be useful for the LB of Hillingdon to liaise with other flood risk management authorities and monitor progress.

5.4 Incorporating new datasets

5.4.1 The following tasks should be undertaken when including new datasets in the LB of Hillingdon SWMP:

- Identify new dataset.
- Save new dataset/information.
- Record new information in log so that next update can review this information.

5.5 Updating SWMP Reports and Figures

5.5.1 In recognition that the SWMP will be updated in the future, the report has been structured in chapters according to the SWMP guidance provided by Defra. By structuring the report in this way, it is possible to undertake further analyses on a particular source of flooding and only have to supersede the relevant chapter, whilst keeping the remaining chapters unaffected.

5.5.2 In keeping with this principle, the following tasks should be undertaken when updating SWMP reports and figures:

- Undertake further analyses as required after SWMP review
- Document all new technical analyses by rewriting and replacing relevant chapter(s) and appendices.
- Amend and replace relevant SWMP Maps.
- Reissue to departments within the LB of Hillingdon and other stakeholders.

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