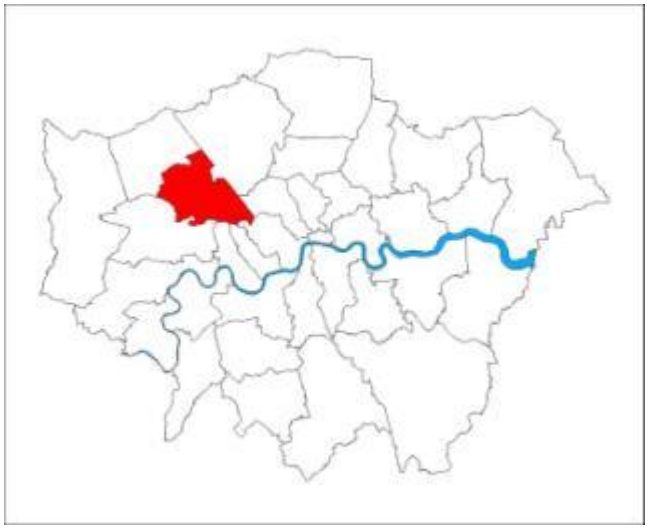
SURFACE WATER MANAGEMENT PLAN
Volume 1



GREATERLONDONAUTHORITY

DRAIN LONDON

LONDON BOROUGH OF BRENT

Thames Water

LONDON COUNCILS

Environment Agency

BRENT COUNCIL

Hyder Consulting (UK) Limited
2212959
Aston Cross Business Village
50 Rocky Lane
Aston
Birmingham B6 5RQ
United Kingdom
Tel: +44 (0)121 345 9000
Fax: +44 (0)121 359 6674
www.hyderconsulting.com

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AUTHOR

Name	Organisation and Role
A McNally	Hyder Consulting (UK) Ltd, Consultant
C Gibson	Hyder Consulting (UK) Ltd, Hydrologist

APPROVALS

Name	Title	Signature	Date
L Foster	PM Hyder Consulting (UK) Ltd		12/10/2011
E Harris	PD Hyder Consulting (UK) Ltd		14/10/2011

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Executive Summary

This document forms the Surface Water Management Plan (SWMP) for the London Borough of Brent which has been delivered as part of the Tier 2 package of works of the Drain London Project. This document is a plan which outlines the preferred surface water management strategy for the London Borough of Brent and includes consideration of flooding from sewers, drains, groundwater and runoff from land, small watercourses and ditches that occurs 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; Phase 1 – Preparation; Phase 2 – Risk Assessment; Phase 3 – Options; and Phase 4 – Implementation and Review.

Phase 1 - Preparation

Phase 1 builds upon work formerly undertaken during Tier 1 of the Drain London Project to collect and review surface water data from key stakeholders and build partnerships between stakeholders responsible for local flood risk management. As part of the Drain London project, the London Borough of Brent has been grouped with the London Boroughs of Barnet and Harrow to undertake Tier 2 of the project and work together to understand local flood risk.

The London Borough of Brent has begun the process to establish a broader partnership with neighbouring London Boroughs in north west London, through the establishment of the West London Strategic Flood Group, in order for these local authorities to pool 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 London Borough of Brent, 27 CDAs have been identified; these are shown in Figure 1. The chief mechanisms for flooding in the London Borough of Brent can be broadly divided into the following categories:

- *River Valleys* - Across the study area, the areas particularly susceptible to overland flow are formed by the river valleys of the River Brent and Wealdstone Brook, and / or along narrow corridors associated with topographical valleys which represent the routes of the ‘lost’ rivers of London including the Wembley Brook and other unnamed surface water connections, including lost tributaries to the River Westbourne.
- *Low Lying Areas* - areas such as underpasses, subways and lowered roads beneath railway lines are more susceptible to surface water flooding;
- *Railway Cuttings* - several stretches of mainline railway track (in cuttings) are susceptible to surface water flooding and, if flooded, will impact services into and out of Euston and Marylebone Railway Stations from northwest London and beyond;

- 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 Borough); 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 including the areas around Kenton, Maida Vale, North Wembley and Willesden;
- Fluvial Flood Risk – areas where extensive and deep surface water flooding is likely to be the influence of fluvial flooding mechanisms (alongside pluvial, groundwater and sewer flooding sources) including Kenton, Stonebridge, Tokyngton, Wembley Park.

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 (1% Annual Exceedance Probability, AEP). A review of the results demonstrate that approximately 70,000 residential properties and 8,000 non-residential properties in the London Borough of Brent could be at risk of surface water flooding of greater than 0.1m depth during a 1% AEP rainfall event. Of those, approximately 350 residential properties and 80 non-residential properties could be at risk of flooding to a depth of greater than 0.5m during the same event.

Further subdivision of the areas is included within the report highlighting the CDAs showing to be at the greatest risk of flooding in terms of the number of receptors at risk, however these are not presented in the Executive Summary, as there is the potential for them to be misused in comparisons with other London Boroughs CDAs to rank the areas at greatest risk. This should be avoided as each of the Drain London Tier 2 groups undertook different approaches to delineating the size and coverage of the CDAs based upon the guidelines for undertaking the works.

Within the London Borough of Brent, the greatest number of receptors are at risk from surface water flooding along the route of the urban valleys representing the ‘lost’ watercourses across the Borough, which generally link closely with the sewerage network assets installed as part of the West Middlesex Drainage Scheme in the 1930’s, which run through the area to join up with the main Rivers crossing the Borough (Wealdstone Brook and the River Brent)

A number of CDAs within the London Borough of Brent are cross boundary, and as such will need to be jointly managed to implement the potential options and manage surface water flood risk in these areas.

Phase 3 - Options Assessment

There are a number of opportunities for measures to be implemented across the Borough to tackle surface water flood risk. 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 London Borough of Brent 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 Development Management Policy works including the potential 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 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 have been identified that could be considered to help alleviate surface water flooding. These measures were subsequently short listed to identify a potential preferred option for each CDA.

Pluvial modelling undertaken as part of the SWMP has identified that flooding within the London Borough of Brent is heavily influenced by existing and historic river valleys, and impacts a number of regionally important infrastructure assets. To address local flood risk in the London Borough of Brent it is recommended that, in the short to medium-term, Brent Borough Council:

- Monitor the developing Drainage Capacity Study in the Wembley Development area in conjunction with Thames Water to determine local drainage capacity, connections and identify flood mitigation options through detailed modelling;
- Undertake a feasibility study to re-green areas of the Borough to help attenuate surface water downstream in the Brent catchment, identified as a potential 'Quick Win' scheme;
- Confirm the resilience of infrastructure to surface water flooding through engaging with energy operators, TfL and Network Rail regarding the surface water flood risk to key infrastructure including TfL red routes, key railway infrastructure (railway cuttings and stations) identified to flood throughout the Borough respectively, and confirming the drainage assumptions used within the SWMP pluvial modelling;
- Contribute to discussions and opportunities to help reduce the surface water elements within the areas that contribute to the Counter's Creek Flood Alleviation Scheme catchment, with TWUL, including seeking and promoting 'pilot' projects to test and reduce the surface water contributions through promotion of source control and other sustainable drainage measures, and;
- Ensure that opportunities for flood storage and source control are prioritised through any new development across the area, and seek opportunities for joint funding of improvement schemes through any redevelopment / local businesses

Borough wide, it is recommended that the London Borough of Brent:

- Improve the current process and protocols for flood risk management and drainage and integrate these within the Council's operations, to include improvements in asset management, recording of flooding incidents, liaison with other functions across the council
- Initiate development forums with those planning to deliver all forms of development within the borough to present the risks and the aspirations of the Borough. These could be used to encourage the developers to achieve the items identified in the potential planning policy section of the Action Plan. This is important to capture new land that may come available subsequent to the Core Strategy.
- 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 London Borough of Brent 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 establishes a long-term Action Plan for London Borough of Brent to assist in their role under the FWMA 2010 to lead in the management of surface water flood risk across the Borough. The purpose of the Action Plan is to:

- Outline the actions required to implement the preferred options identified in Phase 3;
- Identify the partners or stakeholders responsible for implementing the action;
- Provide an indication of the priority of the actions and a timescale for delivery; and,
- Outline actions required to meet the requirements for London Borough of Brent as LLFA under the FWMA 2010.

The SWMP Action Plan is a 'living' document, and as such, should be reviewed and updated regularly, 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 affect the surface water flood risk.

CONTENTS

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
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
Catchment Flood Management Plan	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
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
CIRIA	Construction Industry Research and Information Association
Civil Contingencies Act	This Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums must 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	Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model
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.
DTM	Digital Terrain Model
EA	Environment Agency
Indicative Flood Risk Areas	Areas determined by the Environment Agency as indicatively 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.
FCERM	Flood and Coastal Erosion Risk Management -
FMfSW	Flood Map for Surface Water
Flood defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).

Term	Definition
Flood Forum	A charity that provides support and advice to communities and individuals that have been flooded or are at risk of flooding. It is a collective, authoritative voice that aims to influence central and local government and all agencies that manage flood risk.
Flood Risk Area	An area determined as having a significant risk of flooding in accordance with guidance published by Defra and WAG.
Flood Risk Regulations (FRR)	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	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.
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a main river
IDB	Internal Drainage Board
IUD	Integrated Urban Drainage
LB	London Borough
LDF	Local Development Framework
Local Flood Risk Zone (LFRZ)	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 (LLFA)	Local Authority responsible for taking the lead on local flood risk management
LiDAR	Light Detection and Ranging
Local Resilience Forum (LRF)	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.
LPA	Local Planning Authority
Main River	A watercourse shown as such on the Main River Map, and for which the Environment Agency has responsibilities and powers
NRD	National Receptor Dataset – a collection of risk receptors produced by the Environment Agency
Ordinary Watercourse	All watercourses that are not designated Main River, and which are the responsibility of Local Authorities or, where they exist, IDBs
Partner	A person or organisation with responsibility for the decision or actions that need to be taken.
PFRA	Preliminary Flood Risk Assessment
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.

Term	Definition
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.
PPS25	Planning and Policy Statement 25: Development and Flood Risk
PA	Policy Area
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
RBMP	River Basin Management Plan
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, and the consequence of the flood.
Risk Management Authority	As defined by the Floods and Water Management Act
RMA	Risk Management Authority
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
SFRA	Strategic Flood Risk Assessment
SMP	Strategic Management Plan
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.
SuDS	Sustainable Drainage Systems
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.
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
TfL	Transport for London
TWUL	Thames Water Utilities Ltd
WaSC	Water and Sewerage Company

1 Introduction

1.1 What is a Surface Water Management Plan?

A Surface Water Management Plan (SWMP) is a plan 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 watercourses and ditches that occurs as a result of heavy rainfall.

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.

This document also establishes 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. Future iterations will be required to help address the historical decisions and to help achieve stronger Water Quality drivers associated with surface water management.

1.2 Background

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 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 other sources of flood risk were unclear. To give the issue even greater urgency it is widely expected that heavy storms will increase in frequency with climate change.

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).

DEFRA recognised the importance of addressing surface water flooding in London and fully funded the Drain London project to produce Surface Water Management Plans (SWMPs) for each London Borough. The Drain London project is broken down using a ‘tier’ based approach as shown in Figure 1-1.

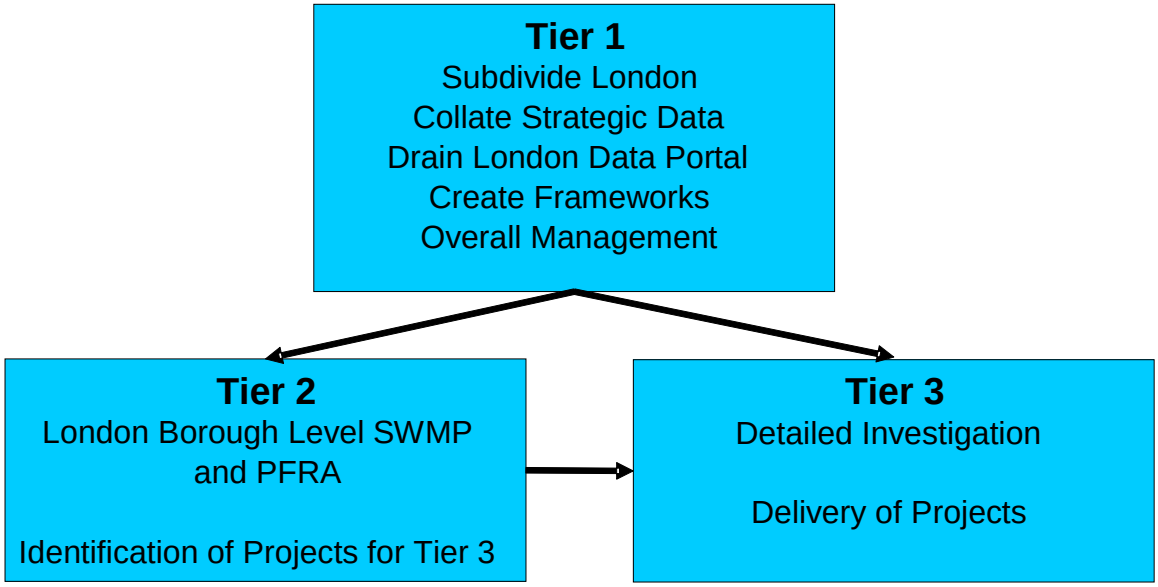

Figure 1-1 Drain London Project 'Tier' Structure

Table 1-1 below further describes the activities undertaken in each of the Tiers. The management groups are shown in Figure 1-2. This SWMP report is a direct output from Tier 2.

Tier	Summary
Tier 1	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. Collection and collation of relevant information across all London Boroughs and strategic stakeholders including the Environment Agency, Thames Water and Transport for London. 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. Develop technical framework documents and prioritisation tools to guide delivery of Tiers 2 and 3.
Tier 2	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. Delivery of 33 Borough-level Preliminary Flood Risk Assessments to comply with the Flood Risk Regulations 2009 requirements for Lead Local Flood Authorities (LLFAs). 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	Summary
Tier 3	Further investigations into high priority Local Flood Risk Zones/Critical Drainage Areas to further develop and prioritise mitigation options. Delivery of demonstration projects of surface water flood mitigation solutions identified in Tier 2 SWMPs. Funding or co-funding within the London area for green roofs and other types of sustainable urban drainage (SUDS). Set up of at least 2 community flood plans in local communities at risk from flooding

Table 1-1 Summary of 'Tier' Activities

Through the subsequent enactment of the Flood Risk Regulations boroughs are also required to produce Preliminary Flood Risk Assessments (PFRA). The Drain London project has been adjusted to deliver both a PFRA and an SWMP for each London Borough. This will be a major step in meeting borough requirements as set out in the FWMA. Another key aspect of the Act is to ensure that boroughs work in partnership with other Lead Local Flood Risk Authorities (LLFA). Drain London has assisted this by creating sub-regional partnerships as set out in Figure 1-2.

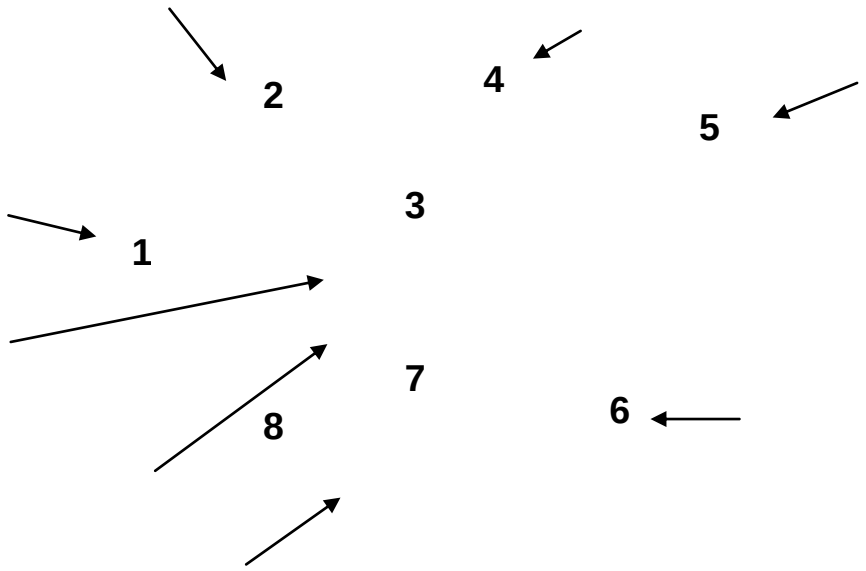

Figure 1-2 Drain London sub-regional partnerships

This current round of SWMP development has been predominantly focused on delivering improvements in understanding and awareness of the risks associated with surface water flooding. However, the management of surface waters should not be wholly focussed on quantity improvements as better and more sustainable approaches will help to deliver multiple benefits, including the ability to help improve the health and quality of the water within the watercourses.

Further works are required to help redress the issues resulting from the development across LBB and as such water quality improvements should feature high within the current Action Plan and future iterations of the SWMP. Furthermore, specific studies should be commenced to help deliver these requirements to help address additional drivers, such as the Water Framework Directive.

1.3 Objectives

The objectives of the SWMP are to:

- 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;
- 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;
- 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;
- Undertake engagement with stakeholders to raise awareness of surface water flooding, identify flood risks and assets, and agree mitigation measures and actions;
- Deliver outputs through a robust Action Plan and guidance that will help deliver change on the ground rather than just reports and models, whereby partners and stakeholders take ownership of their flood risk and commit to delivery and maintenance of the recommended measures and actions;
- Meet Borough specific objectives as recorded at the outset of the development of the SWMP (further details below);
- 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.

Borough specific aims and objectives were discussed at the various meetings held throughout the development of the SWMP. These are summarised below:

- Identify known flood risk hotspots, based upon historic flood incidents.
- Identify high vulnerability areas, based upon regionally and locally important assets.
- Identify new areas of potential flood risk, based on strategic mapping of the area.
- Develop a strategic-scale SWMP action plan for the London Borough of Brent (LBB) including spatial and emergency planning recommendations.
- Develop an action plan that is clear and easy for the LBB and other relevant stakeholders to understand and implement.

1.4 Study Area

The Brent SWMP study area covers approximately 4,310 hectares of North West London (Figure 1-3). The study area includes the urban areas of Brondesbury Park, Kensal Rise, Kenton, Kilburn, Kingsbury, Sudbury, Wembley and Willesden.

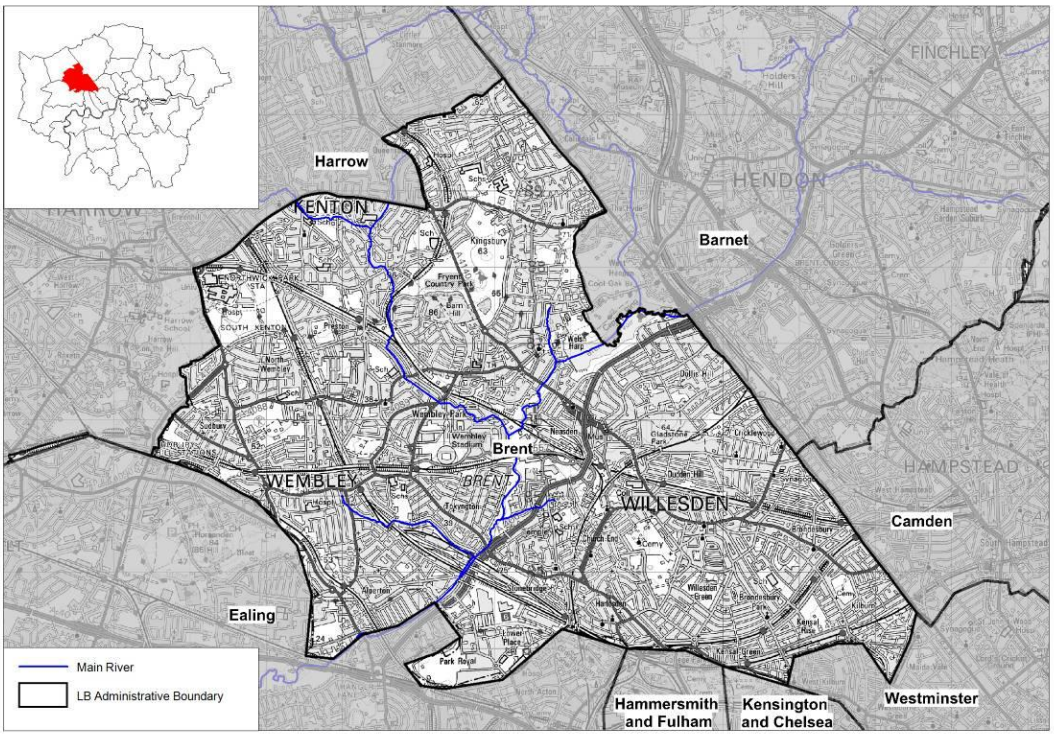

Figure 1-3 Location Plan Brent

Brent is bordered by the London Boroughs of Barnet, Camden, Westminster, Kensington and Chelsea, Hammersmith and Fulham, Ealing and Harrow.

The study area falls within the Thames River Basin District and is served by one water only company – Veolia Water Central Limited and one Water and Sewerage Company - Thames Water Utilities Limited. The study area is served by the Environment Agency South East Region and is part of the Thames Regional Flood and Coastal Committee. The LBB shares a member with Barnet, Ealing, Harrow, Hillingdon and Hounslow on the Thames Region Flood and Coastal Committee. The Environment Agency has proposed that the same Borough grouping should form the West London Flood Risk Management Board (see Figure 2-1).

1.4.1 Topography & Land Use

Within the LBB there are several areas of high ground which range from 75 – 65 m AOD. These ridges of high ground divide the borough up into two main river catchments. The River Brent intersects the borough running from the north-east to south-west and the Wealdstone Brook runs through the London Borough of Harrow to the north of the LBB down to its confluence with the River Brent near the centre of the borough (Figure 1-4). There are several smaller watercourses which form tributaries of the River Brent: Mitchell Brook and Wembley Brook. The Grand Union Canal runs along the south-western boundary of the LBB with a connecting feeder channel running from the Welsh Harp reservoir to the north-east of the borough.

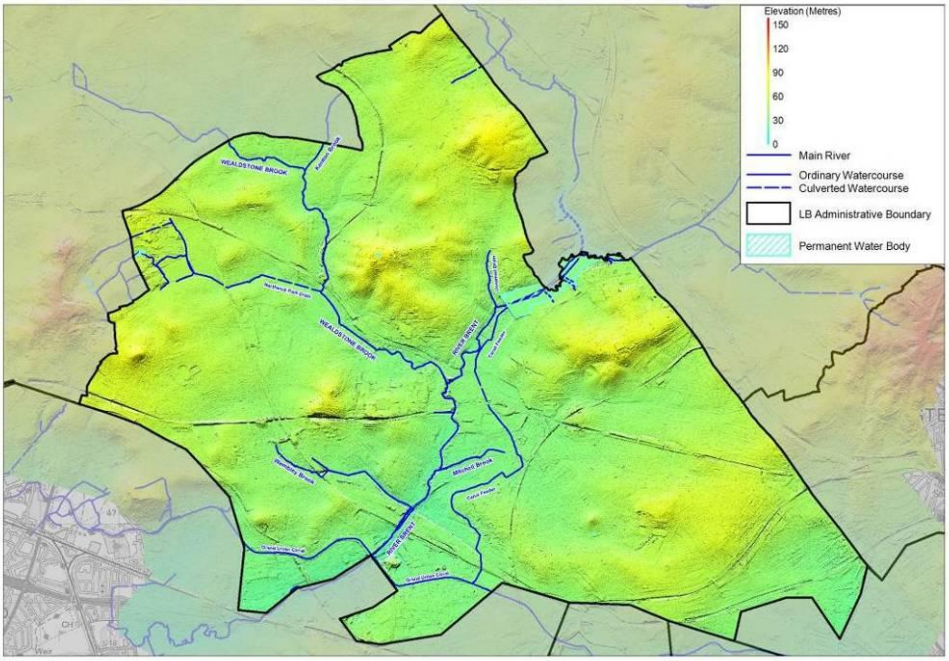

Figure 1-4 Topography Brent (A larger version of this figure is available in drawing number 2202-UA002334-BMD-02)

The lower lying areas of the borough in the river valleys range from 37 – 22 m AOD along the River Brent and to 40 – 33 m AOD along Wealdstone Brook. Approximately 93% (40km^2) of the LBB is urbanised. There are small pockets of open land with the largest being Fryent Country Park to the north east of the borough (Figure 1-5).

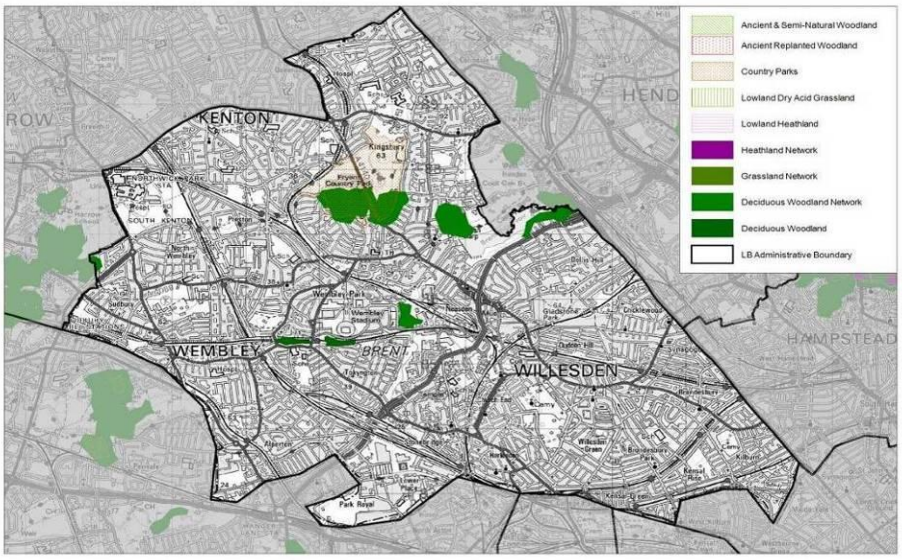

Figure 1-5 Land Use Brent (A larger version of this figure is available in drawing number 2203-UA002334-BMD-02)

There are several small deciduous woodland areas to the north east of the borough.

1.4.2 Flood Risk overview

According to the Environment Agency's property count for their national Flood Map for Surface Water (FMfSW) dataset, approximately 35,500 residential properties and 4,400 non residential properties in LBB could be at risk of surface water flooding of greater than 0.1m depth during a rainfall event with a 1 in 200 probability of occurrence in any given year (0.5% Annual Exceedance Probability, AEP).

Furthermore of those, 12,600 residential properties and 4,400 non-residential properties are estimated to be at risk of flooding to a depth of greater than 0.3m during the same modelled rainfall event. Figure D-2 in Appendix D shows the FMfSW dataset.

Under United Kingdom Climate Projections 2009 (UKCP09), predictions for future rainfall in the UK up to 2080 are that there could be around three times as many days in winter with heavy rainfall (defined as more than 25mm in a day). It is plausible that the amount of rain in extreme storms (with a 1 in 5 probability of occurrence in any given year (20% AEP) or rarer) could increase locally by 40%.

Within the Thames River Basin District, if emissions follow a medium future scenario, UKCP09 projected changes by the 2050s relative to the recent past are:

- Winter precipitation increases of approximately 15% (very likely to be between 2 & 32%);
- Precipitation on the wettest day in winter up by approximately 15% (very unlikely to be more than 31%);
- Relative sea level at Sheerness very likely to increase between 10 and 40cm from 1990 levels (not including extra potential rises from polar ice sheet loss);
- Peak river flows in a typical catchment likely to increase between 8 and 18%. The risk of exceedance of the urban drainage system and surface water flooding in the Borough is therefore likely to increase into the future unless steps are taken to manage and mitigate this form of flooding.

1.4.3 Significant Infrastructure

There are a large number of critical infrastructure assets distributed throughout the London Borough of Brent (Figure 1-6).

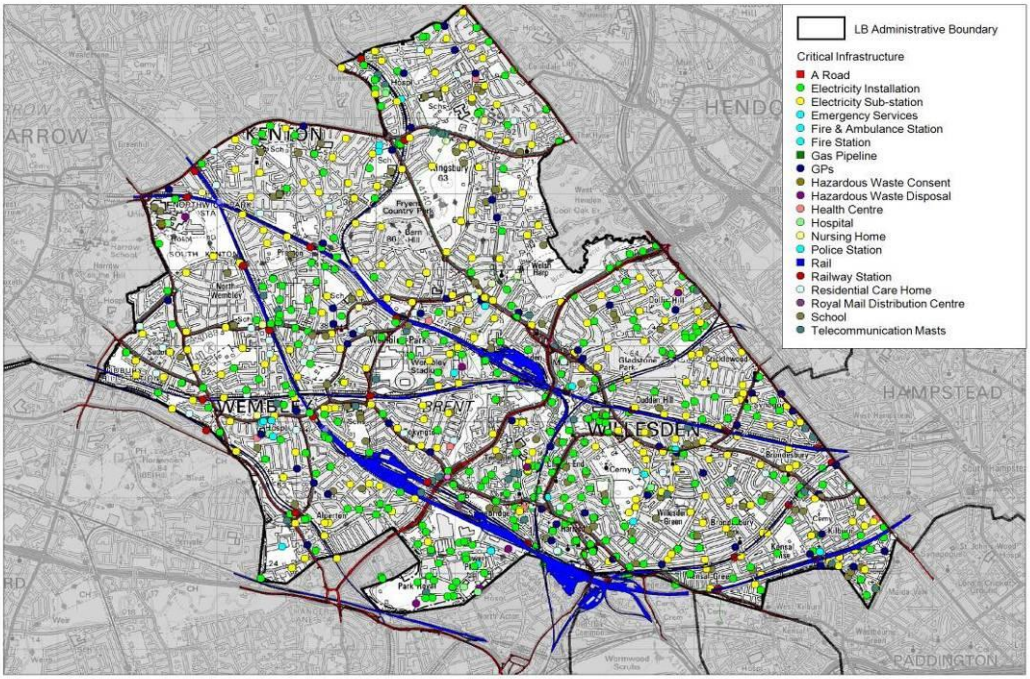

Figure 1-6 Critical Infrastructure in Brent

These assets have been split into three sub-categories based on the Flood Vulnerability Categories from the PPS25 guidance.

Category	Description
Essential Infrastructure	• Essential transport infrastructure • Mass evacuation routes • Tube stations and entrances • Essential utility infrastructure • Electricity generating power stations, grids and sub stations (large installations which generate and supply electricity to large areas of the borough)
Highly Vulnerable	• Police stations, ambulance stations, fire station, command centres and telecommunication installations • Emergency dispersal points • Installations requiring hazardous substances consent
More Vulnerable	• Hospitals • Health services • Educational establishments • Landfill, waste treatment & hazardous waste management facilities • Electricity installations (street level electricity supply control units) • Sewage treatment works • Prisons

Table 1-2 Definition of Infrastructure Sub-Categories

Within the LBB there are the following critical infrastructure asset types.

Type	Number	Category
Essential Transport Infrastructure (Main Roads & Railway)	25	Essential
London Overground & Tube Stations	25	
Essential Utility (Gas Pipeline)	1	
Electricity Sub Stations	312	
Emergency Services (Ambulance, Fire and Police Stations)	24	Highly Vulnerable
Hazardous Waste Consent Sites	6	
Telecommunication Masts	48	
Hospitals	11	More Vulnerable
Health Services (GPs, Health Centre and Care Homes)	135	
Educational Establishments	99	
Hazardous Waste Disposal Sites	10	
Electricity Installations	364	

Table 1-3 Number of critical infrastructure assets within the LBB separated by sub-category

1.4.4 Significant Future Development Plans

Based on the 2001 Census the population of Brent was 263,454. In 2006 the GLA re-estimated the population of the borough to be approximately 278,500. There are approximately 108,000 households in the borough (LBB Core Strategy, 2010). By 2016/2017 the number of new homes within the borough is set to increase by 11,200 according to the London Plan (2008) housing capacity targets. As part of the London Plan the following areas were identified as potential regeneration areas within the borough: Barnhill, Dudden Hill, Harlesden, Kensal Green, Kilburn, Stonebridge, Welsh Harp and Wembley (Figure 1-6).

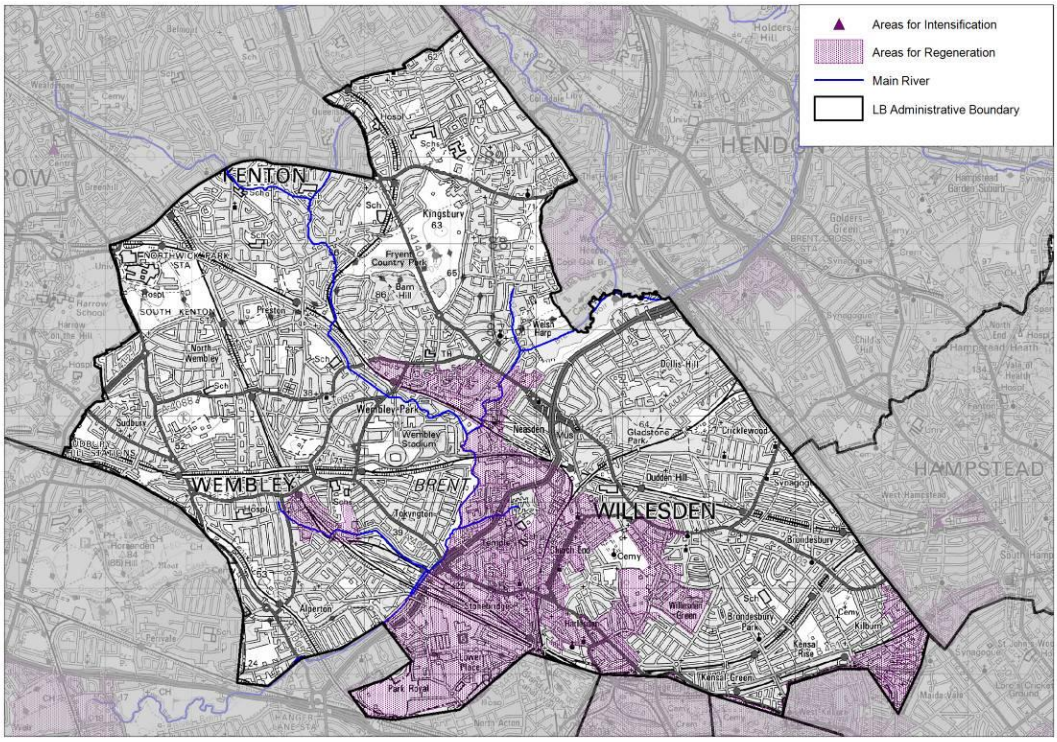

Figure 1-7 Areas for regeneration in the London Borough of Brent

The Brent Core Strategy document outlines more specific key growth areas within the borough along with the major urban areas (Figure 1-7).

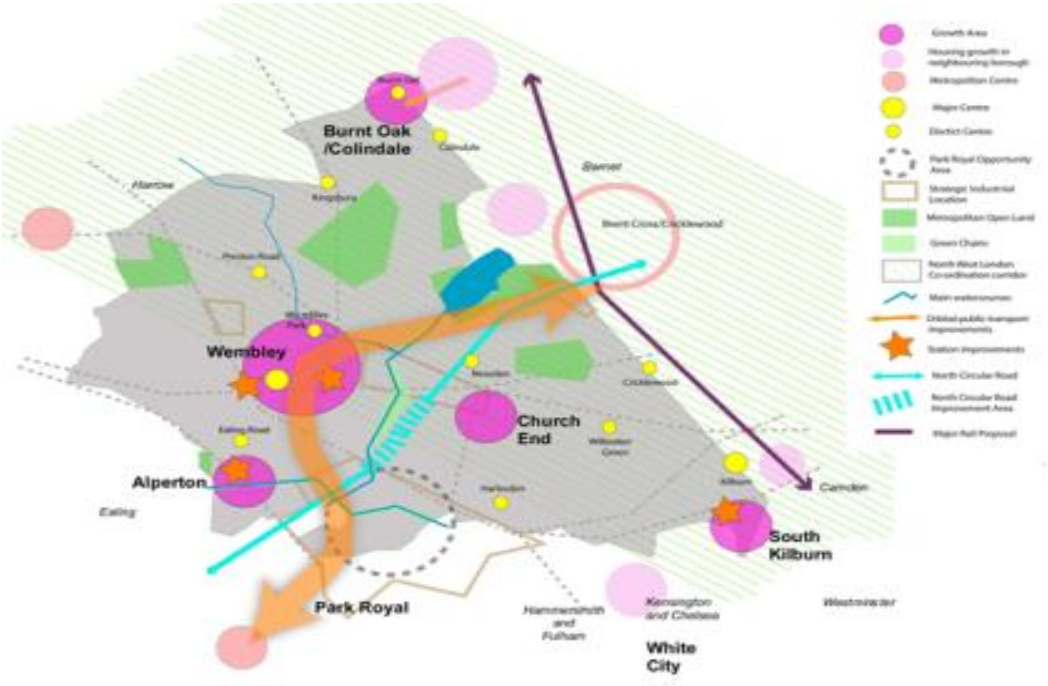

Figure 1-8 Brent Core Strategy Key Spatial Development Strategy

1.4.5 Interactions with Neighbouring Borough Councils

LBB is surrounded by a number of other borough councils as outlined in Section 1.4. The River Brent cross connects into the neighbouring borough of Ealing so the flood risk posed by this watercourse spreads beyond the LBB boundary. This provides scope for the development of cross boundary solutions and partnership development between the LBB and the London Borough of Ealing.

1.5 Flooding Interactions

Planning Policy Statement 25 (PPS25) (Communities and Local Government, 2010) provides explanations on the different sources of flooding, and these explanations are provided below.

1.5.1 Sources of Flooding

Flooding From Rivers (Fluvial Flooding)
Watercourses flood when the amount of water in them exceeds the flow capacity of the watercourse channel. Where flood defences exist, they can be overtopped or breached during a severe event. Flooding can either develop gradually or rapidly, depending on the characteristics of the catchment. Land use, topography and the development can have a strong influence on flooding from watercourses. Flooding can also occur as a result or culverts and bridges becoming blocked with debris.
Flooding from Surface Water (Pluvial Flooding)
Intense rainfall, often of short duration, that is unable to soak into the ground or enter drainage systems can run quickly off land and result in local flooding. In developed areas, this flood water can become polluted with domestic sewage where foul sewers surcharge and overflow. Local topography and built form can have a strong influence on the direction and depth of flow. The design of development down to a micro-level can influence or exacerbate this. Flooding can be exacerbated if development increases the percentage of impervious area.
Groundwater Flooding
Groundwater flooding occurs when groundwater levels rise above ground levels (i.e. groundwater issues). Groundwater flooding is most likely to occur in low-lying areas underlain by permeable rocks (aquifers). Chalk is the most extensive source of groundwater flooding.
Sewer Flooding
In urban areas, rainwater is frequently drained into sewers. Flooding can occur when sewers are overwhelmed by heavy rainfall, and become blocked. Sewer flooding continues until the water drains away.
Flooding from Other Artificial Sources (i.e. reservoirs, canals, lakes and ponds)
Non-natural or artificial sources of flooding can include reservoirs, canals and lakes. Reservoir or canal flooding may occur as a result of the facility being overwhelmed and/or as a result of dam or bank failure.

Table 1-4 Sources of Flooding (Adapted from PPS25, Annex C)

1.5.2 Surface Water Flooding

In the context of SWMPs, the technical guidance[ii] defines surface water flooding as:

- Surface water runoff; 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 watercourse, or cannot enter it because the network is full to capacity, thus causing flooding (known as pluvial flooding);
- Flooding from groundwater where groundwater is defined as all water which is below the surface of the ground and in direct contact with the ground or subsoil;
- Sewer flooding; flooding which occurs when the capacity of underground systems is exceeded due to heavy rainfall, resulting in flooding inside and outside of buildings. Note that the 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 open-channel and culverted watercourses which receive most of their flow from inside the urban area and perform an urban drainage function;
- Overland flows from the urban/rural fringe entering the built-up area; and
- Overland flows resulting from groundwater sources.

This report aims to consider surface water flooding issues in the LBB as above but it does not address sewer flooding where it occurs as a result of operational issues, i.e. blockages and equipment failure. It should also be noted that the compilation of all historical flooding within the study area does include some flooding due to main rivers, further investigation of these occurrences is outside the remit of this report.

1.6 Linkages with Other Plans

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 work completed as part of the Drain London project links to several existing documents:

1.6.1 Regional Flood Risk Appraisal (RFRA)

This 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. The RFRA identifies one main river within the study area and describes the associated flood risk.

- River Brent - The River Brent and its various tributaries have suffered localised flooding, particularly in the upstream catchments of Harrow and Barnet. The Environment Agency has examined options to address this. These options should be examined and recommendations incorporated into SFRAs and LDD policies and form local policy objectives of reducing and storing surface water run-off. The Brent flows through extensive park areas offering opportunities for some flood risk management.

The RFRA provides nineteen recommendations. More specifically the regional policies that should be considered as part of this SWMP in the context of the entire study area are:

RFRA Regional Policies

Recommendation 5 - Developments all across London should reduce surface water discharge in line with the Sustainable Drainage Hierarchy set out in Policy 5.13 of the draft replacement London Plan.

Recommendation 6 - Regeneration and redevelopment of London's fluvial river corridors offer a crucial opportunity to reduce flood risk. SFRAs and policies should focus on making the most of this opportunity through appropriate location, layout and design of development as set out in PPS25 and the Thames CFMP. In particular opportunities should be sought to:

- Set back of development from the river edge to enable sustainable and cost effective flood risk management options.
- Ensure that the buildings with residual flood risk are designed to be flood compatible or flood resilient.
- Use open spaces within developments which have a residual flood risk to act as flood storage areas.

1.6.2 Thames Catchment Flood Management Plan (CFMP)

The Thames Catchment Flood Management Plan 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.

The Plan 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.

This Plan 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.

The River Brent is the main sub area within this Borough and it falls within the preferred policy unit of Policy Option 4. This is defined as 'taking further action to sustain the current level of flood risk into the future (responding to the potential increases in risk from urban development, land use change and climate change)'.

Urban areas such as those present in LBB are increasingly susceptible to rapid flooding from intense rainfall events. Emergency response and flood awareness are particularly important. Furthermore, urban flooding is likely to increase in the future as a result of:

- Ageing drainage infrastructure;
- More development covering previously permeable ground;
- Increase in paving in existing developments e.g. patios and driveways; and
- Climate change i.e. wetter winters and heavier summer rainfall.

Specific CFMP actions for the Borough area are:

- Long-term adaptation of the urban environment is required;
- There are opportunities to reduce flood risk through redevelopment. In most areas we need to change the character of the urban area in the floodplain through the location, layout and design of re-development. It must be resilient and resistant to flooding and result in a layout that recreates river corridors, therefore reducing the consequence of flooding;
- Identify and seek out opportunities to open up culverts and re-create river corridors through redevelopment so that there is space for the river to flow more naturally and space in the floodplain where water can be attenuated; and
- Identify and seek out opportunities to build up flood defences as part of an overall catchment plan for future redevelopment that is linked to the need to allow more space for the river corridors.

1.6.3 Preliminary Flood Risk Assessment (PFRA)

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 (LLFA), to give an overview of all local sources of flood risk. In London, future iterations of the PFRAs will benefit from an increased level of information relating to surface water from the Drain London SWMPs. Boroughs will need to review the PFRA every 6 years.

1.6.4 Surface Water Management Plans (SWMP)

Drain London is producing one of these for each London Borough. They provide much improved probabilistic 2-dimensional modelling and data on what has been made available at a national scale by the Environment Agency. In addition they contain 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 need to 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.

1.6.5 Strategic Flood Risk Assessments (SFRA)

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 in evaluating flooding from other local sources including surface water, groundwater and ordinary watercourses. The information from Drain London will improve this understanding.

1.6.6 Local Development Documents (LDD)

LDDs including the Development Planning Documents, Supplementary Planning Documents 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.

1.6.7 Local Flood Risk Management Strategies

The Flood and Water Management Act 2010 (FWMA) requires each LLFA to produce a Local Flood Risk Management Strategy (LFRMS). Whilst Drain London will not actually produce these, the SWMPs, PFRAs and their associated risk maps will provide the necessary evidence base to support the development of LFRMS. No new modelling is anticipated to produce these strategies.

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

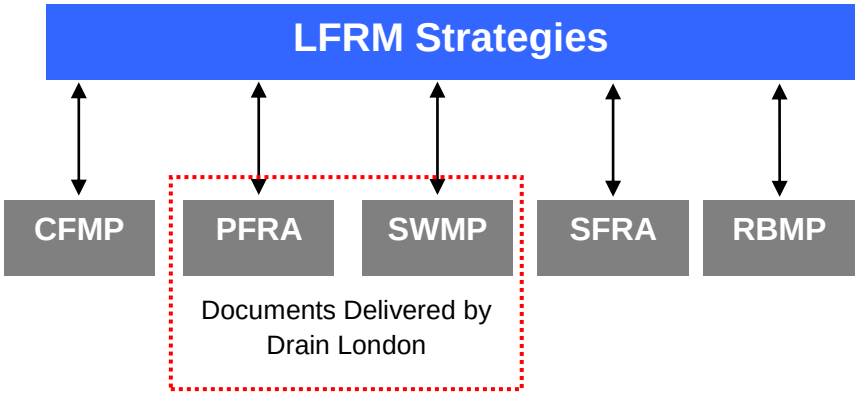

Figure 1-9 Supporting studies used to develop a Local Flood Risk Management Strategy

1.7 Existing Legislation

1.7.1 Flood Risk Regulations 2009

The Flood Risk Regulations 2009 (FRR) transpose the European Floods Directive 2007/60/EC into English and Welsh law. The Regulations bring together key partners to manage flood risk from all sources and in doing so reduce the consequences of flooding on key receptors. Local authorities are assigned responsibility for management of surface water flooding.

As part of the ongoing cycle of assessments, mapping and planning, the FRR required the undertaking of a 'Preliminary Flood Risk Assessment' (PFRA). National guidance was published by the Environment Agency initially as a 'living draft' in July 2010 which was subsequently replaced by the final guidance issued in December 2010[i]. The requirements of FRR have also

been used to shape this report and to inform SWMP elements as appropriate within LBB's PFRA, produced by HCL[ii]. The Regulations require three main types of assessment/plan:

- Preliminary Flood Risk Assessments (maps and reports for Sea, Main River and Reservoirs 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.
- 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.
- 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.

The PFRA, now complete, confirms that the majority of the London Borough of Brent, lies within the London Indicative Flood Risk Area and as it is an area exhibiting significant issues, the London Borough of Brent requires further more detailed, local investigation.

1.7.2 Flood and Water Management Act 2010

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 watercourses). 'Upper Tier' local authorities have been empowered to manage local flood risk through new responsibilities for flooding from surface and groundwater.

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.

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

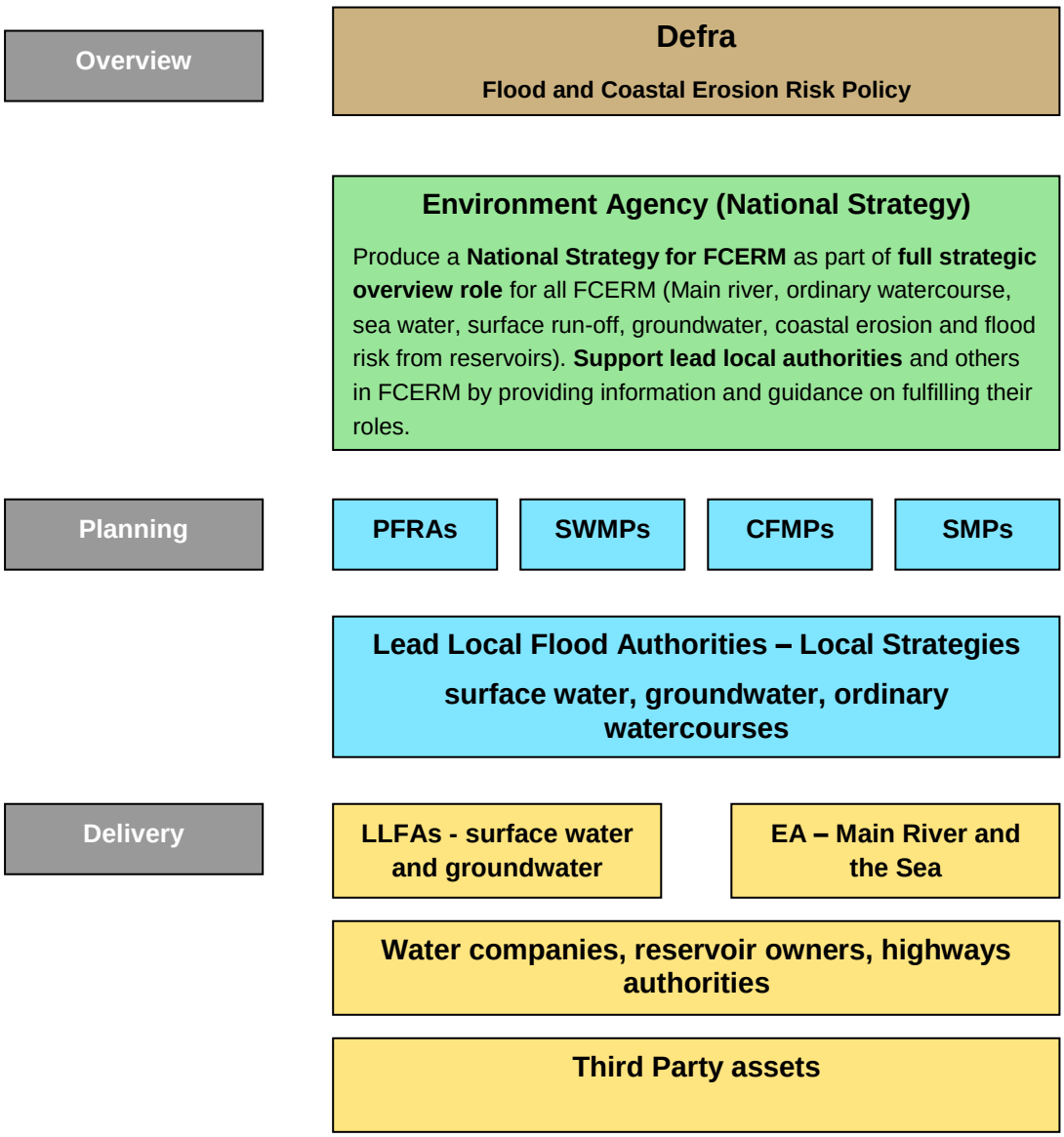

Figure 1-10 Local Flood Risk and Coastal Management Responsibilities

1.7.3 Planning Policy Statement 25

Planning Policy Statement 25 (PPS25) requires that new development should not increase flood risk; a SWMP will support this by informing the Local Planning Authority (LPA) of areas at risk of surface water flooding and developing policy for new development.

1.8 Peer Review

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.
- 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).
- To ensure consistency and comparability between London Borough SWMPs produced, a Peer Review process has been used. The process involved the four consultant teams working on the Drain London SWMPs independently reviewing each other's work. This has assisted in the identification that all these outputs result from a consistent technical approach and are of a high technical quality and are communicated in the specified formats. The peer review report for this SWMP is included in Appendix F (SWMP Report Volume 2).

2 Phase 1: Preparation

2.1 Partnership

The formation of partnerships has an important role in the undertaking of a SWMP, and is required under Defra's SWMP guidance documentation. The SWMP guidance details the identification of those partners/organisations that should be involved and what their roles and responsibilities should be.

It recommends the formation of an engagement plan, which should include objectives for the individual partners, and detail how and at what stages of the SWMP the engagement with stakeholders should take place.

The Environment Agency has proposed Strategic Flood Risk Management Boards within Greater London to coordinate local Flood Risk Management. LBB will form part of the West London FRMP with the surrounding London Boroughs of Harrow, Barnet, Ealing, Hillingdon and Hounslow.

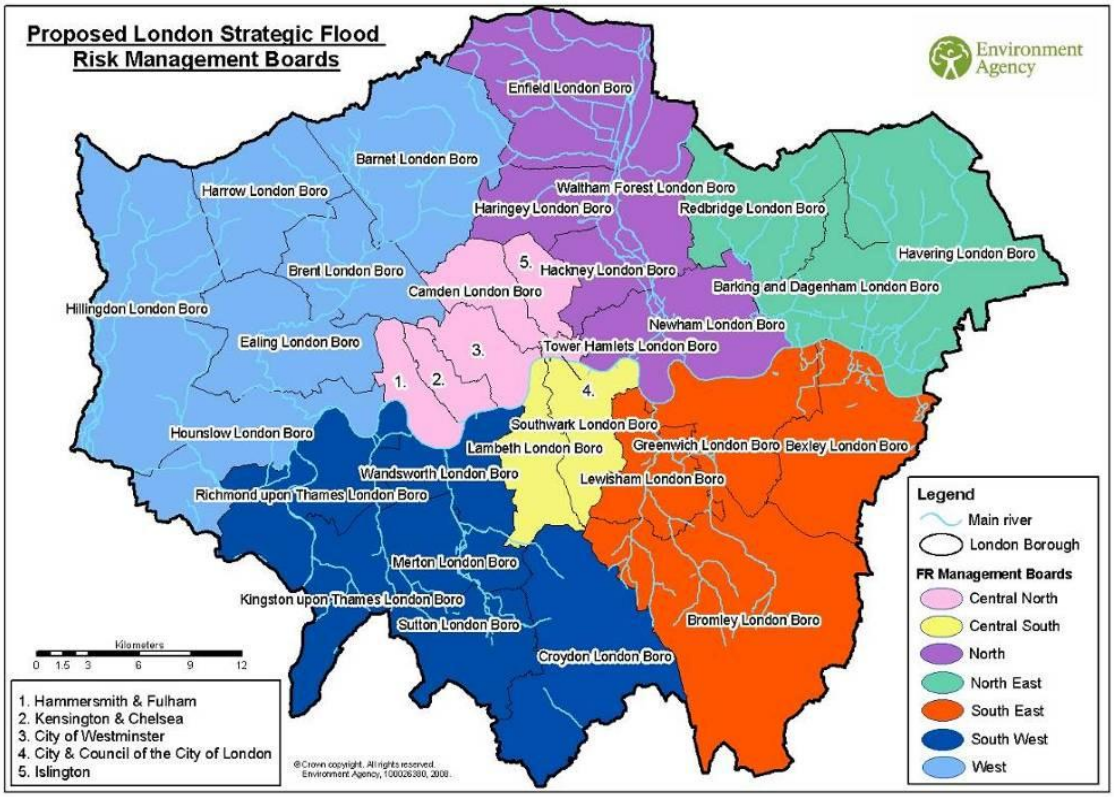

Figure 2-1 Proposed London SFRMBs

The following sections describe the partners, their roles and responsibilities and their objectives as required by the SWMP guidance.

2.1.1 Partners

Partners are defined as those with responsibility for decisions or actions regarding surface water management. In the LBB, these are:

- London Borough of Brent (LBB)
- Environment Agency (EA)
- Thames Water (TWUL)
- Transport for London (TfL)

2.1.2 Roles and Responsibilities

LBB, as the Lead Local Flood Authority has a number of specific responsibilities:

- To lead and co-ordinate the delivery of the relevant Pitt Review recommendations.
- To ensure a consistent approach in the management of current and future flood risk issues in the borough.
- To fulfil any new duties arising from the Floods and Water Management Act when enacted.
- To coordinate the delivery of actions arising from the EU Floods Directive and FRR.

In conjunction with these, LBB and the other partner organisations have further responsibilities to share relevant information and co-operate to facilitate the management of flood risk.

TWUL is the water and sewerage undertaker for the Thames Basin and has a statutory obligation to supply water and wastewater services to its customers. TWUL currently has the responsibility to effectually drain their area and maintain the sewerage network[iii].

The EA is a non-departmental public body and has responsibilities for protecting and enhancing the environment as a whole (air, land and water) and contributing to the government's aim of achieving sustainable development in England and Wales. Following the Pitt review of the 2007 Floods and the Flood and Water Management Act 2010, the EA was given the strategic overview role for the management of all types of flooding, including the management of surface water.

2.1.3 Stakeholders

Stakeholders are defined as those affected by, or interested in, a problem or solution relating to surface water management. In LBB, it is anticipated at this stage that the following additional stakeholders are involved in, or will become involved in, the SWMP:

- Flood Forums
- Residents
- Neighbouring Authorities
- Highways Agency
- National Rail

As the SWMP develops, it is possible that other stakeholders will be identified and become involved; these organisations will be highlighted in future reports and outputs as required.

2.1.4 Public Engagement

Some members of the public have valuable information to contribute to the SWMP and to help improve the understanding and management of local flood risk within the study area. Public engagement will provide significant benefits to local flood risk management including building trust, gaining access to additional local knowledge and increasing the probability of stakeholder acceptance of options and decisions proposed in future flood risk management plans.

However, it is also recognised that it is crucial to plan the level and timing of engagement with communities predicted to be at risk of flooding from surface water, groundwater and ordinary watercourses. This is to ensure that the potential for future management options and actions is adequately understood and costed without raising expectations before solutions can reasonably be implemented.

It is important to undertake some public engagement when formulating local flood risk management plans (including LFRM Strategies) as this will help to inform future levels of public engagement. It is recommended that LBB follow the guidelines outlined in the Environment Agency's "Building Trust with Communities" which provides a useful process of how to communicate risk including the causes, probability and consequences to the general public and professional forums such as local resilience forums.

2.2 Data Collection

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

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

A comprehensive data set was passed onto Tier 2 consultants and in some cases additional supplemental data was provided by individual organisations.

A list of the data provided by stakeholders for Drain London is below.

Stakeholder	Information Provided	
	Publicly Available	Not Publicly Available
British Geological Society		Susceptibility to ground water flooding maps, permeability maps
British Waterways		BW canals network
LBB	Brent IUD (2008), Brent SFRA (2007)	Ordinary watercourses, critical infrastructure (fire stations, schools etc), historical flooding locations, transport infrastructure
London Fire Brigade		Flood incident database
London Underground		Pump site data, station flood risk summary
Greater London Authority		Administrative boundaries, OS Mapping ,Master Maps, LiDAR, London Plan data including proposed regeneration and intensification areas
Highways Agency		Asset data, flood hot spot locations
Environment Agency		National Receptor Databases, historical flood outlines, modelled flood event outlines, flood affected properties, main rivers, detailed river network, groundwater flooding incidents
Natural England	SACs, SSSIs, SPAs, Ancient woodland, LNRs, NNRs, RAMSARs, woodland, agricultural land classifications	
National Health Service	Health Trust Maps	
Network Rail	National Rail Network map	
Thames Water		Sewerage networks, asset information
Transport for London		Main transport links within the Greater London area

Table 2-1 Stakeholders contacted and the information provided

The documents and anecdotal evidence provided by LBB and a local resident, John Timms MBE, provided the main sources of information on local flood risk used within this SWMP. The Brent Integrated Urban Drainage (IUD) Study and Brent SFRA were completed within the last 5 years and have been reviewed and approved by the LBB and Environment Agency. This suggested that these were reliable sources to use to establish the main local flood risk areas within the Borough.

Several meetings with LBB staff and a local resident (John Timms MBE) provided invaluable information about the key flood risk areas within the Borough. Hyder undertook several site visits to assess the potential causes/mechanisms of flooding in these areas.

2.3 Data Review

The SWMP guidance highlights the importance in understanding the quality of the data in order to inform the later stages of the SWMP. Therefore, data incorporated into the data registers was assigned a quality score between one and four based on a high level assessment:

1 Best Possible

2 Data with known deficiencies

3 Gross assumptions

4 Heroic assumptions

2.3.1 Data Use & Licensing

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

The following national datasets provided by the Environment Agency are available to local authorities and their consultants for emergency planning and strategic planning purposes:

- Flood Map for Rivers and the Sea
- Areas Susceptible to Surface Water Flooding
- Flood Map for Surface Water
- National Receptor Database

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

- Strategic Flood Risk Assessments
- Catchment Flood Management Plan

The use of some of the datasets made available for this SWMP has been restricted and is time limited, licensed to LBB via the Greater London Authority for use under the Drain London project, which includes the production of this SWMP. The restricted datasets include records of property flooding held by the Council and by Thames Water Utilities Ltd, and data licensed by the Environment Agency.

Necessary precautions must be taken to ensure that all 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.

2.3.2 Key Datasets

The key datasets used to develop the SWMP are listed below:

- Ordnance Survey 10k and 50k Mapping
- Infoterra 1m LiDAR
- Environment Agency Main River and Digital River Network
- Thames Water Sewer Network
- LBB Flood Incident Records and Hotspots
- Other Stakeholder Flood Incident Records (London Fire Brigade, London Underground, TfL and the Highways Agency)
- Thames Water DG5 Database
- Environment Agency National Receptor Database
- Environment Agency Flood Maps
- Environment Agency Flood Map for Surface Water and Areas Susceptible to Surface Water
- Environment Agency Groundwater Incidents
- British Geological Society Susceptibility to Groundwater Flooding Map
- Jacobs/JBAs Increased Potential to Groundwater Flooding Map
- Drain London Surface Water Mapping (depth, velocity and hazard)
- A detailed summary of the data used as part of the SWMP is outlined in Appendix A

2.4 Asset Register

Section 21 of the FWMA 2010 sets a duty on each London Borough (LLFA) to maintain a register of structures or features, and a record of information about each of those structures or features, which, in the opinion of the authority, are likely to have a significant effect on flood risk in its area. From 6 April 2011, all LLFAs have a duty to maintain a register the legal characteristics of the register and record are outlined below:

	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.	

Table 2-5 Legal aspects of the register and record

Defra have provided each LLFA with templates to demonstrate what information should be contained in the asset register. Although these templates are not intended as a working tool, they provide a good example of how an asset register might be structured.

Populating the asset register is outside the scope of the Drain London project and is the responsibility of each London Borough. The expectation from Defra is that LLFAs (London Boroughs) will utilise a risk-based approach to populate the register and record with those structures or features considered the most significant first.

2.4.1 The Requirement

It is important to identify the primary requirements of a system. It needs to be:-

- Practically based
- Easily useable by non IT specialists
- Easily updatable by non IT specialists
- Focused on the primary requirements for having information available on asset type, ownership and condition while at the same time making provision in the design of the process for other useful functions such as providing data for hydraulic models etc.

2.4.2 A model asset register which could be developed for use by other London Boroughs

LBB does not currently have a well developed system for managing drainage assets in place. Key elements of a practical asset management system are:-

- Drainage professionals should be responsible for identifying the specification of the process related to specific operational requirements.
- The system should use well tried computer software packages such as ArcMap/MapInfo and Microsoft Access.
- The drainage asset system should integrate with the council's overall GIS system.
- External IT costs associated with putting together the asset register should be fairly modest, approximately £5k, with an annual update fee of approximately £500.
- The system should be easy to use so that new staff require minimal training.
- The system should facilitate the recording of data such as information provided by residents on non performing assets, information on works undertaken on a particular asset and the preparation of maintenance routines etc all of which offer benefits in terms of efficiency in surface water management, understanding of the system, etc.

This system will continue to develop and will help the LBB to deliver better flood risk management once the system is set up. Further modifications might be required to enable the system to provide support for other uses further down the line but basically it already works.

The data collected on the system can be used to assist with the identification of risk. This will enable maintenance efforts to be targeted on the assets where the greatest risk of failure is found to exist. This is a fundamental requirement for effective surface water management. It is recommended that the NWLFRMP identify a working solution, which could be based upon the current register in place within the London Borough of Harrow, to the Asset Register to enable the Partnership to help improve the awareness of gaps in ownership across the System.

2.5 Phase 1 Summary

Phase 1 of the SWMP has:

- Engaged key stakeholders including the Environment Agency and Thames Water, and the London Boroughs of Barnet and Harrow, to discuss and agree on local flood risk management within the London Borough of Brent in the future;
- Established a local flood risk partnership working approach within the London Borough of Brent for managing local flood risk in the future;
- Established a sub-regional flood risk partnership structure for the London Boroughs of Barnet, Brent, Ealing, Harrow, Hillingdon and Hounslow (along with other key stakeholders), through the 'North West London Strategic Flood Group', to take forward and manage flood risk in the future;
- Collected and reviewed flood risk data and knowledge from key stakeholders and partner organisations; and
- Set out recommendations for the London Borough of Brent's Asset Register, as required under the FWMA 2010.

3 Phase 2: Risk Assessment

3.1 Intermediate Assessment

3.1.1 Aims

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. The modelling outputs will then be mapped using GIS software.

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'.

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.

Table 3-1 SWMP Study Levels of Assessment (Defra 2010)

As shown 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 suggest that there are ~ 35,500 properties at risk across the Borough, it is appropriate to adopt this level of assessment to further quantify the risks.

The purpose of this intermediate assessment will be 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 (SWMP Report Volume 2).

- A Direct Rainfall approach using TuFLOW software has been selected whereby rainfall events of known probability are applied directly to the ground surface and is routed overland to provide an indication of potential flow path directions and velocities and areas where surface water will pond.
- Two-dimensional pluvial modelling has been supported by hydraulic field visits/surveys and consultation has been undertaken in conjunction with LBB staff and EA staff.
- The outputs from the pluvial modelling are verified (where possible) against historic surface water flood records.

3.2 Risk Overview

3.2.1 Mapping Outputs

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 LBB and its partners to undertake more detailed analysis in areas which are most vulnerable to surface water flooding.

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

Please note that these maps only show the predicted likelihood of surface water flooding for defined areas. They focus on overland flow paths and surface water flooding at local depressions, however they also simulate (less accurately) flooding from sewers, drains, small watercourses and ditches). Due to the coarse nature of the source data used, these 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.

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 we possess 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 described in Appendix C and Section 1-3 below and does not use the maps in isolation.

The Greater London Authority, LBB and the Tier 1 and Tier 2 Drain London Consultants will not be liable if the Drain London maps by their nature are not as accurate as might be desired or are misused or misunderstood despite the warnings. For this reason we are not able to promise that the maps will always be completely accurate or up to date.

3.2.2 Flooding Classification

Flood risk within LBB has been classified based on the source of flooding (surface water, groundwater, fluvial/tidal and/or sewer) and scale (Local Flood Risk Zones (LFRZs), Critical Drainage Areas (CDA), Policy Areas (PA) and Indicative Flood Risk Zones). These categories are discussed in more detail below.

Source of Flood Risk

A range of classifications have been devised for use in the SWMP to identify the primary source(s) of flood risk to areas throughout the Borough identified through the SWMP Phase 2 Risk Assessment to be at a greater risk of surface water flooding (Table 3-2). These classifications have been used to inform the SWMP Action Plan (Section 3) as they also define probable areas of flood mitigation and management responsibility.

Flood Source Classification	Output from Pluvial Modelling	Output from Groundwater Flood Risk Assessment	EA Flood Map Zone 3 – Areas not benefiting from defences	DG5 Records Only
Surface Water*	X			
Groundwater		X		
Fluvial/Tidal			X	
Sewer				X
Surface Water and Groundwater	X	X		
Groundwater and Fluvial/Tidal**		X	X	
Surface Water and Sewer	X			X
Surface Water and Fluvial/Tidal	X***		X	
Surface Water, Groundwater and Fluvial/Tidal**	X***	X	X	
Surface Water, Groundwater and Sewer	X	X		X
All Sources	X	X		X

Table 3-2- SWMP Flooding Source Classification

Notes: * Surface Water = Surface Water and / or Ordinary Watercourse
** Areas where surface water and / or groundwater flooding are fully within the EA Zone 3 (areas not benefiting from defences) are highlighted as having a primary influence from Fluvial / Tidal flooding.
*** Where pluvial modelling outputs demonstrate flooding significantly greater than Flood Zone 3, these areas should be classified as 'pluvial flooding areas'.

Scale of Flood Risk

As part of the Drain London Project, the scale of flooding has been classified as follows, from smallest to largest:

- Local Flood Risk Zone (LFRZ, managed at the local scale)
- Critical Drainage Area (CDA, containing one or more Local Flood Risk Zones – managed at the local scale)
- Policy Areas (PA, containing one or more Critical Drainage Areas and covering the entire Borough)
- Indicative Flood Risk Area (as defined by the Environment Agency/Defra Indicative Flood Risk Areas – an area approximately covering the entire Greater London Area and managed at a strategic scale)

Further information on the scale of flooding and flood risk management areas identified in LBB are provided in Table 3-3.

Scale	Definition	Description	LBB Specific Areas
Local Flood Risk Zone (LFRZ)	*"Discrete areas of flooding that affect houses, businesses or infrastructure".*	The LFRZ is defined as the actual spatial extent of predicted flooding in a single location. Related LFRZs can be grouped together as a CDA or left in isolation and considered within the larger Policy Areas.	Table text
Critical Drainage Area (CDA)	*"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 LFRZs during severe weather thereby affecting people, property or local infrastructure."*	CDA units are larger than LFRZs and denote an area or catchment where mitigation measures may be implemented to reduce flooding experienced in the flood risk zone. The CDA comprises the upstream 'contributing' catchment, the influencing drainage catchments, surface water catchments and, where appropriate, a downstream area if this can have an influence on the LFRZ. CDA units should be used for site specific detailed planning and capital works schemes and may contain one or more LFRZs. *Note: CDAs have been given an identification number, based on the Drain London Sub-Regional Partnership Group Number, and have been defined across the group. Therefore, CDA numbers start at 001 for LBB.*	Group2_034 – Group2_060
Policy Area (PA)	*"A discrete area within an administrative area where appropriate planning policy can be applied to manage flood risk."*	Policy Areas contain one or more CDAs and cover the entire study area. Policy Areas are primarily based on hydrological catchments but may also accommodate geological concerns and other factors as appropriate. Policy areas may be used to provide guidance on general policy across the study area e.g. the use of soakaways in new development	Given the complex and interlinked surface water flooding within LBB, it has been agreed that only one Policy Area should be defined, covering the entire administrative area.
Indicative Flood Risk Area	*"Areas determined by the Environment Agency as indicatively having a significant flood risk, based on guidance published by Defra and WAG and the use of certain national datasets."*	Indicative Flood Risk Areas are defined by the Environment Agency/Defra primarily for the purposes of the preparation of PFRAs.	The Greater London Area has been identified as an Indicative Flood Risk Area, with 696,805 people at risk from surface water flooding deeper than 0.3 metres during the 0.5% AEP rainfall event (based on FMfSW outputs). Minor alterations to the IFRA were proposed within Barnet's PFRA.

Table 3-3 SWMP Flood Risk Management Areas

3.3 Surface Water Flooding

3.3.1 Overview

Surface water runoff occurs as a result of high intensity rainfall causing water to pond or flow over the ground surface before entering the underground drainage network or watercourse, or when water cannot enter the network due to insufficient capacity.

In these conditions surface water builds up locally where ground terrain is flat and then would travel following prevailing terrain gradients. Surface water flooding then occurs at locations where surface water flow paths converge, at local dips in the ground and/or due to overland obstructions.

This is the main mechanism of surface water flooding however it is exacerbated in many cases by mistreatment or asset failures of the below ground infrastructure (including partial or full blockages of gullies and/or within the combined sewers and the accumulation of fats, oils and greases within the sewer networks).

Most of LBB is served by separate sewer systems, receiving foul water, rainwater from roofs and from hard standing and sometimes highways. The sewers across the area were originally designed by J.D.M. Watson in the 1920's for draining foul flows only (for further details please review Appendix B).

> The speed of development since the 1930's, gave way to the relatively easy, however unsustainable solution of connecting more and more new paved areas and roofs into the sewer system, which ultimately resulted in this legacy of a misconnected system, leading to surface water and foul waters being mixed across both systems, causing quality and quantity issues across the Borough.

No single organisation has overall responsibility for surface water flooding with different aspects of the drainage system falling to either The Highway Authority (in this case LBB), Thames Water, riparian owners and Transport for London (red routes including the A40 and A406).

3.3.2 Local Reports of Historic Flooding

The LBB provided a flood incident log for the July 2007 event. The log provided a brief outline of the locations affected and stated if properties were affected but no numbers were given. The incident log suggests that the main cause of flooding was a combination of surface water runoff and inadequate sewer capacity. Figure D-3 in Appendix D outlines the surface water flooding incidents along with the 1 in 100 year rainfall event outputs modelled as part of the Drain London project. Further information on how this output was generated is outlined in Section 3.3.6. In many cases the historic flooding information provided is anecdotal and does not include records of antecedent conditions giving rise to the flooding (therefore typically not attributed to a flood source) or reference to a flood return period.

The Brent SFRA very briefly mentions surface water flood risk within the borough but does not identify any risk areas. As the LBB July 2007 record was the only available surface water incident dataset it was used to identify local flood risk zones within the Borough.

There were a number of uncertainties regarding the quality of the data recorded in the LBB July 2007 dataset. In order to gain a full assessment of surface water flood risk across the borough several other methods were used to identify key local flooding mechanisms.

As LLFA, the LBB is responsible for managing borough wide surface water flood risk. It is also responsible for resolving flooding from the borough highway drainage system. The action plan developed as part of this SWMP (section 5.1) has been designed to ensure that the LBB fulfils their role as LLFA.

3.3.3 Environment Agency Areas Susceptible to Surface Water Flooding (AStSWF) Maps

The Environment Agency has produced the outputs of a simple surface water flood modelling at a national scale. The modelling did not take into account underground sewerage and drainage systems or smaller over ground drainage systems. No buildings were included and a single rainfall event was applied. The model parameters used to produce the maps were:

- 1 in 200 year return period
- 240 minute storm duration
- 1km^2 resolution
- No allowance for underground pipe network
- No allowance for infiltration

The AStSWF map gives three bandings indicating areas which are ‘less’, ‘intermediate’ and ‘more’ susceptible to surface water flooding. The map is not suitable for identifying individual properties at risk of surface water flooding.

These maps were updated and republished in January 2009.

3.3.4 Environment Agency Flood Risk Map for Surface Water (FMfSW)

Following on from the release of the Areas Susceptible to Surface Water Flooding, The Environment Agency updated the original mapping in order to produce the Flood Risk Maps for Surface Water (FMfSW), which were released in October 2010. The existing maps were updated to take account of buildings and the underground drainage system, and more storm events were analysed. The model parameters used to create these new maps were:

- External Publication Scale 1:25,000
- 1 in 30 and 1 in 200 year return periods
- 66 minute storm duration
- 5m^2 resolution with country split into 5km squares
- Adjustment of 12mm/hr to take into account underground drainage network capacity
- In rural areas, rainfall was reduced to 39% to represent infiltration
- In urban areas, rainfall was reduced to 70% to represent infiltration

- Global use of Mannings ‘n’ of 0.1 for rural and 0.03 urban areas

The new maps have two bandings of “deep” or “shallow” and are produced for both 30 year and 200 year return periods (Figure D-1 and D-2 in Appendix D – SWMP Report Volume 2).

Both the AStSWF and the FMfSW were used to validate the surface water modelling generated as part of the Drain London Tier 2 project. The surface water modelling approach is outlined below.

3.3.5 Drain London Surface Water Modelling

Overview

The pluvial modelling undertaken as part of the Drain London project aims to simulate the above ground flood mechanism and includes for a limited capacity of the combined drainage system (with no blockages) and infiltration. The outputs allow us to form an understanding of where the main overland flow routes are and how and where pluvial flooding could occur.

The modelling undertaken has limitations which should be taken into account when interpreting potential pluvial flooding (see further modelling details in Appendix C – SWMP Report Volume 2). These maps should be seen on the scale they were produced and for the inclusion of a set of London wide parameters to allow for similar results to be created. The main limitations are described below:

- The below ground drainage infrastructure, including the combined sewers, have not been modelled and therefore their variable capacity has not been taken into account (instead rainfall has been removed at a constant rate of 6.5 mm/hour everywhere).
- The modelled topography of the ground is based on a grid of points at a 5 m distance between them and therefore any variations within these have not been modelled.
- Obstructions such as railway embankments have been modelled however culvert crossings beneath them (unless clearly seen on OS maps) have not always been.
- The permeability of the ground has been modelled to a certain extent however only by allowing a limited number of soil categories.
- The capacity of watercourses has not been modelled and therefore there is a tendency of building up of surface water along the river floodplain.

Methodology

To ascertain a more accurate understanding of the surface water flood risk and hazard across the LBB a 2-dimensional (2D) direct rainfall model was created using TUFLOW. TUFLOW is a hydrodynamic modelling package which can be used for 2D overland flow modelling or as a 1D-2D linked model where there is an interaction with the linear flow features.

TUFLOW utilises standard GIS packages to manage, manipulate and present input and output data. In order to model surface water TUFLOW requires terrain data. This can be from a variety of sources (GPS, LiDAR, photogrammetry etc) but the more detailed and accurate the source of data, the more accurate and reliable the solution is likely to be. High resolution (1m) LiDAR data was provided by Infoterra in two formats:

- Digital Surface Model (DSM) which is unfiltered so buildings and raised objects are maintained
- Digital Terrain Model (DTM) which is filtered with buildings and raised objects smoothed.

For the LBB surface water modelling the filtered DTM data was used as it removes interference and distortion caused by buildings and trees.

Using the 2D approach a rainfall profile is applied to the DTM within a predefined model domain. For the LBB the borough was divided into hydrological catchments to maximise efficiency and to reduce model run times. Five separate model domains were created for the LBB (Figure 3-1):

- Wealdstone Brook to the North of the Borough,
- River Brent covering a majority of the Borough,
- Silk Stream to the East of the Borough, and
- Two further models (undertaken as part of Group 3 modelling works) to the South East of the Borough.

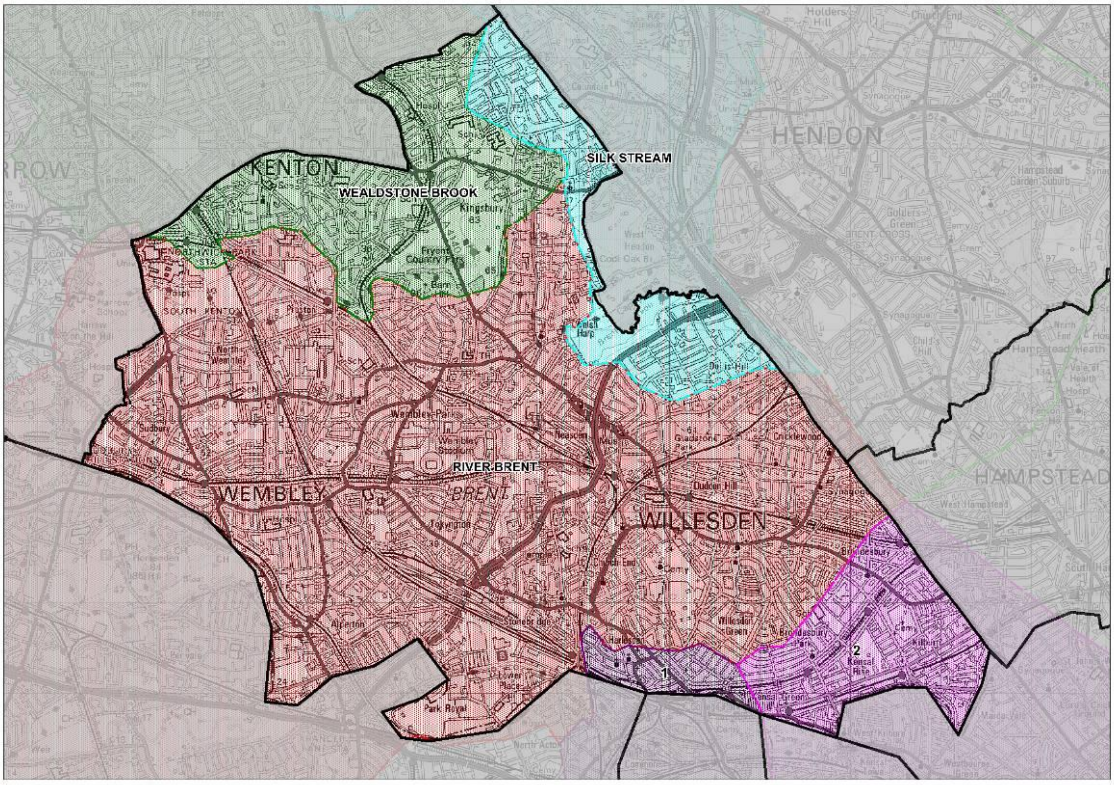

Figure 3-1 Model Domain coverage of LBB

By using 2D direct rainfall models key overland flow routes were identified along with areas at risk of significant ponding. The model was run for a range of return periods:

Modelled Return Period	Suggested Use
3.33% AEP (1 in 30 chance of occurring in any given year)	This layer will help to identify areas that could be prone to regular flooding and could inform maintenance regimes.
1.33% AEP (1 in 75 chance of occurring in any given year)	This layer could be used to help inform spatial planners of where development may not be viable, as there is the potential for no insurance coverage.
1% AEP (1 in 100 chance of occurring in any given year)	In conjunction with the EA Flood Zone 3 mapping, this could be used to inform emergency and spatial planning teams.
1% AEP (1 in 30 chance of occurring in any given year) plus 30% climate change	This layer could be used to help inform spatial planners of the potential long term sustainability of developments.
0.5% AEP (1 in 200 chance of occurring in any given year)	This layer should be used by emergency planning teams when formulating Multi Agency Flood Plans and emergency evacuation plans from areas at risk of flooding.

Table 3-4 Modelled Return Periods and their possible uses.

A more detailed modelling summary is provided in Appendix C (SWMP Report Volume 2).

Summary of Results

As a result of the surface water modelling the following mechanisms of flooding were identified:

- Ponding of flow in topographical depressions.
- Ponding in areas as a result of poor drainage/soil infiltration.
- Ponding upstream of structures with small underpasses/subways.
- Overland flow along topographical lows and valley channels such as residential streets, gardens and through property.

The surface water modelling was validated using the FMfSW shallow and deep outlines, historic flood incidents and Hyder site visits to establish if there was a correlation between the mapped areas identified at risk. There was a good match between the Drain London mapping, historic flood incidents and the EA FMfSW.

The mapping did not correspond with all of the historic flood incidents, however it may be that the source and location of the exact flood incident has not been accurately reported or recorded in the past. The Drain London mapping identified clearer connections between areas of flooding as well as showing flow velocity and hazard.

The hazard mapping produced should be treated with caution as inconsistencies in the LiDAR surface received for the study, as a result of inconsistent processing, have resulted in areas where there low depths of surface water are showing to be high hazard rating. The depth and hazard mapped outputs for all five of the modelled return periods are illustrated in figure numbers D-9 to D-18 in Appendix D.

3.4 Ordinary Watercourse Flooding

Introduction

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, and in particular its potential to cause significant and widespread flooding.

The Water Resources Act (1991) defines a 'Main River' as "a watercourse shown as such on a Main River Map". The Environment Agency keeps and maintains information on the spatial extent of the Main River designations. The FWMA defines any watercourse that is not a Main River as an ordinary watercourse- being any river, ditch, stream, cut, sluice, dyke or non-public sewer.

The Environment Agency has 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.

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).

Extent of Ordinary Watercourses

As LLFA, LBB is responsible for the maintenance and management of flood risk from three unnamed ordinary watercourses in the Borough. There have been no flood risk studies undertaken on any of the ordinary watercourses within the Borough.

Historical Records - Ordinary Watercourses

The North London SFRA[iv] mentions several fluvial flooding events within LBB however very little information is provided about specific locations affected.

The Brent SFRA (2007)[v] listed several major flood events on the River Brent (1928, 1977, 1988, 1990 and 2000) and on the Wealdstone Brook (15 flood events between 1928 and 1981). However both of these watercourses are Main River. No further information regarding the extent of the flooding or the consequences were reported so it was difficult to determine if there was any ordinary watercourse flooding in the LBB.

The Environment Agency Flood Map (Figure 3-2: drawing number 2207-UA002334-BMD-02) is a national dataset which is comprised of mapping from multiple hydraulic models. The map is split into two categories of risk Flood Zone 3 which outlines the area at risk of a 1 in 100 year fluvial flood event and Flood Zone 2 which outlines the areas at risk of a 1 in 1000 year fluvial flood event. The Flood Map outlines incorporate the historic fluvial event extents where available.

Ordinary Watercourse Summary of Flood Risk

Ordinary watercourses have been included in the surface water flood modelling undertaken as part of this study, further details of how these are included within Appendix C.

It is evident that due to the historic development and treatment of these watercourses, largely in hiding the watercourses within culverts to achieve greater land available for development, a ***moderate to high risk*** exists across the Borough in relation to flooding from ordinary watercourses. This is further exacerbated due to the current climatic trends with more intense storms, increasing levels of urban impermeability (speeding up the runoff from the area) and pressure on maintenance budgets for all parties involved in flood risk management.

3.5 Groundwater Flooding

Groundwater flooding occurs as a result of water rising up from an underlying aquifer or from water flowing from abnormal springs. This tends to occur after long periods of sustained heavy rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by major aquifers, although increasingly it is also associated with more localised floodplain sands and gravels.

Groundwater flooding tends to occur sporadically in both location and time, and tends to last longer than fluvial, pluvial or sewer flooding. When groundwater flooding occurs, basements and tunnels can flood, buried services may be damaged, and storm sewers may become ineffective, exacerbating the risk of surface water flooding. Groundwater flooding can also lead to the inundation of farmland, roads, commercial, residential and amenity areas.

It is also important to consider the impact of groundwater level conditions on other types of flooding e.g. fluvial, pluvial and sewer. High groundwater level conditions may not lead to widespread groundwater flooding. However, they have the potential to exacerbate the risk of pluvial and fluvial flooding by reducing rainfall infiltration capacity, and to increase the risk of sewer flooding through sewer/groundwater interactions.

Groundwater may become elevated by a number of means: (a) above average rainfall for a number of months in Chalk outcrop areas; (b) shorter period of above average rainfall in permeable superficial deposits, (c) permeable superficial deposits in hydraulic continuity with high water levels in the river, (d) Interruption of groundwater flow paths; and (e) cessation of groundwater abstraction causing groundwater rebound.

Groundwater flooding is responsibility of the LLFA.

3.5.1 Geology

The solid geology of LBB is underlain by a thick layer of London Clay. There are layers of gravel deposits interlaced into the clay which could provide a pathway for groundwater surcharge. Figure D-8 in Appendix D illustrates the borough wide geology.

3.5.2 Hydrogeology

The geology of the LBB area suggests that in a majority of areas groundwater recharge is unlikely to occur. The areas adjacent to the watercourses in the borough may have an increased likelihood of groundwater recharge due to the presence of alluvial substrate.

3.5.3 Potential Groundwater Flooding Mechanisms

There are three main mechanisms for groundwater flooding:

1 Prolonged rainfall that causes the water table to rise in unconfined aquifers, usually when antecedent groundwater levels are high (most common in upper reaches of chalk catchments within the UK).

2 Lateral flow through river banks (particularly raised embankments) into low lying areas as river levels rise.

3 Blockage of groundwater flow routes (such as by a hard defence) which artificially raises the water table.

As the LBB is predominantly underlain with a thick layer of London Clay the risk of groundwater flooding from the first mechanism is likely to be very low.

The second mechanism of groundwater flooding is likely to pose a moderate risk to properties in the LBB as there are several large watercourses within the borough. If groundwater flooding is triggered in the surrounding alluvial deposits it is likely to affect properties with basements or those that are not raised up above the floodplain.

The third mechanism of groundwater flooding occurs where the artificial ground is thick and permeable which can create a perched water table. Flooding from this mechanism is unknown in the LBB and has not been reported.

3.5.4 Evidence for Groundwater Flooding

The Environment Agency provided a groundwater flooding GIS dataset which documented all reported groundwater incidents across London. The dataset shows a large number of incidents across the LBB however a majority are reported as waterlogging/standing water in gardens rather than groundwater flooding to property.

There is no particular correlation between the flooding incidents and a majority seem to be individual instances of flooding. This makes it difficult to establish a link between the reported groundwater incidents with any other historic flooding incident records (Figure 3-3: drawing number 2211-UA002334-BMD-02).

3.5.5 Increased Potential Elevated Groundwater

As part of the Drain London project, a London wide map was commissioned to identify areas at risk of increased elevated groundwater flooding. The Increased Potential for Elevated Groundwater (iPEG) map was produced using four data sources:

- British Geological Survey 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.

The resulting iPEG map shows those areas within the LBB 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 iPEG map identifies the potential groundwater flooding in areas with superficial permeable deposits (unconsolidated aquifers) and consolidated aquifers.

Based on this dataset a majority of the areas identified as having an increased potential elevated groundwater correspond with the main river channels within the borough. Figure 3-3 illustrates the iPEG mapping for the LBB.

3.5.6 Infiltration SuDS Suitability

Based on the BGS maximum and minimum permeability datasets infiltration SuDS suitability was analysed across LBB. The table below summarises the infiltration SuDS suitability categories and the data classifications within each.

Infiltration SuDS Suitability	Minimum Permeability	Superficial Deposits
Potentially Suitable	High/very high	High/very high (if they exist)
Potentially Unsuitable	Low/very low	Low/very low (if they exist)
Uncertain	Low/very low or High/very high	High/very high or Low/very low

Table 3-6 Infiltration SuDS Suitability Summary

Within the LBB several areas were classified as potentially suitable for infiltration SuDS. The main potentially suitable areas are within the River Brent corridor. Dollis Hill, Barn Hill, Blackbird Hill, Cool Oak, Wembley Park and Tokyngton are all potentially suitable sites. A majority of the borough falls within the potentially unsuitable category due to the underlying Clay geology. Figure D-7 in Appendix D outlines the infiltration SuDS suitability across the LBB.

3.5.7 Groundwater Flood Risk Summary

The risk of groundwater flooding is ***low*** across a majority of the borough due to the thick London Clay geology beneath the borough. The areas at highest risk of groundwater flooding within the borough are those adjacent to watercourses. The surface geology in these areas is prone to groundwater re-charge and lateral groundwater flow.

3.6 Sewer Flooding

3.6.1 Introduction

Sewer flooding is often caused by excess surface water entering the drainage network. Water companies, in this case Thames Water, are obliged under the Water Industry Act[vi] to facilitate drainage of surface water up to a 1 in 20 year return period event.

Asset Type	Description
Foul	The foul system is maintained and operated by TWUL.
Surface Water	The surface water sewer system is maintained and operated by TWUL, with connections from both TfL and LBB highways assets.
Combined	The combined system is maintained and operated by TWUL.

Table 3-6 LBB Public Sewerage System

The sewerage system across the west of London was installed in the early 20th century and was predominantly designed to accommodate green field run off. There was significant development and expansion into this area in the 1930s which resulted in the West Middlesex Main Drainage board installing a more substantial waste water system. The sewers were designed to cope with significant population growth but an increase in surface water runoff was not factored in when the system was developed (further details are presented in Appendix B).

It is understood that a large proportion of the surface water systems across the borough were installed pre-1980. The expanding urban area within the borough has led to more impermeable surface coverage. This has caused a significant increase in surface water runoff which results in the surface water drainage system being overwhelmed on a more frequent basis.

Overflows from the foul sewers through gullies and manholes (where their covers are blown due to the internal water pressure) into roads, footpaths, etc, can also occur during large storm events. This type of sewer flooding is partially alleviated via overflow pipes that currently take some of the excess flows from the system directly into the urban watercourses across LBB.

> The water quality issues that arise from the above discharging into the urban watercourses are significant and as such should be addressed as part of the developing Surface Water Management Plan framework. These represent significant challenges across London to assist with achieving good ecological status or potential for water bodies as part of the requirements laid down within the EU Water Framework Directive.

As LLFA, LBB is responsible for undertaking investigations into overflows from the drainage system as a result of heavy rainfall events. Thames Water is responsible for overflows from the drainage system as a result of blockage or poor maintenance and where the network capacity is inadequate.

It is important to note that the mechanism of surface water flooding identified in Section 1.3 (surplus surface water not able to soak and/or enter into the surface water or combined sewers) can be combined with overflows from the combined sewers themselves. If surface water is

unable to enter the system it is because it is already full or it is already overflowing, as a result of the same storm event or a previous storm.

3.6.2 Thames Water Data

DG5 Register

TWUL maintains a register of flooding as a result of surcharging of the foul and combined sewer network. This register records incidents of flooding locations and likely causes. Thames Water has provided their DG5 database for the LBB area however the data was only provided with four digit postcode references so it was difficult to establish specific areas at risk. The general areas identified on the DG5 register are mapped in Figure D-6 in Appendix D.

The DG5 data shows that the southern area of Kenton (postcode HA3 0) to the north west of the borough has the highest number of recorded sewer flooding incidents 51-100 records. There are six other areas within the borough that also have a significant number of reported sewer flooding incidents (21-50 records). Two are to the west of the borough near Wembley (HA0 3 and HA9 8), two to the south of the borough in south Willesden (NW109 and NW102) and two other post code areas NW9 7 and NW6 5. Based on the DG5 register the entire borough has experienced sewer flooding at some point with no postcode regions registering no recorded incidences. Two thirds of the borough has experienced less than 20 sewer flooding incidents in each four digit postcode region.

Postcode	Total	Postcode	Total	Postcode	Total	Postcode	Total	Postcode	Total
HA0 1	3	HA9 7	5	NW104	16	NW2 6	11	NW2 6	11
HA0 2	15	HA9 8	21	NW105	2	NW2 7	17		
HA0 3	31	HA9 9	14	NW107	4	NW6 5	21		
HA0 4	8	NW100	3	NW108	1	NW6 6	7		
HA3 0	66	NW101	5	NW109	21	NW6 7	19		
HA9 0	1	NW102	21	NW2 4	1	NW9 0	9		
HA9 6	13	NW103	9	NW2 5	3	NW9 8	20		

Table 3-7 Summary of DG5 Register (as of April 2011)

Based on the DG5 register the entire borough has experienced sewer flooding at some point. Most of the borough has experienced less than 20 sewer flooding incidents in each four digit postcode region. Once a property is identified on the water companies DG5 register, it typically means that the water company can put funding in place to take properties off the DG5 register.

Sewer Network Location

TWUL also provided information on their drainage infrastructure including sewers, pumping stations and outfalls. This information has been overlain onto CDAs to help identify opportunities for collaboration to help reduce the risk across the area. Subject to their being sufficient cause, TWUL is keen to work with Councils in order to mitigate flood risk issues and would assist in undertaking combined studies to help provide greater benefits from potential mitigation options. Figure D-5 in Appendix D shows the Thames Water sewer network serving LBB.

The majority of Brent is served by separate sewers which, in many cases as described in Section **1.6.1**, have been subject to a history of misconnections and inappropriate usage as the area has been developed. In many instances, the potential level of service for the below ground infrastructure has been further eroded through urban intensification, increasing impermeability and cross-connections and, as such, it is likely that the sewers across the Borough have varying standards of capacities, particularly in the north.

3.6.3 Sewer Flood Risk Summary

The risk of sewer flooding is shown to be ***high*** across the majority of the borough for a number of historical reasons highlighted above, which include but are not limited to:

- Misconnections
- Cross connections
- Urban intensification
- Poor historical planning decisions
- Urban creep (paving front drives)
- Natural catchment - impermeable soils
- Inappropriate use (fats, oils and greases)
- Diversion of 'natural' watercourses into the sewerage system

The below ground 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. The risk is exacerbated in areas towards the west and east of the borough, where similar issues contribute to the problems experienced in these 'lower-lying' areas.

3.7 Other Influences

The Environment Agency has responsibility for managing and mitigating flood risk from designated Main Rivers and flooding from this source has been further assessed as part of the previously completed Level 1 and 2 SFRAs for the London Borough of Brent. There are a number of Main Rivers that traverse LBB:

- River Brent – the Brent runs generally from east to west through the centre of the Borough and into the London Borough of Ealing. The River Brent is underlain by London Clay with very limited permeability which can generate significant volumes of rapid surface water during periods of heavy rainfall, before leaving the Borough. The Environment Agency holds a model of the River Brent which was modified and rerun for the "River Brent Modelling & Mapping Study" delivered in January 2011.
- Wealdstone Brook – the Wealdstone Brook (and its tributary the Kenton Brook) runs from north to south through the centre of the Borough from the London Borough of Harrow and discharges into the River Brent to the east of Wembley Stadium, in between Fourth Way and Hannah Close.
- Mitchell Brook - flows from east to west from the Harlesdon area of Brent and joins the River Brent in Tokyngton Park to the north of the junction of the A404 and A406.
- Wembley Brook - flows from west to east from Wembley and joins the River Brent at Wembley Point within the Stonebridge Culverts running adjacent to the A406.
- The Environment Agency historic fluvial flood outline maps are displayed in Figure D-4 in Appendix D. The EA historic maps contain two flooding records for the River

Brent. The largest outline was recorded for the January 1977 event with flooding extending into Tokyngton, Stonebridge and Alperton. The July 2007 event outline is smaller and only flooded the river floodplain at Tokyngton.

Asset management and regular drainage system checks are important to ensure that effective maintenance regimes are in place to ensure that assets and drainage components do not contribute to flood risk within the borough.

3.8 Critical Drainage Areas

A Critical Drainage Area (CDA) is defined as "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 (LFRZ) during severe weather thereby affecting people, property or local infrastructure."[vii] A LFRZ is defined as a discrete area of flooding that does not exceed the national criteria for a 'Flood Risk Area' but still affects houses, businesses or infrastructure.

The CDA comprises of the upstream 'contributing' catchment and extends downstream of an area where it has an impact on an LFRZ. The CDA incorporates influencing drainage catchments as well as surface water catchments. The CDA accounts for the following factors:

- Significant underground linkages: Underpasses, rail/road tunnels, large diameter surface water/sewer/combined pipelines and culverted watercourses.
- Cross boundary linkages: CDA extents should not be curtailed by political boundaries.
- Incorporate the hydraulic catchment contributing to the LFRZ and the areas available for flood mitigation options.
- Should only be defined on a local scale – ideally as individual tributaries of surface water flow paths.
- Significant infrastructure: Main road (access to hospitals or evacuation route), rail routes, rail stations (national and underground), main hospitals and schools.

The LBB CDAs have been derived by assessing areas of significant interaction between the 100yr mapped depth and hazard outputs with critical infrastructure and property (EA National Receptor Data). Where areas of significant surface water flooding was shown to be affecting property and/or critical infrastructure a CDA was drawn using the underlying topography and the drainage network.

Twenty-seven CDAs were defined in the LBB within each CDA one or more LFRZs were identified (drawing number 1201-UA002334-BMD-02 in the Executive Summary). Furthermore, the categories were sub-divided to identify the presence of basements and area deprivation to provide a fuller picture of the potential risks and ability of an area to prepare and recover from an event. Table 3-8 describes this process further:

Category	Description
Households	• All residential dwellings • Caravans, mobile homes and park homes intended for permanent residential use • Student halls of residence, residential care homes, children's homes, social services • homes and hostels
Deprived Households	• Those households falling into the lowest 20% of ranks by the Office of National Statistics' Indices of Multiple Deprivation.
Non-Deprived Households	• Those households not falling into the lowest 20% of ranks by the Office of National Statistics' Indices of Multiple Deprivation.
Basements	• All basement properties, dwellings and vulnerable below ground structures (where identified in existing dataset including those provided by Thames Water and Environment Agency's National Receptor Database).

Table 3-8 Household and Basement Sub-Categories.

The 1 in 100 year mapping was validated using historical flood incident data compiled by the LBB and also the Environment Agency FMfSW 1 in 200 year shallow and deep outlines. There is a good correlation between the EA FMfSW and the Drain London mapping. The mapping did not correspond with all of the historic flood incidents, however it must be noted that, historically, the source and exact location of the flood incident have not been accurately reported.

The model has not taken into account any known issues or engineering adaptations o the underground drainage network, undertaken since the incidents occurred and as such, it may be that the previously recorded flood incidents were compounded by other issues which the current model cannot represent.

Appendix E contains the details of each of the 27 CDAs, with the following sections, presenting a summary of the data corresponding to these defined areas. It is important to note that in several areas the model is showing extensive ponding upstream of drainage assets, in most cases this may not be a realistic representation of what would happen in an actual event, due to the presence of significant below ground infrastructure. Where necessary and evident from site visits/aerial photography, above ground openings and passages through road and rail embankments have been incorporated into the model.

In several locations there are no visible above ground connections however the TWUL sewer network shows that there are underground connections, these have not be modelled as part of this study. Although these are highlighted within the LBB CDAs, the developing options have not wholly focussed upon aiming to fully resolve these issues, other than to review the potential for the flooding to occur.

Additionally, the presence of the ponding does help to highlight the value of the particular assets that cross these linear barriers and the potential risks if the asset is not maintained or if it fails.

3.9 Summary of Risk

3.9.1 Overview of Surface Water Flooding in Brent

The following conclusions are taken from the Phase 2 Risk Assessment, which has involved pluvial modelling combined with site visits and review of historical flood records provided by the Council, Thames Water and the Environment Agency:

- Across the study area, the areas particularly susceptible to overland flow are formed by the river valleys of the Wealdstone Brook and River Brent. Other low lying areas that are present throughout the study area such as underpasses, subways and lowered roads beneath railway lines are also at risk;
- The outputs from the intermediate level 2D pluvial modelling, alongside historic records, revealed that several stretches of the main line (Wembley Stadium), Jubilee line (between Queensbury & Kingsbury), London Overground (Brondesbury Park, Queens Park, Kensal Rise & Kensal Green) and Bakerloo line (Kensal Green, Kilburn Park and Queens Park) are susceptible to surface water flooding and, if flooded, will impact services into and out of London;
- The outputs from the intermediate level 2D pluvial modelling revealed discrete surface water flooding locations along the up-stream side of sections of raised rail embankment; and
- The outputs from the intermediate level 2D pluvial modelling revealed that several areas within the Main River Valleys are susceptible to surface water flooding as well as fluvial flooding.

There are two areas where surface water flooding is likely to be the caused by pluvial, sewer and groundwater flooding:

- Kenton – The pluvial modelling indicates that this area is at risk of significant flooding during the 1% AEP rainfall event with approximately 240 properties falling within the modelled extent. Additionally the DG5 sewer flooding database records over 51 properties at risk of sewer flooding in this vicinity. It is also an area identified as having an increased potential for elevated groundwater and parts of the area are believed to interact with the local Main River (Wealdstone Brook), and;
- Northwick Park and Preston Road- The pluvial modelling indicates that this area is susceptible to significant flooding in the 1% AEP rainfall event with approximately 220 properties falling within the modelled extent, Additionally the DG5 sewer flooding database records 21+ properties at risk of sewer flooding in this vicinity. The area to the South of Preston Road has been identified as having an increased potential for elevated groundwater.

The Problem

The issue for the LBB and similarly for most of the London Boroughs is that a majority of the Borough is urbanised meaning there is little natural space for water to flow naturally through its catchment. Large volumes of water generated from storm events, due to both the natural and man-made impermeability of the Borough are all contained within the two main systems (as there is very little infiltration potential across the Borough):

- The watercourses – which have largely been constrained by development and are either contained within canalised straight open sections or put into culverts and hidden away to secure additional land for development; and
- The below ground sewerage network, which as highlighted above has had its potential capacity eroded away.

Each of these systems is by and large unable to take any additional flows (bearing in mind the foul system was designed for a population greater than that residing in the areas) and as such the historical development decisions and increasing need for development represents a ***CRITICAL*** risk to the current and future level of flood risk experienced across the LBB, particularly bearing in mind the climatic trends towards more intense storms.

This problem is not restricted to the LBB, the problem is further exacerbated in adjacent 'downstream' boroughs, where the surface water volumes from the upper boroughs such as Barnet contributes to the flooding issues within the Boroughs nearer the River Thames.

3.9.2 Risk to Existing Properties and Infrastructure

As part of the Phase 2 assessment, a quantitative assessment of the number of properties at risk of flooding has been undertaken for each CDA and for the Borough as a whole. The 1% AEP rainfall event has been used to inform this assessment, as specified in the Drain London Data and Modelling Framework.

The Borough-wide quantitative assessment is provided in Table 3-9. Table 3-9 provides a summary of the flooded properties for each identified CDA within LBB alongside information on the various property categories used, and methodology for defining these. The property count has been calculated for infrastructure, households and commercial/industrial properties for the 1% AEP rainfall event.

Property Type	Sub Category	No. of Properties flooded <0.1m	No. of Properties flooded >0.5m
Infrastructure	Essential Infrastructure	215	7
	Highly Vulnerable	54	
	More Vulnerable	434	3
	Other Infrastructure		
Households	Deprived (All)	19091	55
	Deprived (Basements)	1107	
	Non-Deprived (All)	47173	298
	Non-Deprived (Basements)	1025	
Commercial/ Industrial	Commercial/Industrial (All)	7843	85
	Commercial/Industrial Basements		
Other			

Table 3-9 – Borough-Wide Summary of Flood Risk

Due to the large number of CDAs identified within LBB it was necessary to prioritise the CDAs to allow for the identification of those at higher risk than others. Each CDA was initially prioritised based on the number of properties (residential and commercial) and the amount of critical infrastructure at risk (Table 3-10). The larger the number affected the higher the CDA on the prioritisation list. This initial list did not take into account areas with historic flood records.

The prioritisation list was adjusted to take into account areas of known flood risk. Where one or more historic incidents have been recorded within a CDA, these CDAs were moved to the top of the prioritisation list. In some cases, a CDA that has several incidents has been moved higher up the list than a CDA with no incidents and a larger number of properties/infrastructure assets within the surface water mapped outline.

Table 3-10 below outlines the initial priority and the revised priority based on areas of known flood risk, number of property and critical infrastructure at risk in the 1 in 100 year surface water mapping.

CDA_ID	Location	Area (Km²)	No. of Historic Incidents	Initial Priority	Revised Priority
Group2_037	Northwick Park	3.38	4	4	**1**
Group2_034	Belvedere Way	2.55	4	5	**2**
Group2_049	Dudden Hill	2.46	3	2	**3**
Group2_054	Forty Bridge	1.31	3	15	**4**
Group2_047	Church End	2.65	1	1	**5**
Group2_038	Barham Park	1.58	1	3	**6**
Group2_059	Capitol Way Commercial area	1.47	1	7	**7**
Group2_055	Wembley Stadium	1.36	1	9	**8**
Group2_035	Winchester Avenue	0.70	1	13	**9**
Group2_056	Harrow Road	0.43	1	22	**10**
Group2_044	Tokyngton	0.55	1	23	**11**
Group2_048	Neasden	0.95	0	6	**12**
Group2_052	Review Road	0.64	0	8	**13**
Group2_058	Willesden Junction Station	0.19	0	10	**14**
Group2_045	Brentfield A404	0.64	0	11	**15**
Group2_046	Stonebridge	0.57	0	12	**16**
Group2_039	King Edward VII Park	0.43	0	14	**17**
Group2_041	Alperton	0.79	0	16	**18**
Group2_040	A4089	1.21	0	17	**19**
Group2_042	North Circular	1.46	0	18	**20**
Group2_043	Park Royal	1.54	0	19	**21**
Group2_053	Tudor Gardens	0.80	0	20	**22**
Group2_051	The Circle	0.24	0	21	**23**
Group2_060	Roe Green Park/Fryent Country Park	1.55	0	24	**24**
Group2_050	A4088	0.41	0	25	**25**
Group2_036	Preston sports ground	0.63	0	26	**26**
Group2_057	Monks Park North	0.24	0	27	**27**

Table 3-7 CDA Prioritisation

In Appendix E (SWMP Report Volume 2), mitigation options are considered for each of the CDAs. It should be noted that although the historic incidents were used to prioritise sites the mapping did not always coincide with the incident locations. Therefore, in some cases the preferred options developed for a CDA may not focus on resolving the cause of a historic flood incident if the source and location of the incident is unclear. Where this is the case the preferred options have been developed to mitigate the main areas of surface water risk identified by the mapping.

The table below outlines the number of properties the Drain London modelling has identified as being at risk of surface water flooding. The table is divided into the different asset types and outlines the assets at risk from deep (>0.5m) surface water flooding.

CDA ID	Scheme Location	Moderation		Infrastructure						Households								Commercial / Industrial				Validation
		Primary	Secondary	Essential		Highly Vulnerable		More Vulnerable		Non-Deprived (All)		Non-Deprived (Basements)		Deprived (All)		Deprived (Basements)		All		Basements Only		
				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	
Group2_037	Northwick Park	Regionally Important Infrastructure	Health and Safety	4	0	7	0	11	0	219	47	0	0	0	0	0	0	87	4	0	0	FMfSW and historic incidents
Group2_034	Belvedere Way	H & S	Deliverability	4	0	0	0	4	0	242	28	0	0	0	0	0	0	37	2	0	0	FMfSW and historic incidents
Group2_049	Dudden Hill	H & S	None	8	0	0	0	8	0	548	70	1	0	94	0	0	0	72	3	0	0	FMfSW and historic incidents
Group2_054	Forty Bridge	H & S	None	2	0	0	0	4	0	108	2	0	0	19	0	0	0	30	0	0	0	FMfSW and historic incidents
Group2_047	Church End	Regionally Important Infrastructure	Health and Safety	6	0	2	0	19	0	63	0	0	0	576	2	0	0	83	3	0	0	FMfSW and historic incidents
Group2_038	Barham Park	H & S	None	6	0	0	0	6	0	352	75	0	0	0	0	0	0	68	2	0	0	FMfSW and historic incidents
Group2_059	Capitol Way Commercial area	None	None	2	0	1	0	11	0	211	0	0	0	0	0	0	0	39	0	0	0	FMfSW and historic incidents
Group2_055	Wembley Stadium	Regionally Important Infrastructure	None	4	0	0	0	3	0	167	1	0	0	0	0	0	0	91	6	0	0	FMfSW and historic incidents
Group2_035	Winchester Av	H & S	None	0	0	0	0	3	0	126	23	0	0	0	0	0	0	15	5	0	0	FMfSW and historic incidents

CDA ID	Scheme Location	Moderation		Infrastructure						Households								Commercial / Industrial				Validation
		Primary	Secondary	Essential		Highly Vulnerable		More Vulnerable		Non-Deprived (All)		Non-Deprived (Basements)		Deprived (All)		Deprived (Basements)		All		Basements Only		
				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	
Group2_056	Harrow Road	Regionally Important Infrastructure	None	1	0	0	0	2	0	69	0	0	0	0	0	0	0	14	0	0	0	FMfSW and historic incidents
Group2_044	Tokyngton	Regionally Important Infrastructure	None	1	0	2	0	1	0	69	0	0	0	0	0	0	0	11	0	0	0	FMfSW and historic incidents
Group2_048	Neasden	Regionally Important Infrastructure	Health and Safety	6	0	1	0	6	0	52	0	2	0	189	41	0	0	79	11	0	0	FMfSW
Group2_052	Review Road	Regionally Important Infrastructure	Health and Safety	1	0	2	0	2	0	181	19	0	0	0	0	0	0	18	0	0	0	FMfSW
Group2_058	Willesden Junction Station	Regionally Important Infrastructure	None	4	0	0	0	4	0	0	0	0	0	165	0	0	0	35	0	0	0	FMfSW
Group2_045	Brentfield A404	Regionally Important Infrastructure	None	2	0	2	0	7	0	0	3	0	0	141	0	0	0	11	0	0	0	FMfSW
Group2_046	Stonebridge	Regionally Important Infrastructure	None	3	0	0	0	2	0	0	0	0	0	136	0	0	0	25	1	0	0	FMfSW
Group2_039	King Edward VII Park	None	None	2	0	0	0	1	0	123	0	0	0	0	0	0	0	2	0	0	0	FMfSW
Group2_041	Alperton	Regionally Important Infrastructure	None	3	0	0	0	3	0	49	3	0	0	0	0	0	0	44	18	0	0	FMfSW
Group2_040	A4089	Regionally Important Infrastructure	Health and Safety	4	0	2	0	6	0	93	0	0	0	64	10	0	0	58	4	0	0	FMfSW
Group2_042	North Circular	Regionally Important Infrastructure	None	5	0	0	0	5	0	53	0	0	0	0	0	0	0	56	0	0	0	FMfSW
Group2_043	Park Royal	None	None	0	0	1	0	4	0	12	0	0	0	10	0	0	0	52	3	0	0	FMfSW
Group2_053	Tudor Gardens	H & S	None	1	0	0	0	1	0	98	4	0	0	0	0	0	0	11	0	0	0	FMfSW
Group2_051	The Circle	H & S	None	0	0	0	0	0	0	71	0	0	0	0	0	0	0	7	0	0	0	FMfSW

CDA ID	Scheme Location	Moderation		Infrastructure						Households								Commercial / Industrial				Validation
		Primary	Secondary	Essential		Highly Vulnerable		More Vulnerable		Non-Deprived (All)		Non-Deprived (Basements)		Deprived (All)		Deprived (Basements)		All		Basements Only		
				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	
Group2_060	Roe Green Park / Fryent Country Park	Regionally Important Infrastructure	None	2	0	1	0	1	0	68	0	0	0	0	0	0	0	19	0	0	0	FMfSW
Group2_050	A4088	Regionally Important Infrastructure	None	2	0	1	0	1	0	35	0	0	0	14	0	0	0	12	0	0	0	FMfSW
Group2_036	Preston sports ground	Health and Safety	None	2	0	0	0	2	0	31	4	0	0	0	0	0	0	4	1	0	0	FMfSW
Group2_057	Monks Park North	None	None	0	0	0	0	1	0	12	0	0	0	0	0	0	0	3	0	0	0	FMfSW

Table 3-8 CDA Summary Risk Table

Note: The summary of risk table is populated by calculating the total number of units from each sub-category that are affected by surface water flooding from a 1% AEP rainfall event. The infrastructure and household sub-categories are described in Table 1-2.

4 Phase 3: Options

As part of the LBB SWMP a range of options were assessed for each of the CDAs listed in Table 3-10. Appendix E outlines the option assessment process for each CDA in more detail.

4.1 Objectives

The purpose of Phase 3 is to identify a range of structural and non-structural measures for alleviating flood risk and assess them to eliminate those that are not feasible or cost beneficial. The remaining options are then developed and tested against their relative effectiveness, benefits and costs. The target level of flood protection has been set at 1 in 75 years to align solutions with the likely level of insurance cover available to the general public.

To maintain continuity within the report and to reflect the flooding mechanisms within the Borough the option identification has taken place on an area-by-area (site-by-site) basis following the process established in Phase 2. Therefore, the options assessment undertaken as part of the SWMP assesses and short-lists the measures for each CDA and identifies any non-standard measures available.

Phase 3 delivers a high level option assessment for each of the Critical Drainage Areas (CDAs) identified in Phase 2. No monetised flood damages have been calculated and flood mitigation costs have been determined using engineering judgement and high level estimates (CIRIA SUDS Manual 2007, EA FRM Estimating Guide 2010 and SPONS Price Book 2006) but have not undergone detailed analysis.

Costs are not whole life costs and they exclude operational and maintenance costs. They should be treated at an order of magnitude level of accuracy. The options assessment presented here follows that described in the Defra SWMP Guidance but is focussed on highlighting areas for further detailed analysis and immediate ‘quick win’ actions. Further detailed analysis may occur for high priority Critical Drainage Areas as defined by the Prioritisation Matrix (Table 3-11 and 4-2) the next Tier (Tier 3) of the Drain London project.

Any mitigation solutions across LBB need to address the performance of the below ground infrastructure and its potential to exacerbate flooding across the Borough, as well as critical infrastructure flooding.

4.2 Measures

The nature of flooding from local sources within London is by its nature widespread and without a significant investment of money it will be impossible to solve all of them in one attempt and in the near future. For this reason, preferred options that are being promoted within Appendix E are to influence planning policy with the aim of reducing run-off rates and increasing community resilience.

In relation to the CDAs, some local options have been chosen based upon those areas that are worst affected and for which historical flood information exists and where future flooding is shown to be a major risk area by the outputs of the Drain London modelling. Even within these areas, the scale of flooding is too diverse to be solved universally and cost-effectively. As a result, options rely on the localised implementation of smaller schemes and some pilot projects that aim to alleviate flooding for the worst affected properties across a broader

spectrum of flood events in an area and demonstrate the effectiveness of the proposed measures for future work.

A range of measures have been proposed to mitigate flood risk within the CDAs. Where possible and economical the use of sustainable drainage systems (SuDS) and surface water reduction strategies have been promoted over hard infrastructure alternatives such as the upgrading of existing sewers. The key constraints associated with the implementation of all of the options are space, cost and stakeholder/public acceptability.

Accordingly, the engineering options proposed within this report have been designed to be accommodated within the urban environment. Each option has been placed into one of three categories: Source, Pathway and Receptor. Further descriptions and details of each of these potential measures can be found in Appendix E.

4.3 Preferred Options

4.3.1 Brent Wide Preferred Options

As part of this phase of work Policy Areas have been defined across the Borough within which appropriate planning policies should be applied to manage flood risk. The LBB is predominantly covered by the River Brent and Counters Creek Policy Areas. The policy areas cover the entire Borough and are not limited to the CDA extents or borough boundaries. ***The reason for the inclusion of these areas is to highlight the fact that even if an area does not fall within a CDA it does not mean that surface water discharge from these areas can be uncontrolled, merely that the need for considering direct options for the area are not so critical.***

A number of Borough-wide options and policies have been identified that the Council and relevant stakeholders may consider adopting as part of their responsibility as LLFA for local flood risk management, with further details presented in Section 5.

Avoidance

A - Ongoing Improvements to Maintenance of Drainage Network - The management and maintenance of urban drainage network in LBB is the responsibility of a number of organisations:

- LBB – highway drainage including gully pots, non-main river channel and culvert maintenance including flood defence structures such as trash screens, bypass channels, wet/dry storage ponds, flood storage areas;
- Thames Water - main foul and surface public sewers;
- Environment Agency - flood risk management assets including culverts, raised defences, trash screens, Main River channel;
- TfL – highway drainage along the ‘Red Routes’; and
- Network Rail - railway track drainage.

Effective cleansing of gully pots is fundamental to the drainage across the Borough and LBB operate a regular maintenance regime for gully cleansing.

Gully pots are fundamental to integrated urban drainage as during intense precipitation events, surface water runoff is routed off roadways and other hard-standing into gully pots and

then into the public sewer system or in some case either highway drain or culverts. In essence, gully pots are a critical link in the performance of the overall drainage network.

Table 4-1 provides a summary of the identified drainage maintenance issues in the LBB.

Level of Service	LBB's Highways Department maintenance cycle is on a risk based rolling cycle of maintenance.
Development Pressure and Urban Creep	The conversion of front gardens to paved areas for car parking is prevalent across the Borough. This increase in impermeability results in cumulative impact and pressure on the drainage system, having to cope with greater volumes of water.
Blocked Gullies	Several locations across the Borough have reported regular flooding due to blocked gullies, resulting from insufficient capacity within TWUL network and high sediment levels in runoff from across the Borough.
Data Collation Weaknesses	Improvement in all stakeholders' data management systems is required to help understand the situation better and to further improve the levels of risk across the Borough.

Table 4-1 Summary of Identified Drainage Maintenance Issues across LBB

B – Planning & Development Policies - 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 LBB 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.***

Further details of the potential policies are included in Section 5.2.2. The potential policies help to achieve the 'twin-track' approach for adapting the urban environment promoted by this SWMP, namely:

Short term Development Management based policies to influence current and future development; and

Longer term Adaptation based policies to help achieve the Urban Water Vision for LBB through recreating the natural watercourses within the urban area to provide more space for water along it's pathways, through creating an extended network of linked corridors, building on those promoted within the London Plan and its Blue Ribbon Network

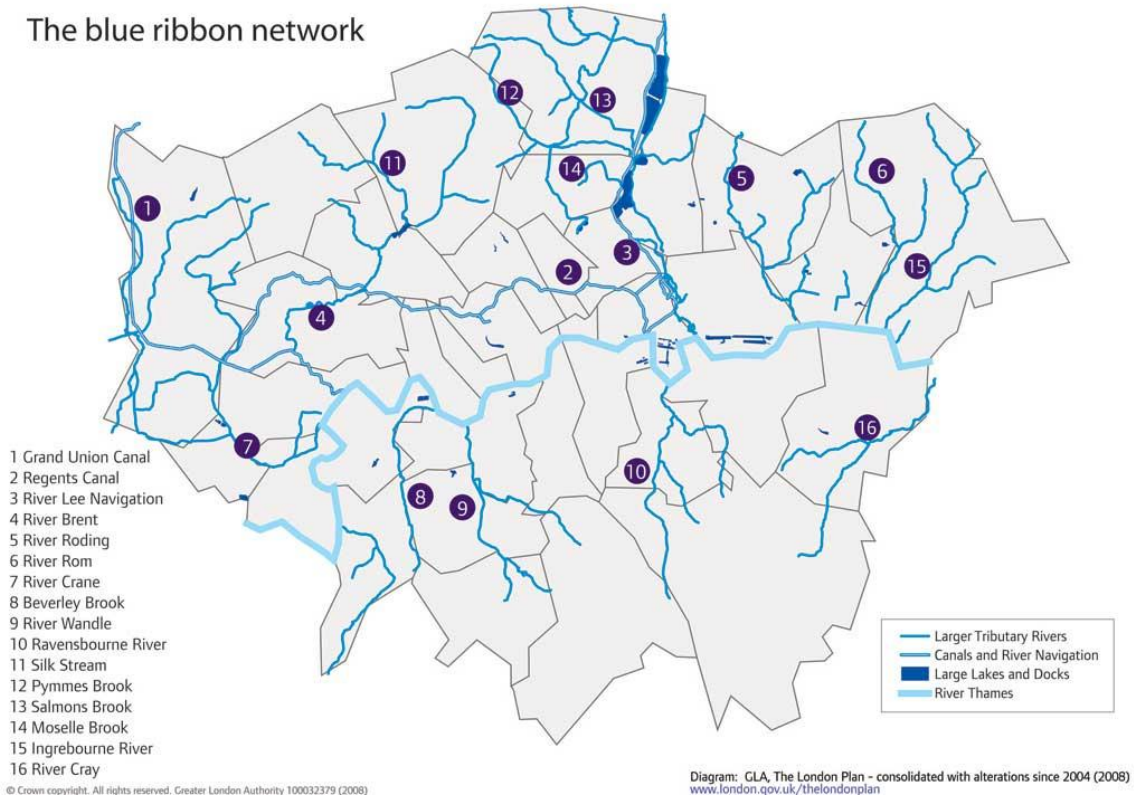

Figure 4-1 GLA – London Plan – Blue Ribbon Network (2009)

C – Resilience and Resistance – This element should also be promoted to help the communities prepare and live with flooding into the future. This element incorporates items under the planning policy development in that prevention is the best form of defence and as such strong policies should be instigated that avoid developing in areas of present and future flood risk, as well as adapting the future developments, businesses, infrastructure and communities to be more resilient to flooding.

Awareness

A 'quick win' action that should be implemented in the short-term is to increase awareness of flooding within communities at risk, and across the Borough as a whole. This could be achieved through a number of measures including:

- Website improvements
- Newsletters

The aim of this action is to raise the risks and consequences of surface water flooding amongst local communities and, through this, encourage residents to take up measures to combat flooding, such as installation of water butts to capture roof runoff, consideration to the extent and materials used when replacing permeable areas with hard standing areas within their property e.g. through the installation of driveways and patios.

Assistance

A 'quick win' action that should be implemented in the short-term is to increase assistance of flooding within communities at risk, and across the Borough as a whole. This could be achieved through a number of measures including:

- Provision of support to Community Flood Groups and Plan development;
- Provision of improved communications to help communities ***prepare, live and recover*** quickly to events;
- Building capacity and links within the LLFA and leading stakeholders to help with delivering more sustainable surface water management across the borough; and
- Maintaining closer links to enable quicker recovery of businesses and communities

Alleviation - CDA Level Preferred Options

Benefits

For the purpose of the Drain London Prioritisation Matrix, it is necessary to determine the benefits of each preferred option. The potential benefits of the scheme are measured using an estimated percentage of units removed from the predicted floodplain (eliminated) or where flood frequency is reduced (mitigated). This percentage has been determined by calculating the number of units within the LFRZ that the particular scheme has been designed to mitigate, as a percentage of the number of units within the CDA as a whole.

The input is restricted to multiples of five percent. It should be noted that the information within this table is purely for input into the Drain London Prioritisation Matrix and should be treated as such. Further modelling would be required to determine more accurately the potential benefits of the suggested schemes. An estimated cost for the preferred flood mitigation option for each identified CDA has been calculated based on standard unit costs provided as part of Tier 1 of the Drain London Project to mitigate the 1 in 75 year (1.3% AEP) event.

Costs

No monetised damages have been calculated, and flood mitigation costs have been determined using engineering judgement, but have not undergone detailed analysis. The following standard assumptions have been applied, as determined in the Drain London Prioritisation Matrix Guidance. The costs are a guide as to the potential capital costs for implementation of the scheme only. As a result, costs have been provided as cost bands, reflecting the strategic nature of the SWMP study and options identification:

- Costs do not include provisions for consultancy, design, supervision, planning process, permits, environmental assessment or optimum bias.
- No provision is made for weather (e.g. winter working).
- No provision is made for access constraints
- No provision made for land acquisition components.
- No operational or maintenance costs are included.
- No provision is made for disposal of materials (e.g. for flood storage or soakaway clearance).

Optioneering Approach

For each of the CDAs identified within LBB, a standard set of mitigation measures were compiled based on the Defra SWMP guidance. Each set of measures was assessed for its applicability and its effectiveness to mitigate flood risk on a CDA level. Appendix E summarises this option appraisal stage and includes a justification for each of the options

discounted and those taken forward as preferred options. It should be noted that no additional modelling has been undertaken as part of this SWMP.

Several of the mitigation measures assessed were likely to be more effective if they were applied on a borough wide scale and so these have been included in LBB Action Plan outlined in Section 5.1 of this report.

The options, however pursued within the urbanised area tend to follow the alteration to the pathway and are generally, at the lower cost scale of the options available for pursuit across LBB. This is predominantly, due to the urbanised nature of Brent, the limited opportunities within the green open spaces and the fragmented ownership of land within the Borough, making options that re-mould the urban environment to one that is greener by design harder to undertake, without significant and strong policy drivers or regeneration opportunities.

Discounted Option Discussion – Increasing the below ground drainage capacity

Options which would involve significant investment such as sewer separation have not been taken forward as preferred options. Although sewer separation would help to reduce and in some cases eliminate flood risk within the LBB it would need to be implemented on a large scale to be most effective. The Brent IUD study identified that flood risk in north Brent was exacerbated by system wide rather than localised issues.

A Borough wide scheme would incur excessive costs and would require cross-collaboration between a large number of stakeholders. These works would also be incredibly disruptive in such a heavily urbanised Borough. These more costly options need to be given more thought as they would help to address quantity and quality issues caused by the current system and the identified prevalence of mis- and cross connections.

A phased approach of implementation may be more appropriate but an in-depth discussion between the appropriate stakeholders would be required to identify where to start a network improvement programme. The selection of potential options for further examination has been focussed on reducing the risks of flooding being experienced across these CDAs, rather than attempting to eliminate the risks of flooding in the 1.33% AEP (1 in 75 chance of occurring in any given year) across most of the CDAs.

4.4 Next Steps

Taking into account the nature of the surface water flooding in LBB, the options identified through the Phase 3 Options Assessment, and requirements under the FWMA and FRR, it is considered that LBB should prioritise the following actions, as explained further in Section 5 in the short to medium-term:

- Identify and record all forms of flooding events across the borough, using the Drain London Template identified and supplied, so as to help improve the knowledge of events and their consequences in the future;
- Identify and record surface water assets onto the LBB Asset Register, prioritising those areas that are known to regularly flood and are therefore likely to require maintenance or upgrading in the short-term;

- Review the drainage, environment, water quality and flood risk management policies in light of the findings of the SWMP to identify where further policies/items would benefit LBB in achieving their duties as the LLFA.
- Initiate development forums with those planning to deliver all forms of development within the borough to present the risks and the aspirations of the Borough. These could be used to encourage the developers to achieve the items identified in the potential planning policy section of the Action Plan. This is important to capture new land that may come available subsequent to the Core Strategy.
- Consider the provision of an 'Information Portal' via LBB's website, for local flood risk information and measures that can be taken by residents to mitigate surface water flooding to/around their property. This could be developed in conjunction with the North West London Flood Group and include:
- A list of appropriate property-level flood risk resilience measures that could be installed in a property;
- A list of 'approved' suppliers for providing local services, such as repaving of driveways;
- A link to websites/information sources providing further information;
- An update on work being undertaken in the Borough by the Council and/or other Stakeholders to address surface water flood risk; and,
- A calendar showing when gullies are to be cleaned in given areas, to encourage residents to ensure that cars are not parked over gullies/access is not blocked during these times.
- 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.
- Undertake further drainage capacity studies for the CDAs identified in the report/Action Plan to determine the drainage capacity and potential for future improvements such as the provision of additional storage within the network. The study could consider the following:
- Identifying and recording surface water assets, including type, location and condition, as required for preparation of the Asset Register;
- Determining the condition and capacity of gullies and carrier pipes;
- Determining the connections to Thames Water surface sewers and assets
- Undertaking CCTV surveys of those areas which experience regular surcharging and flooding;
- Clearing those gullies or pipes identified as blocked during investigations (as part of annual maintenance routine); and,
- Determining upgrade requirements and costs for the local drainage infrastructure and seek funding opportunities to implement these.
- Consider undertaking a feasibility study to assess the potential for flood storage in the public open spaces across the Borough;
- Use the findings of the SWMP to review the priority areas that are currently targeted for gully cleansing and maintenance and amend if necessary.

- Collate and review information on Ordinary Watercourses in the Borough to gain an improved understanding of surface water flooding in the vicinity of these watercourses as well as ownership and maintenance responsibility for each watercourse.

4.5 Preferred Options Summary

Below is a table summarising the perceived benefit of the preferred options outlined in Appendix E. The benefits have been derived subjectively by assessing the area(s) at risk and the measure(s) proposed. In a majority of cases the preferred options are derived to mitigate flood risk to key property/assets rather than completely eliminate flood risk across the CDA. To gain a more accurate assessment of the benefits each option would provide further modelling would be required. No additional option modelling has been undertaken as part of this SWMP.

CDA ID	Scheme Location	Scheme Category	Infrastructure						Households				Commercial/ Industrial		Capital Cost Band
			Essential		Highly Vulnerable		More Vulnerable		Non-Deprived (All)		Deprived (All)		All		
			Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	
Group2_037	Northwick Park	Other or combination of above		25		15	15	20	35	40			10	15	501k-1m
Group2_034	Belvedere Way	Other or combination of above		40				15	25	25			5	15	501k-1m
Group2_049	Dudden Hill	Other or combination of above		10				10	50	20	50	20		10	251k-500k
Group2_054	Forty Bridge	Other or combination of above		25				25	10	15			10	10	51k-100k
Group2_047	Church End	Other or combination of above		10				10		10		10		10	101k-250k
Group2_038	Barham Park	Other or combination of above		25				15		35				20	<25k
Group2_059	Capitol Way Commercial area	Other or combination of above		10				20	100					25	51k-100k
Group2_055	Wembley Stadium	Source control, attenuation and super SuDS	25	25									5	5	101k-250k

CDA ID	Scheme Location	Scheme Category	Infrastructure						Households				Commercial/ Industrial		Capital Cost Band
			Essential		Highly Vulnerable		More Vulnerable		Non-Deprived (All)		Deprived (All)		All		
			Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	
Group2_035	Winchester Avenue	Other or combination of above		5					15	30		20	15	25	101k-250k
Group2_056	Harrow Road	Other or combination of above		25				25	20	15			10	35	26k-50k
Group2_044	Tokyngton	Other or combination of above		20						10					<25k
Group2_048	Willesden Junction	Other or combination of above		10				10		10		10		10	101k-250k
Group2_052	Review Road	Other or combination of above		25					5	35				5	<25k
Group2_058	Willesden Junction Station	Source control, attenuation and super SuDS	100					20							26k-50k
Group2_045	Brentfield A404	Other or combination of above	100								80				26k-50k
Group2_046	Stonebridge	Other or combination of above		10								10	100		26k-50k
Group2_039	King Edward VII Park	Other or combination of above		50					25	15					101k-250k
Group2_041	Alperton	Other or combination of above	100					10		10			100		101k-250k
Group2_040	A4089	Preferential/ Designated Overland flow routes		25		25		15		15		10		10	<25k
Group2_042	North Circular	Other or combination of		20											<25k

CDA ID	Scheme Location	Scheme Category	Infrastructure						Households				Commercial/ Industrial		Capital Cost Band
			Essential		Highly Vulnerable		More Vulnerable		Non-Deprived (All)		Deprived (All)		All		
			Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	
		above													
Group2_043	Park Royal	Source control, attenuation and super SuDS												20	<25k
Group2_053	Tudor Gardens	Other or combination of above						50		25				10	26k-50k
Group2_051	The Circle	Source control, attenuation and super SuDS								25					<25k
Group2_060	Roe Green Park/Fryent Country Park	Other or combination of above	60						95					10	101k-250k
Group2_050	A4088	Preferential/ Designated Overland flow routes		20											<25k
Group2_036	Preston sports ground	Source control, attenuation and super SuDS		50				25	20	15		20	25	25	101k-250k
Group2_057	Monks Park North	Other or combination of above						50	20	5			35	25	51k-100k

Table 4-2 Perceived Benefit of the Preferred Options for LBB

4.6 Option Prioritisation

The Prioritisation Matrix (Table 3-11 and 4-2) was developed out of the need for a robust, simple and transparent methodology to prioritise the allocation of funding for surface water management schemes across the 33 London Boroughs by the Drain London Programme Board. As such, the prioritisation should be understood in the high-level decision-making context it was designed for. It is not intended to constitute a detailed cost-benefit analysis of individual surface water flood alleviation schemes.

5 Phase 4: Implementation and Review

5.1 Introduction

There is an increasing recognition that surface water management should be undertaken in a safe and ecologically sustainable manner. Surface water has traditionally been regarded as a nuisance, causing economic damage and social upheaval. The surface water management plan process should assist with developing a more sustainable approach to managing risk within the urban environment. This is in line with the aspirations for LBB, including the water vision. This vision identifies that there is no easy solution following over 90 years of intense development, leading us to a twin track approach towards the Action Plan as shown in Figure 5-1.

Figure 5-1 Action Plan Twin Track Approach to surface water management

Many urban communities are aiming to adopt a more integrated land and drainage approach to surface water management at a variety of scales from singular developments to catchment wide approaches. The overwhelming evidence shows that there are substantial social, economic and environmental benefits to be had from driving communities and our urban environments to a more sustainable approach.

As identified in the vision for Surface Water Management in LBB (Appendix B), it is now time to undertake and plan for a shift in the way water is perceived in our urban environments. Our traditional approaches of hiding the problem away and removing water from an urban area quickly is no longer sustainable.

The plan should help us to achieve a better way of managing surface water that helps to achieve multiple objectives, such as protecting vital water resources, improving water quality and delivering sustainable solutions to help reduce on-going maintenance costs.

The greatest challenge that faces the stakeholders is finding an effective method to reduce both the volume of surface water entering the below ground system and to the amount of surface water pollution. Methods currently used to manage surface water largely fail to address the underlying problem of the impermeable nature of urban environments.

In this context, the surface water management train is incorporated into the wider remit that the term ***"green infrastructure"*** allows. It includes a wide array of practices at multiple scales to manage and treat surface water, maintain and restore the natural hydrology and ecological function by infiltration, evapotranspiration, capture and reuse of surface water, and the establishment of natural vegetative and habitat features.

On a catchment scale, green infrastructure will lead to the preservation and restoration of natural landscape features, such as floodplains and wetlands, in this case, termed 'blue corridors', coupled with policies that require re-design of infill development to reduce the overall imperviousness across the catchment. On a local or development scale, green infrastructure consists of site-based specific practices and runoff reduction techniques.

These local practices essentially result in runoff reduction through the re-establishment of habitat areas with significant utilisation of soils, vegetation and engineered media rather than traditional hard landscaped approaches common across LBB. Some examples include green roofs, trees and tree boxes, permeable paving, rain gardens, vegetated swales and protection and enhancement of riparian buffers and blue corridors.

5.2 Action Plan

The LBB action plan has been developed to resolve the issues identified in Section 3 of this report and Appendix E (SWMP Report Volume 2). The actions within the plan have been divided into seven sub categories (Table 5-1) to allow for easier implementation and assessment by the LBB and key stakeholders.

Action Type	Definition
Floods and Water Management Act (FWMA) and Flood Risk Regulations (FRR) Actions	These are actions that LBB as LLFA must undertake in order to comply with the FWMA and FRR.
Policy Action	Actions to incorporate into future spatial planning and/or development controls.
Communication Actions	Actions to communicate risk internally/ externally. Actions to improve flood risk related partnerships.

Action Type	Definition
Financial and Resourcing Actions	Actions to secure funding internally/externally to support works or additional resources to deliver actions.
Investigation/Feasibility/Design Actions	Actions to instigate further area investigations and to outline future planning aspirations within LBB.
Asset Management Actions	Actions to build on the established maintenance and capital works programs to manage, mitigate and defend flood risk in the Borough..
Water Quality	Actions to deliver water quality improvements across LBB.

Table 5-1 Action Plan sub categories

The action plan is generally split into two key themes listed below, both of these are aimed at achieving the overall vision for LBB to restore a more natural and organised approach to surface water management, with an aim to remove pollution at source rather than removing it from within the below ground drainage infrastructure. The plan includes specific and generic actions which apply across LBB and are collated within the spreadsheet presented in Appendix I.

- The structural source, pathway and receptor control options are techniques that can reduce the quantity, and improve the quality, of surface waters at or near source. These actions, once taken forward, will result in the mitigation/management or further investigation of local flood risk issues identified on a Local Flood Risk Zone (LFRZ) basis.
- Generic non-structural actions address aspects of the FWMA or FRR and the broader role of LBB as Lead Local Flood Authority (LLFA) in its widest sense and the actions required to integrate overall water environmental requirements through techniques that help change human behaviours to reduce pollutant loads entering the surface water systems (pollution prevention).

These non-structural source controls include community education, council management, operations and maintenance activities, and land use and site planning. The main advantages of using non-structural source controls are:

- longer term sustainability;
- cost-effective solutions;
- preference for polluter pays and prevention;
- reducing the long term and ongoing operation or maintenance liability (compared with structural controls); and
- effective use of all resources - including the wider “Big Society” aspirations.

5.2.1 Floods and Water Management Act Actions

The FWMA gives LLFAs new powers to help manage local flood risk in a more strategic way whilst also placing a duty on key partners to co-operate and support the LLFA. A key requirement on the LLFA is the duty to produce a local flood risk management strategy. Actions from FWMA are ongoing, and there are no deadlines placed on them.

Appendix I lists the actions required, including the timescales and who is responsible for implementation, to help LBB comply with the FWMA and the specific tasks necessary to meet them. Where required, further details are given in the sections below.

Local Flood Risk Management (LFRM) Strategies

The FWMA states that a LFRM strategy must contain certain information based on the draft guidance produced by the Local Government Association (LGA) in February 2011[viii], this strategy will specify the following:

1 The risk management authorities in the LLFA area and what flood and coastal erosion risk management functions they may exercise in relation to the area. It will be important for the local strategy to identify any special arrangements agreed in the area where functions normally carried out by one authority are done by another.

2 The objectives for managing local flood risk. These should be relevant to the circumstances of the local area and reflect the level of local risk. The Regulations have a narrow scope focussing on identifying and addressing 'significant' flood risk. The scope of the LFRM strategy is not specified in FWMA and can be much wider to reflect the local circumstances.

3 The measures proposed to achieve the objectives.

4 How and when the measures are expected to be implemented.

5 The costs and benefits of those measures and how they are to be paid for.

6 The assessment of local flood risk for the purpose of the strategy. In the first instance, it is likely that the LLFA will use the findings from the PFRA and any other studies that are available, such as Catchment Flood Management Plans and Strategic Flood Risk Assessments. The strategy can identify gaps in understanding of the local flood risk and specify what actions need to be taken to close these gaps.

7 How and when the strategy is to be reviewed. A review cycle is not specified, so it is up to the LLFA to decide what is appropriate. It may be advisable to link it to the cycles for the FRR outputs.

8 How the strategy contributes to the achievement of wider environmental objectives.

The LFRM strategy must consider a full range of measures, including resilience and other approaches which minimise the impact of flooding. It must also interact with the proposed National Flood and Coastal Erosion Risk Management strategy[ix] whilst maintaining distinct objectives relevant to the local community. Consultation on this finished in February 2011.

The national strategy sets out long-term objectives for flood and coastal erosion risk management and how these will be achieved. In guiding the LFRM strategy, the national strategy aims to improve the communities who are at greatest risk. The national strategy document states that it should also aim to encourage more effective risk management by enabling people, communities, business and the public sector to work together to:

- Ensure a clear understanding of national and local flood and coastal erosion risks in order to effectively prioritise investment in risk management;
- Make clear and consistent risk management plans so that communities and businesses can make informed decisions;
- Encourage innovative management of flood and coastal erosion risks taking account of the needs of communities and the environment;

- Support communities in their response to flood warnings whilst also ensuring that emergency responses to flood incidents are effective;
- Assisting communities with rapid and effective recovery post flooding.

The LLFA has a duty to maintain and monitor the LFRM strategy.

Flood Incident Register

The LLFA has a duty to investigate flooding incidents and in doing so identify the responsible risk management authority, noting any actions that have been completed, or are intended, in relation to the incident. Additionally, in the future, the LLFA will be required to publish results of any investigation and, therefore, the actions identified relate to setting up a protocol for the collection and management of this information.

The Drain London programme of works has commenced this task through the collation of a wide range of information, to produce a factual LBB Wide Flood Incident Register. This work should be carried on by LBB to ensure that robust and detailed records are maintained so that future iterations of the PFRA and SWMP have increasing levels of information available to determine the risk of local flooding better across the Borough.

Asset Register

The LLFA has a duty to maintain a register of structures and features considered to have a significant effect on local flood risk. The LBB should work with flood risk management authorities and other London Boroughs in order to define criteria for determining significance on a local level. As a minimum, the asset register needs to record the ownership and state of repair of each identified asset. As with the incident register, the asset register should be made available for inspection and, therefore, a framework for the collection and management of the data should be set up. LBB should ensure that they are aware of any regulations regarding the content as set out in the future by the Secretary of State.

The Drain London programme of works has commenced this task through the delivery of a potential register for use and its associated guidance. The LLFA should identify if this system meets with the internal processes in terms of information control, data management and format and, if appropriate, commence the delivery of an Asset Register by April 2012.

SuDS Approving Body (SAB)

A SAB will be responsible for approving, adopting and maintaining drainage plans and SuDS schemes that meet the proposed National Standards for sustainable drainage. Although the LLFA is the default SAB, there is scope for appointing another organisation to take on this role if appropriate.

At present, this activity has not been commenced as part of the FWMA and as such LBB should start to prepare for its commencement (likely to be post April 2012), on receipt of the likely guidance for the SAB.

Non-Performance Bond

The SAB can request a non-performance bond from the applicant which will be refunded following satisfactory construction of the SuDS. The FWMA states that in requiring a non-performance bond, a SAB must specify a value which does not exceed the best estimate of the maximum likely cost of work required to ensure that the drainage system meets with the approved proposals.

In future, guidance may be issued concerning what amounts may be required by way of non-performance bonds; SAB must have regard to the guidance and should keep up to date with any future changes.

5.2.2 Policy Actions

The co-ordinated management of development across boroughs offers the potential to achieve widespread benefits in the control of surface water. Boroughs have reached different stages in the preparation of their Local Development Frameworks but most have an adopted or well-advanced spatial strategy for their area. However, this Surface Water Management Plan may still influence the preparation of more detailed Development Management Policies and Area Action Plans and in so doing help to achieve a consistent approach to the reduction of surface water runoff.

Although beyond the scope of Local Development Frameworks, the potential to influence Building Control practices across the boroughs may also deliver tangible benefits in terms of surface water management.

Borough Wide Policy Areas Planning Policies

As local planning authorities the boroughs the boroughs have responsibility to implement the provisions of PPS 25 both through their Local Development Frameworks and their Development Management decisions. Strategic Flood Risk Assessments form part of the evidence base for all Local Development Frameworks and these should provide detailed and up-to-date flooding information, in addition to the EA flood maps, for the application of the sequential test in site allocations and planning decisions. The aim of PPS25 is to steer development to the lowest flood risk areas. Where new development is exceptionally necessary in such areas, policy aims to make it safe without increasing flood risk elsewhere and where possible, reducing flood risk overall.

LBBs policies should require development proposals to incorporate wider surface water management measures, or to contribute to planned improvements where appropriate, where the proposal would be located:

- In areas of Medium or High flood hazard (as identified within the Drain London outputs); or
- Along fundamental surface water flow paths; or
- In locations of historical flooding; or
- Greater than 0.5ha in size.

Policies should also make it clear that site specific Flood Risk Assessments, in accordance with PPS 25, will be required to identify the appropriate surface water management measures to be incorporated into the proposed development. To assist in achieving the overall surface water vision for the Borough, the following key policy is recommended to help allow spatial planners to begin to mould the urban area towards a more natural, sustainable and ultimately more cost effective approach to surface water management:

A specific river corridor management policy to provide multiple benefits, including flood defence, recreation, amenity, biodiversity and creating spaces where people want to live, though the restoration of green and blue corridors. This will enhance watercourse corridors by setting back

development from all forms of urban watercourse, de-culverting watercourses as well as linking with the aspirations of the All London Green Grid and the Blue Ribbon Network;

Other potential Development Management Policies Document (DMPD) or Supplementary Planning Document (SPD) provisions to help achieve more sustainable surface water drainage for new developments across LBB. Recommendations for polices to be included in these documents, which should be implemented to all developments greater than 1ha is size or are shown to be at risk of flooding from any source, are given below:

Agreement across London for the specification of runoff rates from new developments stating that development on both new (greenfield) and previously developed (brownfield) sites must achieve surface water runoff at or below present greenfield runoff rates;

The need for a Planning Brief in any part of the CDA or policy area to address specific site constraints;

Development **must** be safe from flooding over its whole lifetime, including for the impacts of climate change, and should use all opportunities to reduce flood risk overall;

Green Infrastructure within development should protect existing floodplains and provide an opportunity for linking habitats and creating environmental highways through the integration of SuDS through urban areas;

SuDS **should** be used to control the rate and volume of runoff. Pollution controls should be incorporated within them to protect and improve watercourse quality. Typical SuDS methods are described in Section 4;

All developments exceeding 0.5 hectares **must** include source control and/or natural surface water storage options within the site boundary; and design for greenfield run off rates;

Development proposals for surface water must be entirely separated from foul drainage;

New developments should demonstrate that during events that exceed the design capacity of the surface water drainage system excess water is safely stored or conveyed from the site without adverse impacts;

Until such time as the SAB requirements are in place, the long term management and responsibility for the maintenance of any new SuDS systems **must** be agreed with the council (until such time as the SuDS Approval Body is in place) prior to the granting of planning permission;

All development **pre commencement** of construction must submit and be approved by Brent Drainage Section (LLFA) detailed drainage design including storage calculations for the attenuated flows and flow restriction methods. (However this will not negate other planning requirements, for example to achieve inclusive access to new development);

All new properties within a fluvial flood zone or local flood risk zone should have a finished floor level at least 0.3m above surrounding ground levels and be fitted with flood resilience measures up to 0.5m above finished floor level. (However this will not negate other planning requirements, for example to achieve inclusive access to new development);

There are approximately 2,000 properties in LBB with basements. Following further review of these, post Drain London and these are deemed to be at risk, they should be fitted with

resilience measures and their use controlled, i.e. used for storage rather than living accommodation;

As it is recommended that, where possible, surface runoff for the extreme events should be contained within roads to protect properties, so amendments to emergency plans to incorporate temporary road closures will be required, particularly with regard to the passage of emergency vehicles;

The Borough must also provide as part of this element:

- Guidelines on the provision of onsite storage including the AEP event and necessary freeboard;
- Guidelines on the need for strategic mitigation measures, particularly in identified regeneration areas, required to contribute to managing surface water flood risk on a wider scale, and;
- Guidance on what is classed as permitted development within a CDA or policy area and any deviation from national guidance via local development orders for example.

LBB may also in line with the aspirations of improving the water quality within our urban watercourses and to help improve the ecological potential as defined within the UK Water Framework Directive, wish to consider the inclusion of the following policy for the emerging SuDS Approval Body partnership to approve, to manage the pollutant loads generated from proposed development applications:

- Best Management Practices (BMP) are required to be demonstrated for all development applications within the London Borough of Brent. The following load-reduction targets must be achieved when assessing the post-developed sites SuDS treatment train (comparison of unmitigated developed scenario versus developed mitigated scenario):

  - 80% reduction in Total Suspended Sediment (TSS);

  - 45% reduction in Total Nitrogen (TN);

  - 60% reduction in Total Phosphorus (TP); and

  - 90% reduction in litter (sized 5mm or greater).

Specific Additional Policy Area – Cross Boundary

Counter's Creek Policy Area – Although predominantly covering Drain London Group 3, the Counter's Creek Policy Area includes a large part of the south of LBB. In addition to Brent, the policy area includes parts of the Boroughs of Barnet, Camden, Ealing, Hounslow and Westminster and the entire Boroughs of Hammersmith and Fulham and Kensington and Chelsea. The extent of the policy area is shown in the figure below.

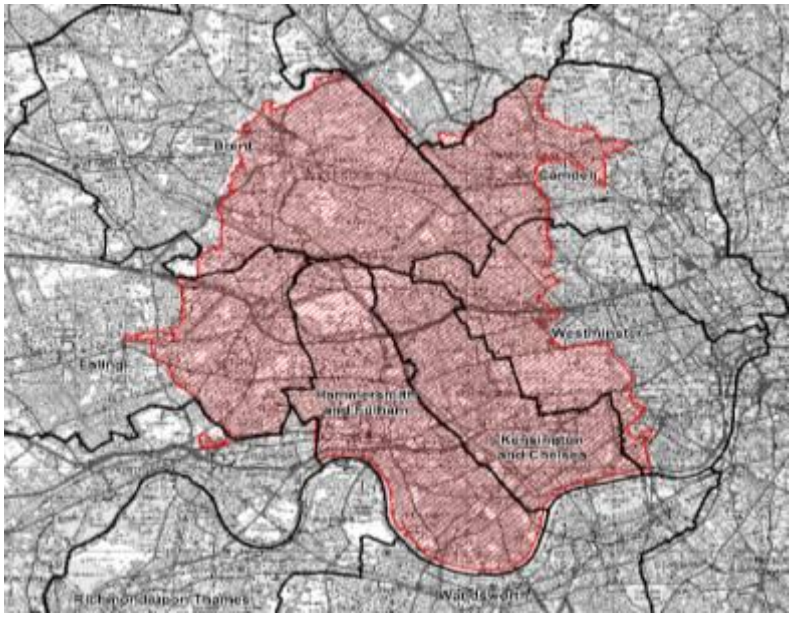

Figure 5-2 TWUL's sewerage catchment – Counter's Creek Flood Alleviation Scheme

The recommended actions for this policy area are detailed in full in the Group 3 Action Plan, but a summary is given below.

The policy area is prone to flooding for the following main reasons:

- A predominance of basement properties
- High levels of impermeability across the policy area
- A combined sewer system

Specific actions to reduce the flood risk in the Counter's Creek Policy Area include:

- Investigations to reduce the contributions of surface water through the sub-surface network through the restoration of a fully separated network and a move towards the management of surface water above ground, particularly in the upper parts of the catchment within the Boroughs of Barnet, Brent, Camden and Ealing*[2].
- Upgrading sewer networks – TWUL are currently investigating this option, but this will take time to undertake*[2].
- Campaign to amend planning and building control regulations.
- Pilot studies to improve basement, and community, resilience.
- Pilot studies to retro-fit existing properties, where possible, with green roofs, permeable paving and water re-use technologies.

The overall aim of policies is to ensure that the installation and management of surface water measures in development proposals are capable of reducing the level of surface water flooding to surrounding areas. This should be made clear in the reasoned justification to the policies and this Surface Water Management Plan used as the supporting component of the evidence base. For the avoidance of doubt, the above policy provisions should take into account the predicted effects of climate change.

*[2] Please note that there will be limited ability for TWUL to participate in these items at this stage due to the way that TWUL are funded to deliver flooding solutions and improvements across their network.

5.2.3 Communication Actions

LBB are not alone in managing Local Flood Risk throughout the area and as such consideration should be given on how best to encourage the collaboration of a number of organisations to deliver flood risk improvements. The communications and engagement activities undertaken in the development of this SWMP were designed to consolidate the partnership that was previously established as part of the Drain London Tier 1 works. In future, these messages should be further disseminated and developed to address the issues and concerns of two distinct audiences:

- The public, including the resident population and businesses
- The leading stakeholders, including elected officials, administrative, professional staff from across all the functions of the relevant organisations, in particular LBB, EA and TWUL.

Social Change, Education and Awareness

Increased education and awareness on flood risk including a wider appreciation of the consequences of flooding could significantly improve resilience to flooding in the long term. This may be achieved through such measures as establishing local flood action groups, flood wardens and local community flood resistance and resilience plans, and is particularly relevant to the Government's localism agenda to empower communities to take control of matters that affect them.

Increasing public understanding of local flood risk, including surface water management, is a primary role of the LLFA. A programme of education and raising awareness on local flood risk issues is required to enable effective management of surface and ground water flooding.

Not all surface and ground water flood risk can be mitigated by physical measures. LBB has a primary role in empowering communities to adapt to the impact of future flood risk by helping them to become more resistant and resilient to the consequences of flooding.

Promoted Actions for Communication

- The Partnership to develop a comprehensive Communications Plan to identify the key SWMP and LLFA messages for the two key audiences:

For the General Public:

- Improve current communications and run campaigns to deliver surface water management improvements;
- Review, and where appropriate update, the content on various websites and other supporting media, to increase public knowledge of river, watercourse, catchment and surface water flooding issues including water quality requirements and good practice examples;
- Undertake public campaigns, through council mailings such as Council Tax bills and posters to point the residents to the supported website, containing the most up

to date information on when and who to call for support, advice etc and how to prepare for an event;

- LBB to support existing Local Flood Action Groups and to identify other areas that may require similar groups to help increase the resilience of a local community to flood events. LBB to identify the need for, and to assist in, the development of Community Resilience Plans.
- Campaign - Educate the residents on flood risk, surface water management and general duties, including the communication of the difficult message of 'personal' responsibility, impacts on others and good practice such as looking after watercourses, consideration of how much surface water runoff they generate.
- Communications - Work co-operatively with the partners to develop key and consistent messages for surface water management. This could then be developed into an organised series of publications or news releases to help improve understanding of the issues facing the local community.
- Campaign – LBB and the partners, to encourage, and if appropriate, assist in the development of a London wide education programme in order to improve public awareness of surface water management, through the development and hosting of activities that will inform and develop an educational program in schools to highlight the issues and develop necessary social change.

For Leading Stakeholders:

- Communications - LBB to present to the lead members of each LBB Directorate on the value, risk and links to LBB's implementation of the SWMP and developed Action Plan, to encourage and increase the potential for all departments to be conversant in surface water flood risk and the need for collaborative working to help reduce the current and predicted future levels. To include, as a minimum:

Emergency Planning and Business Continuity – Assisting in the transfer of knowledge and to enable better and safer preparation of responses to such events

Regeneration, Planning, Development and Building Control - A key department as involvement of Spatial Planning will deliver the vision.

Highways and Transportation (including Drainage) – Knowledge of key assets, historical events and the potential to influence local flood risk management

Parks and Environment – Involvement is required to help ensure opportunities for improvements are captured and included.

Elected Members – Buy in is crucial, regular briefings to lead member required to help improve the potential to deliver the Action Plan

- Communications - Delegated officers (involved with the SWMP development) from within the major stakeholders should be encouraged to educate and encourage involvement in the SWMP of the relevant Leads in their organisations, so that the Actions and the level of involvement are understood and can be delivered with full support.
- Communications - Development of methods to communicate the messages and requirements of developers, through the setting up of Developer Forums or delivery

of guidance documents for developers detailing the minimum expectations for development in the area.

5.2.4 Financial & Resourcing Actions

Defra currently has little or no funding available for schemes to improve surface water flooding and small scale schemes will need to be resourced through community actions, most probably through Local Flood Action Groups. These schemes could look to the partners of the group to contribute skills and time to investigate and prepare solutions without the need for financial contributions. When funds are needed to implement schemes these may come from collaborations with other groups to deliver multiple benefits.

Currently, Defra, through the EA, do make funds available for schemes that provide benefits from flooding of watercourses. This is part of the annual Flood Defence Grant in Aid (FDGiA) and needs to be identified by the Boroughs through their medium term plans submitted to the EA. From the 1st April 2012, a new 'outcome measures' funding approach will be implemented for all capital maintenance and defence projects. This new funding approach will allow Boroughs to apply for FDGiAs to mitigate flood risk from all sources. As a minimum each scheme must demonstrate that the expected whole-life benefits will exceed the whole life costs. Funding will be allocated if a scheme falls within one or more of the four categories listed below:

- All benefits arising as a result of the investment, less those valued under the other outcome measures (Outcome Measure 1)
- Households moved from one category of flood risk to a lower category (Outcome Measure 2)
- Households better protected against coastal erosion (Outcome Measure 3)
- Statutory environmental obligations met through flood and coastal erosion risk management (Outcome Measure 4)[x].

At a local level, each Regional Flood and Coastal Defence Committee has the power to raise funds through a local levy. This levy can be used at the discretion of the committee and is likely in the future to be made available to help deliver some surface water schemes.

Promoted Actions for Finance & Resourcing

In summary, the emerging items that require action are:

- ***Secure Central Government finding into the correct department*** - Identifying the importance of the delivery of Local Flood Risk Management within the Borough to help enable the use of funding received from Defra or other organisations, which should be ring fenced within the Borough LLFA team budgets to ensure it is used for flood risk management.
- Undertake Cross Directorate discussions to identify internal opportunities for development/scheme to maximise benefit to communities/Borough Council - Within the Borough it is important that each Directorate recognises the multiple benefits that can be achieved by working together to deliver their program and impacts that the Borough has on the urban environment and flood risk. Therefore a value management exercise should be promoted across all directorates to help identify the capital and maintenance programs of work to identify potential for cross-collaboration to mutually beneficial solutions. This cross funding and resource support can be allocated to help the LLFA implement their duties in the future to

drive through the Vision to remodel the urban environment and deliver real flood risk improvements to the local community.

- ***Identify opportunities for securing funding from additional sources*** - The Borough should work with stakeholders to identify opportunities that exist for achieving funding support and develop an approach to streamlining the process. The Partnership should identify a potential funding plan for the delivery of schemes in the future. This should focus on the opportunities that exist, ranging from European funds, Defra's Outcome Measure Based Funding policies, Community and Business contributions, S106. Developer contributions and Community Infrastructure Levy or identifying a business model that focuses on the beneficiary pays for the risk reduction across the Borough.
- ***Investigate alternative funding requirements*** -The Partnership should investigate and, if appropriate, develop an Impermeable Area tax to restore the natural environments in the Borough, providing opportunities to retrofit impermeable areas. Consideration must be given to the ability of customers to pay an additional tax and how it will be used specifically to develop surface water and flood risk management improvements.
- ***Investigate opportunities to encourage domestic level surface water management*** - The Partnership should investigate and, if appropriate, develop an incentive to encourage residents to store water at source, through the implementation of grants for source control measures, including rainwater harvesting to help reduce the volume and slow down the rate of surface water contribution to flood risk across the area.
- ***Review current skills and technical resources available*** **-** Resources, both financial and human, to implement the actions will come from a range of organisations and will need to be managed and lead by the Borough. The Borough should undertake an internal exercise to identify the resource requirements required to deliver compliance with the FRR and the FWMA into the future. This investigation should also undertake a gap analysis of the skills required to provide evidence to develop an 'upskilling' training program.

5.2.5 Investigation/Feasibility/Design Actions

CDA Specific Actions

Adopting the 'Source, Pathway and Receptor' model, the CDA specific actions look to provide potential solutions that help reduce the main risks in each LFRZ. Please note that, by and large, the solutions proposed are aimed at removing the more frequent 'nuisance' flooding of properties and to reduce the impacts of the larger scale events. Opportunities across the LBB are limited for installation and inclusion of additional engineered infrastructure to manage surface water, due to the highly urbanised environment, however areas to the north of LBB present opportunities for reducing and/or slowing the flow and volume from rainfall events from arriving in the urban area.

Source measures, on a 'property-by-property' basis, will provide limited benefit without collective application. In 5.2.2, the use of green roofs, water butts and rain harvesting has been recommended as a specific policy across LBB. At this stage, we have not included their implementation within CDAs as part of specific options derived, as their application, maintenance and on-going monitoring will require a broader policy position to be taken before

they can provide a meaningful local measure. Their uptake, however, even on an individual basis should never be hindered, if the willingness is there.

Pathway measures, including the use of road side rain gardens / land management options, increased maintenance, detention ponds, ponds and wetlands are all considered to offer significant benefit. In some areas they offer 'quick win' solutions, particularly where land is owned by LBB or where Highway Maintenance programmes facilitate opportunities. Investigations of culvert capacity, particularly under road and rail infrastructure, are key in ensuring the risk identified in the modelling is truly representative. There are also opportunities to review existing storage capacity in some areas.

Receptor measures, such as the use of resistance and resilience and de-mountable barriers offer significant opportunity to limit the impact of flooding on built assets. At present, we have generally not promoted them across the CDAs as their appropriateness is dependent on a range of other factors, including that of exposure to historical flooding and frequency. As such we recommend that investigations should occur only in areas that have experienced regular flooding.

Water Quality Considerations

It is evident that the greatest change in pollutant loads discharged to waterways from urban areas occurs during the more frequent storm events. Reducing runoff volumes from these storm events will assist in reducing pollutant loads.

Urban and peri-urban surface waters present a diverse management challenge in terms of quantity, quality and the aquatic ecosystem health. LBB should adopt a multiple and integrated objective approach, which should equally consider and adapt solutions that:

- Restore the natural and pre-development surface storm water systems, and
- Minimise the impacts of new developments

Due to the impacts of urbanisation detailed in previous chapters, there are no simple solutions that are appropriate for the management of all urban surface water systems. It is important for an integrated approach to be adopted that considers and helps to deliver improvements to:

- The health of our ecosystems, both in terms of the aquatic and terrestrial environments;
- Manage the quantity of surface water resulting from urbanisation;
- Protect the health and safety of the public;
- Help to maintain the economic viability of our communities;
- Public open space for recreational opportunities;
- Social considerations; and
- Aesthetic values including odour and visual pollution.

Surface water runoff from the urban environment can have a significant impact on water quality, especially where the flood waters interact with the sewer network. The elements are highlighted and identified within Table 5-2, however the biggest challenge still remains in reaching a common agreement on the environmental, social and economic goals for the environment, in spite of the fact that effective and efficient systems are essential to ensure that the quality of life for all LBB population can be sustained now and into the future.

The watercourses within LBB have been identified within the Thames River Basin Management Plan (RBMP) as identified in the Table below:

Waterbody ID & Name	Hydro morphological Designation	Current Overall Potential	Status Objective (Overall)	Justification for missing 2015	Protected Area Designation
GB106039023590 Brent (below Silk Stream down to the Thames)	Heavily Modified	Poor	Good by 2027	Technically unfeasible	Bathing Water Directive; Freshwater Fish Directive
GB106039022940 Wealdstone Brook	Heavily Modified	Moderate	Good by 2027	Disproportionately expensive; Technically unfeasible	Freshwater Fish Directive

Table 5-2 Thames River Basin Management Plan – Water body Status in LBB

As identified, within the RBMP, it is important to set a vision and policies for the area that are focussed on helping achieve the requirements of the water bodies achieving 'good' ecological status by 2027, such as providing space for flooding and reducing pollution entering the watercourse from urban drainage.

Table 5-3 summarises the main sources of pollution likely to affect watercourses as a result of surface water flooding and suggestions for mitigating this risk.

Source of Pollution	Modelling Outputs	Mitigation Suggestions	Partnership Responsible
Direct runoff into water courses from rural & open space areas	Surface runoff from rural & open space areas drain through the urban areas, entering the sewer & urban watercourse network heading south towards the River Thames.	Promotion of Codes of Good Practice, identification of potential nuisance flooding from open spaces and recognition of designation as Nitrate Vulnerable Zones.	EA Land owners LBB
Direct runoff into watercourses from residential areas	Surface water drains along roads and between buildings to the low lying watercourses.	Implementation of filtering SuDS schemes to trap pollutants along key drainage paths and along the banks of watercourses.	LBB TfL TWUL Developers
Foul Water Sewers	Several locations have extreme system pressure on the network due to cross connections and misconnections of the past. This results in flooding occurring at several locations resulting in overland flow to the lower topography.	Where all other sustainable measures have been investigated and utilised as far as possible it may be necessary to assess the short term potential to reconnect a number of emergency overflows in critical areas, in consultation with the EA and TWUL. There were 35 present on the Mogden system as designed, of which approximately 30 have been sealed in the past to help achieve other water and environmental drivers. These have further exacerbated the pressure on the below ground assets further downstream	EA LBB TWUL
Surface Water Sewers	Several locations have surface water sewers that outfall directly to the watercourse, having collected drainage across large urban areas.	Implementation of filtering SuDS schemes to trap pollutants on a property or street scale, before the water enters the sewer network.	Developers LBB TWUL
Cross Connections	Several locations are known to have dual manholes whose links were originally sealed, however these seals may have eroded over time or been removed to prevent flooding.	Investigate the prevalence of these dual manholes and model the impact of re-sealing the foul and surface systems at these upper parts of the catchment to reduce pressure on the downstream below ground assets. Review the impacts on the surface water system.	LBB TWUL
Runoff from Industrial Estates	Surface water flows around Industrial Estates and downstream through the urban areas into various urban watercourses.	Retrofitting of filtering SuDS schemes to trap pollutants on a property or street scale, before the water enters the drainage network.	Landowners/ Businesses LBB Developers

Table 5-3 Water Quality Investigation Actions

If a detailed cost-benefit assessment is undertaken during any future SWMP stages, damages to environmental assets resulting from the surface water flooding will require quantification within the damage calculations. They have not been included within the high level Annual Average Damage (AAD) calculations within this report.

Promoted Actions for Water Quality

In summary, the emerging items that require action are:

- An investigation to understand the potential for retrofitting source control measures across the range of urban environments (residential, industrial, highways) to assist in improving the water quality of the receiving watercourses
- An investigation of the potential to ease flood risk in the short term and help evolve a more sustainable approach to capital investment across the area. The investigation should include reviewing and potentially re-instating several of the key overflows on the trunk main system in the area. This should be undertaken in consultation with the Environment Agency and TWUL to deliver an appropriate response that will not compromise the health of the receiving watercourse. *It is important to note at this stage, that the system has discharged large volumes of unscreened and untreated sewage onto the surface, which travels overland to the lowest point, usually an open watercourse (i.e. manholes flooding public open spaces or highways in a number of locations across the Borough)*. This potential 'pressure release valve' could be the implementation of a new overflow chamber that once triggered will pass ***screened*** sewage into the adjacent watercourse and not via an overland flow route. Note – this is only suggested as a short term measure to help reduce the risk of flooding along the Trunk Main sewers
- An investigation into the prevalence of 'Dual Manholes' across Group 2. Historically, the systems within a dual manhole were kept separate through a seal within the chamber, however, over time these seals have either eroded away or been removed and have not been replaced. This allows flows to pass indiscriminately between the two separate systems resulting in storm response issues in the Foul Trunk system in the Mogden and Beckton WwTW catchments. Following the investigation and dependent on the scale, targeted improvements could be made to reinstate the seals, in consultation with the EA, TWUL and LBB to ensure that flood risk is not passed on to others, along the surface water system and urban watercourses.

5.2.6 Asset Management

Ownership

Watercourses

For the purposes of this assessment, the following criteria have been used:

- Riparian landowners have certain rights and responsibilities which are established in common law and can be viewed in a publication by the Environment Agency called 'Living on the Edge'.
- Riparian landowners will include:
- LBB where a watercourse is in the highway
- Network Rail where watercourses pass beneath or alongside their assets
- LUL where watercourses pass beneath or alongside their assets
- LBB are the Land Drainage Authority and have permissive powers to inspect ordinary watercourses, maintain flood defences and ensure riparian landowners fulfil their duties.

- The EA have permissive powers to maintain and improve main rivers; they are not obliged to carry out maintenance or construction of new works on main rivers.
- Where the authorities listed above are riparian owners consent for any works must be sought from the EA.

Sewers

- TWUL are responsible for maintaining the condition and capacity of all their assets regardless of the ownership of the land above them.

Other Structures

For the purposes of the action plan, the following assumptions have been made:

- LBB own all non trunk roads and adjacent footways and green strips
- TfL own all trunk roads and red routes as shown on the TfL Road Network (TLRN) map (available at www.tfl.gov.uk). Locations where TfL pumped drainage is known to exist is identified separately to TfL road crossings.
- Where a railway line is used by main line trains and LUL or London Overground, Network Rail is the owner
- London Overground and London Underground have been listed as asset owners although it is recognised that ultimately they are part of TfL

Promoted Actions for Asset Management

Asset Register

Under the FWMA LBB has a duty to maintain a register of assets. Further details on this are given in Section 5.2.1 (FWMA duties).

Identification of 'Critical' Assets

The Drain London modelling was inspected for each identified CDA; where areas of deeper flooding were highlighted, a review of the surrounding assets was carried out to identify:

- Structures on ordinary watercourses and main rivers
- Surface Water Sewers
- Non flood risk management structures

The assets identified at this stage should be reviewed to identify their appropriateness to be included within the Asset Register (assets that are likely to have a significant effect on flood risk). Additionally, it is worth noting at this stage that a further review should be undertaken to identify the assets that are currently shown to be at a lower risk of flooding, and these should be investigated as water could potentially escape from these to exacerbate the downstream situation.

Non Flood Risk Management Structures

Non flood risk management structures are those structures which, whilst not constructed with the specific intention of managing flood risk, have an observed or predicted impact on flood flows. Structures may include:

- Road underpasses conveying flows from one side of an embankment to the other,
- Pedestrian subways acting as flow routes,

- Railway tunnels and bridges.

Designation of Third Party Assets

Where surface water models have highlighted that a particular asset may be critical in terms of surface water flooding, a third party owner should be aware that LBB has the power to officially designate this under the FWMA. Once an asset has been designated, the owner must seek consent from the authority to alter, remove or replace it.

Maintenance of Assets

It is recommended that there is a collated effort from all parties to understand the location of and status of their assets across LBB, to assist in the derivation of 'Critical' Assets. Historically, the maintenance of asset records has been a low priority within organisations and issues still remain with the transfer of responsibilities and identification of asset ownership.

As such, the partnership should identify spatially, their ownership so that a gap analysis can be undertaken to identify assets where no ownership is claimed and undertake exercises to ensure that these assets are included in the future, to avoid potential difficulties in the future for the partnership. Additionally, the process for divestment of below ground infrastructure, between stakeholders, should be clearly followed and recorded.

5.3 Review Timeframe and Responsibilities

The Action Plan timescales are included in the master Action Plan and are presented in Appendix I. The Actions should be reviewed in line with the review timetable and progress tracked as part of the LLFA Partnership meetings, which should be held on a regular basis. It is suggested that the Partnership meet more regularly in the first year to embed the concepts of partnership, working together and tracking progress against changing guidance within the legislation.

Key items, particularly those that affect adjacent Boroughs, should be discussed and agreed with adjacent Borough Partnerships. In particular, LBB should present the key items that affect the emerging North West London Flood Risk Management Partnership at those meetings and identify opportunities for joint working and identify the potential for cumulative impacts and potential solutions derived to achieve multiple objectives.

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

5.4 Ongoing Monitoring

The partnership arrangements established as part of the SWMP process (i.e., LBB, EA and TWUL working in collaboration) should continue beyond the completion of the SWMP in order to discuss implementation of the proposed actions, review opportunities for operational efficiency and review any legislative changes, proposed by the formation of the LLFA Group for LBB and the over-arching area partnership being promoted as part of the emerging North West London Flood Risk Management Partnership.

The SWMP and its Action Plan should be reviewed and updated once every six years as a minimum; however there may be circumstances which might trigger a review and/or an update of the action plan in the interim, for example:

- 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.

The Action Plan is a live document to be updated and amended on a regular basis, so it can form the basis of the FRR 2009 ‘Local Flood Risk Management Strategy/Plan’, required by December 2015.

6 References

[i] Environment Agency (2010) Preliminary Flood Risk Assessment (PFRA) Final Guidance. GEHO1210BTGH-E-E

[ii] London Borough of Brent – Preliminary Flood Risk Assessment – Preliminary Assessment Report, Hyder Consulting (May 2011)

[iii] Water Industry Act 1991

[iv] Mouchel (2008), North London SFRA, Environment Agency

[v] Jacobs (2007), LBB Strategic Flood Risk Assessment

[vi] Water Industry Act 1991

[vii] Drain London Forum Technical Note – DLF-T2-TechNote-Definitions-SWF+CDA-20110304_v3.pdf

[viii] Environment Agency Guidance, available at http://learning.environment-agency.gov.uk/courses/FCRM/capacity/legal/responsibility_206.html. Accessed May 2011.

[ix] EA/DEFRA (2011) –National Flood and Coastal Erosion Risk Management Strategy for England, Environment Agency, Bristol.

[x] DEFRA (2011) – Flood and Coastal Resilience Partnership Funding. Available from: http://archive.defra.gov.uk/environment/flooding/funding/documents/flood-coastal-resilience-policy-statement.pdf. Accessed August 2011