SURFACE WATER
MANAGEMENT PLAN
Volume 2 - Appendices

DRAIN LONDON

LONDON
BOROUGH OF
BARNET

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Thames Water

LONDON COUNCILS

Environment Agency

BARNET
LONDON BOROUGH

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Front Cover: LBB Drainage Department – Flooding on Finchley Road NW11 2/05/2010

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

Appendix A – Data Review

Appendix B – SWMP Context

Introduction

In the past, urban surface water management has tended to concentrate on the collection and removal of excess water from the urban environments as quickly and cheaply as possible. This was largely undertaken to avoid flooding of our communities and economic damages being incurred, largely through the development of systems to channel the water within drains, pipes and channels altering the natural catchments and re-aligning the natural streams and rivers.

Additionally, water pollution problems in London have evolved since the days of the Wallbrook Stream, a tributary of the River Thames, which was subject to an Act of Parliament in 13831 to prevent further pollution from latrine discharges. Increasingly, water pollution from discrete polluting sources such as factory pipes are greatly overshadowed by that of overland flows from the roads and rooftops, which rapidly inundate the downstream urban drainage system every time it rains.

Residual pollution within the watercourses has been caused by misconnections of developments and individual homeowners waste water systems to the network. Further sources include a whole series of dual manholes within the current TWUL foul and surface water network which can allow, flow to pass freely between the two systems.

Context

The London Borough of Barnet has developed as most of the suburban London Boroughs have, with the intensification of the surrounding village centres and suburbs, largely as a result of an intense transport led development (including the Metropolitan and Jubilee lines) during the early to mid 20th century. This intensification of development has directly affected the status and pollution levels within the watercourses of the Borough.

As this previously undeveloped land is built upon, the amount of water running off roofs, streets, and other impervious surfaces into nearby waterways increases. The increased volume of water runoff and the pollutants carried within it, continue to degrade the quality of the once-natural watercourses. The natural river corridor and natural floodplain is replaced resulting in a significant reduction in the Borough’s ability to hold back the water where it falls, this is further exacerbated by the largely impermeable nature of the underlying geology being that of London Clay. This increased imperviousness results in a marked degradation of the quality of the waters within the watercourses as the traditional approaches to drainage result in two main methods:

- Separate Foul and Surface water sewerage system - For most parts of the Borough, domestic and industrial wastewaters and surface water runoff are discharged into separate sewer systems: the foul waste is carried to one of two Wastewater Treatment Works (WwTW) at Modgen or Beckton, while the surface water is channelled directly to local brooks, urban watercourses and main rivers.
- Combined Sewerage Systems - In some areas across the Borough, the domestic and industrial wastewater, rainwater and street runoff are collected in the same sewers and then conveyed together to Mogden WwTW (or Beckton). This is known as a combined sewer system.

Development during the interwar and post war periods was intense and rapid, with the population of the West Middlesex catchment growing from approximately 410,000 to 1.3 million over the 30 years to 1941. Fortunately for the residents of the area, the West Middlesex Drainage Board had the foresight to develop a scheme that would serve (most/part) of the

Borough and increase the capacity of the Wastewater Drainage system to accommodate a six time Dry Weather Flow (6DWF) for a domestic population of approximately 2 million people.

The scheme designed, by J.D Watson, during the 1920's would replace 28 smaller WwTW and develop a Trunk Sewer Mains network to transfer the domestic wastewaters through to Mogden WwTW, for parts of Barnet, Brent, Ealing, Harrow, Hillingdon, Hounslow and Richmond.

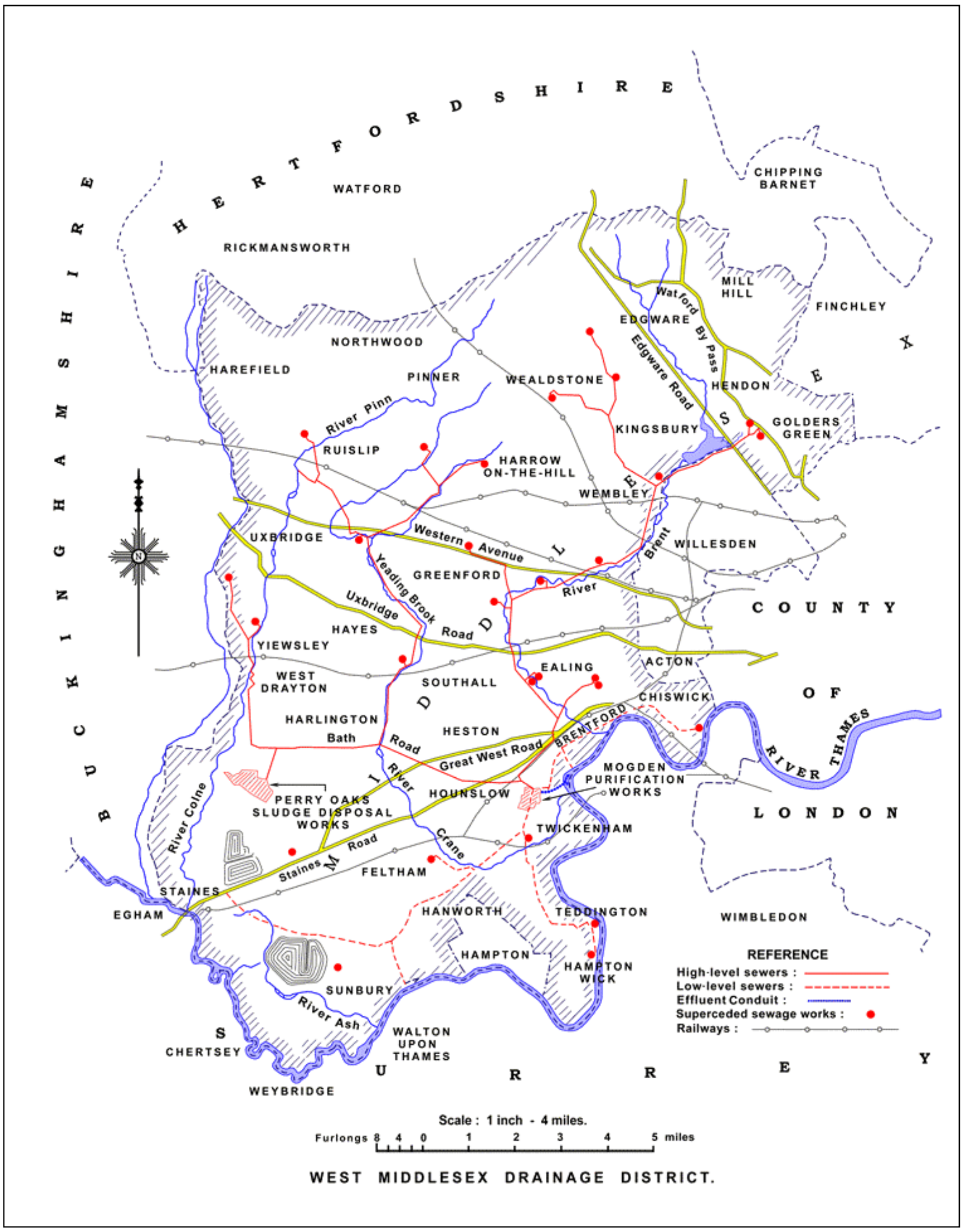


Figure B-1 Schematic of the West Middlesex Drainage Board plans for Mogden WwTW (after J. Timms)

Unfortunately, although the population has not yet reached that level (the domestic population from the 2001 Census data, draining to Mogden WwTW is approximately 1.7million), all spare capacity of this foul network has been exhausted by the widespread connection of surface water into foul sewers. It appears that as the subsequent development led to increased runoff, the surface water system was not upgraded to cope with it. Instead, the additional surface runoff was diverted into the foul sewers to take advantage of the spare capacity it had at that time.

Another route of surface water entry to foul sewers is via the large numbers of dual manholes in the area. These chambers were designed to allow access to both surface and foul sewers within a common chamber but with the two systems still isolated from each other. If the sealing arrangements between the separate sewers fail or are removed, flow can pass freely between the two systems. Misconnections also occur during property modifications, when rainwater down-pipes and yard drainage are connected to the foul sewers, either by the owners or their tradesmen.

The impact of these factors is that the main foul trunk system is shown to have a very defined response to rainfall, more typical of a combined sewer. The Brent IUD study shows that more than two thirds of the flow in the Wembley Branch Trunk Sewer is not foul or wastewater. This results in widespread flooding from the trunk sewers and vast quantities of untreated sewage being discharged into the local urban watercourses, even for relatively small rain storms.

Finally, a combination of poor historical planning decisions, urban creep and infill development has had a further detrimental impact on the ability of the Borough to hold back the rain where it falls, Thames Water have calculated that there has been a 17% increase since 1971 in impermeable area across North West London, as residents have added extensions or have paved over front gardens. This results in greater volumes of surface water for each rain event entering the system. This effect accumulates further down the system where the increasing volumes create greater pressures on the below ground piped assets, tending to result in overland flood flows, increasing frequencies and levels of discharges at overflows and flooding of peoples properties with contaminated foul and commercial wastewaters.

This steady degradation of drainage capacity in the borough has occurred at the same time that both community expectations for flood protection and pressure from environmental legislation have placed increasing demands on its performance. Additionally, climate change is expected to increase the frequency of larger storms and higher rainfall intensities, both of which are likely to increase the frequency and impacts of this flooding across the Borough, further impacting the lives of the resident populations.

Objectives

As such, the management of surface water within LBB is dependent upon the outcomes of the SWMP process, and as such the following objectives are key to helping to resolve the historical issues:

- Stressing the importance of the new LLFA role and employing suitably skilled resources to carry out these duties;
- Education of residents to accept the risk of flooding, change their behaviours and promoting flood resilience within flood risk areas;
- Derivation of a Water Vision for LBB and the surrounding Boroughs.

The Surface Water Vision

The water vision for LBB and the emerging North West London Flood Risk Management Partnership over the 30 – 50 year time period will be to achieve a more natural and sustainable approach to coping with rain events across the urban environment.

“An approach that promotes the reversal of historical and current approaches to the drainage system and the watercourses. One that achieves a more sustainable approach to water quality and quantity issues, providing space to flood during the larger events.”

The vision can be achieved through adherence to the following principles whereby:

- Surface water is held back at source and increase the uptake of water re-use activities across the Borough, including the provision of schemes to store water upstream of and throughout the urban environment.
- Surface water is managed above ground, using the topography and infrastructure to deliver safe transport, above ground, of water through the urban environment, for the whole range of events including the extreme events.
- Place making is key to the urban area – through the promotion of natural vegetation to achieve multiple benefits (including improvements in water quality, flooding, biodiversity, public perception and amenity). Stopping the current impermeable trend within our urban areas and reversing the current levels of impermeability across LBB.
- Co-operation across the stakeholders to achieve the best solution for the residents, helping to install greater public confidence in our abilities to manage the issues and safely design our future city through the delivery of an integrated Water Management plan.
- Learning to live with water – preparation for the extreme event is vital as in some cases re-location of people or property may not be viable.

Appendix C – Risk Assessment Technical Details

Introduction

As part of the Drain London Tier 2 project stage, Hyder and AECOM were commissioned to create surface water models to identify key flood risk areas and generate hazard mapping for Group 2 within the Greater London area. The 33 London Boroughs were divided into eight groups (Figure C-1) by the Drain London Forum.

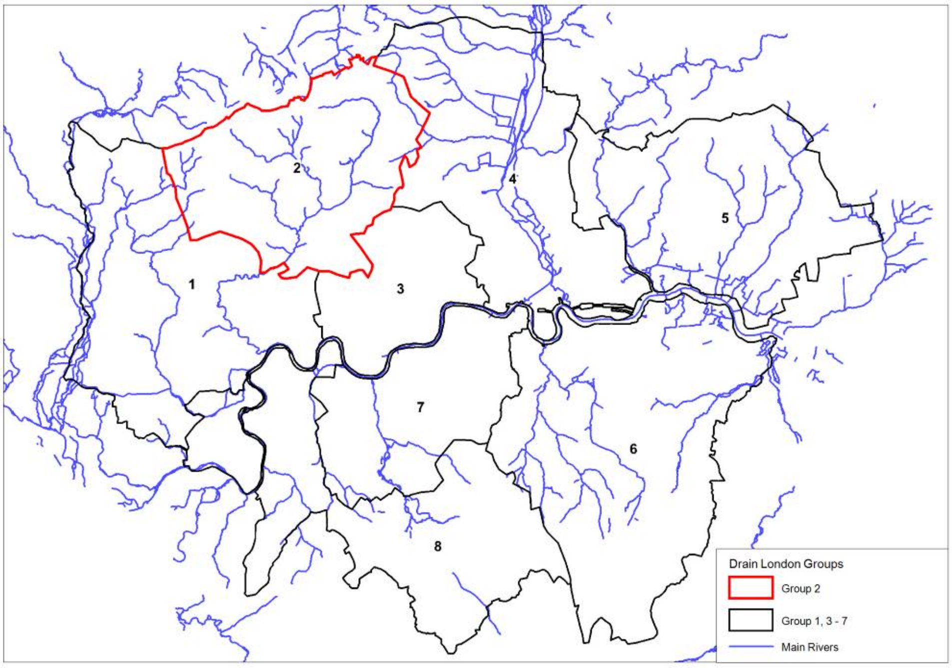


Figure C-1 Drain London Groups

Group 2 comprises three London Boroughs: Barnet, Brent and Harrow (Figure C-2).

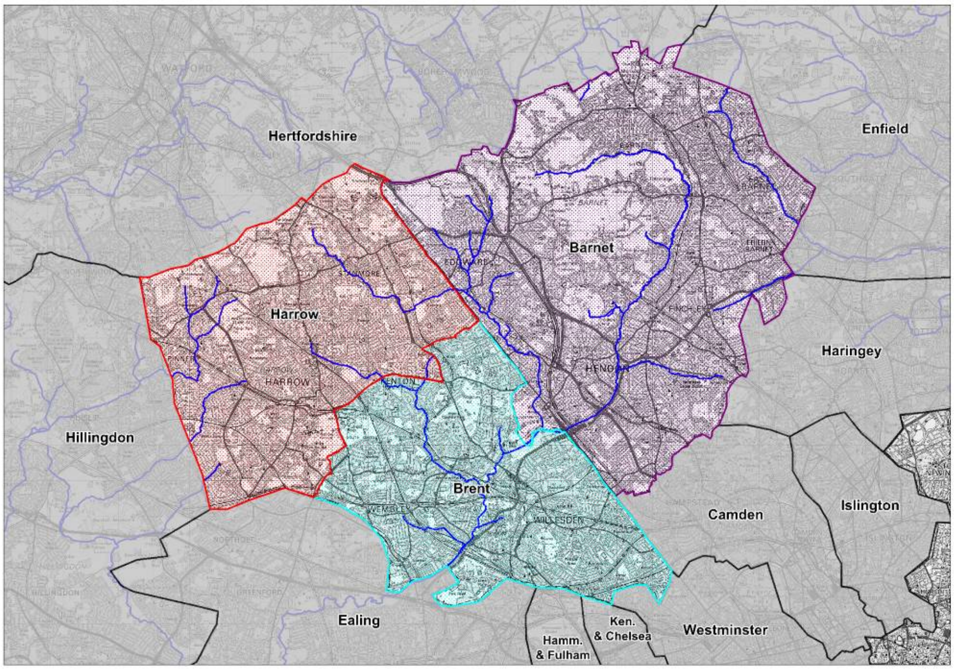


Figure C-2 Group 2 London Boroughs

The three boroughs were divided into hydrological catchments to maximise modelling efficiency and to reduce model run times. The main hydrological catchments provide natural model boundaries. However, these model boundaries are not coincident with the borough boundaries.

The London Borough of Barnet (LBB) is covered by four model extents (Figure C-3).

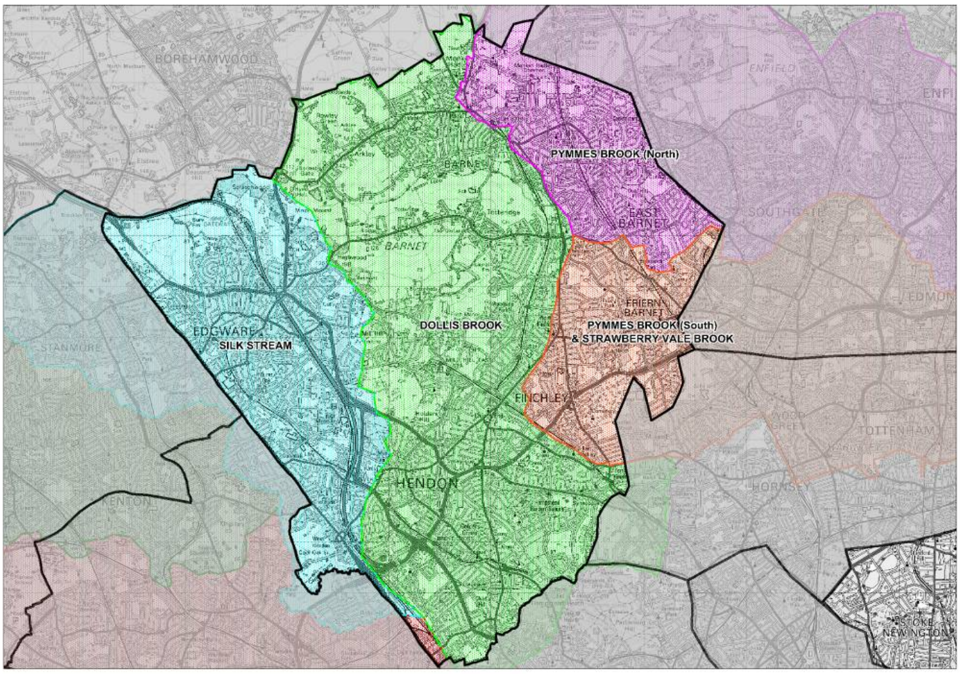


Figure C-3 LBB Model Coverage

The main hydrological catchments provide natural model boundaries. However, these model boundaries are not coincident with the borough boundaries. This results in an overlap with one other Drain London Group.

The Pymmes Brook and Strawberry Vale Brook catchments in Barnet overlap with Group 4. Due to these hydrological overlaps Capita Symonds have modelled the Pymmes Brook and Strawberry Vale Brook as part of their modelling programme. Hyder/AECOM have modelled the Dollis Brook and Silk Stream.

1.1 Model Development

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

This approach enables the effect of the topography on overland flood routes to be simulated by direct application of a rainfall profile to a 2d hydraulic model domain. TUFLOW's 2d solution is based on the Stelling solution scheme. It is a finite difference, fixed grid, alternating direction implicit (ADI) scheme solving the full 2d free surface shallow water flow equations.

1.1.1 Hydrological Modelling

The Drain London modelling was designed to analyse the impact of heavy rainfall events across each London Borough by assessing flow paths, velocities and catchment response.

The Drain London Data and Modelling Framework[1] specified that the direct rainfall method should be used in the modelling approach. This method incorporates conservative allowances for the drainage network and infiltration. The following key assumptions were made to generate the model input:

- Initial Loss – None
- Infiltration Loss – None
- Allowance for Drainage System – A constant value of 6.5mm/hr was applied
- No aerial reduction factor applied
- 'Summer' profile was used

1.1.2 Design Rainfall

To comply with the Drain London framework requirements rainfall inputs were generated at a 10km grid square resolution (Figure C-4). As specified in the framework guidance hyetographs for the following rainfall events were generated:

- 3.33% AEP (1 in 30 chance of occurring in any given year)
- 1.33% AEP (1 in 75 chance of occurring in any given year)
- 1% AEP (1 in 100 chance of occurring in any given year)
- 1% AEP (1 in 30 chance of occurring in any given year) plus 30% climate change
- 0.5% AEP (1 in 200 chance of occurring in any given year)

[1] Drain London – Data and Modelling Framework v1.0, 10th December 2010

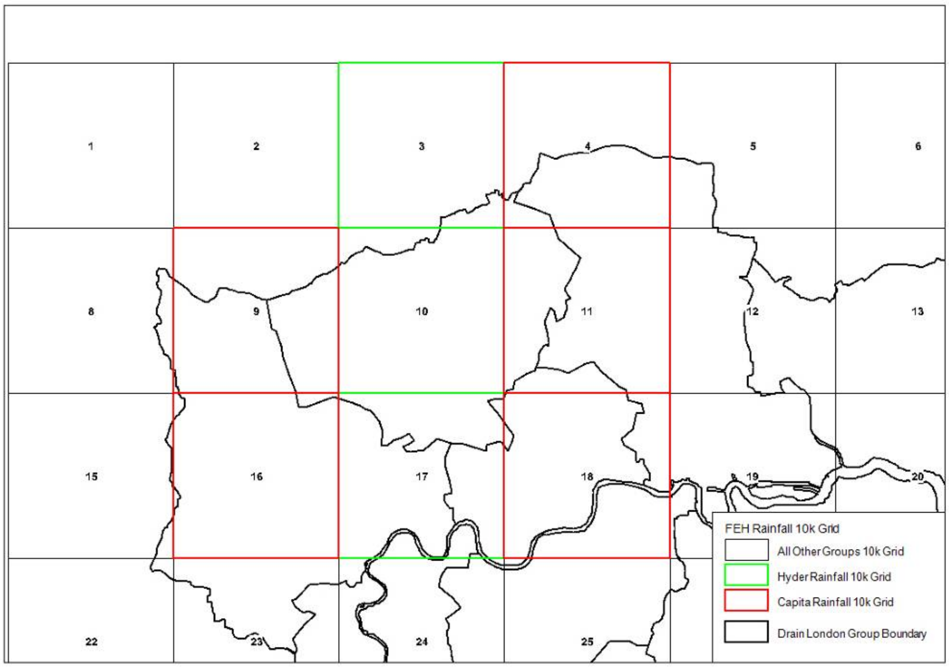


Figure C-4 10k rainfall grid

A two stage process was used to generate the rainfall hyetographs for TUFLOW. The first stage involved the extraction of total rainfall depths at each 10km grid centroid for all required return periods from the FEH CD-ROM (v3) Depth Duration Frequency (DDF) model. A comparison between the peak rainfall depths in adjacent 10km grid squares was completed to confirm the suitability of the 10km grid resolution for modelling purposes. The difference in total rainfall depths between the grid centroids was less than 5% which suggests that the data is suitable for use in TUFLOW. Table C-1 below outlines the peak rainfall depths generated for each 10km grid square by Hyder and Capita Symonds.

	Hyder 10k Grid Rainfall Depth (mm)			Capita 10k Grid Rainfall Depth (mm)				
TUFLOW Rainfall Grid ID	**3**	**10**	**17**	**9**	**16**	**4**	**11**	**18**
10k Grid Centroid ID	**2A**	**2B**	**2C**	**1b**	**1d**	**4a**	**4c**	**4e**
30 year	43.92	42.54	45.32	44.98	47.1	45.45	48.55	48.77
75 year	57.61	55.84	59.18	58.48	61.01	59.82	64.36	64.6
100 year	62.71	60.79	64.33	63.48	66.15	65.18	70.3	70.53
200 year	76.87	74.56	78.60	77.32	80.35	80.11	86.86	87.1

Table C-1 Peak Rainfall Depths for each 10k Grid Centroid

The second stage of input generation involved the use of ISIS which is an industry standard 1d modelling package. Within ISIS an FEH inflow boundary was populated with the DDF rainfall data, a critical storm duration of 3 hours was set and a summer rainfall profile was selected. The 3 hour critical storm duration was predetermined by the Drain London framework guidance document. This process generated the required rainfall hyetographs to apply in each grid square for each return period in TUFLOW.

1.1.3 Critical Storm Duration

Critical duration is a complex issue when modelling large areas for surface water flood risk. The critical duration can change rapidly even within a small area, due to the topography, land use, size of the upstream catchment and nature of the drainage systems. The ideal approach would be to model a wide range of durations. However, this is not always practical or economic when modelling large areas using 2d models which have long simulation times – such as within the Drain London study.

A high level investigation was undertaken to understand the effect of rainfall event duration on the Drain London Study area using a rapid modelling technique. The intention of the investigation was to show variation in critical duration across the study area and thus identify whether it was possible to identify single critical durations for each sub-model. The study used the 1 in 100 year hyetographs for 1, 3, 6 and 12 hour durations along with a simplified terrain model to route overland flow. The key result was that critical duration is highly variable across surface water catchments but the influence was not sufficiently significant to justify considering multiple event durations within the Drain London Study. Therefore, a single duration of 3hrs was selected for all model runs to ensure result consistency and comparability across the Greater London area.

1.1.4 Runoff Coefficients

Runoff coefficients for varying surfaces were standardised and are specified in the Drain London Data and Modelling Framework V1.0. The standardised coefficients were applied to the rainfall event profiles in order to simulate an appropriate level of infiltration for each land use type.

The runoff coefficients were applied in TUFLOW using 2d_rf boundaries which apply rainfall to every active cell in the model.

1.1.5 Software Version

All of the models have been run using the 2010 versions of TUFLOW. The Dollis Brook, Silk Stream, Pymmes Brook and Strawberry Vale Brook were run using the 64bit version of TUFLOW (2010-10-AA-iDP-w64) due to their size. The 64bit version has been designed to deal with large domain models.

1.1.6 Hydraulic Model Parameters

All of the LBB hydraulic models were set up according to the specification in the Drain London Data and Modelling Framework document.

1.1.7 Digital Elevation Model

A key component of the TUFLOW modelling process was the acquisition of a Digital Terrain Model (DTM). 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.

Filtered DTM data was used for the Drain London surface water modelling. This provided complete coverage of the Group 2 area (Figure C-5). A TUFLOW topography file, zpt layer, was generated from the DTM at a 5m resolution.

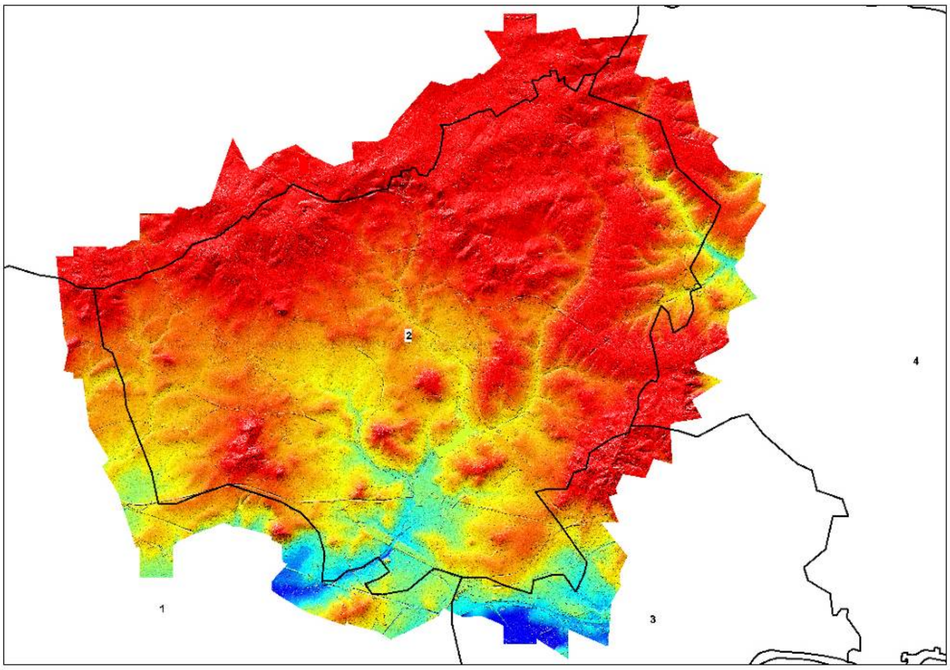


Figure C-5 Group 2 LiDAR

Standard practice for TUFLOW modelling is to use filtered LiDAR as it removes interference and distortion caused by buildings and trees to represent the 'bare earth'.

While the majority of the Infoterra data provided was of a suitable standard, there were a number of issues identified following initial model runs that required corrective measures. Figure C-6 to C-9 show the main issues identified with the DTM.

Buildings have been poorly filtered leaving anomalous spikes in the ground model which can adversely affect the model results. These buildings have been smoothed using a zshape polygon to mask the building in the DTM. This reduces its impact on the modelled results.

Figure C-6 Poorly filtered buildings in Group 2 LiDAR

Raised structures (e.g. bridges, underpasses and subways) have not been filtered out of the DTM. These features create unnatural barriers to flow where in reality flow would pass beneath or through the structure. To remove these structures from the DTM a 2d zshape was drawn over the structure with node points at all four corners of the polygon. The four points were populated with elevations from the DTM on either side of the structure to effectively cut through the feature. This 2d zshape is then read into TUFLOW where the structure is removed.

Figure C-7 Poorly filtered structures in Group 2 LiDAR

A further issue in the draft modelling identified an error in the filtering process in the DTM creating a speckled model output. This anomaly was referred back to Infoterra for re-filtering of the DTM. A new dataset was issued and has been used to produce the subsequent modelling.

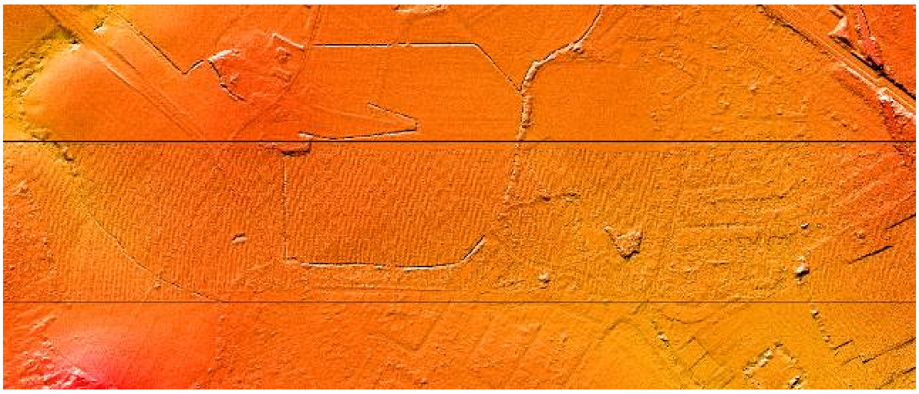


Figure C-8 Speckled LiDAR anomoly

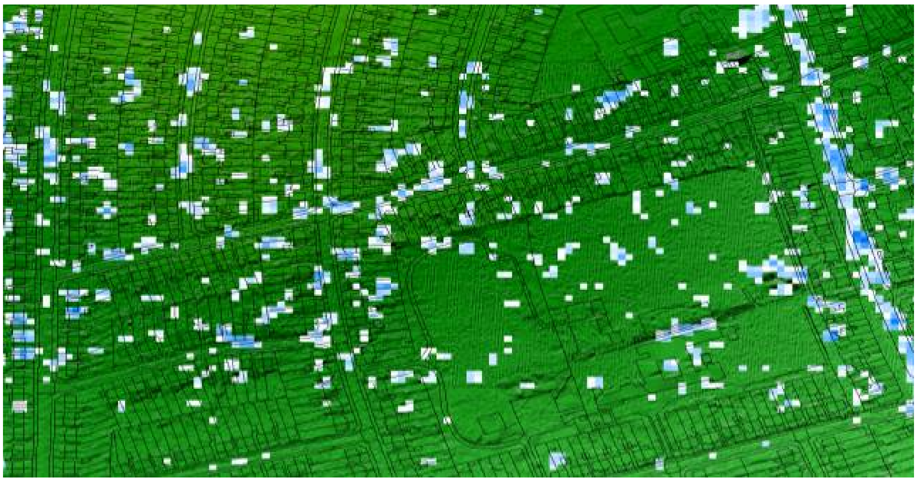


Figure C-9 LiDAR anomaly caused unusual TUFLOW model outlines

1.1.8 Grid Size

The LBB models have all been created at a 5m grid resolution. This grid size was chosen to ensure that key urban features were represented while ensuring a reasonable model run time.

This grid size falls within the approved range as specified in the Drain London Data and Modelling Framework.

1.1.9 Building Representation

MasterMap data was used to identify all building footprints within the Group 2 study area. The buildings were separated from the main Master Map dataset and an average ground level within the building footprint was calculated in MapInfo. An 'upstand' of 100mm was applied to the average ground level for each building footprint. Only buildings where the 'upstand' was above the surrounding ground level were applied within the TUFLOW simulation.

A depth varying roughness was applied to all buildings within the model domain. For depths up to 30mm a Manning's n of 0.015 was applied and above this depth, a value of 0.5 was applied.

1.1.10 Floodplain Structures

During the development of the hydraulic models, a number of flow paths through bridges or culverts were identified. Where necessary these structures have been modelled using a 2d zshape within the 2d TUFLOW domain. No structural information was made available for the Drain London study so the width and invert levels of the structures were estimated using the OS10k map, DTM and Google Maps.

The 2d zshapes were predominantly used for wider structures where the assessment of flow through the structure was not required. As no structural information was made available for the smaller watercourse crossings these were not included in the model. This has resulted in a more conservative model output across Barnet.

1.1.11 Watercourses

All open watercourses within the model domain were assumed to be at bank full throughout each of the model simulations. Bank top levels were determined by using a combination of the Ordnance Survey 10k mapping, Drain London DTM and Google Maps. To represent the bank full watercourses in TUFLOW a 2d zshape polygon was generated at bank top along the length of each watercourse with a node point at each vertex. Each node was populated with an elevation value from the underlying 'bare earth' DTM.

1.1.12 Use of PO lines

In order to analyse the model results at points of interest a series of PO (Point Output) lines were drawn within the TUFLOW model domain to record integral flows, water levels and velocities throughout the simulation. These lines were placed mainly perpendicular to main flow routes. The PO lines can be analysed to determine the total volume of flow passing through it over the simulation. PO lines were not used in all of the LBB models.

1.1.13 Downstream Boundaries

In order to represent flow out of the model domain HQ (Stage vs Flow) boundary lines were added at the edge of the 2d model domain. HQ lines were not used in all of the LBB models.

1.1.14 Cross Boundary Issues

Within the LBB there are several boundary connections between the models. In a majority of cases the model boundaries are located along high topographic features therefore there is minimal flow between the models. Where flow paths between models were identified a downstream boundary as outlined in section 1.2.13 was added. The flow recorded between models was minimal so these flows were not inputted into neighbouring models.

1.1.15 Manning's Values

A common set of Manning's roughness coefficient values were defined in the Drain London Data and Modelling Framework v1.0 to provide consistency between the Borough models. The Manning's values were applied in TUFLOW with in a materials file (.tmf). The Drain London tmf file contained the roughness values along with continuing runoff losses. The tmf file is read in by TUFLOW in conjunction with a 2d_mat.mif file, created based on feature code, and the 2d_rf boundary files.

1.1.16 Model Run Time

All of the LBB models were initially run for six hours as specified in the Drain London Data and Modelling Framework. The model files were checked to ensure that the modelled depths were not increasing and that no further flow paths were being formed. Within LBB only the Pymmes Brook (South) & Strawberry Vale Brook model required an additional hour and so was run for seven hours. All of the other models were run for six hours.

1.1.17 Sensitivity Testing

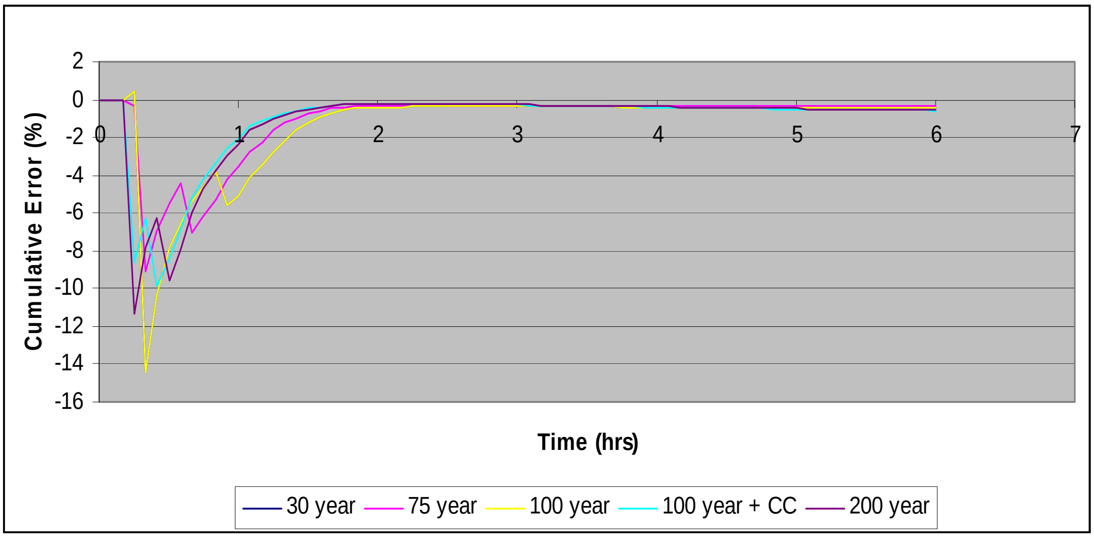
In order to assess the LBB models sensitivity to changes in drainage the models loss to drainage parameter was amended by +/-25% from 6.5mm/hr to 8.125mm/hr and 4.875mm/hr. The 0.5% AEP model was re-run with these amended parameters to assess what impact this would have on the modelled extents and depths. The results from the sensitivity analysis were compared with the baseline 0.5% AEP results. A significant impact on results was identified if the percentage change in depth was greater than the percentage change in the parameter.

The LBB models showed minimal sensitivity to changes in the drainage loss parameter. With the sensitivity results showing less than a 25% change in depth from the baseline model results across the Borough. There were several isolated areas which showed larger differences in depth however these were in areas where there were sudden changes in elevation in the underlying DTM (e.g. railway embankments).

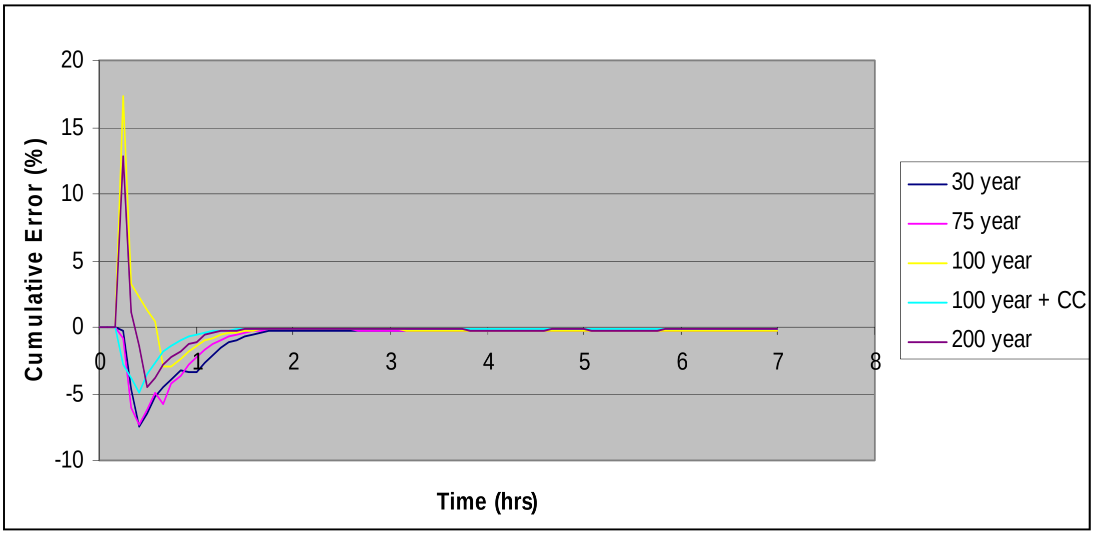
1.2 Model Stability

An assessment of the LBB models stability was made by analysing the mass balance (cumulative error %) for each model run. The warnings in the model output files were also checked to ensure that these were not highlighting any fundamental issues with the model. This assessment was an important stage in establishing the accuracy of the model outputs.

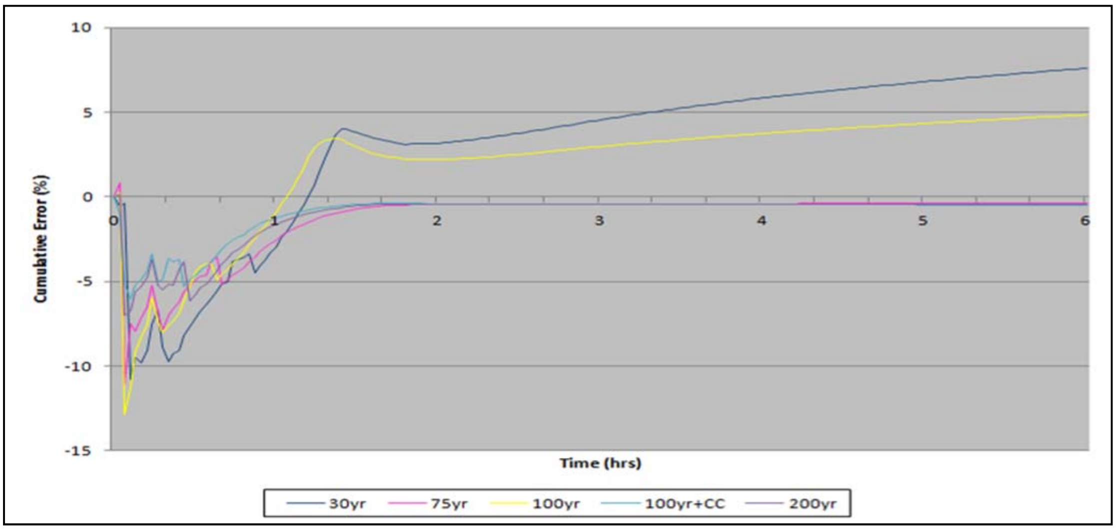
The Drain London Data and Modelling Framework document suggests that the recommended range of cumulative error should be +/- 5% for a majority of the simulation. Figures C-10 – C-13 outline the cumulative error range in each of the LBB models. As can be seen in the figures all of the models report very high cumulative errors at the beginning of the model simulation. This is caused by TUFLOWs initial wetting process at the beginning of the rainfall event. The models all settle down beyond the one hour mark with the rest of the simulation falling within the recommended range. As the errors occur at the beginning of the simulation at varying times and are not prolonged it is deemed unlikely that they would have an impact on the model results. For the Dollis Brook model the 30yr and 100yr mass balance highlight an error in the ground model at the north-eastern boundary of the model, where flow travels beyond the model domain. As this was identified as a very localised issue it would have a minimal impact on the overall model results.



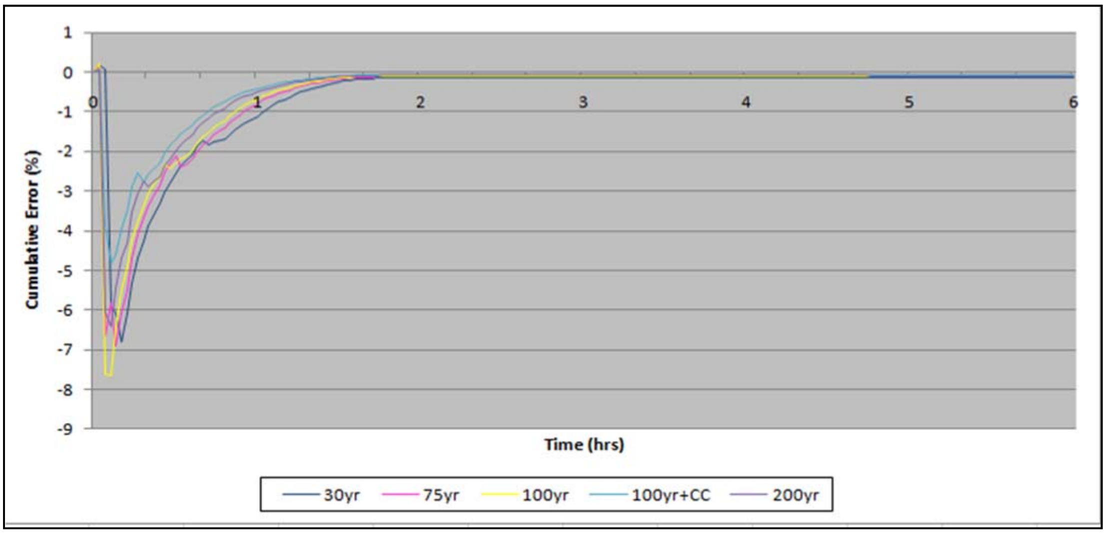
C-10 – Pymmes Brook (North) Mass Balance



C-11 – Pymmes Brook (South) and Strawberry Vale Brook Mass Balance



C-12 – Dollis Brook Mass Balance



C-13 – Silk Stream Mass Balance

The warning messages were also checked for all four of the models. There were repeated warnings in all of the models prior to the start of the simulations. This was caused by the use of very small MasterMap polygons being used in the 2d_rf and 2d_mat files. No further action was taken as this was not likely to impact on the overall model results. Convergence errors occurred in all of the LBB models. A majority of the convergence issues were identified as being caused by areas of poorly filtered LiDAR. As the warnings were in a variety of locations and occurred at differing times during the simulation they were deemed to have a minimal impact on the model results.

1.3 Model Summary

The table below summarises the Drain London models run along with a summary of their LBB coverage.

Catchment Name	Model Naming Convention	TUFLOW Build	Grid Size	Storm Duration	Total Run Time	Borough Coverage	Borough Coverage	Total Model Size
Pymmes Brook (North)	DLT2_G4SG_0100R_022	2010-10-AA-iDP-w64	5m	3hrs	6hrs	10.5km^2	12%	50km^2
Pymmes Brook (South) & Strawberry Vale Brook	DLT2_G4WG_0100R_024	2010-10-AA-iDP-w64	5m	3hrs	7hrs	10km^2	12%	36km^2
Dollis Brook	DB_BL_100_180_V3	2010-10-AA-iDP-w64	5m	3hrs	6hrs	44km^2	51%	48km^2
Silk Stream	SS_BL_100_180_V3	2010-10-AA-iDP-w64	5m	3hrs	6hrs	12km^2	24%	37km^2

1.4 Model Output Files

In order to assess areas at risk of surface water flooding flood depths greater than 0.1m were analysed. The depth grids were broken down into depth bands to allow for the identification of areas at risk of overland flow and deep ponding (>1.5m).

The flood hazard outputs were broken down into bands based on the joint Environment Agency and Defra R&D Technical Report FD2320 (January 2006). This was deemed the most applicable to the heavily urbanised Greater London area. The output was represented by three degrees of critical flood hazard: Moderate (0.75 -1.25) danger for some; Significant (1.25 – 2.0) danger for most; Extreme (>2.0) danger for all. Anything less that 0.75 was not represented as the hazard level was deemed very low.

The velocity outputs were used to assess significant changes in velocity. Velocities above 0.5m/s were analysed as these higher velocity areas were deemed to pose higher risk levels. Velocity vectors were also exported from the models to represent changes in flow direction and magnitude.

The mapped model outputs are included in Appendix D of this SWMP report.

1.5 Model Validation

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.

1.6 Model Limitations

There are a number of limitations associated with the modelling methodology:

- The below ground sewerage 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 6.5mm/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.

1.7 Conclusions and Recommendations

As part of Drain London Tier 2 strategic surface water models were developed for all 33 of the London Boroughs. The models were designed to allow for the assessment of surface water flood risk across each London Borough. Within the LBB the models have helped to identify key flow paths, critical drainage areas (CDAs) and local flood risk zones (LFRZs).

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

- Ponding of flow in topographical depressions.
- 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 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.

Several recommendations for future improvements to the models are outlined below.

- Develop detailed integrated models in the local flood risk zones to take the underground drainage network and the fluvial network into account.
- Re-run the models as and when improved LiDAR becomes available.
- Obtain survey data for key structures within LFRZs to improve the accuracy of the modelled output.
- Obtain more information relating to key watercourse structural crossings to improve the accuracy of the modelled output.
- Increase the model resolution in LFRZs to improve the accuracy of the modelled flow paths.

Appendix D – Maps

Appendix E – Option Assessment Details

E1 – CDA Descriptions

E2 – Summary of Measures

E3 – Option Assessment (refer to separate spreadsheet)

APPENDIX E1 – CDA Descriptions

1.7.1 Scratch Wood – Group2_001

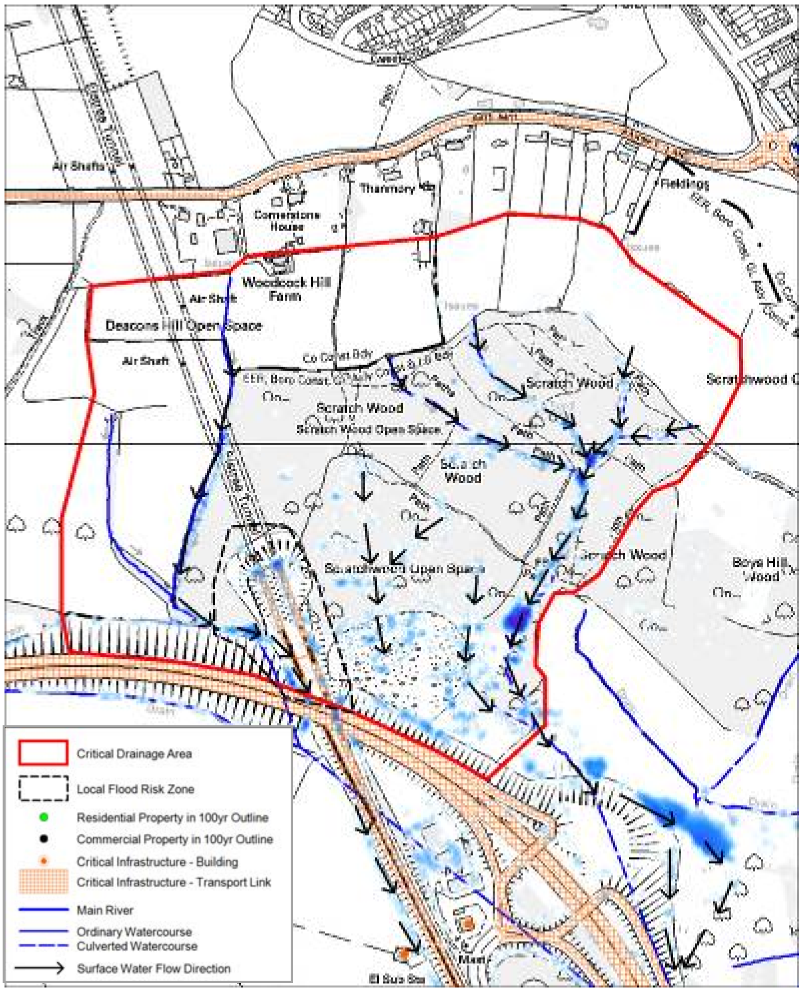


Figure E1-1 Scratch Wood CDA

Group2_001 is located to the north west of the borough adjacent to Scratch Wood and covers an area of 0.6km^2. The modelling shows that the main line rail link into London from Elstree and Borehamwood is at risk from shallow (<0.5m) surface water flooding in a 1 in 100 year event. The railway line is embanked and is surrounded by open land so any flow from the surrounding land will runoff onto the railway line. The main source of flood risk is from the small open drain to the west of the railway line with a small amount of runoff from the quarry and open space to the east. A Section of the M1 runs to the south of the CDA but is not affected by flooding as it is raised above the surrounding area.

This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.2 Arkley – Group2_002

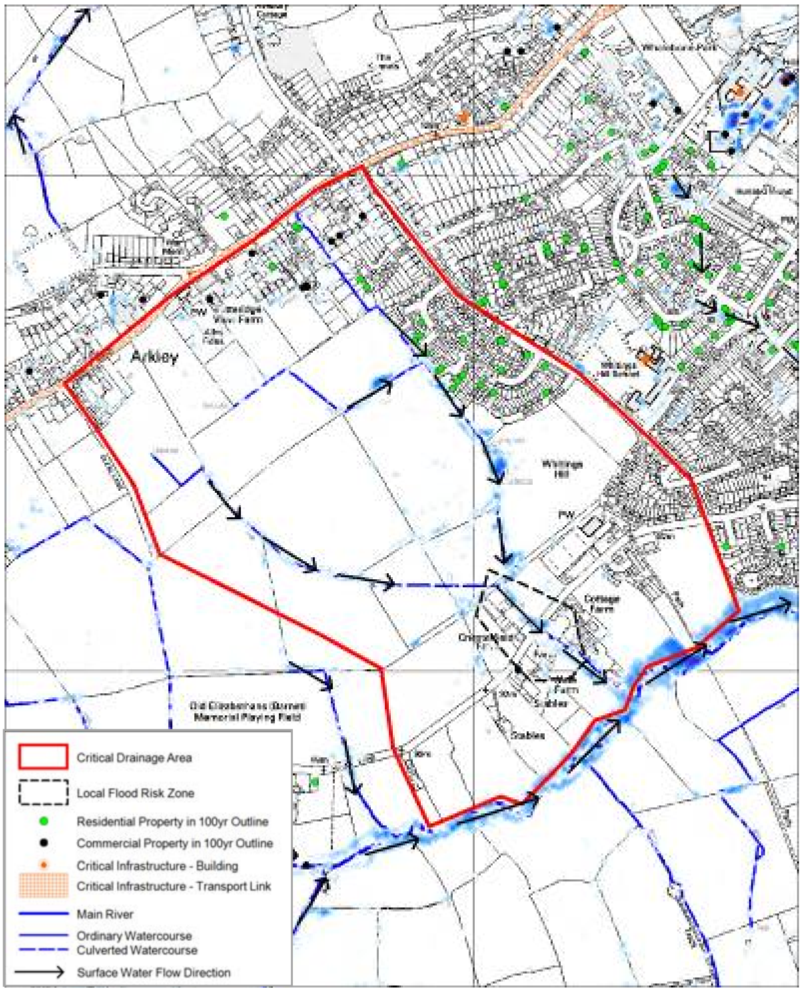


Figure E1-2 Arkley CDA

Group2_002 is located to the north of the borough near Arkley and is approximately $0.9km^2$. This is a predominantly rural area with no critical infrastructure within the CDA boundary. The modelled 1 in 100 year output indicates that 34 non-deprived properties are at risk of shallow surface water flooding in this area. The main source of risk within this CDA is from the field drains which run alongside the urban area of Arkley to the north and through several farms to the south-east of the CDA. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.3 Ducks Island - Group2_003

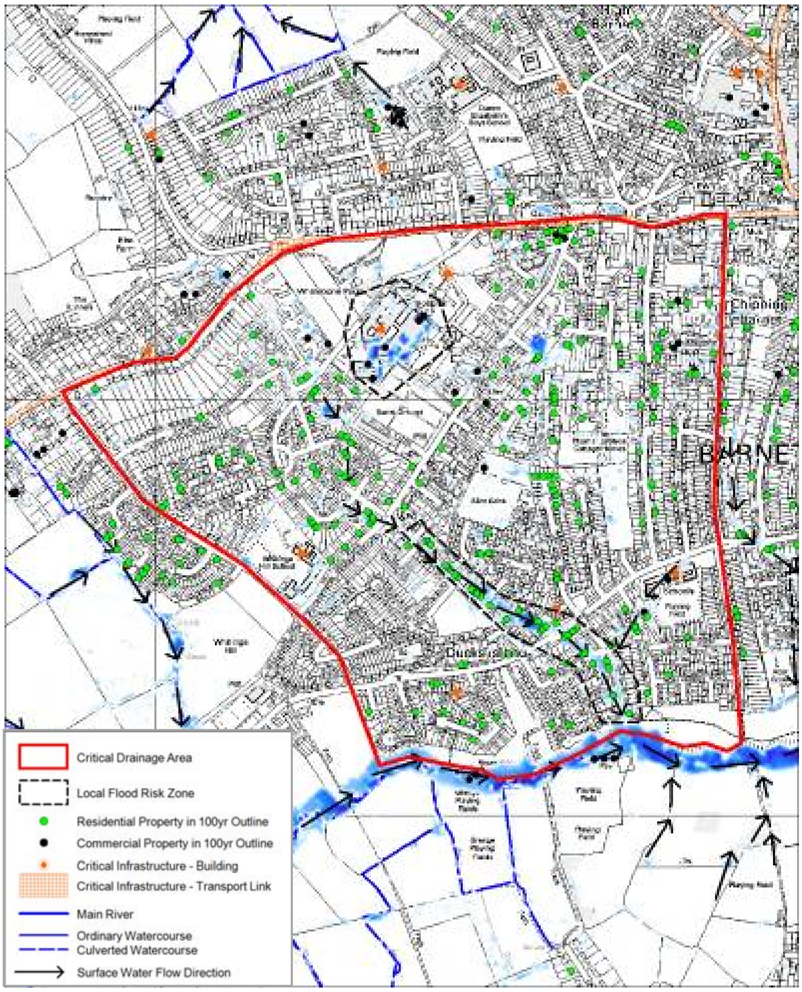


Figure E1-3 Ducks Island CDA

Group2_003 is located to the north of the borough in a moderately urbanised area adjacent to Group2_002. This CDA is approximately 1.5km^2. The 1 in 100 year modelled output indicates that there are 264 non-deprived properties at risk of shallow water flooding (<0.5m) and one property on Wood Street at risk of deeper flooding (>0.5m). There are 24 commercial properties at risk of shallow water flooding and four at risk of deeper flooding.

There are four ‘more vulnerable’ critical infrastructure sites which are at risk of flooding within this CDA. Barnet Hospital and a hazardous waste site adjacent to the hospital are at risk of deep flooding and two schools which are at risk of shallow flooding.

The main source of risk in this CDA is overland flow from Whalebone Park down through the urban area of Ducks Island. There is a Section of open channel in Whalebone Park which goes into culvert just north of Wellhouse Lane. The surface water flow is following the course of the old open watercourse as there is still a slight topographical low through the Ducks Island area to the Dollis Brook. An LFRZ has been designated in the area next to Chesterfield Road, May Lane and Alan Drive as this area has the largest concentration of residential property at risk. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.4 Underhill – Group2_004

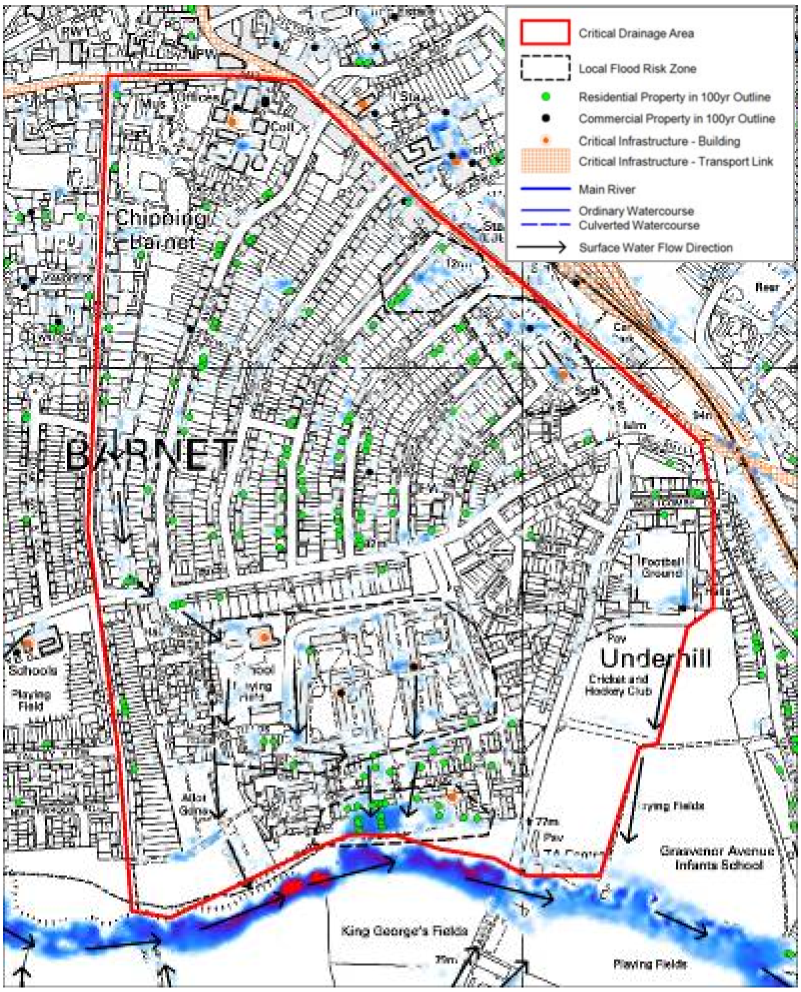


Figure E1-4 Underhill CDA

Group2_004 is a moderately urbanised area covering Underhill, Chipping Barnet and Barnet. The CDA is approximately 0.9km^2. The 1 in 100 year modelled output indicates that there are 189 non-deprived properties at risk of shallow flooding and two properties at risk of deep flooding. There are nine commercial properties at risk of shallow flooding.

There are six 'more vulnerable' critical infrastructure sites three schools and three electricity installations. Underhill to the south-east of this CDA has been designated a regeneration site as part of the London Plan. The regeneration area falls completely within this CDA but not all of this site is at risk of flooding. The main source of flood risk is from overland flow from Chipping Barnet to the north of the CDA down to the Dollis Brook in the south.

Several smaller overland flow paths were also identifiable from the mapped extents in this area. Four LFRZs have been designated within this CDA, three correspond with the locations of five of the 'more vulnerable' critical infrastructure sites and the fourth is located in an area of deep residential flooding. This CDA was validated against the EA FMfSW and the historic surface water flooding incidents in this area.

1.7.5 Hadley – Group2_005

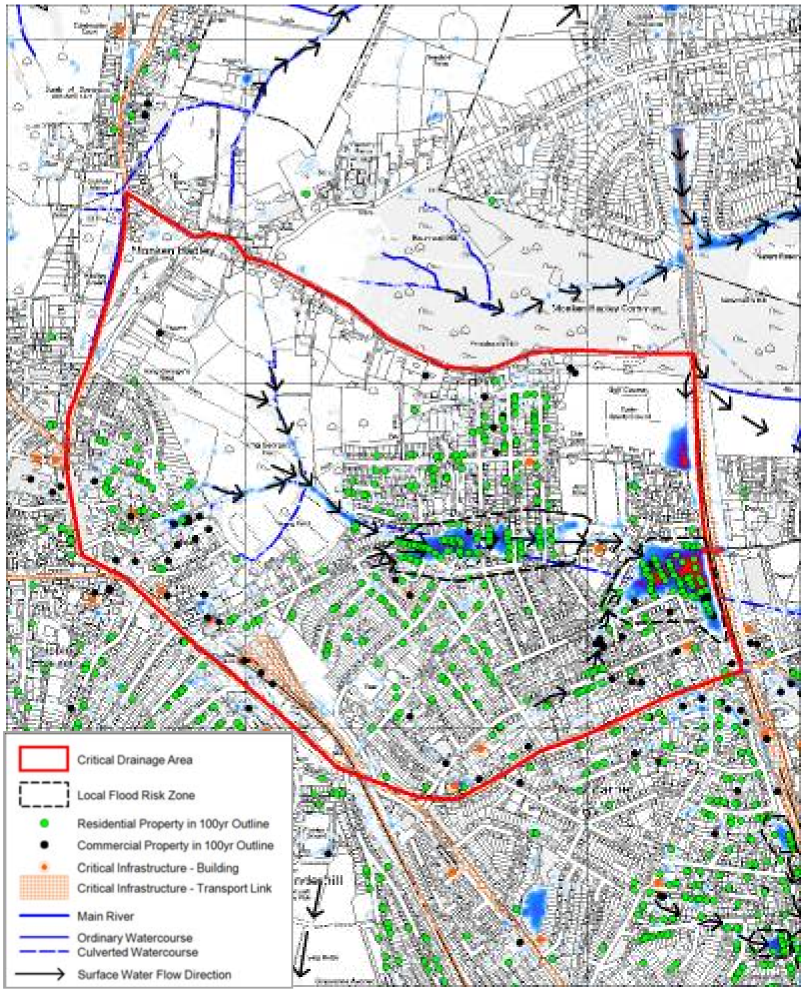


Figure E1-5 Hadley CDA

Group2_005 is a moderately urbanised area to the north of LBB. The CDA is approximately 2.1km^2. The 1 in 100 year modelled output indicates that there are 562 non-deprived properties at risk of shallow flooding and 154 properties at risk of deeper flooding. There are 59 commercial properties at risk of shallow flooding and 5 at risk of deeper flooding.

Within the CDA there are two ‘essential’ infrastructure sites at risk of shallow flooding High Barnet station and the railway line. There are two ‘highly vulnerable’ infrastructure sites at risk of shallow flooding; one police station and one ambulance station. There are also four ‘more vulnerable’ sites are at risk of shallow flooding; two schools and two electricity installations.

The main source of flood risk in this CDA is from overland ponded flow. There are several topographic depressions within this CDA which are behaving like retention ponds in the larger modelled return periods. There are several drains to the west of the CDA which combine into one drain and enter a culvert at Bosworth Road. The modelled overland flow is following the old open watercourse valley. The area of deep ponding to the east of the CDA at Shaftesbury Avenue is caused by the constriction of flow through the subway under the railway line. This appears to be the only flow path through the railway line.

Two LFRZs have been designated within this CDA these correspond with the areas of deep flooding which are affecting 154 residential and five commercial properties. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.6 Pricklers Hill – Group2_006

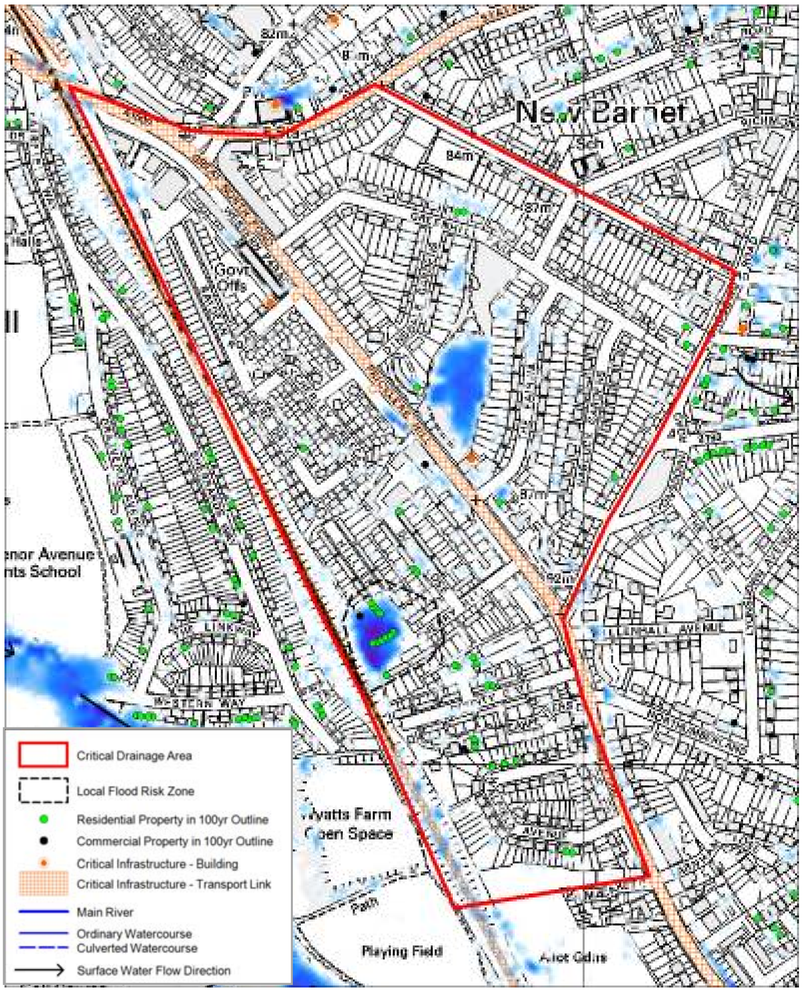


Figure E1-6 Pricklers Hill CDA

Group2_006 is a densely urbanised area to the north-east of the borough. The CDA is approximately 0.45km^2. The 1 in 100 year modelled output indicates that there are 54 non-deprived properties at risk of shallow flooding and 6 at risk of deep flooding. There are 25 commercial properties at risk of shallow flooding and one property at risk of deep flooding.

There are two 'essential' infrastructure assets within the 1 in 100 year output; the A1000 Great North Road and the Northern Line from High Barnet. The main risk of flooding in this CDA is caused by a topographic depression at Hillier Close and Cherry Hill which is causing the formation of a deep area of ponded surface water. One LFRZ has been created around the area of deep flooding to the west of the CDA; this is the largest concentration of flooding within the CDA. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.7 Longmore Avenue – Group2_007

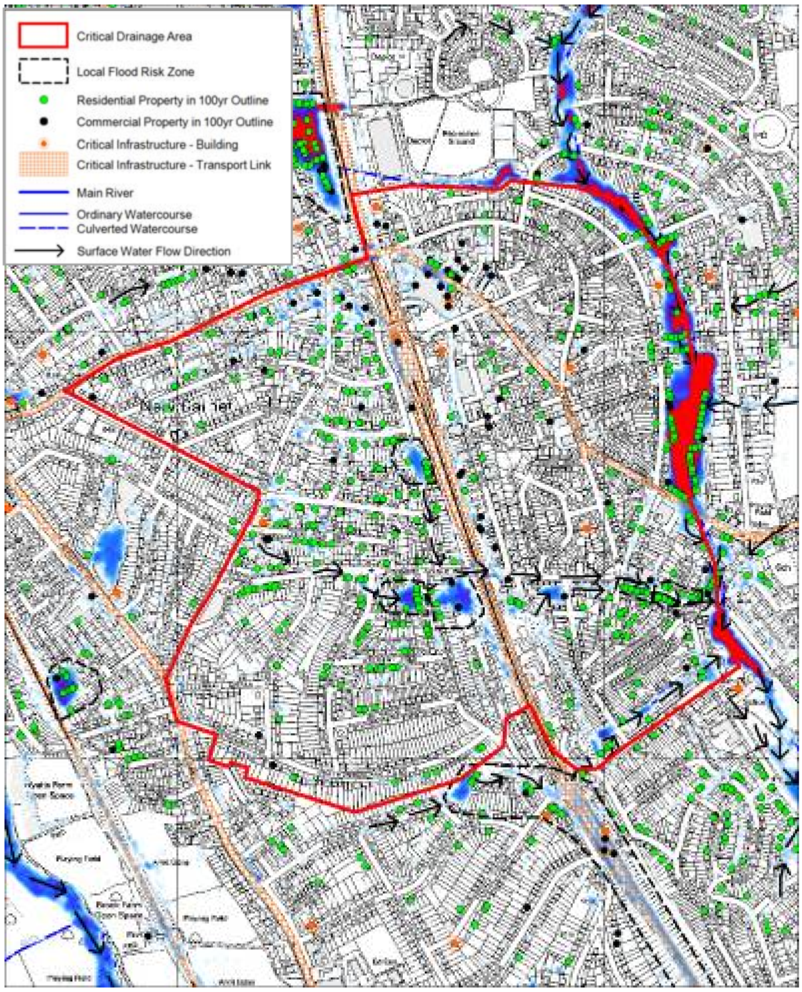


Figure E1-7 Longmore Avenue CDA

Group2_007 covers a densely urbanised area to the north-east of the borough. The CDA is approximately 1.5km^2. The 1 in 100 year model output indicates that 573 non-deprived properties are at risk of shallow flooding and 96 are at risk of deep flooding. There are 197 commercial properties at risk of shallow flooding and 18 at risk of deep flooding.

There are three ‘essential’ infrastructure assets at risk of shallow flooding within the CDA; New Barnet railway station, Northern Line and the A110 East Barnet Road. There is one ‘highly vulnerable’ asset at risk of shallow flooding; the community police station on Cat Hill. There is also one ‘more vulnerable’ asset at risk of shallow flooding an electricity installation.

The main source of risk within this CDA is from overland flow and surface water ponding. There are several topographic low spots within this CDA. Five LFRZs were designated within this CDA, all of which coincide with areas of ponded flooding which are affected multiple properties. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.8 Oakleigh Park – Group2_008

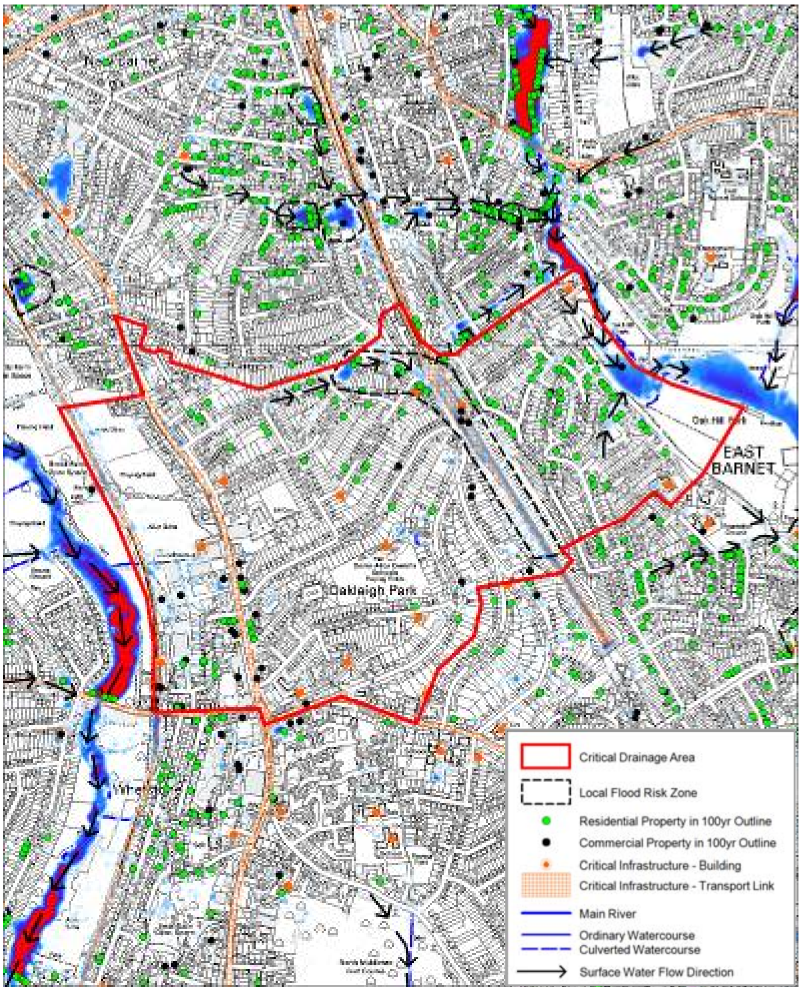


Figure E1-8 Oakleigh Park CDA

Group2_008 encompasses the densely urbanised Oakleigh Park. The CDA is approximately 1.4km^2. The 1 in 100 year modelled output indicates that there are 127 non-deprived properties at risk of shallow flooding. There are approximately 57 commercial properties at risk of shallow flooding and 2 of deep flooding.

There are five 'essential' infrastructure assets within this CDA: Oakleigh Park station, Totteridge and Whetstone station, Main Line railway, Northern Line railway and the A1000. There are four 'more vulnerable' assets at risk: two schools and two electricity installations.

The main source of flood risk in this CDA is overland flow. The land to the west of the CDA is higher than the land to the east near Pymmes Brook. Any surface water flow will run down from the elevated western areas and inundate the lower lying areas to the east near the railway line and Pymmes Brook. One LFRZ has been designated around the railway line and adjacent property at risk within this CDA. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.9 Friern Barnet – Group2_009

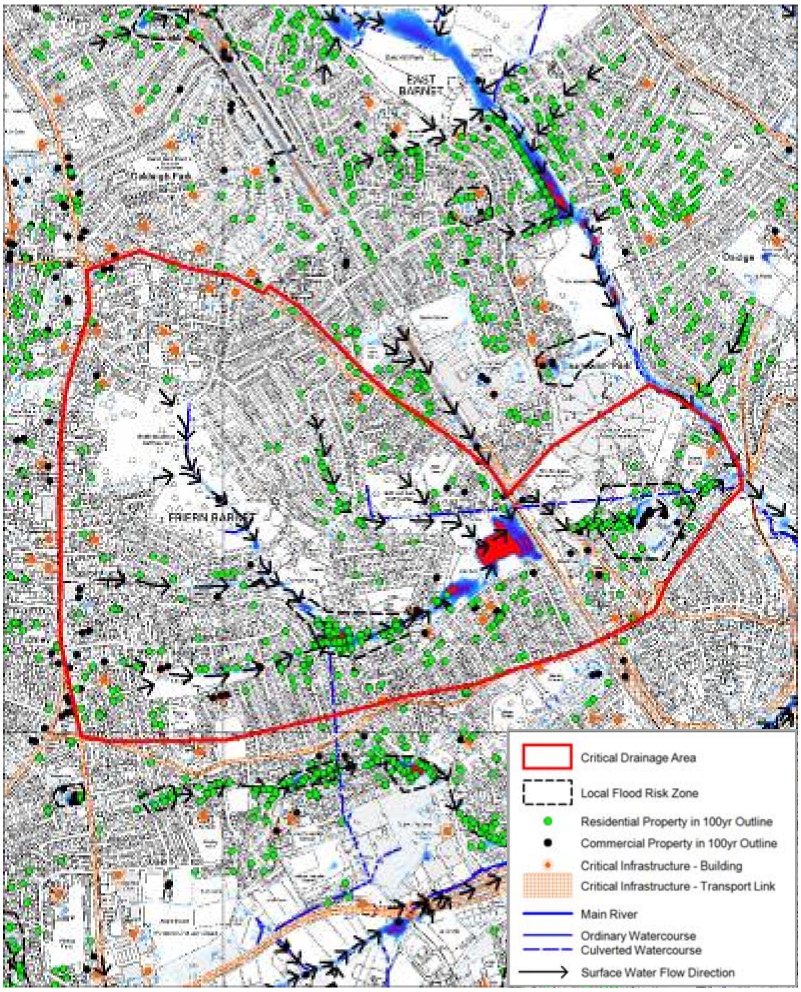


Figure E1-9 Friern Barnet CDA

Group2_009 is located to the east of LBB and covers the Friern Barnet, New Southgate and Bethune Park areas of the borough. The CDA is approximately 3.6km^2. The 1 in 100 year model output indicates that there are 415 non-deprived properties at risk of shallow flooding and 32 are at risk of deep flooding. There are 69 commercial properties at risk of shallow flooding and six at risk of deep flooding.

There are two ‘essential’ infrastructure assets at risk of shallow flooding: the Main Line railway and the A109. There is one ‘highly vulnerable’ infrastructure assets at risk Whetstone police station. There are also 16 ‘more vulnerable’ assets at risk of shallow flooding: 10 schools and six electricity installations.

The main sources of flood risk in this CDA are overland flow and surface water ponding. There are several topographic features which aid the conveyance of flow through the urbanised areas within this CDA. There is a culverted watercourse running from north to south mid-way through this CDA which creates a cross connection between GROUP2_009 and GROUP2_010. The modelled flow paths suggest that flow would run from west to east rather than north to south along the culverted watercourse pathway. This CDA was validated against both the EA FMfSW and several historic surface water flooding incidents.

1.7.10 Coppetts Wood – Group2_010

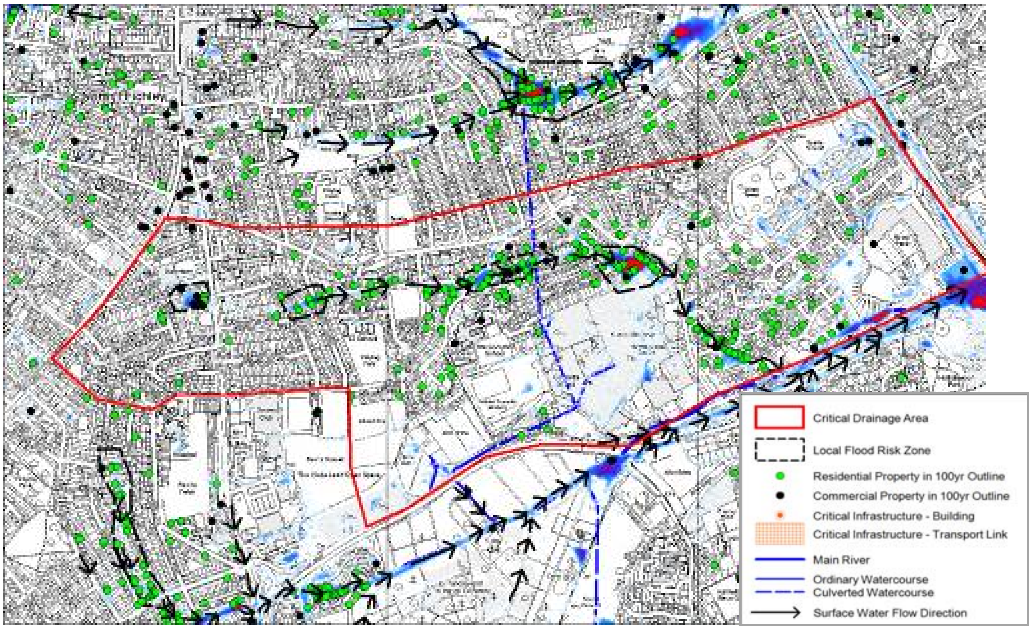


Figure E1-10 Coppetts Wood CDA

Group2_010 covers an area of mixed use to the east of the borough. The CDA is densely urbanised to the east, north and west with open space to the south dominated by a nature reserve and two allotment gardens. The 1 in 100 year modelled output suggests that there are 377 non-deprived properties at risk of shallow flooding and 22 properties at risk of deep flooding. There are 74 commercial properties at risk of shallow flooding and 5 at risk of deep flooding.

There are three 'essential' infrastructure assets at risk within this CDA: A406 North Circular, A1000 and the A1003. There is one 'highly vulnerable' asset at risk: Colney Hatch Lane ambulance depot. There are five 'more vulnerable' assets at risk: three schools and two electricity installations.

The main sources of flood risk in this CDA are overland flow and surface water ponding. There are several topographic features which aid the conveyance of flow through the urbanised areas within this CDA. The culverted watercourse cross connecting from GROUP2_009 could exacerbate the issues in this area although the surface water flow paths do not show a clear flow path connection from the north. Four LFRZs were designated within this CDA to encompass areas at significant risk of ponded surface water flow.This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.11 Victoria Park – Group2_011

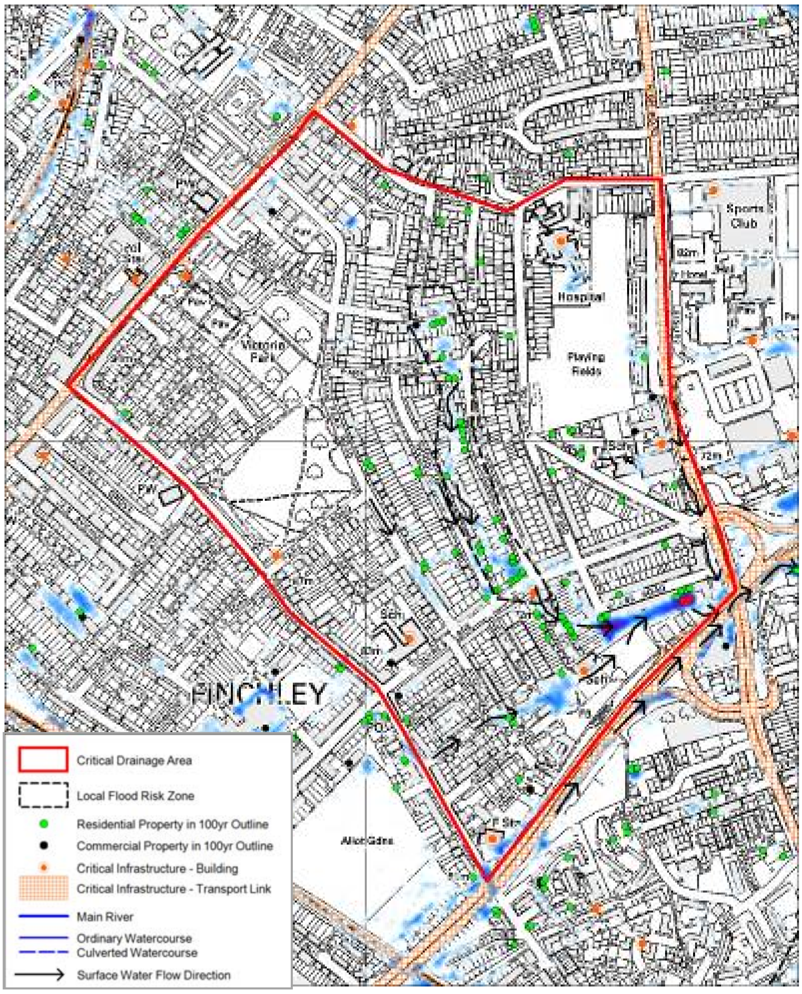


Figure E1-11 Victoria Park CDA

Group2_011 covers an area of mixed use to the east of the borough. The CDA is quite densely populated with small open areas to the east and west. The 1 in 100 year modelled output suggests that there are 96 non-deprived properties at risk of shallow flooding. There are 7 commercial properties at risk of shallow flooding.

There is one 'highly vulnerable' asset at risk of shallow flooding: Long Lane Fire Station. There are six 'more vulnerable' assets at risk of shallow flooding within this CDA: Finchley Memorial Hospital, two schools and three electricity installations.

The main source of flood risk in this CDA is overland flow. There are several topographic features which aid the conveyance of flow through the urbanised areas within this CDA. One LFRZ has been designated within this CDA to encompass the area at most significant risk of overland surface water flow. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.12 Long Lane – Group2_012

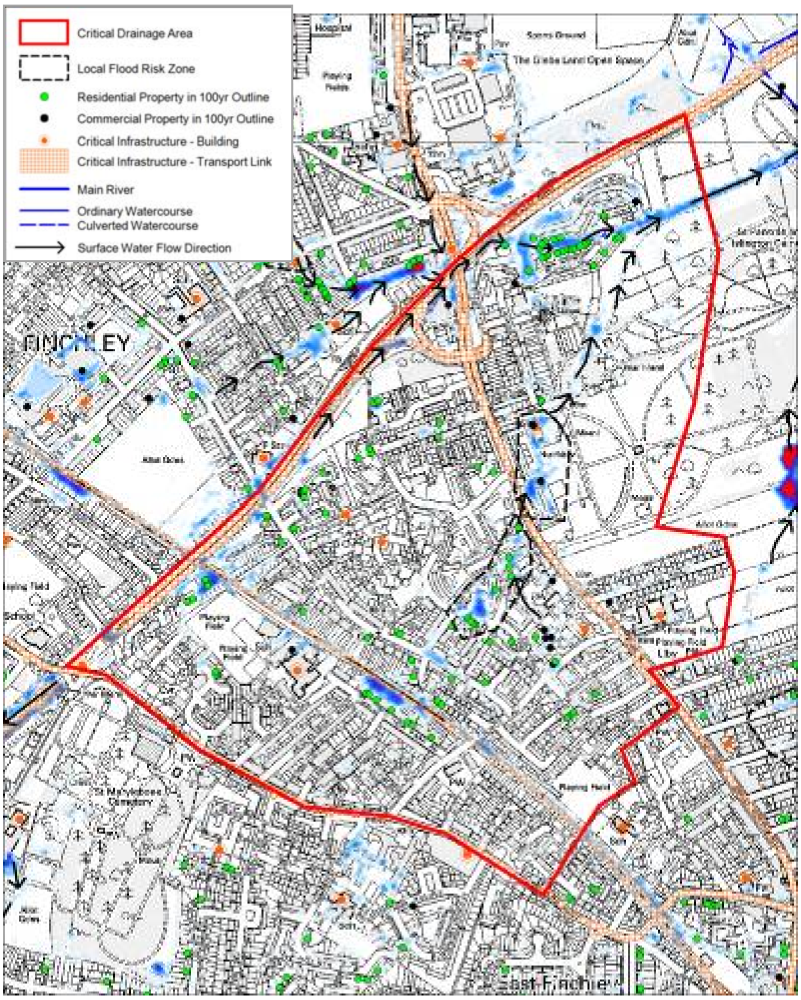


Figure E1-12 Long Lane CDA

Group2_012 covers a densely urbanised area to the east of the borough. The CDA is approximately 1.1km^2. The 1 in 100 year modelled output indicates that there are 227 non-deprived properties at risk of shallow flooding and two properties at risk of deep flooding. There are 16 commercial properties at risk of shallow flooding and two at risk of deep flooding.

There are three 'essential' infrastructure assets at risk of shallow flooding: Northern Line railway line, A1000 and A406 North Circular Road. There are three 'more vulnerable' assets at risk of shallow flooding: three schools.

The main source of flood risk in this CDA is overland flow. There are multiple overland flow paths through this CDA with a particularly clear pathway running from west to east through the centre of the CDA. Two LFRZs have been designated within this CDA, these cover areas of more extensive, deep overland flow. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.13 Creighton Avenue – Group2_013

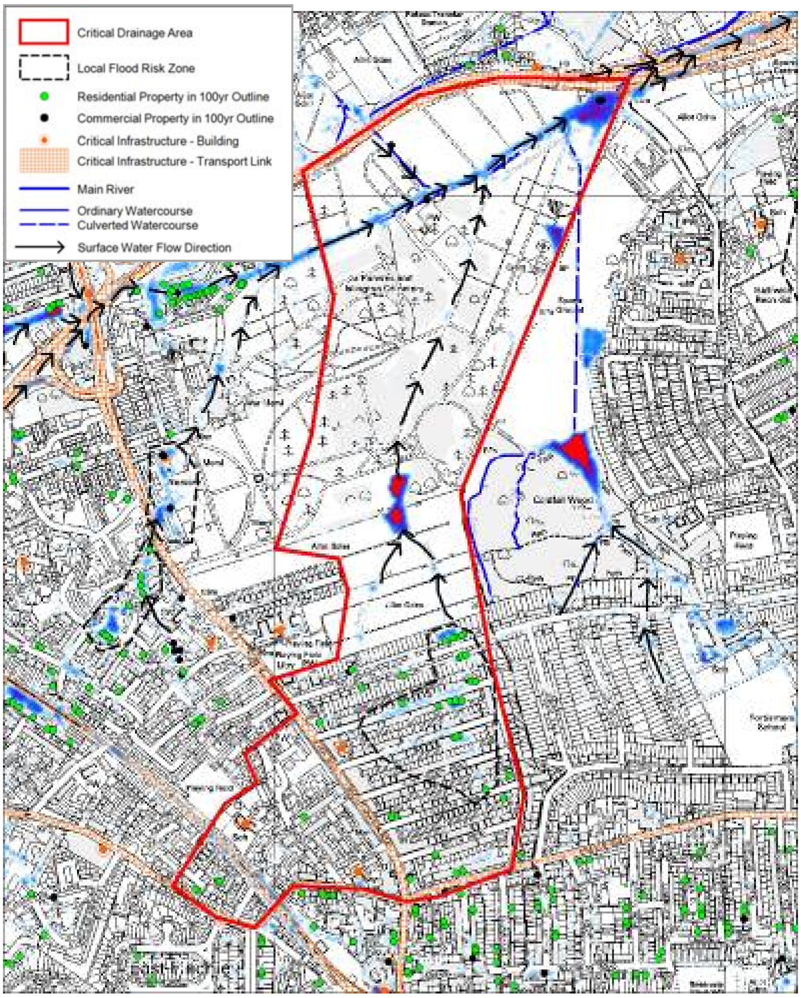


Figure E1-13 Creighton Avenue CDA

Group2_013 is a mixed use area with a dense urban area to the south and open park land to the north. The CDA is approximately 0.9km^2 and is located to the east of the borough. The 1 in 100 year modelled output indicates that there are 54 non-deprived properties at risk of shallow flooding and 7 commercial properties at risk of shallow flooding.

There are three 'essential' infrastructure assets at risk of shallow flooding: Northern Line railway line, A1000 and A406 North Circular Road. There are two 'more vulnerable' assets at risk of shallow flooding: one school and one electricity installation.

The main source of flood risk in this CDA is overland flow. There are multiple overland flow paths along the residential roads to the south of the CDA. One LFRZ has been designated within this CDA which covers a majority of the urban area to the south of the CDA. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.14 Muswell Hill – Group2_014

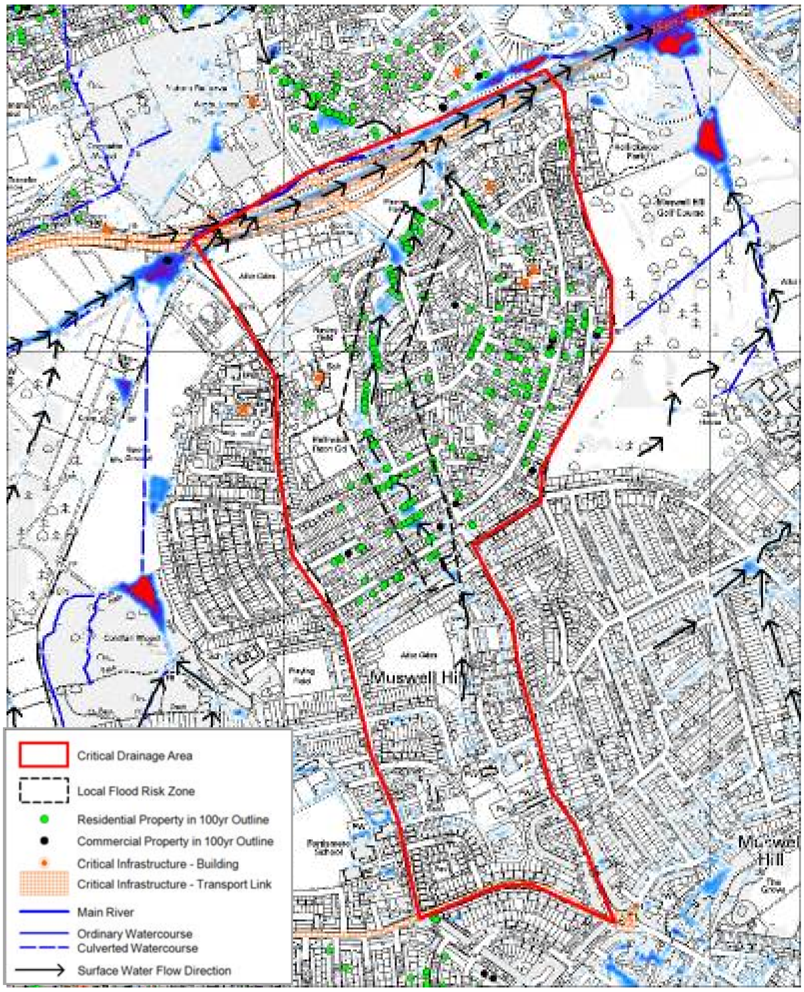


Figure E1-14 Muswell Hill CDA

Group2_014 is a densely urbanised area with an open area to the north-east of the CDA. The CDA is approximately 1.1km^2 and is located to the east of the borough. This CDA overlaps into the London Borough of Haringey. The 1 in 100 year modelled output indicates that there are 323 non-deprived properties and 18 commercial properties at risk of shallow flooding.

There is one ‘essential’ infrastructure asset at risk of shallow flooding: A406 North Circular Road. The main source of flood risk in this CDA is overland flow. There are several overland flow paths which follow topographical lows through the residential areas in this CDA. One LFRZ has been designated within this CDA which covers a majority of the urban area to the north of the CDA. The mapping within this CDA has been validated with both the EA FMfSW and a historical flood incident record.

1.7.15 Bittacy Park - Group2_015

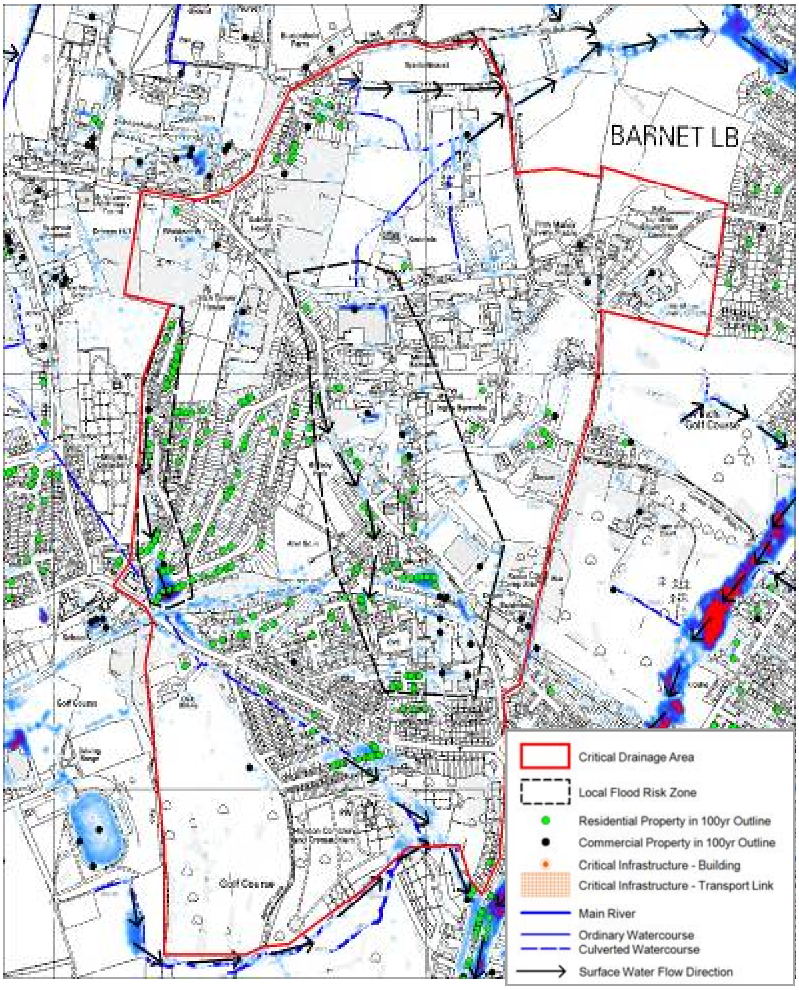


Figure E1-15 Bittacy Park CDA

Group2_015 is a mixed use area with open land to the north and south-west, dense residential property in a band through the middle of the CDA and a large military barracks to the east. The CDA is approximately 2.2km^2 and is located at the centre of the borough. The 1 in 100 year modelled output indicates that there are 226 non deprived and 47 deprived properties at risk of shallow flooding with 11 non-deprived properties at risk of deep flooding. There are 15 commercial properties at risk of shallow flooding and three at risk of deep flooding.

There are three 'essential' infrastructure assets at risk of shallow flooding: Frith Manor substation, Mill Hill East station and the Northern Line railway line. There are four 'more vulnerable' assets at risk of shallow flooding: four electricity installations. The main source of flood risk in this CDA is overland flow. There are several overland flow paths which follow topographical lows through the residential areas in this CDA. Two LFRZs have been designated within this CDA, these cover the most distinct flow paths through the CDA. The mapping within this CDA has been validated with both the EA FMfSW and a historical flood incident record.

1.7.16 Westchester Drive – Group2_016

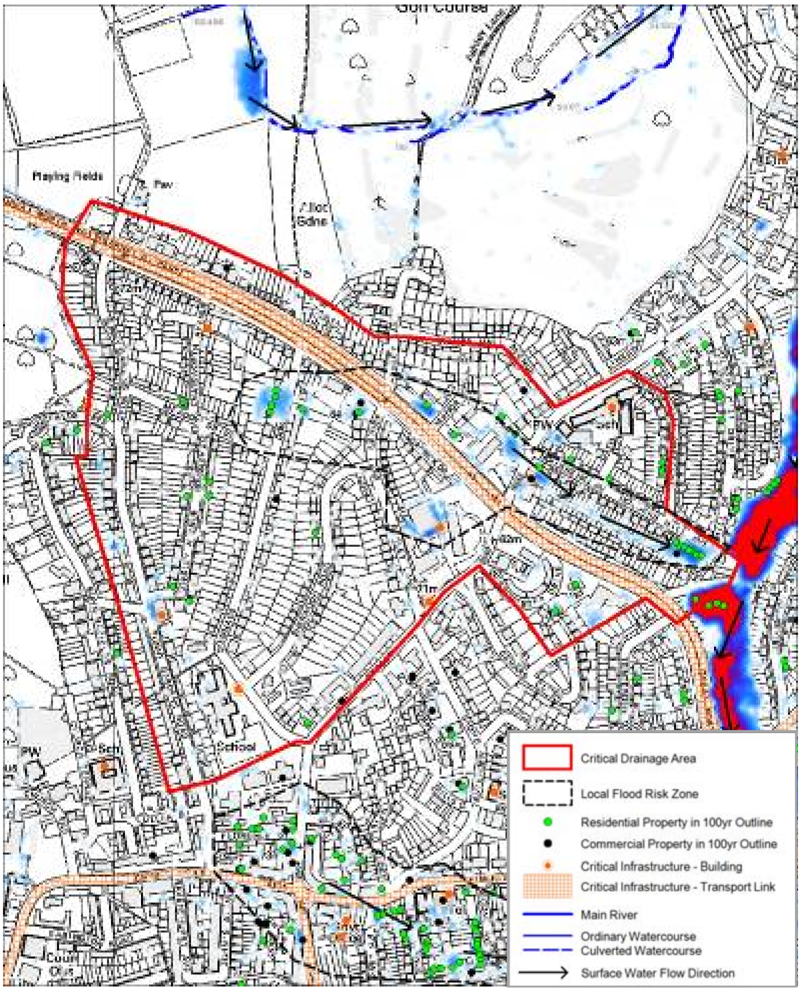


Figure E1-16 Westchester Drive CDA

Group2_016 is a densely urbanised area which has a large area of open land to the north and west of the CDA. The CDA is approximately 0.5km^2 and is located to the south of the borough. The 1 in 100 year modelled output indicates that there are 86 non-deprived properties at risk of shallow flooding. Seven properties are at risk of deep flooding all of which are classified as basement properties. There are eight commercial properties at risk of shallow flooding.

There are four 'more vulnerable' infrastructure assets at risk of shallow flooding within this CDA: Garden Hospital, one school and two electricity installations. The main source of flood risk in this CDA is overland flow. There is one main overland flow path which follows a topographical low through the residential area within this CDA.One LFRZ has been designated within this CDA, it covers the main overland flow path through the CDA. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.17 Victoria Road – Group2_017

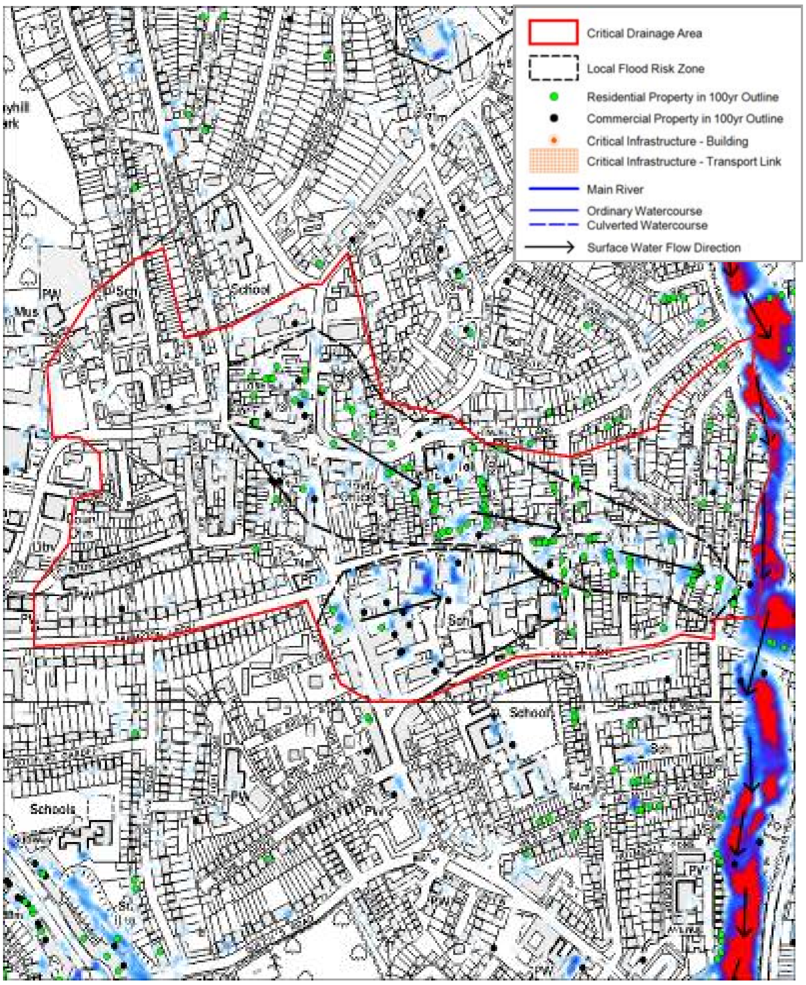


Figure E1-17 Victoria Road CDA

Group2_017 is a densely urbanised area to the south of the borough. This CDA is approximately 0.4km^2. The 1 in 100 year modelled output indicates that there are 152 non-deprived properties are at risk of shallow flooding, of these 17 are properties with basements. There are 28 commercial properties at risk of shallow flooding within this CDA.

There are two 'essential' infrastructure assets at risk of shallow flooding: A502 Brent Street and A504 Church Road. There is one 'more vulnerable' asset at risk of shallow flooding: one electricity installation. The main source of flood risk in this CDA is overland flow. There are several overland flow paths which follow topographical lows through the residential areas in this CDA. One LFRZ has been designated within this CDA that covers the main flow path through this CDA. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.18 Golders Green – Group2_018

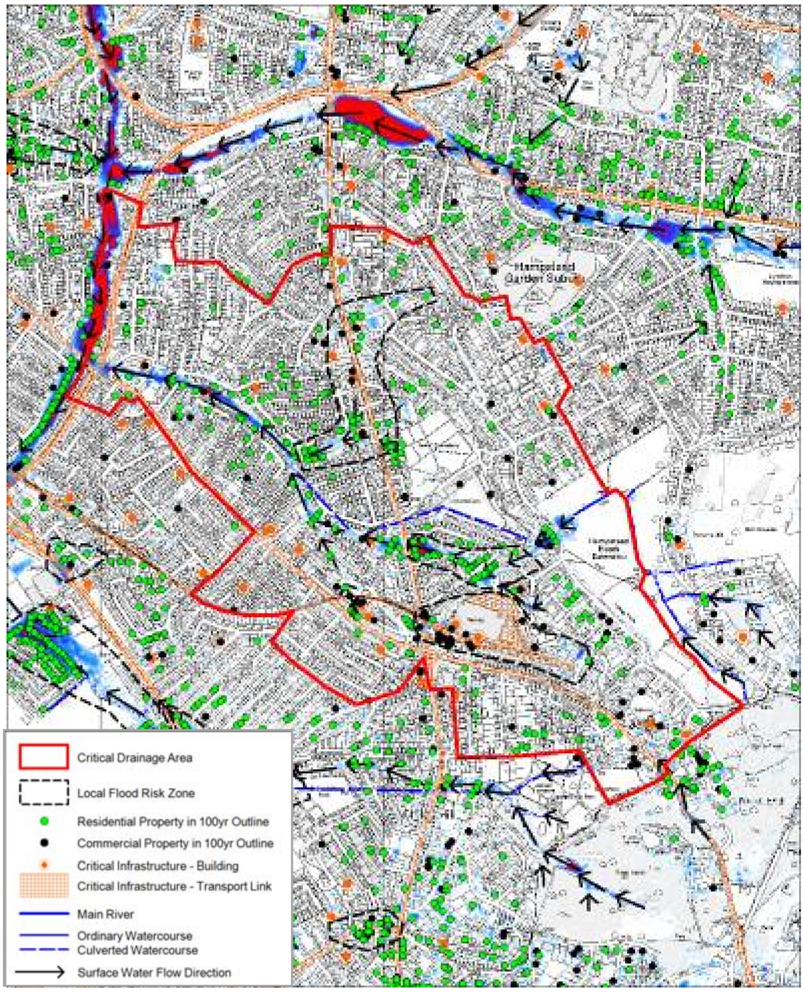


Figure E1-18 Golders Green CDA

Group2_018 is a densely urbanised area to the south of the borough. The CDA is approximately 2.5km^2. The 1 in 100 year modelled output indicates that there are 553 non-deprived properties at risk of shallow flooding, 57 of which are basement properties. Of these two properties with basements and 23 properties without basements are at risk of deep flooding. There are 112 commercial properties at risk of shallow flooding and seven at risk of deep flooding.

There are two 'essential' infrastructure assets at risk of shallow flooding: Northern Line railway line and the A406 North Circular Road (at junction with Golders Green Road). There is one 'highly vulnerable' asset at risk of shallow flooding: Finchley Road police station. There are 14 'more vulnerable' assets at risk of shallow flooding: one school and 13 electricity installations.

The main source of flood risk in this CDA is overland flow between the open channel Sections of the Decoy Brook. There are several overland flow paths which follow topographical lows through the residential areas in this CDA.Two LFRZs have been designated within this CDA; these cover the areas at most significant risk from surface water flooding. The mapping within this CDA has been validated with both the EA FMfSW and historical flood incident records.

1.7.19 Hendon Way – Group2_019

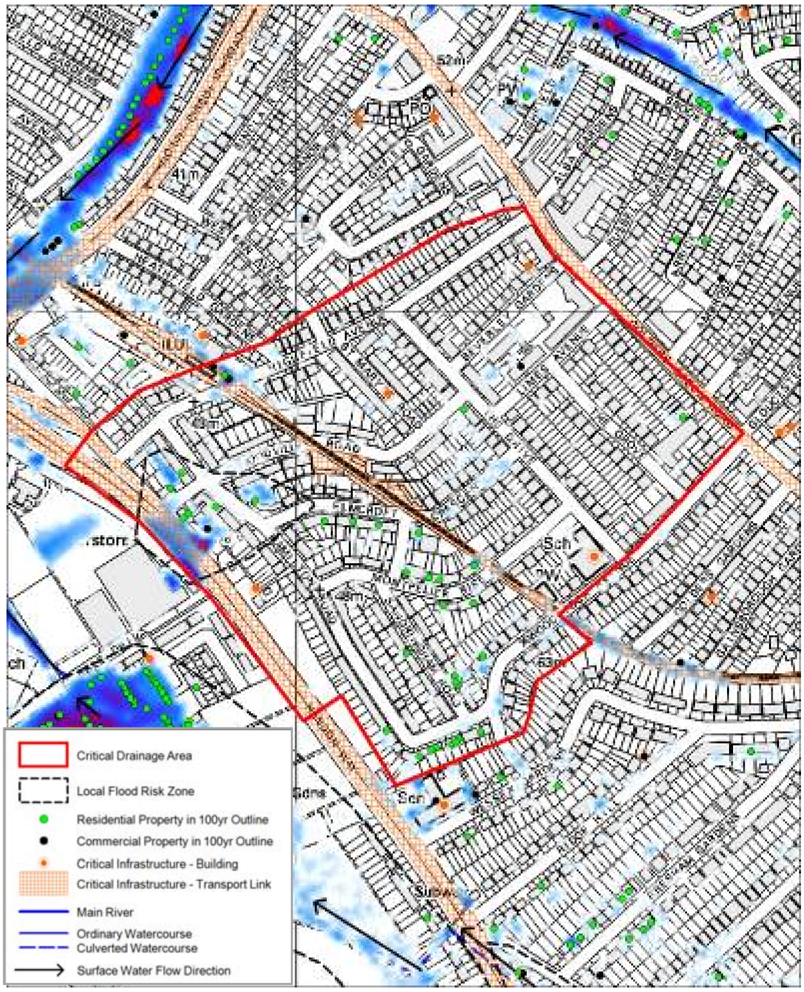


Figure E1-19 Hendon Way CDA

Group2_019 is a densely urbanised are to the south of the borough. The CDA is approximately 0.3km^2. The 1 in 100 year modelled output indicates that there are 38 non-deprived properties at risk of shallow flooding, one of which has a basement. There are four commercial properties at risk of shallow surface water flooding.

There are two 'essential' infrastructure assets at risk of flooding: the Northern Line railway line is at risk of shallow flooding and the A41 Hendon Way is at risk of deeper flooding. There is one 'more vulnerable' asset at risk of shallow flooding: one school.

The main source of flood risk in this CDA is overland flow and ponding in topographical low spots. One LFRZ has been designated within this CDA; this covers the area at most significant risk from surface water flooding. The mapping within this CDA has been validated with both the EA FMfSW and historical flood incident records.

1.7.20 Childs Hill – Group2_020

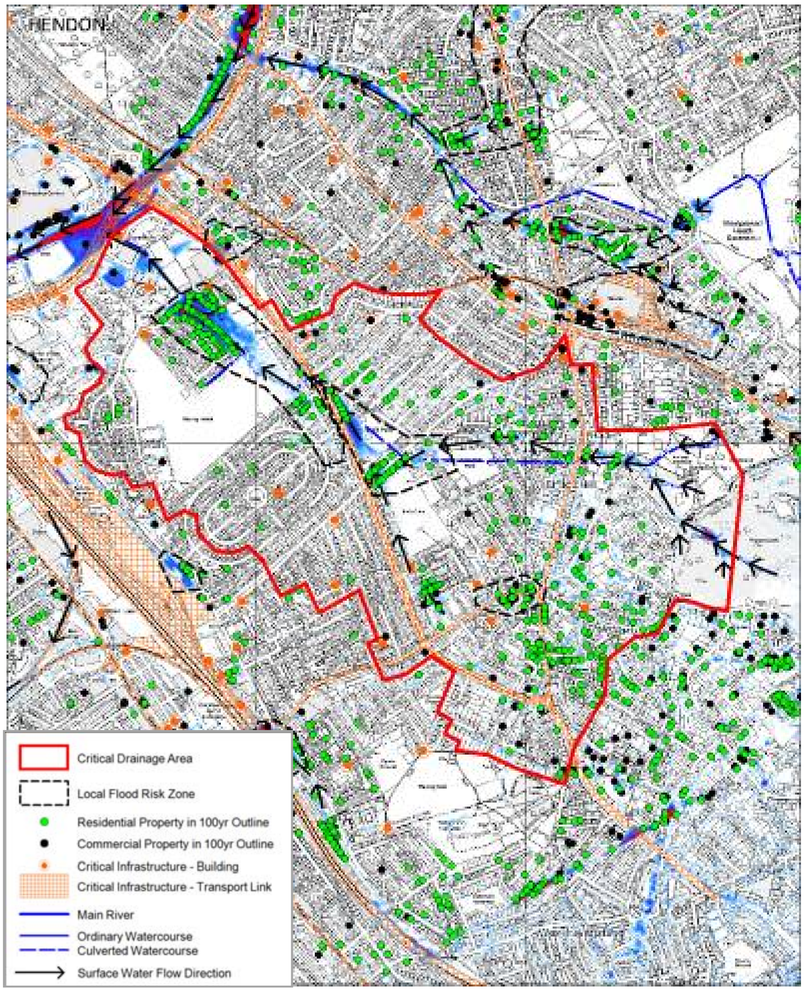


Figure E1-20 Childs Hill CDA

Group2_020 covers a densely urbanised area with open parkland to the south east and north west of the CDA. The CDA is approximately 2.6km^2 to the south of the borough. The 1 in 100 year modelled output indicates that there are 726 non-deprived and 76 deprived properties at risk of shallow flooding. 77 of the non-deprived properties are classified as basement properties. There are 26 non-deprived and 53 deprived properties at risk of deep flooding. There are 77 commercial properties at risk of shallow flooding and four at risk of deep flooding.

There are four 'essential' infrastructure assets at risk of shallow flooding: the A406 North Circular Road, A41 Hendon Way, A598 and A407. There are nine 'more vulnerable' assets at risk of shallow flooding: three schools and six electricity installations.

The main source of flood risk in this CDA is overland flow between the open channel Sections of the Clitterhouse Stream. There are several overland flow paths which follow topographical lows through the residential areas in this CDA. There are also several areas of ponded flow upstream of culverted Sections of the Stream and at constriction points through structures. Three LFRZs have been designated within this CDA; these cover the areas at most significant risk from surface water flooding. The mapping within this CDA has been validated with both the EA FMfSW and historical flood incident records.

1.7.21 Claremont Way Industrial Estate – Group2_021

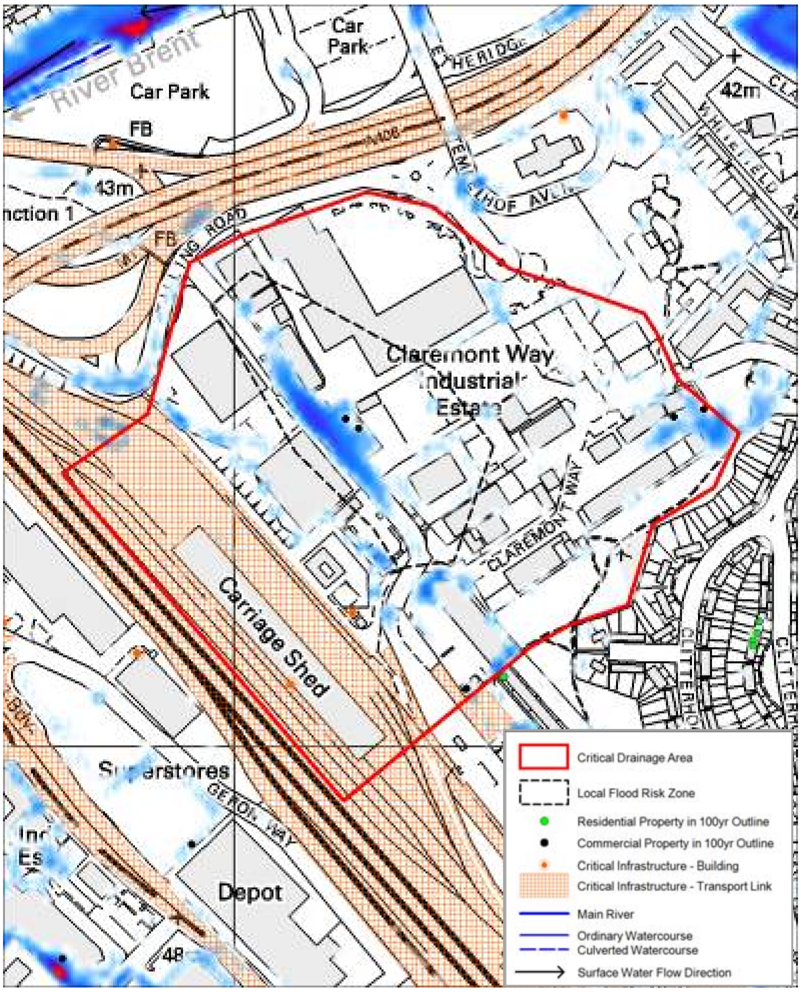


Figure E1-21 Claremont Way Industrial Estate CDA

Group2_021 covers an industrial area to the south of the Borough. The CDA is approximately 0.18km^2. The 1 in 100 year modelled output indicates that there are five commercial properties at risk of shallow flooding in this CDA. There are two 'more vulnerable' assets at risk of flooding: waste transfer stations. There are no residential properties located within this CDA.

The main source of flood risk in this CDA is ponding of surface water flow in topographic low spots. One LFRZ has been designated within this CDA; it covers the area at most significant risk from surface water flooding. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.22 Brent Terrace – Group2_022

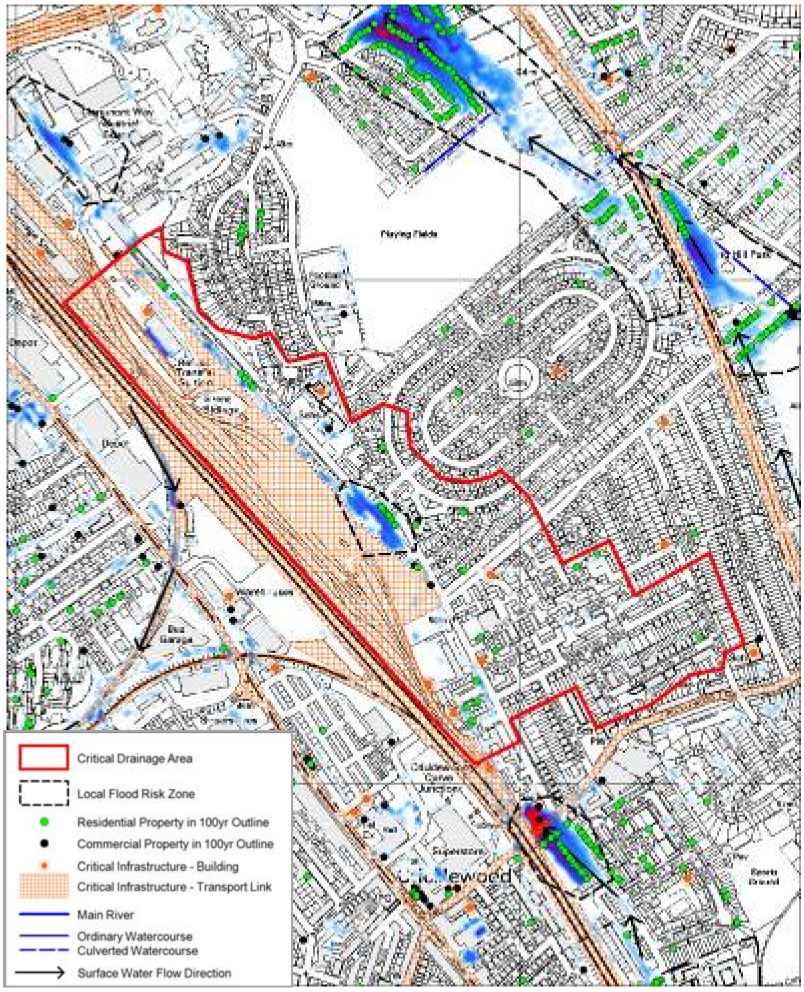


Figure E1-22 Brent Terrace CDA

Group2_022 is a mixed use area to the south of the borough. The CDA is approximately 0.5km^2. The 1 in 100 year modelled output indicates that there are 20 non-deprived and 36 deprived properties at risk of shallow flooding. There are 4 commercial properties at risk of shallow flooding.

There is one ‘essential’ infrastructure asset at risk of shallow flooding: Cricklewood railway station. There is also on ‘more vulnerable’ asset at risk of shallow flooding: an electricity installation.

The main source of flood risk in this CDA is from ponding surface water in topographic low spots. One LFRZ has been designated within this CDA; this covers the area at most significant risk from surface water flooding. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.23 Lichfield Road – Group2_023

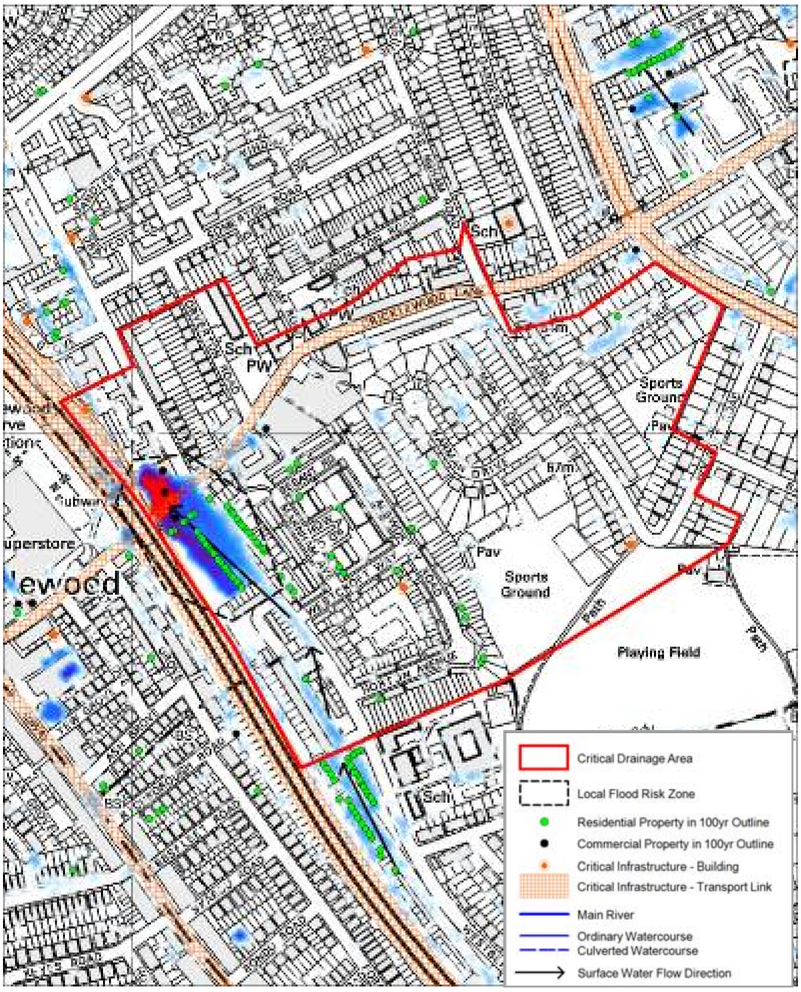


Figure E1-23 Lichfield Road CDA

Group2_023 covers a mixed use area to the south of the borough. The CDA is approximately 0.3km^2. The 1 in 100 year modelled output indicates that there are 113 deprived properties at risk of shallow flooding and 58 deprived properties at risk of deep flooding. There are four commercial properties at risk of shallow flooding and two at risk of deep flooding.

There is one 'essential' infrastructure asset at risk of deep flooding in this CDA: A407 Cricklewood Lane. There is on 'more vulnerable' asset at risk of deep flooding: an electricity installation.

The main source of flooding in this CDA is ponding flow in a topographic low spot adjacent to the railway line. One LFRZ has been designated within this CDA to correspond with the location of the ponding flow in Cricklewood. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.24 Edgware Station – Group2_024

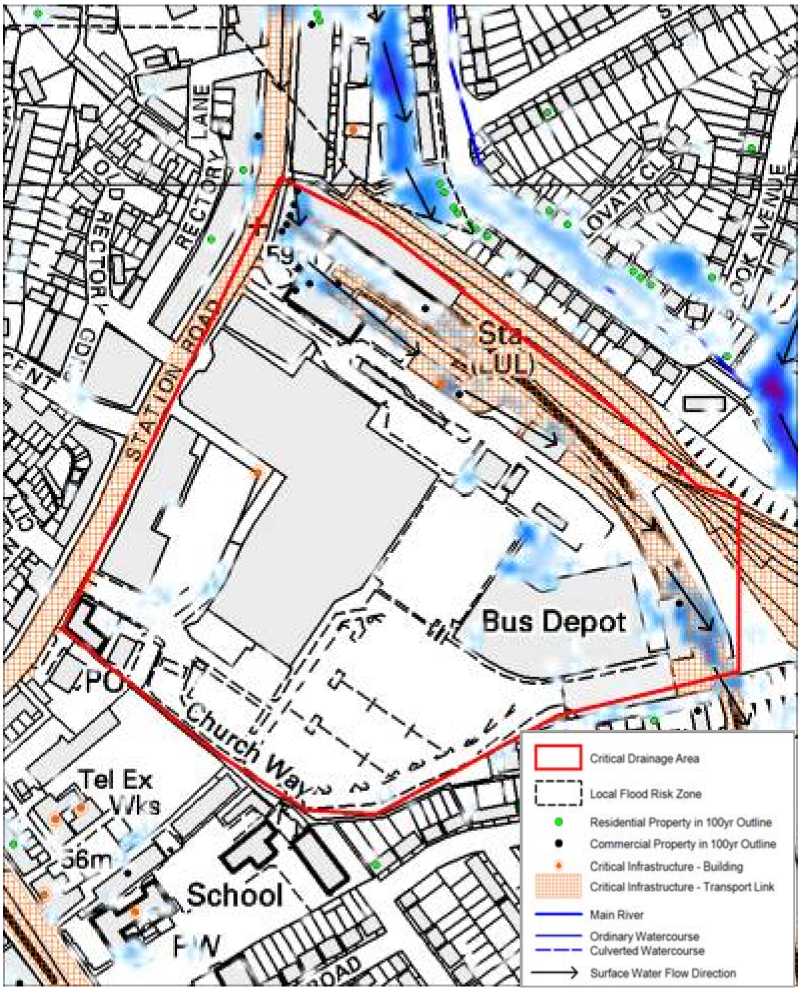


Figure E1-24 Edgware Station CDA

Group2_024 covers Edgware station and the bus depot to the north west of the borough. This CDA is approximately 0.1km^2. The 1 in 100 year modelled output indicates that there are 12 commercial properties at risk of shallow flooding in this CDA.

There are two 'essential' infrastructure assets at risk of shallow flooding: Edgware railway station and the Northern Line railway line. The main source of flooding in this CDA is ponding surface water flow in and around Edgware station in a topographic low. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.25 Mill Hill – Group2_025

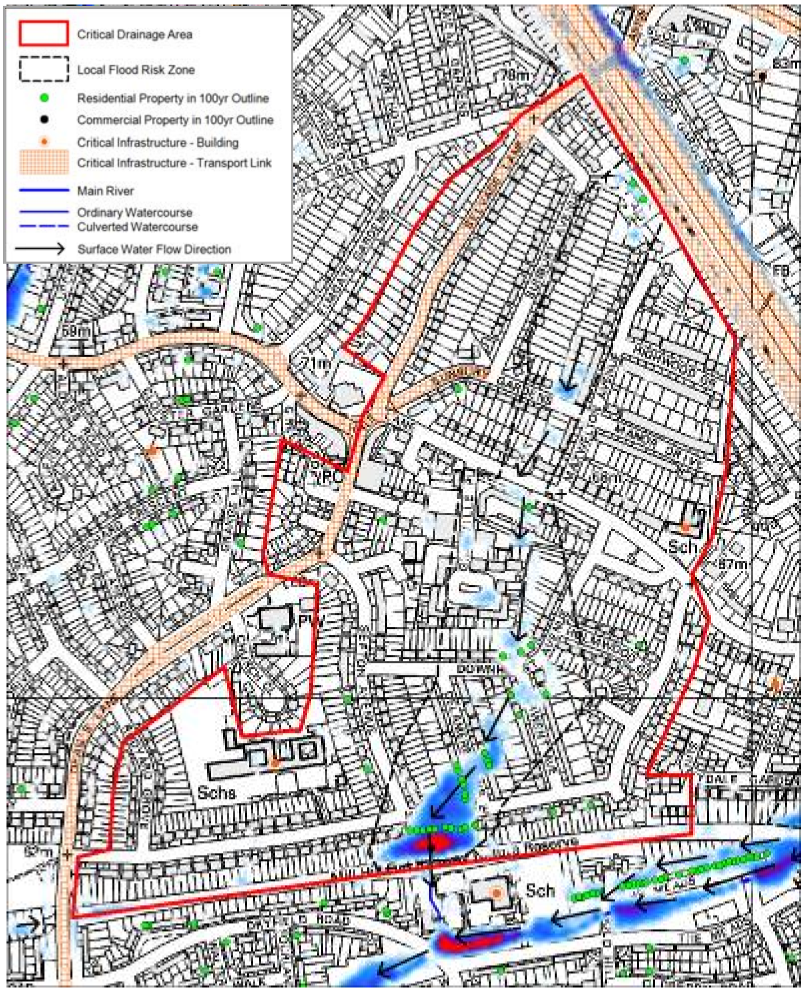


Figure E1-25 Mill Hill CDA

Group2_025 covers the densely urbanised Mill Hill area to the north east of the borough. The CDA is approximately $0.4km^2$. The 1 in 100 year modelled output indicates that there are 49 non-deprived properties at risk of shallow flooding and six at risk of deep flooding. There is one commercial property at risk of deep flooding within this CDA.

There are no critical infrastructure sites at risk of flooding within this CDA.

The main source of flooding in this CDA is overland flow from north to south through the residential area of Mill Hill. To the south of the CDA there is an area of deep ponding to the north of Mill Hill Old Railway Nature Reserve. One LFRZ has been designated within this CDA which highlights the main overland flow path and area of ponding to the south of the CDA.This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.26 Mill Hill Circus – Group2_026

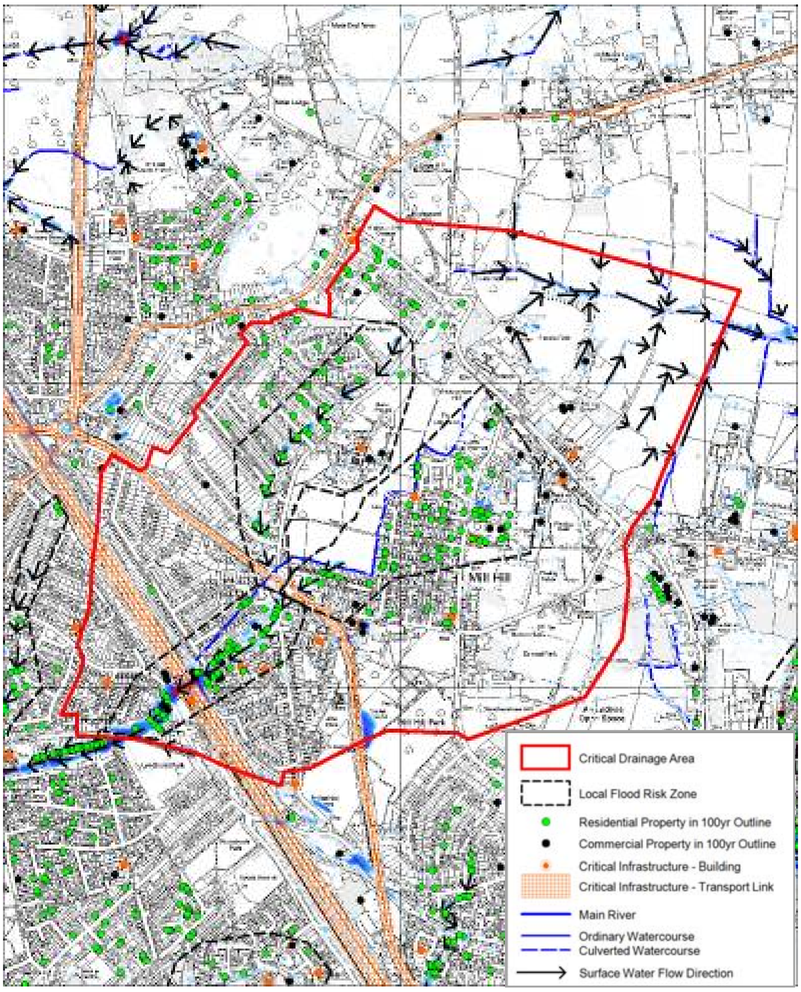


Figure E1-26 Mill Hill Circus CDA

Group2_026 covers a mixed use area with dense residential areas to the south and west and open fields to the north and east. This CDA is approximately 2.7km^2 to the north east of the borough. The 1 in 100 year modelled output indicates that there are 240 non-deprived properties at risk of shallow flooding and five at risk of deep flooding. There are 159 commercial properties at risk of shallow flooding and three commercial properties at risk of deep flooding.

There is one 'essential' infrastructure asset at risk of shallow flooding within the CDA: A1. There are four 'more vulnerable' assets at risk of shallow flooding: three schools and one electricity installation.

The main source of flood risk in this CDA is overland flow between culverted Sections of the drainage network in the Mill Hill Circus area. The flow is following the old open watercourse valley parallel to Lawrence Street and along the Broadway to the south of Mill Hill Circus. Three LFRZs have been designated within this CDA, they follow the overland flow paths on either side to the Mill Hill Circus roundabout and highlight the areas at most significant risk of surface water flooding. The mapping within this CDA has been validated with both the EA FMfSW and historical flood incident records.

1.7.27 Blondell Road – Group2_027

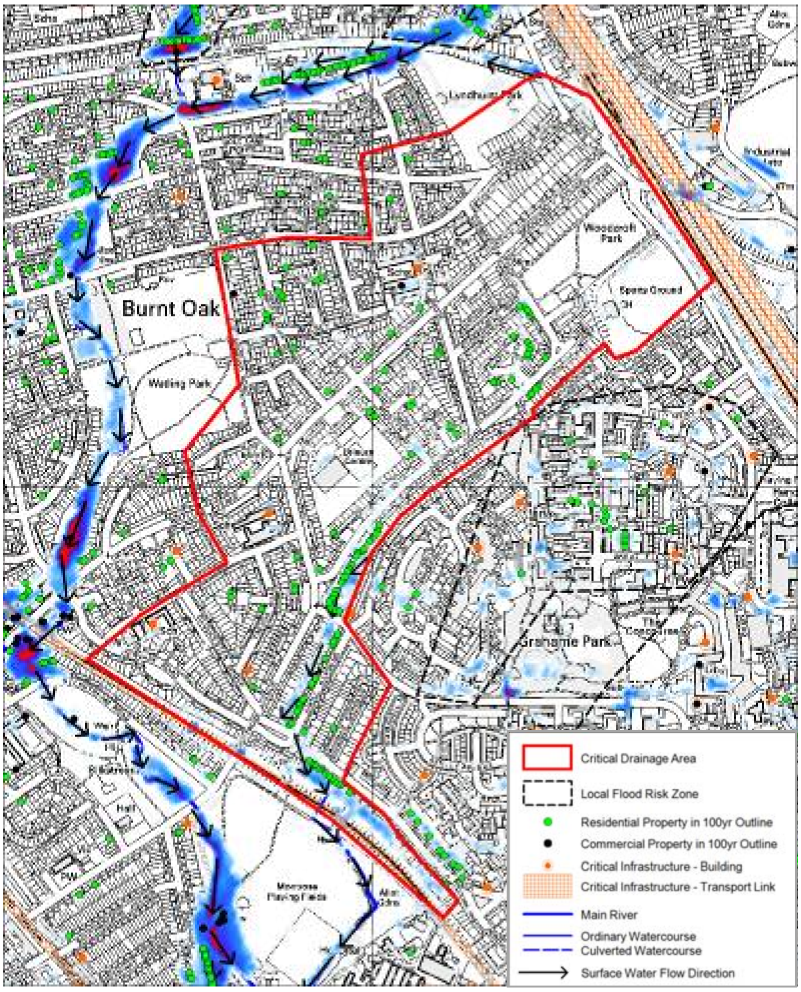


Figure E1-27 Blondell Road CDA

Group2_027 covers a densely urbanised area with several small recreation areas to the north east and centre of the CDA. The CDA is approximately 0.7km2 and is located to the west of the borough. The 1 in 100 year modelled output indicates that there are 98 non-deprived properties and 34 deprived properties at risk of shallow flooding. There are two commercial properties at risk of shallow flooding within the CDA.

There are three 'more vulnerable' infrastructure assets at risk of shallow flooding within this CDA: three schools. The main source of flood risk is from overland flow between culverted Sections of watercourse. The flow is following the old open watercourse valley from Woodcroft Park through the residential area (north east to south west) to Gervase Road at the south of the CDA where the drainage network comes out of culvert. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.28 Grahame Park – Group2_028

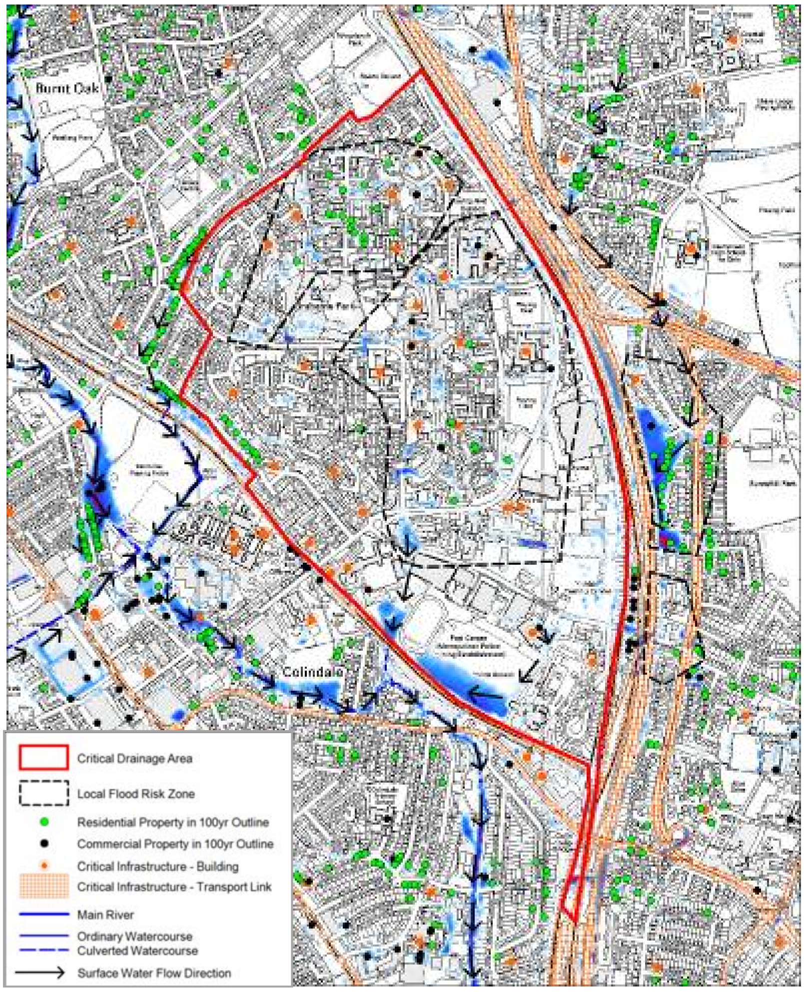


Figure E1-28 Grahame Park CDA

Group2_028 covers a densely populated mixed use area of Colindale to the east of the borough. This CDA is approximately 1.6km2. The 1 in 100 year modelled output indicates that there are 43 non-deprived and 51 deprived properties at risk of shallow surface water flooding. There are 13 commercial properties at risk of shallow flooding within this CDA.

There are seven ‘more vulnerable’ infrastructure assets at risk within this CDA: one school and six electricity installations.

The main source of flood risk in this area is from a combination of overland flow and ponded flooding. Two LFRZs have been designated within this CDA which cover the areas with the largest number of properties at risk of surface water flooding. A large proportion of this CDA falls within several designated regeneration areas as part of the London Plan. As a result of the Colindale SWMP (June 2009) report findings a majority of this area is currently being re-developed with surface water flood risk being taken into account in the re-development process. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.29 Oak Hill Park – Group2_029

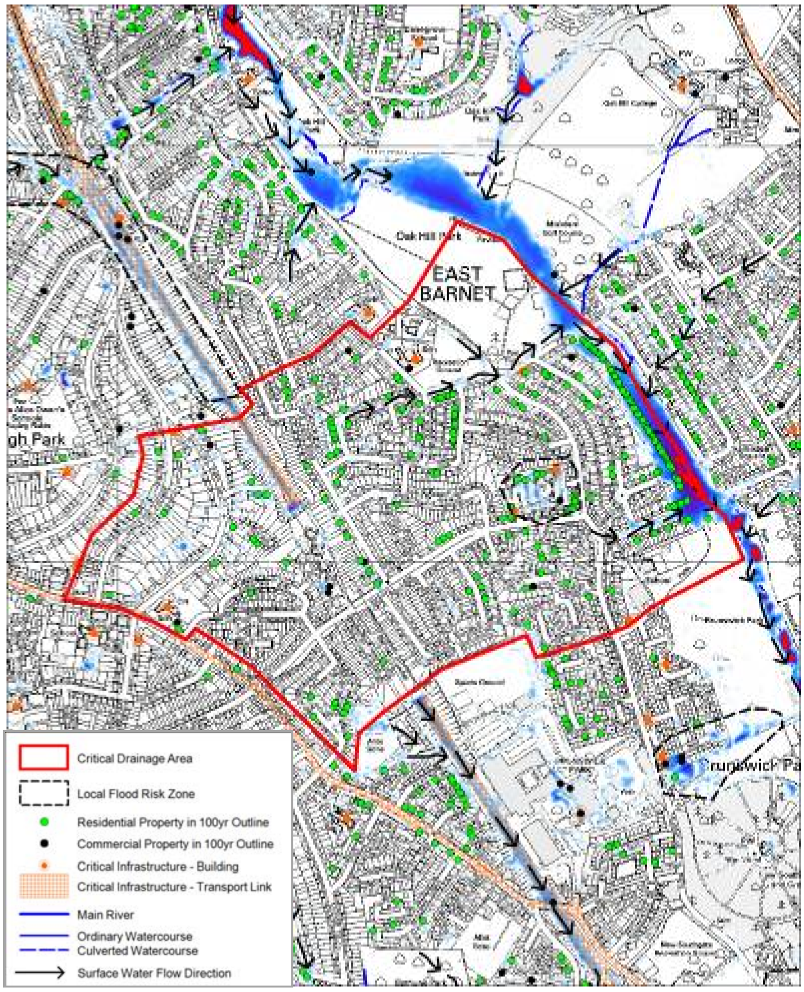


Figure E1-29 Oak Hill Park CDA

Group2_029 covers a densely urbanised area to the east of the borough. This CDA is approximately 1.1km2. The 1 in 100 year modelled output indicates that there are 283 non-deprived and 3 deprived properties are at risk of shallow flooding. There are 11 commercial properties are at risk of shallow flooding.

There is one ‘essential’ infrastructure asset at risk of shallow flooding within this CDA: Main Line railway. There are five ‘more vulnerable’ assets at risk of shallow flooding: one school and four electricity installations.

The main source of flood risk within this CDA is from ponding flow in topographic depressions. There is also an overland flow path the east of the CDA down to the Pymmes Brook. One LFRZ has been designated around the properties at Fitzwilliam close as there is a significant cluster of residential properties at risk in this area. The mapping within this CDA has been validated with both the EA FMfSW and a historical flood incident record.

1.7.30 Brunswick Park – Group2_030

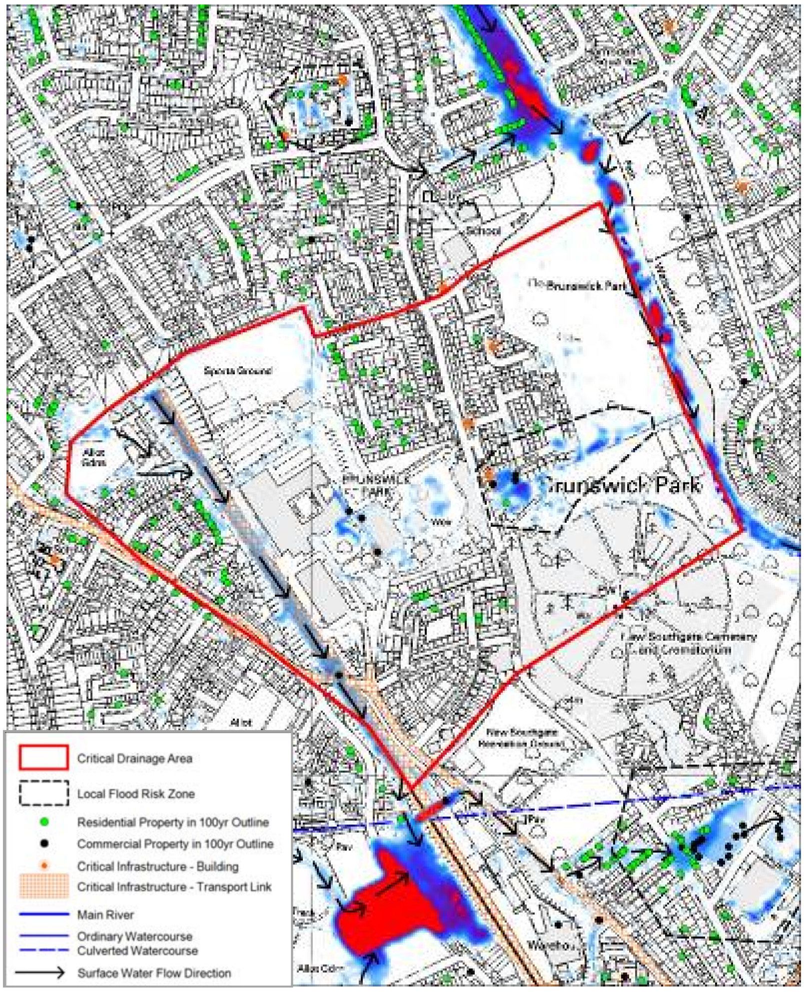


Figure E1-30 Brunswick Park CDA

Group2_030 covers a mixed use area, with property to the north, south and west of the CDA and Brunswick Park to the east and north west. This CDA is approximately 0.65km2 to the east of the borough. The 1 in 100 year modelled output indicates that there are 111 non-deprived properties at risk of shallow flooding in this CDA. There are seven commercial properties at risk of shallow flooding and one at risk of deep flooding.

There is one 'essential' infrastructure asset at risk of shallow flooding within this CDA: Main line railway. There are four 'more vulnerable' assets at risk of shallow flooding: four electricity installations. The main source of flood risk within this CDA is ponding of flow along the railway line and on Benfleet Way. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.31 Broadfields Ditch – Group2_031

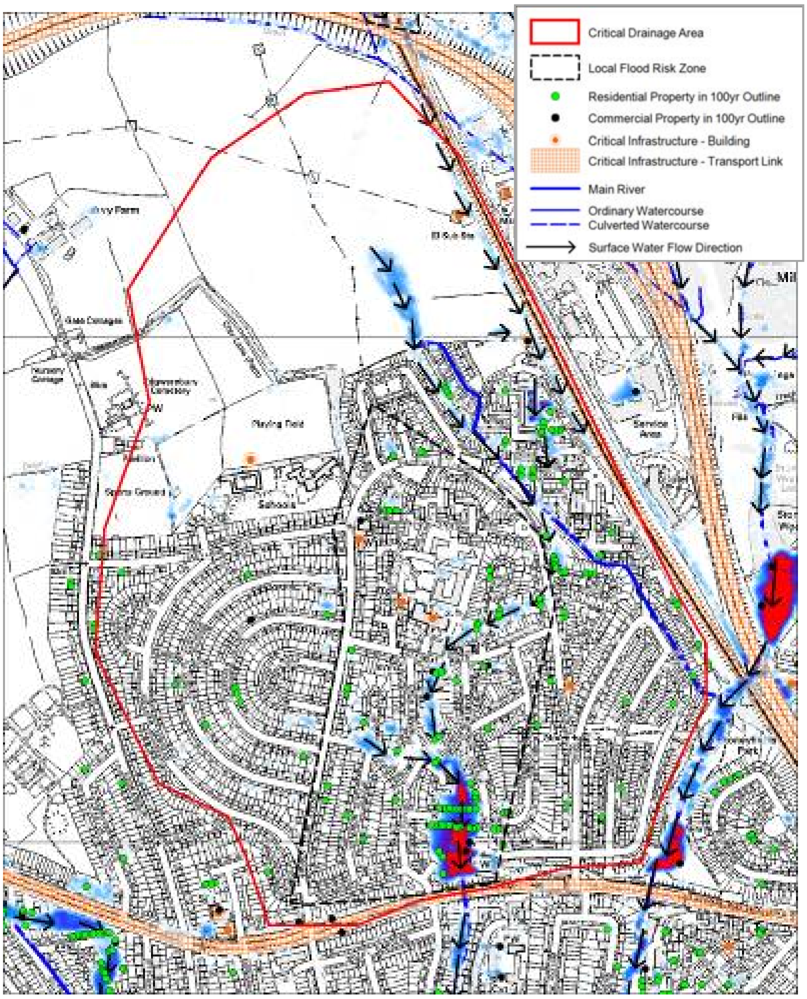


Figure E1-31 Broadfields Ditch CDA

Group2_031 covers a densely urbanised area to the north of the borough. This CDA is approximately 0.64km2. The 1 in 100 year modelled output indicates that there are 182 non-deprived properties at risk of shallow flooding and 26 at risk of deep flooding. There are 11 commercial properties at risk of shallow flooding and two at risk of deep flooding.

There is one 'essential' infrastructure asset at risk of shallow flooding within this CDA: one electricity sub-station. There are two 'more vulnerable' assets at risk of shallow flooding: a school and an electricity installation.

The main source of flooding in this CDA is overland flow between culverted stretches of the Broadfields Ditch. The flow is following the old open watercourse valley through the urbanised areas. One LFRZ has been designated within this CDA to cover the areas at most significant risk of overland flow. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.32 Sunnyhill Park – Group2_032

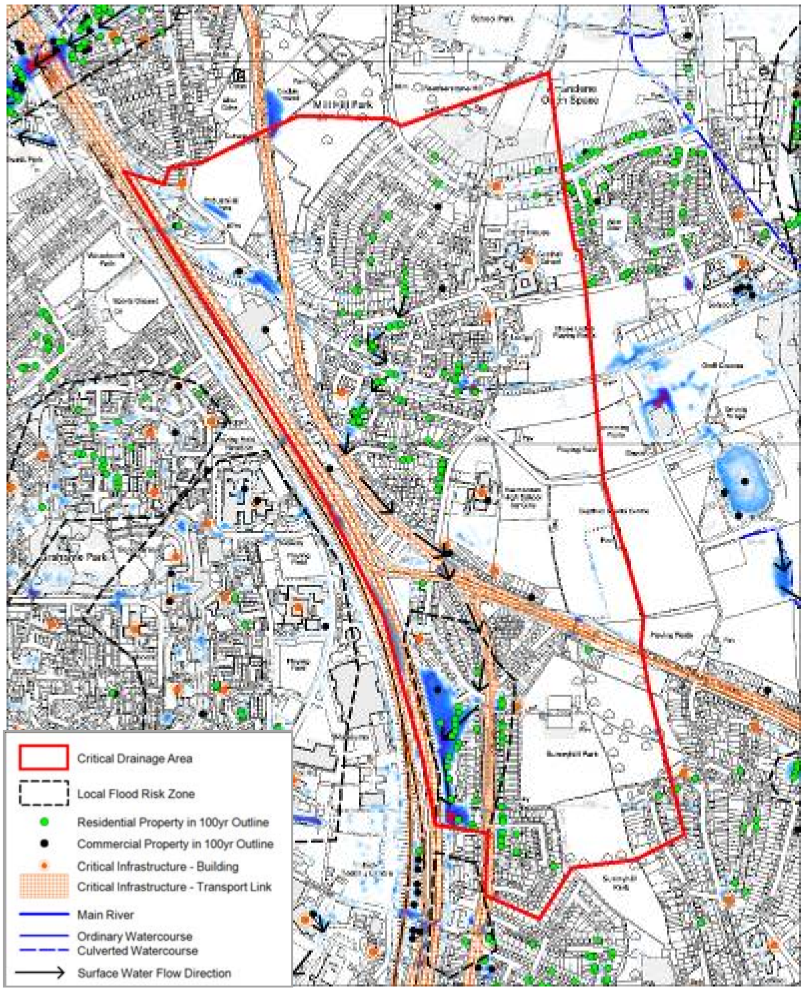


Figure E1-32 Sunnyhill Park CDA

Group2_032 covers a mixed use area to the west of the borough. The CDA is approximately 1.6km2. The 1 in 100 year modelled output indicates that there are 212 non-deprived properties at risk of shallow flooding. There are 11 commercial properties at risk of shallow flooding.

There is one ‘essential’ infrastructure asset at risk of shallow flooding: A41 Watford Way and the A1. There are two ‘more vulnerable’ assets at risk of shallow flooding: two schools.

The main source of flood risk in this area is overland flow and ponding in topographic low spots adjacent to raised embankments. One LFRZ has been designated within this CDA, this covers the area of significant ponding to the south west of the CDA. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

1.7.33 Church End Farm – Group2_033

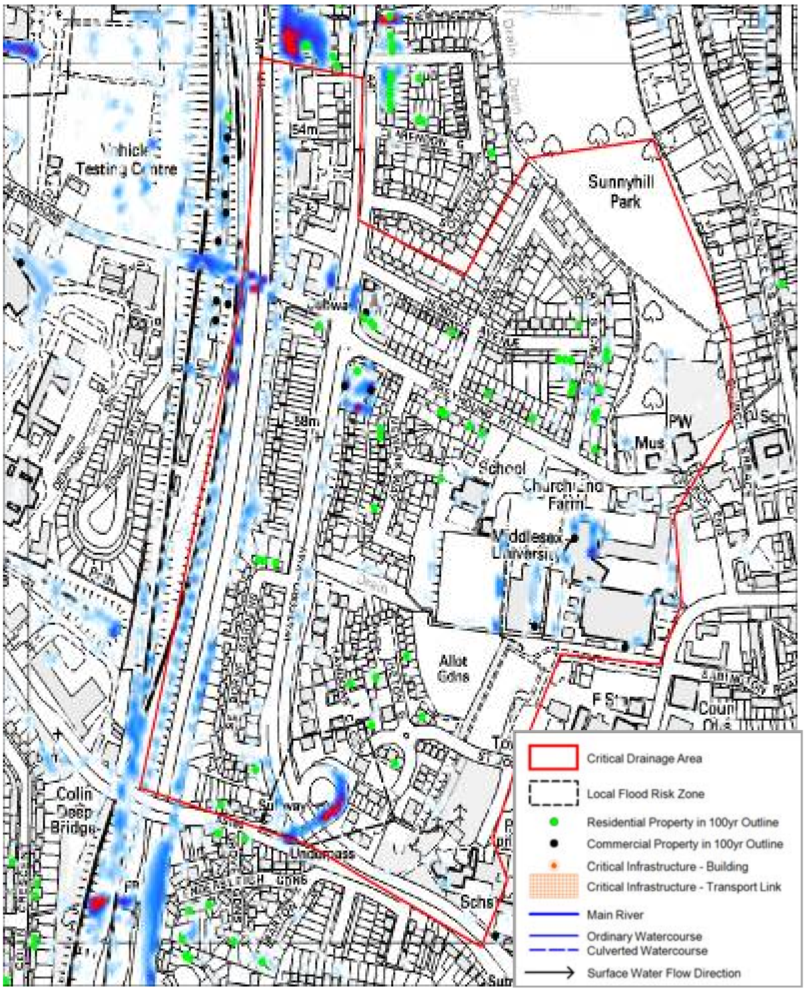


Figure E1-33 Church End Farm CDA

Group2_033 covers a densely urbanised area to the west of the borough. The CDA is approximately 0.48km2. The 1 in 100 year modelled output indicates that there are 134 non-deprived properties at risk of shallow flooding, two of which have been classified as basement properties. There are six commercial properties which are at risk of shallow flooding.

There is one 'essential' infrastructure asset at risk of shallow flooding: A41 Watford Way. There are two 'more vulnerable' assets at risk of shallow flooding: two schools. The main source of flood risk in this area is ponding flow in topographic low spots. This CDA was validated against the EA FMfSW, no historic surface water flooding incidents have been recorded in this area.

APPENDIX E2 – Summary of Measures

Source

Green Roofs

Green roofs are designed to intercept rainfall and slow down its entry into the ground level drainage system. Vegetation such as grass and small shrubs are added to residential, commercial or shed roofs (Figure E2-1). The green roof systems can improve the quality of the runoff before it enters the drainage system.

Figure E2-1 Example of a residential green roof (Ecotips, 2010[i])

The advantages and disadvantages of green roofs are shown below.

	Advantage/Disadvantage
Advantage	Green roofs are effective at managing and reducing rainfall runoff from property.
	Low maintenance once installed as hardy vegetation is used.
	Management of potential flooding at the source, 'upstream' of any high risk areas.
	Water treatment by pollutant removal.
	Does not require extra land space on new development, good for constrained areas.
	Reduces net annual volume required by the storm sewer system.
Disadvantage	Construction on existing properties is disruptive.
	Storage Capacity within green roof can be full prior to commencement of storm
	High associated construction cost on existing properties.
	Challenging to encourage existing homeowners to consider this option.

Table E2-1 Advantages/Disadvantages of Green Roofs

Soakaways

Soakaways are designed to provide an alternative infiltration route for storm water to prevent overburdening the sewerage system. There are several different soakaway options; Figure E2-2 below illustrates a small scale soakaway system within a residential development.

Figure E2-2 Example of a soakaway within a residential development (BCProfiles, 2011[ii])

The advantages and disadvantages of soakaways are shown below.

	Advantage/Disadvantage
Advantage	Management of potential flooding at the source, 'upstream' of any high risk areas.
Advantage	Reduces likelihood of property flooding as alternative storm water infiltration route.
Advantage	Reduces net volume required by the storm sewer system.
Disadvantage	Installation is disruptive in existing residential areas.
Disadvantage	Not useable in areas underlain by thick clay.
Disadvantage	High associated construction cost.
Disadvantage	Can only be constructed on highways with low traffic volumes where speed restrictions not exceeding 30mph are present.

Table E2-2 Advantages/Disadvantages of Soakaways

Water Butts and Rainwater Harvesting

Water butts are designed to be a low maintenance, easy to install rain water collection receptacle. A large barrel is connected up to a residential property down pipe to collect water for use in the resident's garden (Figure E2-3).

Figure E2-3 Example of a water butt (Water Features Online, 2011[iii])

	Advantage/Disadvantage
Advantage	Management of potential flooding at the source, 'upstream' of any high risk areas.
	Easy to implement on a property level.
	Minimal maintenance required to the water butt once it is in place.
	Reduces net volume required by the storm sewer system.
Disadvantage	May require incentives to encourage residents to install a water butt
	Cannot be guaranteed storage as may be full at the time of a storm.
	In densely urbanised areas may not be applicable if properties do not have gardens as they may not have a use for the water collected.

Table E2-3 Advantages/Disadvantages of Water Butts

Rainwater harvesting is a more comprehensive system that is designed to allow for the re-use of 'grey' water within a property for non-potable purposes (Figure E2-4).

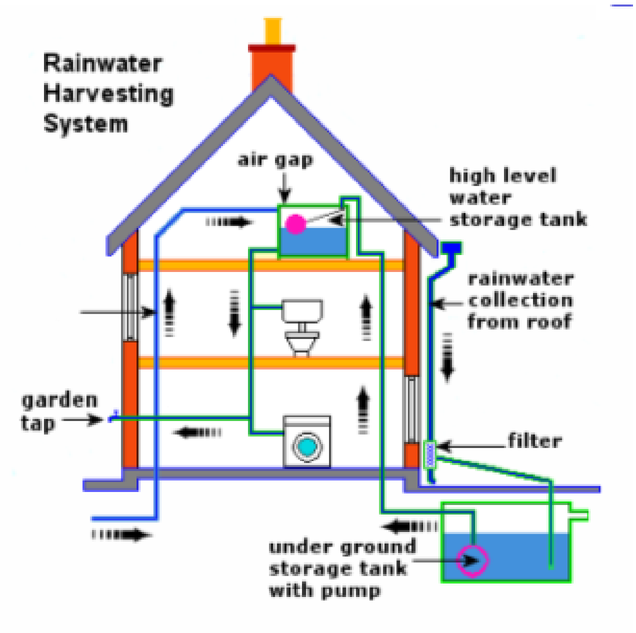


Figure E2-4 Example of a rainwater harvesting system (lowenergyhouse.com, 2011[iv])

	Advantage/Disadvantage
Advantage	Management of potential flooding at the source, 'upstream' of any high risk areas.
	Reduces mains water usage at a property level.
	Reduces net volume required by the storm sewer system.
Disadvantage	Expensive to install this system into an existing residential property.
	Disruptive to install this system into an existing property.
	Maintenance costs would be high.

Table E2-4 Advantages/Disadvantages of Rainwater Harvesting

Permeable Paving

Permeable paving systems are designed to allow water to infiltrate to the underlying granular sub-grade material and eventually provide local groundwater recharge (Figure E2-5). They provide significant benefits in relation to rainfall interception as well an option for removal of surface water volume.

Figure E2-5 Example of permeable paving

The advantages and disadvantages of permeable paving, in combination with filter drains, are shown below.

	Advantage/Disadvantage
Advantage	Permeable paving surfaces have been demonstrated as effective in managing and reducing runoff from paved surfaces.
	Management of potential flooding at the source, 'upstream' of any high risk areas.
	Sustainable alternative to creating a larger capacity sewer network.
	Encourage natural groundwater recharge.
	Water treatment by pollutant removal.
	Allows multi-functional use of space.
	Reduces net volume required by the storm sewer system.
Disadvantage	Construction within the road will lead to temporary road closures.
	High associated construction cost
	Can only be constructed on highways with low traffic volumes where speed restrictions not exceeding 30mph are present.
	Annual inspection of permeable pavement will be required.

Table E2-5 Advantages/Disadvantages of Permeable Paving

Roadside Rain Garden

The purpose of the road side rain gardens system is to create a chain of surface water storage areas each connected with a filter/French drain. Surface water is temporarily stored in the soil and granular layer at the base of the structure before being gradually released into the groundwater through infiltration into the ground. Intentionally situated in roadside verges, this will provide areas of storm water infiltration and planting in the smallest area. Roadside rain gardens typically contain hydrophilic flowers, grasses, shrubs and trees.

Figure E2-6 Typical example of a roadside rain garden in Seattle USA[v]

The advantages and disadvantages of using road side rain gardens are shown in the table below.

	Advantage/Disadvantage
Advantage	Roadside rain gardens have been demonstrated as effective in managing and reducing runoff conveyed by highway surfaces.
	Sustainable alternative to creating a larger capacity sewer network.
	Encourage natural groundwater recharge.
	Reduces net volume required by the storm sewer system.
	Contribution to aesthetic appeal and habitat in urbanised areas.
	Flexible for use in areas of various shapes and sizes.
Disadvantage	Regular maintenance of vegetation, such as weeding, soil replacement and watering during dry periods.
	Inspection following large rainfall events. This includes clearing of the access channel from the road to the soil.
	Periodic replacement of planting is required.
	Retrofitting costs are high and would be disruptive in heavily urbanised areas

Table E2-6 Advantages/Disadvantages of Roadside Rain Gardens

Swales

Swales are landscape features designed to remove silt and pollution from surface water runoff (Figure E2-7) constructed with shaped sloped sides and filled with vegetation. The water's flow path, along with the wide and shallow ditch, is designed to maximize the time water spends in the swale, which traps pollutants and silt. Depending upon the geometry of land available, a swale may have a meandering or almost straight channel. A common application is around car parks or alongside roads, where substantial automotive pollution is collected by the paving and then flushed by rain. The swale treats the runoff before releasing it to the watershed or storm sewer.

Figure E2-7 Example of swale under construction (completed swale shown in background)

	Advantage/Disadvantage
Advantage	A decreased conveyance of overland flow of flood water toward an area with historical records of flooding.
	Manage the rate of runoff and reduce flooding caused by urbanisation.
	Encourage natural groundwater recharge
Disadvantage	Temporary closure of the areas during construction.
	Swales to route flow in to structures will need regular maintenance.

Table E2-7 Advantages/Disadvantages of Swales

Detention Basins

A detention basin is a large area of ground laid to grass which is dry for the majority of the time and fills up with water during periods of heavy rainfall, which it releases slowly. Permanent ponds may be incorporated towards inlets and outlets for visual amenity and settlement of silts. They can also act as offline storage structures when positioned alongside existing watercourses, which fill when river levels are high. This can help to alleviate pressure on the drainage network elsewhere in the catchment.

Figure E2-8 Example of Detention Basin © Copyright BJ Smur[vi]

The following Figure shows an offline basin during construction.

Figure E2-9 Example of an offline storage structure under construction

The advantages and disadvantages of providing this form of flood mitigation measure are as follows:-

	Advantage/Disadvantage
Advantage	Attenuation of storage of flood water when water levels are high
	Manage the rate of runoff and reduce flooding caused by urbanisation.
	Encourage natural groundwater recharge
Disadvantage	Potential health and safety implications of adding flood storage areas in and around schools without significant costs associated with education and warning requirements. However the CIRIA W12 Sustainable Water Management in Schools provides guidance on overcoming these health and safety issues.
	Temporary closure of parkland/open space during construction and when water levels are high.

Table E2-8 Advantages/Disadvantages of Detention Basins

Ponds and Wetlands

Ponds and wetlands can be used to manage storm water runoff, prevent flooding and downstream erosion. They can also be used to improve water quality in an adjacent river, watercourse or lake and to encourage biodiversity through the creation of new habitats. They can vary in size but they are essentially areas that are designed to accommodate and intercept storm water slowing their entry into nearby watercourses and/or drainage systems. They can be designed to discharge into watercourses with overflow structures pipes or weirs that only operate during flood conditions.

	Advantage/Disadvantage
Advantage	A decreased conveyance of overland flow of flood water toward an area with historical records of flooding.
	Manage the rate of runoff and reduce flooding caused by urbanisation.
	Encourage biodiversity and habitat creation.
Disadvantage	Temporary closure of the areas during construction.
	Usage dependent on underlying ground conditions/soil type.
	Swales to route flow in to structures will need regular maintenance.

Table E2-9 Advantages/Disadvantages of Ponds and Wetlands

Pathway

Improved Maintenance Regimes

This option involves the implementation of an effective maintenance regime to ensure that blockage by vegetation or deposition will not reduce the hydraulic capacity of the existing drainage infrastructure including the public drains, ordinary watercourses, highway gullies, storm and foul sewers. Maintenance would include regular inspection, treeworks, jetting and clearance of debris, gravel and silt where required.

In the context of blockage by trees, the "maintaining to a better standard" option would entail implementing good arbori-cultural practice including:

- surveys for root-plate stability of the larger specimens,
- selective thinning and coppicing of the developing scrub to increase vigour,
- thinning for better specimens,
- removal of non-native species,
- improvement of the stand for amenity, bank stability and biodiversity purposes,
- removal of major fallen dead-wood, obstacles and other debris.

The objective of these works would be to reduce the amount of woody debris liberated in flood conditions which could accumulate on bridges or in sewers.

Maintenance also assumes enforcement of notices served under the Land Drainage Act[vii]. It would be beneficial to identify assets that are more at risk of blockage than others to allow for a more pragmatic approach to setting maintenance regimes. Therefore if an asset is considered at greater risk then it should be maintained more frequently than others in the borough.

The advantages and disadvantages of providing an effective maintenance regime are:

	Advantage/Disadvantage
Advantage	Clearance of drains and swale networks will ensure that water drains freely and to the best of its design capacity.
	Regular and effective maintenance and record keeping could help to support flood defence funding decisions.
Disadvantage	Inspection of the flood defence systems and assets should take place prior to and after potential significant rainfall events, representing a burden on the asset owners, both in terms of cost and time.

Table E2-10 Advantages/Disadvantages of Maintaining Existing System

Increase Capacity in Drainage System

Drainage network improvements involve upsizing of sewer pipes, increased gully entry point locations, construction of off/on-line storage tanks etc. Their advantages and disadvantages are shown below.

	Advantage/Disadvantage
Advantage	Manage the rate of runoff and reduce flooding caused by urbanisation.
	Reduce the risk of manhole surcharging.
Disadvantage	Temporary closure of the roads during construction causing disruption.
	Network improvements are generally expensive to carry out.
	Could lead to an increase in flood risk downstream of the system improvements.

Table E2-11 Advantages/Disadvantages of Network Drainage Improvements

Separation of Foul & Surface Water Sewers

Historically foul and surface water sewer networks were combined into one piped system. In areas where urbanisation has significantly increased along with the expanse of impermeable surface this combined network is not always capable of dealing with the associated increase in surface water runoff. This can lead to an increase of sewer surcharging events resulting in effluent spilling above ground which poses a significant risk to public health. The separation of the two networks ensure that if the surface water network does surcharge there is no effluent mixed with the overflow (Figure E2-10).

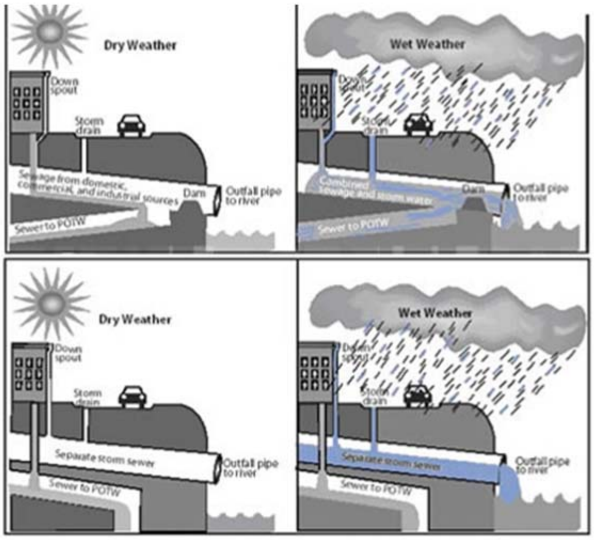


Figure E2-10 Example of a combined sewer system at the top and a separated sewer system at the bottom (Department for Environmental Protection, 2011[viii])

The advantages and disadvantages of sewer separation are provided below.

	Advantage/Disadvantage
Advantage	Manage the rate of runoff and reduce flooding caused by urbanisation.
	Significant reduction in the likelihood of effluent flooding.
	Reduce the risk of manhole surcharging.
Disadvantage	Temporary closure of the roads during construction causing disruption.
	Network improvements are generally expensive to carry out.

Table E2-12 Advantages/Disadvantages of Sewer System Separation

Managing Overland Flows

This option involves the installation of raised features to manage overland flow through an area. Raised features such as high kerbs and full width speed humps can be used to divert flow along carriageways when the sewer system is overburdened (Figure E2-11).

Figure E2-11 Example of a speed hump (Geograph, 2011[ix]) and of raised kerbing (Barkingside, 2009[x])

The advantages and disadvantages of overland flow management are provided below.

	Advantage/Disadvantage
Advantage	Contain surface water runoff in the road carriageway preventing property flooding.
	Speed humps will also have a traffic calming effect.
	Would be quick to implement, depending on scale of management required.
Disadvantage	This setup can cause the temporary closure of the roads during a flood event.
	Disruption caused during the initial installation of both overland flow options.
	Depending on the scale of management required this can be quite an expensive option to implement.

Table E2-13 Advantages/Disadvantages of Overland Flow Management

Land Management Practices

Through the masterplanning of strategic growth areas or large development sites, modification of land contours, profiles and ground levels may be used to channel surface water flows away from property and infrastructure. The advantages and disadvantages of land management practices are provided below.

	Advantage/Disadvantage
Advantage	Highly effective method for surface water flooding of property and/or infrastructure.
Disadvantage	This can be a disruptive option to implement particularly in areas where there is existing occupied development.
	This will be a costly option to implement and may require on-going management to ensure modifications which adversely affect the effectiveness of the measure are not subsequently made by occupiers.

Table E2-14 Advantages/Disadvantages of Land Management Practices

Receptor

Improved Weather Warning

In key flood risk areas this could be a beneficial option to ensure that residents with temporary/demountable defences have time to prepare their properties prior to an event. The EA already have several telemetry stations on the river catchments across the LBB to allow for flood monitoring. More monitoring stations could be put in place by both the EA and TWUL in areas that are particularly prone to flooding. An alarm system or call centre contact approach could be used to alert residents prior to an event.

The advantages and disadvantages of weather warning are provided below.

	Advantage/Disadvantage
Advantage	Will give local residents more time to prepare their property for an event.
	Will allow for better monitoring of frequency of flood events and may allow for the identification of key causes.
	Would be relatively straight forward to put the monitors in place.
Disadvantage	Requires a system to be in place for contacting the local residents, this can be costly and disruptive depending on the system.
	Can be a costly option depending on the number of monitors required.

Table E2-15 Advantages/Disadvantages of Improved Weather Warning

Planning Policy

In preparing this Surface Water Management Plan consideration has been given to the potential of policy as well as engineering interventions to contribute to flood risk mitigation. In developing its Development Management and other local planning policies, in support of the Local Flood Risk Management Strategy, it is recommended that Barnet give consideration to the following matters:

- the need to avoid 'urban creep';
- using redevelopment opportunities to improve the drainage characteristics of the site over those which currently exist;
- using water corridors to achieve sustainability and where appropriate public access benefits;
- deculverting of watercourses;
- improving the surface water management through the design and layout of development; and
- realisation of the All London Green Grid (ALGG).

Urban creep is the term used to refer to the cumulative impact on towns and cities of gradual increases of impermeable areas. The Pitt Review discussed the risks relating to urban creep and through Recommendation 9 expressed the view that urban creep should be minimised. Recommendation 9 of the Pitt Review recommended that: "Householders should no longer be able to lay impermeable surfaces as of right on front garden and the Government should consult on extending this policy to back gardens and business premises". To date this has not been extended to back gardens and business premises but this study highlights the importance of considering such initiatives within the CDAs assessed.

As a minimum all new development in Barnet that go through a Flood Risk Assessment process must provide betterment to greenfield run off rates in the existing site. The SWMP can be used as part of the Local Development Framework evidence base to support local policies and provide additional evidence base for the CDAs identified. Local policies should be developed to deculvert sections of local watercourses and safeguard river corridors from future development to reduce flood risk and maximise environmental benefits.

Development design and layout should be considered in terms of making efficient use of land and ensuring that the resulting urban form achieves sustainable management of surface water. There are opportunities to work with the natural topography for cost effective and sustainable developments that minimise engineering land movement.

There are opportunities to provide new outdoor amenity space, areas of biodiversity, and new recreational uses within areas of higher flood risk. The key SuDS features such as swales, detention and wetlands areas should be located within public open spaces. Where this is not possible due to the extent of current urbanisation, suitable easement land strips should be incorporated within the design layout development and land covenants to avoid potential access and riparian ownership issues to safeguard long-term maintenance.

It is also considered that flood risk can be mitigated through a progressive policy on planning and urban design. This would include rolling out design policies associated with:

- The use of SuDS on all new developments to reduce overall flood risk and to remove surface water from the storm sewer system.
- Encouraging the use of green roofs in new development.
- Incorporation of SUDS and highway source control measures within highway, traffic calming and community schemes.
- Minimisation of the use of hard landscaping in conjunction with the use of positive drainage systems to remove surface water.

The All London Green Grid (ALGG) is a "strategic framework for creating, improving and managing high quality Green Infrastructure"[xi]. The ALGG provides an opportunity to not only improve the aesthetics of LBB but also to incorporate methods of flood risk mitigation into areas being re-greened. One of the objectives within the expanded ALGG is to manage flood risk so it is important that LBB liaises with the ALGG team to ensure that the where possible the most appropriate flood risk mitigation measures are incorporated. This collaborative approach could lead to significant benefits between as well as within boroughs.

Social Change, Education and Awareness

As part of education and awareness, it is important that residents within key flood risk areas are made aware of what to do when a flood occurs, who they should contact and the information that they should provide. It is also important that Council staff can respond swiftly and appropriately when alerted to a flood event. LBB in conjunction with the EA could hold meetings in key risk areas and/or produce information leaflets for local residents to outline this information.

Within LBB any staff that may possibly be contacted by the general public should be made aware of the most appropriate method for recording a flood incident within the borough. Staff should be made aware of what key information is required to ensure that the event is fully logged and that it is passed onto the relevant person within LBB for resolution. Even if the flooding incident is not from a source within the administrative area of LBB, staff should still record the incident and refer the member of the public to the relevant body responsible.

Collaboration between LBB, the EA and TWUL to educate local residents to make them more aware of the impact small property level changes can have on local flood risk. Introducing property level options that residents could implement themselves such as green roofs, water butts and permeable paving to reduce localised flood risk would be beneficial. Informing local residents of the available property level protection measures will improve general awareness and may encourage residents to make their own preparations to protect their properties against future floods.

Improved Resilience and Resistance Measures

Property resistance measures are those which prevent flood water from entering a property. Resistance measures include:

- Flood resistant gates
- Periscope air vents
- Waterproof wall renders and facings
- Non return valves in waste pipes and outlets
- Temporary measures such as free standing barriers, door boards, flood skirts and airbrick covers
- Water resistant external doors and windows

The advantages and disadvantages of this option are outlined below.

	Advantage/Disadvantage
Advantage	Installation of these measures will help to minimise the likelihood of flow entry into property.
	Allows for faster community recovery following an event.
	Gives residents peace of mind at low return period events.
Disadvantage	Many of these measures are temporary so need to be fitted by the residents prior to a flood so require the resident to be at home to put up/install the resistance measures.
	Sufficient warning needs to be provided to ensure the residents have time to respond.
	To be most effective several resistance measures need to be implemented which can be quite costly.
	Only provides protection to property for low return period events.

Table E2-16 Advantages/Disadvantages of Property Resistance Measures

Property resilience measures are those that are carried out within a property to minimise internal floodwater damage. Resilience measures include:

- Tanking
- Concrete floors
- Raised electrical sockets
- Horizontal plasterboard replacement
- Flood resilient kitchens – plastic, stainless steel, free standing removable units

- Water resistant internal walls (rendered or tiled)
- Plastic skirting boards
- Pump and sump systems in place
- Water resistant internal doors
- The advantages and disadvantages of this option are outlined below:

	Advantage/Disadvantage
Advantage	Minimises property damage during a flood event
	Quicker recovery of property after an event
	Gives peace of mind to residents during an event
Disadvantage	This is a costly option for a property owner to have to implement
	Relies on all adjoining properties implementing resilience measures to ensure the scheme is effective

Table E2-17 Advantages/Disadvantages of Property Resilience Measures

Raising Doorway/Access Thresholds

This is a permanent resistance measure which involves the raising of property access points through the incorporation of steps or a ramped access.

The advantages and disadvantages of this option are outlined below.

	Advantage/Disadvantage
Advantage	Installation of these measures will help to minimise the likelihood of flow entry into property.
	Allows for faster community recovery following an event.
	Permanent measure so there is no need for the resident to be in place to install the measure.
	Gives residents peace of mind at low return period events.
Disadvantage	This is a costly measure to implement into existing residential properties.
	This option alone will not completely protect a property other measures may also be necessary.
	Only provides protection to property for low return period events.

Table E2-18 Advantages/Disadvantages of Raising Doorway/Access Thresholds

Temporary or Demountable Flood Defences

This option involves the installation of fittings to allow for the placement of temporary/demountable flood defences at a property level.

The advantages and disadvantages of this option are outlined below.

	Advantage/Disadvantage
Advantage	Installation of these measures will help to minimise the likelihood of flow entry into property.
	Allows for faster community recovery following an event.
	Gives residents peace of mind at low return period events.
Disadvantage	Sufficient warning needs to be provided to ensure the residents have time to respond.
	This measure is temporary so needs to be fitted by the residents prior to a flood which requires the resident to be at home to put up/install the resistance measures.
	To be most effective several resistance measures need to be implemented which can be quite costly.
	Only provides protection to property for low return period events.

Table E2-19 Advantages/Disadvantages of Temporary/Demountable Flood Defences

APPENDIX E3 – Option Assessment

1.7.34 Golders Green – Group2_018

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. The main flood risk issues in this area relate to surface water ponding in topographic depressions along the Decoy Brook, an ordinary watercourse running through this CDA.

There are approximately 553 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, 53 properties fall within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety. There are 57 properties classified as basement properties, two of which fall within areas of deep flooding.

To mitigate the flood risk in this area, the following preferred option has been derived. Three detention basins are proposed, two to the south east and one to the north west of the CDA. The two detention basins to the south east of the CDA have been positioned within areas of open space in Hampstead Heath extension.

In addition, a swale system is proposed to provide additional storage for surface water flow to the south west of the CDA. In conjunction with the detention basins and swale, a series of roadside rain gardens in and around this area to intercept the surface water runoff in these areas are also proposed. The storage area to the north west of this CDA is located to the east of the North Circular and will be combined with a series of roadside rain gardens on Princes Park Avenue. Figure E3-1 below outlines the proposed locations of the detention basins and the roadside rain gardens within this CDA.

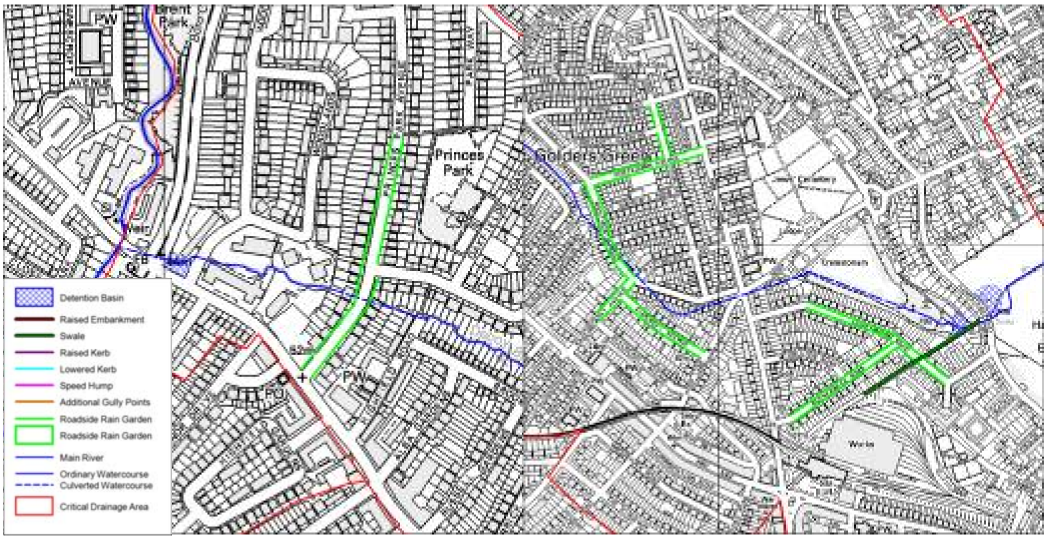


Figure E3-1 Golders Green Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Roadside Rain Gardens, Swales	£101k - 250k

Table E3-1 Golders Green Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The preferred options for this CDA will help to reduce the amount of surface water and fluvial risk in this area. In addition to this preferred option, the maintenance regime along Decoy Brook should be assessed to ensure that it is sufficient to keep the trash screens to the east of Woodlands kept clear of debris. This was one of the contributing factors to the recent inundation of the North Circular. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

Further investigation should be made in the area to the north west of this CDA. There may be the potential to create a more substantial detention basin between the A502 and Woodlands along the Decoy Brook which would help to reduce the flood risk posed to the A406. Additional integrated modelling in this area would be beneficial as it would ensure that the fluvial flood risk is taken into account when determining the most appropriate mitigation measures in this area.

1.7.35 Friern Barnet – Group2_009

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. The main flood risk issues in this area relate to surface water ponding in topographic depressions and along an unnamed ordinary watercourse running through this CDA.

There are approximately 415 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, 32 properties fall within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety.

To mitigate the flood risk in this area, the following preferred option has been derived. Two detention basins are proposed, one to the north of Friary Road and another to the north of Torrington Park. In addition, several areas of raised kerb are proposed on Manor Drive, Friars Avenue, Gresham Avenue and one the southern side of Torrington Park, and to the east of the CDA, two embankments are proposed along the northern side of The Crescent and to the west of Beaconsfield Road. An area of raised kerb/wall along the railway line adjacent to Beaconsfield Road is also proposed to prevent surface water runoff from the railway line affecting the properties further south near the subway. Figure E3-2 below outlines the proposed locations of the detention basins, raised kerb and the raised embankments within this CDA.

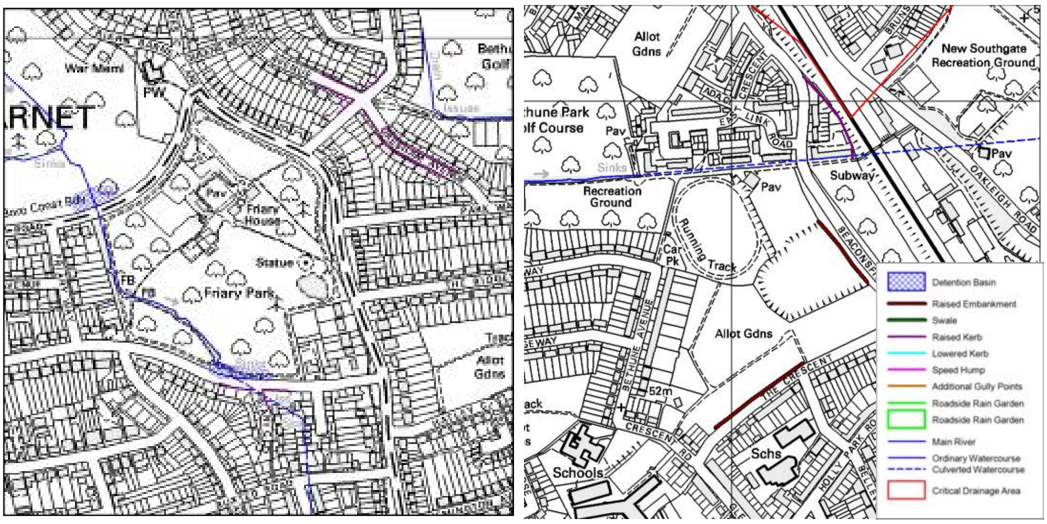


Figure E3-2 Friern Barnet Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Raised Embankment, Raised Kerb	£101k – 250k

Table E3-2 Friern Barnet Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The preferred options for this CDA will help to reduce the amount of surface water and fluvial flood risk in this area. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding. The deep area of ponding at Beaconsfield Road will be contained by the embankments on either side of the open area of land which should reduce the risk posed to the adjacent properties.

Further investigation should be made in the area to the east of this CDA to assess cross connections under the railway line in this location. An additional flow path assessment may be required to ensure that the proposed raised embankments will not cut off smaller flow paths.

1.7.36 Childs Hill – Group2_020

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. The main flood risk issues in this area relate to the Clitterhouse Stream, an LBB ordinary watercourse asset, and surface water ponding in topographic depressions at Basing Hill Park and Granville Road allotments.

There are approximately 726 non-deprived and 76 deprived residential properties at risk of surface water flooding within this CDA. Of these, 26 deprived and 53 non-deprived properties fall within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety.

To mitigate the flood risk in this area, the following preferred option has been derived. To reduce the amount of ponding water, a series of swale systems and detention basins are proposed in the north west of the CDA. Figure E3-3 below outlines the proposed locations of the two swales and two detention basins within this CDA.

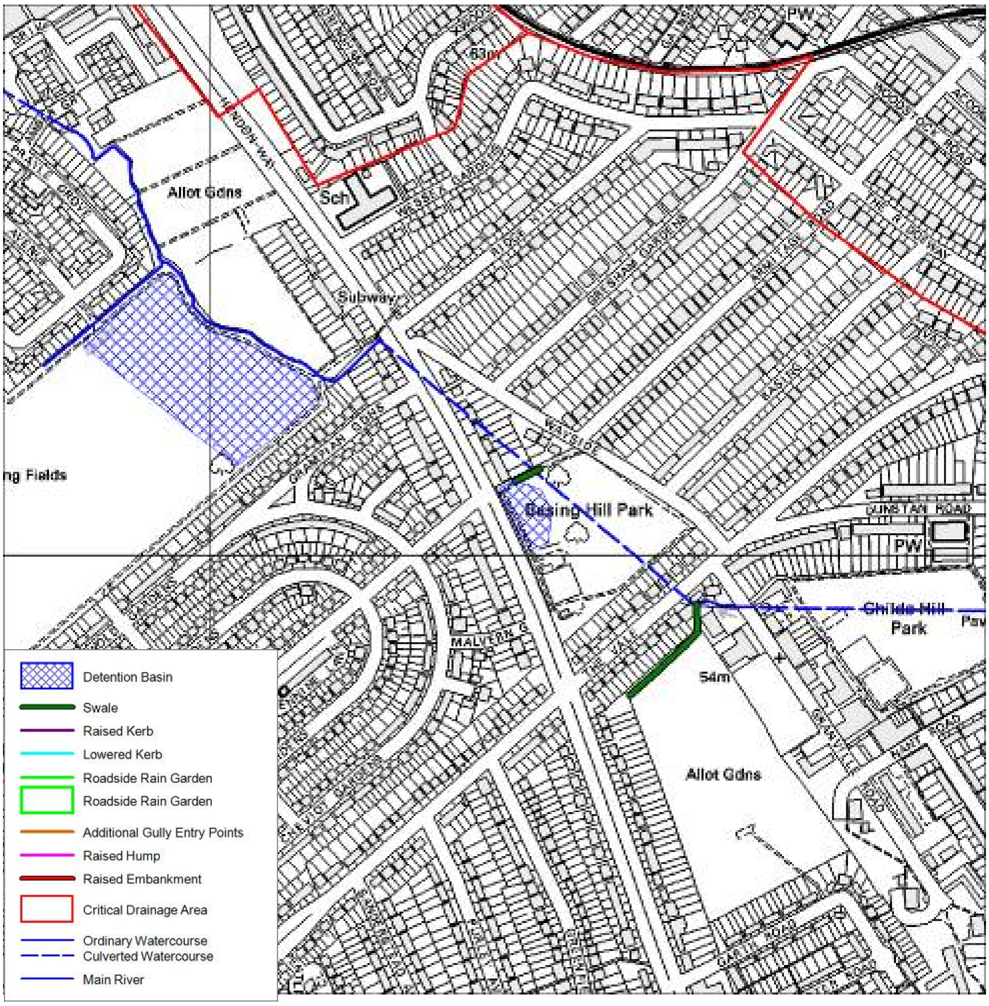


Figure E3-3 Childs Hill Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Swales	£1m – 10m

Table E3-3 Childs Hill Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed detention basins and swale systems would help to reduce localised surface water ponding and fluvial flood risk at Prayle Grove, Amber Grove and Marble Drive. It would also have benefits to areas further up the Clitterhouse Stream as the culverted system will have more capacity as surface water runoff will be entering the system at a slower rate. This option will not completely eliminate the risk posed to property but it should mitigate the risks. This option is predominantly focused on reducing the deeper areas of ponding within the CDA.

Further investigation should be made in Childs Hill Park to assess the possibility of localised land lowering within the park to create an additional offline storage area which would only be used in extreme events.

1.7.37 Bittacy Park – Group2_015

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. There are multiple surface water flow paths, notably influenced by the railway line running across the CDA. Much of the north of this CDA is within the Mill Hill East regeneration area. As a result, it is vital that stringent planning policy is in place to ensure that any future development in this area takes into account source control measures and does not contribute to flood risk in this area.

There are approximately 226 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, 11 properties fall within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety.

To mitigate the flood risk in this area, the following preferred option has been derived. In order to reduce the amount of overland flow reaching Bittacy Rise/Engel Park, a series of roadside rain gardens are proposed on Salcombe Gardens and Bittacy Rise where there are wider residential roads and existing green space. Some kerb raising on the junction of Bittacy Hill and Bittacy Road and also on Oakhampton Road will assist in channelling surface water flow away from properties in these locations. In addition, it is recommended that a wide range of SuDS are implemented as part of the Mill Hill East regeneration proposals. Figure E3-4 below outlines the proposed locations of the combined preferred option for this CDA.

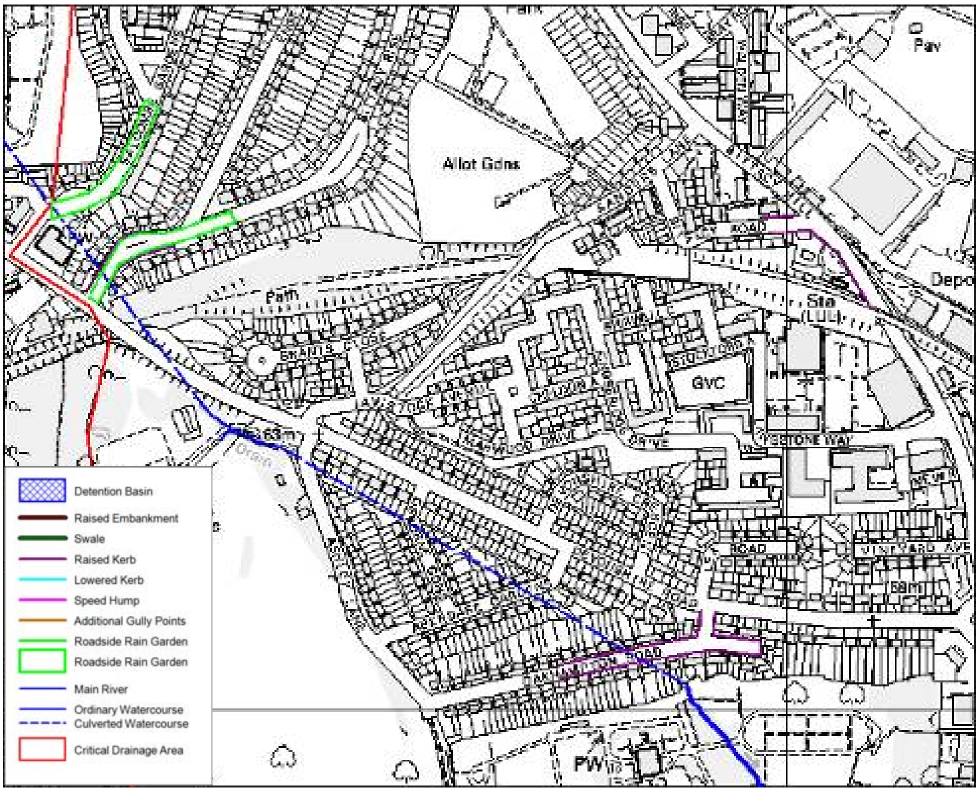


Figure E3-4 Bittacy Park Preferred Options

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Garden, Raised Kerbs	< £25k

Table E3-4 Bittacy Park Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy. This option will not completely eliminate the risk posed to property but it should mitigate the risks.

1.7.38 Mill Hill Circus – Group2_026

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. There is a prominent surface water flow path along The Broadway under the M1 and onto residential areas to the west of the M1. In the north of the CDA, there is a surface water flow route which flows into the line of an existing watercourse.

There are approximately 240 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, five properties fall within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety.

To mitigate the flood risk in this area, the following preferred option has been derived. The construction of three detention basins on Lawrence Street, Mill Hill Circus and Victoria Road will help to attenuate and reduce flooding downstream. The detention basins are proposed as offline storage adjacent to the open ordinary watercourses in this area. In addition, the installation of a raised embankment adjacent to the properties on Victoria Road will prevent localised flooding in this area. Figure E3-5 below outlines the proposed locations of the combined preferred option for this CDA.

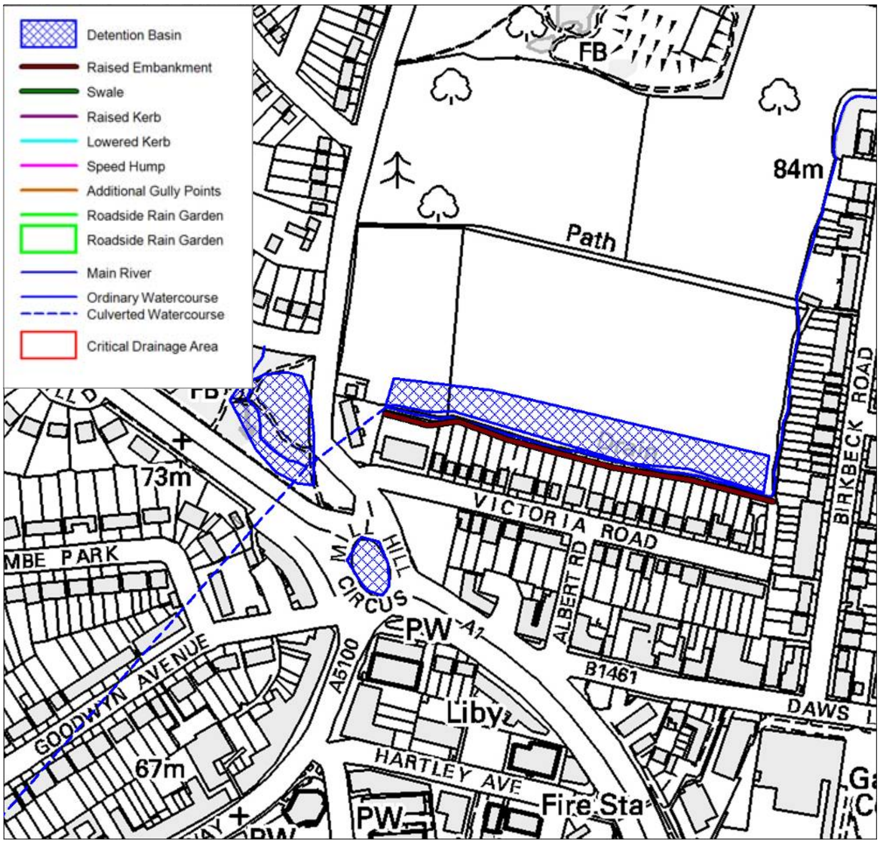


Figure E3-5 Mill Hill Circus Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Raised Embankment	£251k - £500k

Table E3-5 Mill Hill Circus Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed detention basins would help to reduce localised surface water ponding and fluvial flooding at Mill Hill Circus and the A1. It would also have benefits to areas upstream and downstream of this location as the surface water drainage system will have more capacity due to runoff entering the system at a slower rate. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

Further investigation should be made into the possibility of “daylighting” and widening sections of the culverted watercourse running parallel to Lawrence Street. This would help to reduce the likelihood of property flooding in the valley adjacent to Lawrence Street and may help to improve the situation at Mill Hill Circus.

1.7.39 Oak Hill Park – Group2_029

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. There is extensive flooding predicted along West Walk, Uplands Road and Osidge Avenue adjacent to the Pymmes Brook. Further risk areas are identified at Fitzwilliam Close and within the railway cutting. This area is at risk of flooding from surface water runoff and river overtopping. As a result, any options considered for this area need to address the risk from both sources.

There are approximately 283 non-deprived and 3 deprived residential properties at risk of surface water flooding within this CDA. Of these, 28 non-deprived properties fall within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety.

To mitigate the flood risk in this area, the following preferred option has been derived. A series of raised kerbs and small walls are being suggested along Avondale Avenue, Parkside Gardens, East Walk, West Walk and Osidge Lane. In addition, the installation of small speed humps will help to contain shallow surface water and fluvial flows in the existing green area adjacent to Pymmes Brook. A small detention basin along Parkside Gardens would help to attenuate and reduce flooding downstream. Figure E3-6 below outlines the proposed locations of the combined preferred option for this CDA.

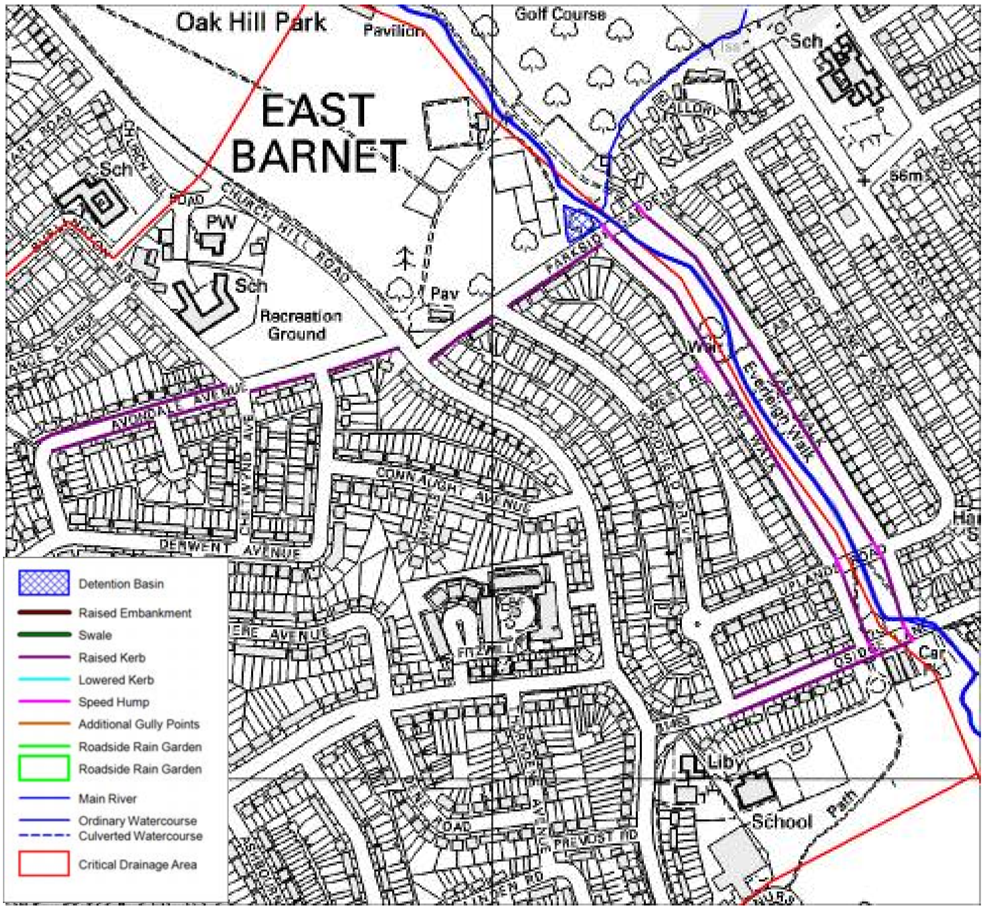


Figure E3-6 Oak Hill Park Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Raised Kerbs, Speed Humps	£51k – 100k

Table E3-6 Oak Hill Park Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed options to the north of this CDA are designed to use the road network as a method of channelling surface water flow into open areas of land adjacent to the river. The measures suggested along East and West Walks are designed to contain any out of bank flow from Pymmes Brook and prevent interaction with any localised surface water flooding. This option will not completely eliminate the risk posed to property but it should mitigate the risks.

Further investigation is required to ensure that the proposed raised kerbs do not reduce the existing fluvial storage area as this may result in the alleviation measures replacing one problem with another.

1.7.40 Muswell Hill – Group2_014

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. There is an identifiable surface water flow path through this CDA towards the Bounds Green Brook which puts a number of properties at risk. The North Circular is also predicted to be at risk of flooding.

There are approximately 323 non-deprived residential properties at risk of surface water flooding within this CDA. None of these properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Installation of roadside rain gardens on Sections of Halliwick, Sutton, Wilton and Greenham Roads, Georges Crescent and Colney Hatch Lane will help to reduce overall surface water volumes in the CDA. Figure E3-7 below outlines the proposed locations of the combined preferred option for this CDA

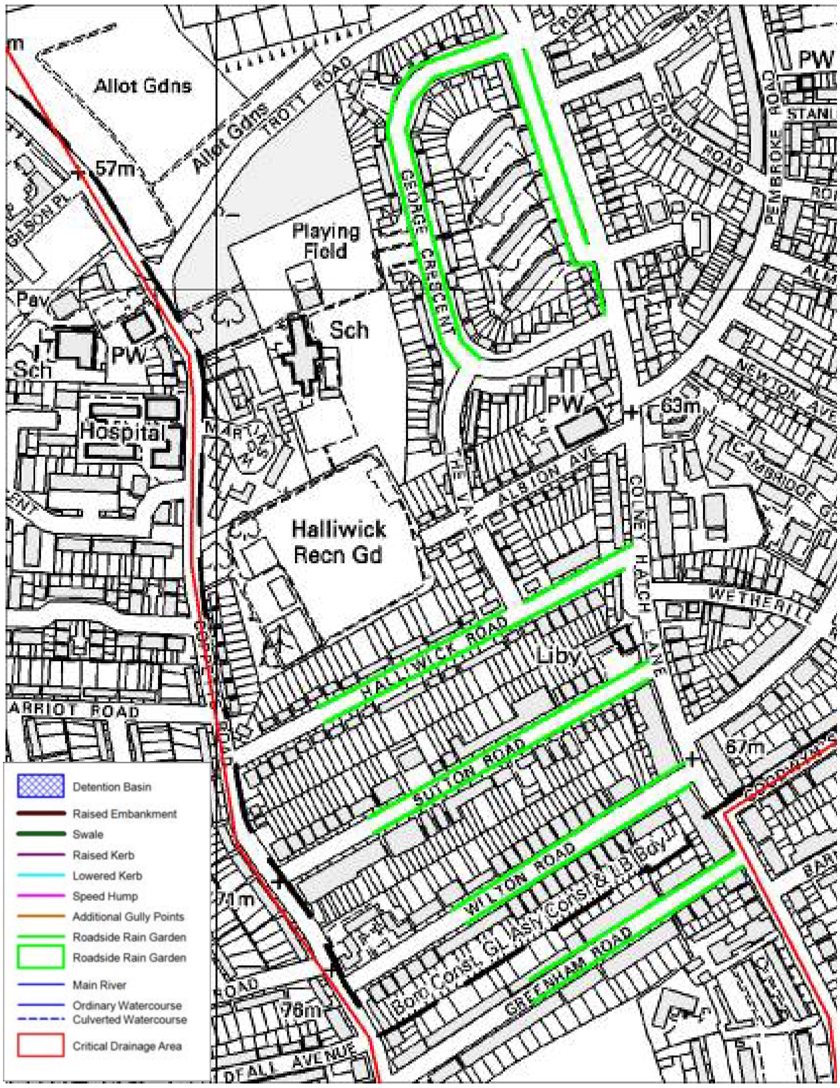


Figure E3-7 Muswell Hill Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Gardens	< £25k

Table E3-7 Muswell Hill Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.41 Barnet – Group2_004

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Areas of flooding are predicted across a number of residential roads in this CDA. Deeper areas of flooding are predicted on Meadow Close, Crocus Field and between the railway line and Vale Drive. Part of the CDA is covered by the Underhill regeneration area. As a result, it is vital that stringent planning policy is in place to ensure that any future development in this area takes into account source control measures and does not contribute to flood risk in this area.

There are approximately 189 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, two non-deprived properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Installation of roadside rain gardens in the existing green space alongside Fitzjohn Avenue and Hammond Close will help to reduce overall surface water volumes in the CDA. Part of the CDA is covered by the Underhill regeneration area. Figure E3-8 below outlines the proposed locations of the combined preferred option for this CDA.

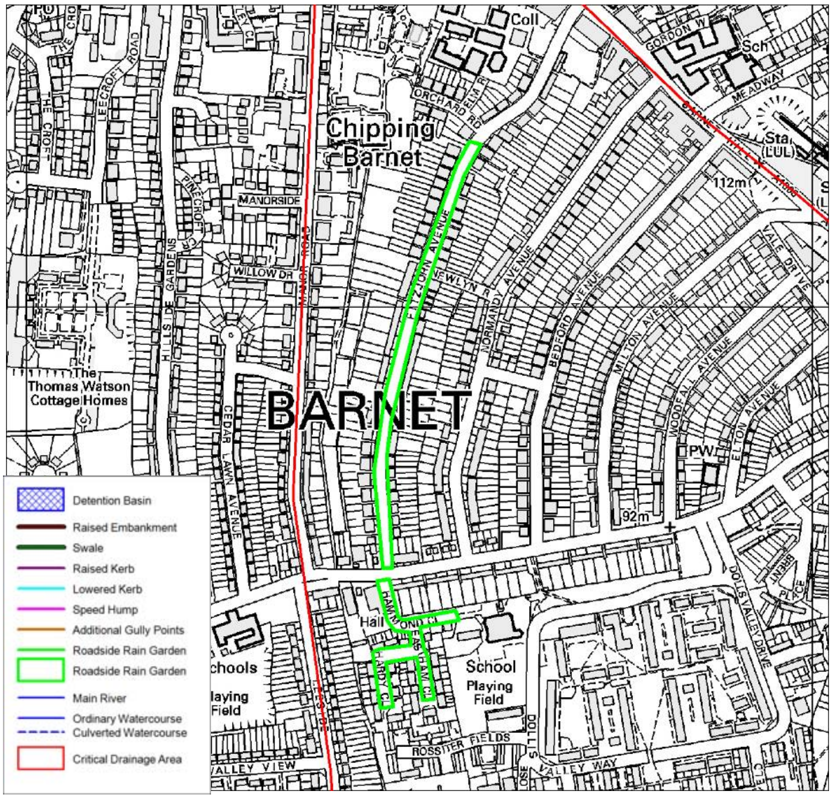


Figure E3-8 Barnet Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Gardens	< £25k

Table E3-8 Barnet Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

This option will help to slow down and reduce the amount of surface water runoff entering the surface water sewer system. This should help to reduce the likelihood of flooding on the Crocusfield Estate to the south of the CDA. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

A majority of the properties on Dollis Valley Way and Dollis Valley Drive to the south east of the CDA are purpose built blocks of flats with garages comprising the ground floor. So although the surface water mapping indicates that shallow water would affect these properties in reality shallow flooding (<0.5m) would only affect garages.

1.7.42 Hendon Way – Group2_019

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted on Hendon Way opposite the Tesco store. This is a known area of historical flooding.

There are approximately 38 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, six properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Installation of roadside rain gardens alongside Hendon Way, Woodville Road, Hamilton Road and Highfield Avenue will help to slow runoff towards the main road. Figure E3-9 below outlines the proposed locations of the combined preferred option for this CDA.

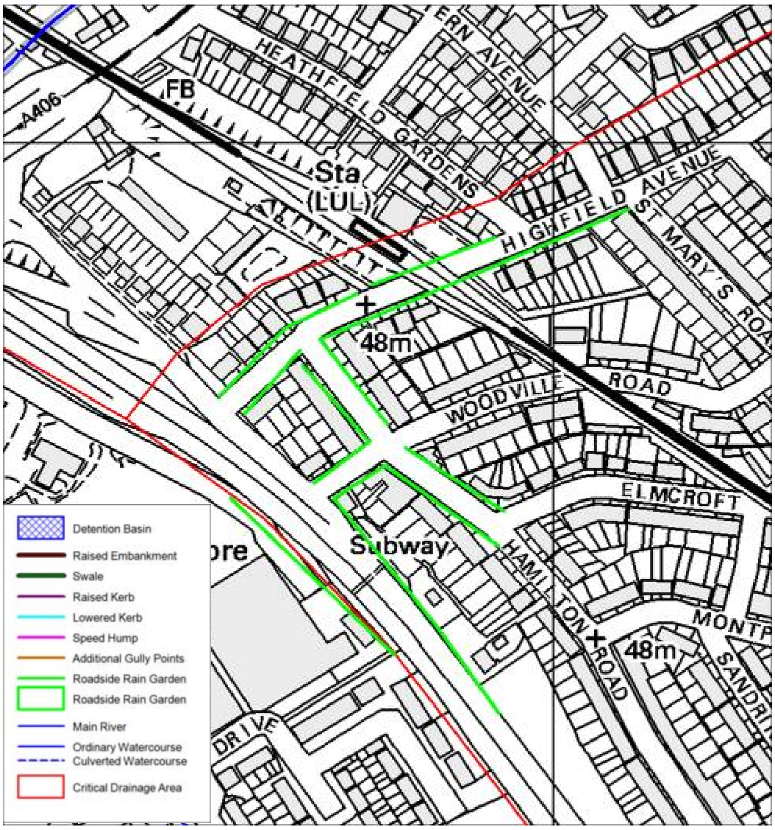


Figure E3-9 Hendon Way Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Gardens	< £25k

Table E3-9 Hendon Way Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed roadside rain gardens are a quick flood risk mitigation solution in this area. The densely urbanised nature of this area means that larger scale schemes are more difficult to implement in the short term. Small scale schemes such as this one will have an impact on residual risk on the ground. This option will not completely eliminate the risk posed to property but it should mitigate the risks.

The main cause of the historical flooding in this area has been from the below ground network where there are a number of cross-connection issues which are exacerbated in heavy rainfall events. The surface water modelled flood extent is similar to those experienced in this location, however the model does not take into account the known drainage network issues in this area. A borough wide assessment of all assets and cross connections by LBB, TfL and TWUL would be beneficial in identifying problem areas.

1.7.43 Longmore Avenue – Group2_007

The Drain London mapping identified several areas of ponding within this CDA. These areas of risk have been discussed in Section E1. The main flood risk issue in this area is from ponding overland flow.

There are approximately 573 non-deprived residential properties that fall within the mapped outline in this area. Of these approximately 96 are at risk from deep flooding. Sections of the railway line and the entrance to New Barnet station are at risk of shallow flooding.

To mitigate the flood risk in this area, the following preferred option has been derived. To help prevent the areas of ponding, a series of roadside rain gardens and raised kerbs are proposed in several locations within the CDA. Figure E3-10 below outlines the proposed locations of the roadside rain gardens and the raised kerbs.

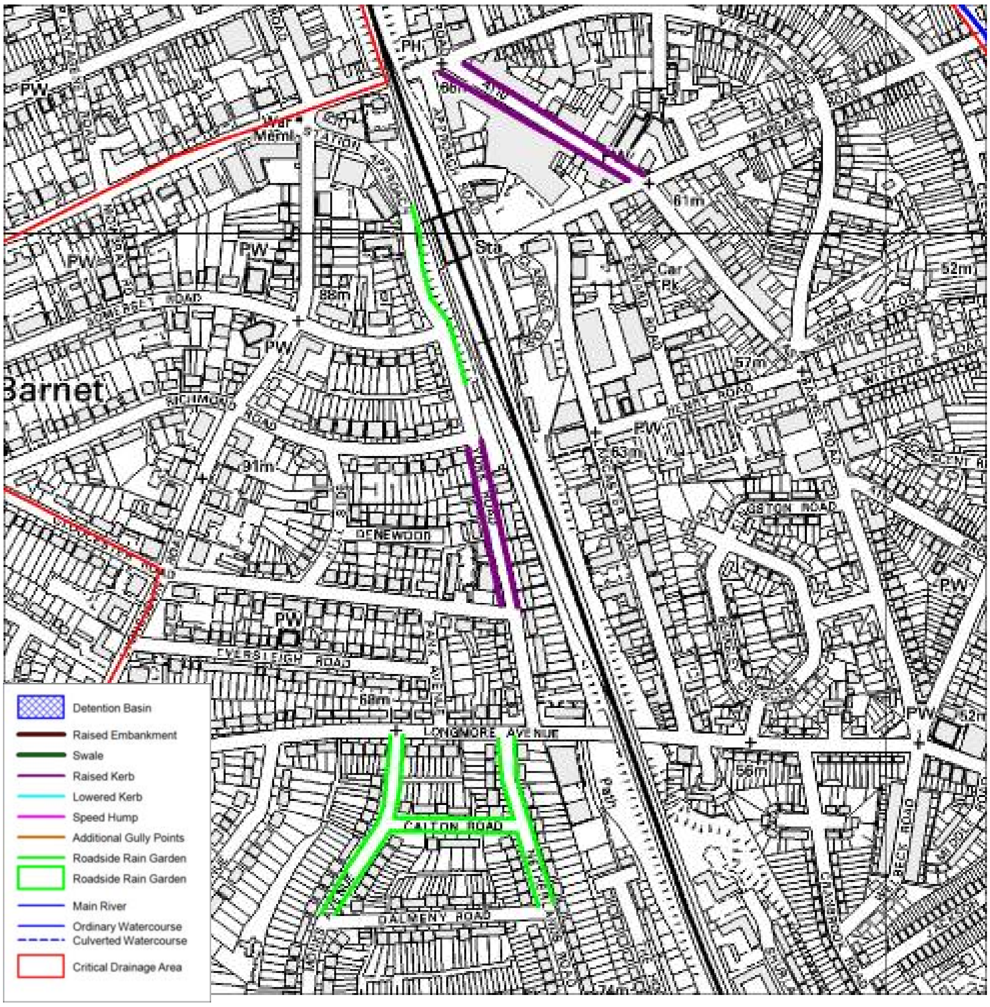


Figure E3-10 Longmore Avenue Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Gardens, Raised Kerbs	< £25k

Table E3-10 Longmore Avenue Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

With the proposed measures in place there should be a significant reduction in the number of properties affected by surface water flooding in this area. The roadside rain gardens should mitigate the flood risk posed to properties along Calton Road and Netherlands Road, while the raised kerbs along York Road and East Barnet Road should prevent property flooding in these areas during low return period events. This option will not completely eliminate the risk posed to property but it should mitigate the risks.

1.7.44 Hadley – Group2_005

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. The main flood risk issues in this area relate to the ordinary watercourses in King Georges Field and surface water ponding in topographic depressions at Meadway, Bosworth Road, Woodville Road, Hadley Road, Clifford Road, Shaftesbury Avenue and Lytton Road.

There are approximately 562 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, 156 properties fall within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety.

To mitigate the flood risk in this area, the following preferred option has been derived. In order to reduce the amount of ponding in the residential areas to the east of the CDA, a linear detention basin has been proposed in King Georges Field just upstream of the culverted Section of drain. A flow control structure has been incorporated into this option to hold excess flows back in the detention basin to allow the culverted system downstream to recover during a severe rainfall event. A small swale has also been incorporated at the eastern end of the detention basin to assist in the slowing down of surface water and ordinary watercourse flow in this area. A further swale along the edge of the railway embankment to the east of this CDA will help to reduce the amount of surface water affecting property in this location.

In addition to these measures, localised kerb raising has been incorporated into this preferred option on Meadway, St Marks Close, Shaftesbury Avenue and Lytton Road. However, it should be noted that a minimum number of areas have been assessed for the potential for kerb raising and more may be required. Figure E3-11 below outlines the proposed locations of the detention basin and the raised kerbs within this CDA.

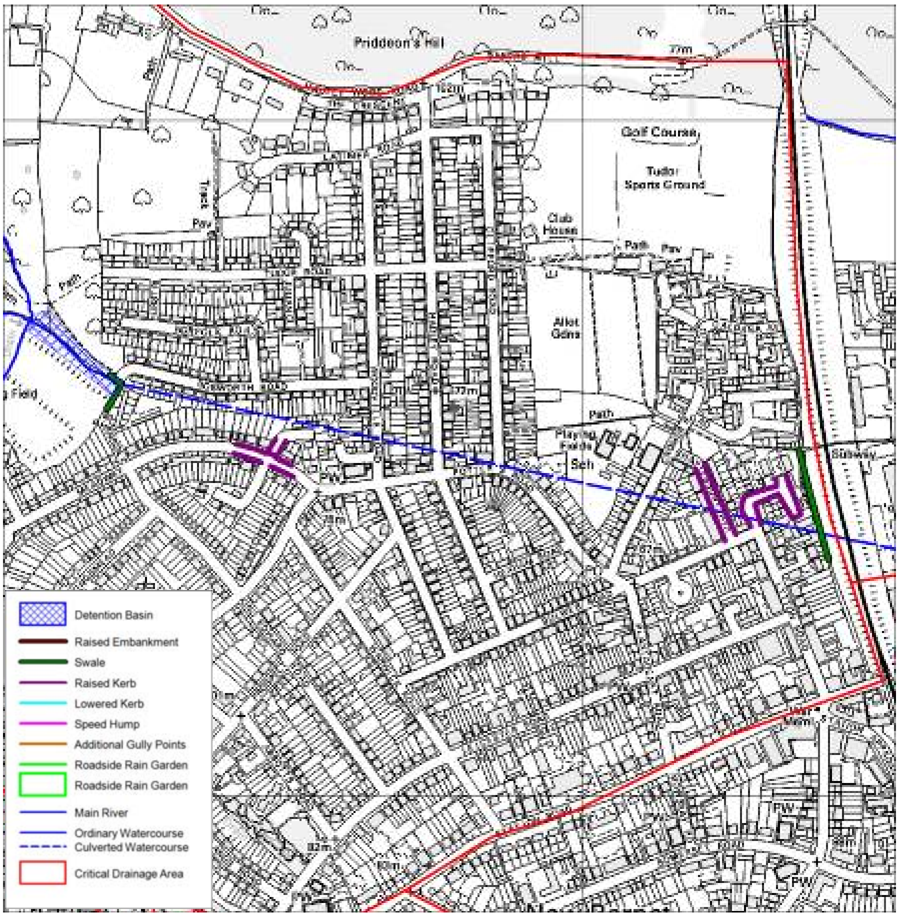


Figure E3-11 Hadley Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Raised Kerbs, Swales	£251k - 500k

Table E3-11 Hadley Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed detention basin and swale system in King Georges Field would help to reduce localised surface water ponding in nearly all areas of this CDA due to a reduction in the amount of water entering the culverted system during a large rainfall event. It would also have benefits in areas to the east of the CDA, as the culverted system will have more capacity available to accommodate surface water runoff. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

Further investigation should be made in this area to assess the most appropriate flood mitigation measures. The proposed measures in King Georges field would need to be assessed to ensure that it will not have a detrimental impact on flood risk upstream. This preferred option incorporates the minimum of measures but is the most cost effective. It is important to assess the true risk and the need for resilience measures in and around Lytton Road.

1.7.45 Coppets Wood – Group2_010

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. The main flood risk issues in this area relate to surface water ponding in topographic depressions.

There are approximately 377 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, 22 properties fall within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety.

To mitigate the flood risk in this area, the following preferred option has been derived. To reduce the amount of surface water ponding on Dudrich Close, adjacent to Colney Hatch Lane, a series of raised kerbs linked to a ditch, swale and a small detention basin are proposed. To reduce the amount of overland flow reaching Dudrich Close, a series of roadside rain gardens are proposed where the residential roads are wide enough to the north and to the west. Figure E3-12 below outlines the proposed locations of the combined preferred option for this CDA.

Figure E3-12 Coppetts Wood Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Roadside Rain Garden, Raised Kerbs, Swales, Ditch	£26k - 50k

Table E3-12 Coppetts Wood Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The preferred options for this CDA will help to reduce the amount of surface water ponding affecting property at Dudrich Close, Summer Lane, Woodleigh Avenue. The deep area of ponding at Beaconsfield Road will be contained by the embankments on either side which should reduce the risk posed to the adjacent properties. This option will not completely eliminate the risk posed to property but it should mitigate the risks.

Further investigation should be made to ground truth the area of deep flooding in and around Dudrich Close. There have been no historical incidents of flooding in this area, and, therefore, it is important to ensure that the predicted flooding is realistic and then complete a more detailed study to assess the effectiveness of the proposed preferred option.

1.7.46 Oakleigh Park – Group2_008

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted in Oak Hill Park adjacent to the Pymmes Brook, as well as within the railway cutting and along Netherlands Road and Holland Close.

There are approximately 127 non-deprived residential properties at risk of surface water flooding within this CDA.

To mitigate the flood risk in this area, the following preferred option has been derived. Two detention basins are proposed; one in existing green space north of Holland Close and one in existing green space at Rushdene Avenue. In conjunction with some works to raise and lower kerbs in these areas, these basins will act to store surface water flows which would otherwise flood properties. Figure E3-13 below outlines the proposed locations of the combined preferred option for this CDA.

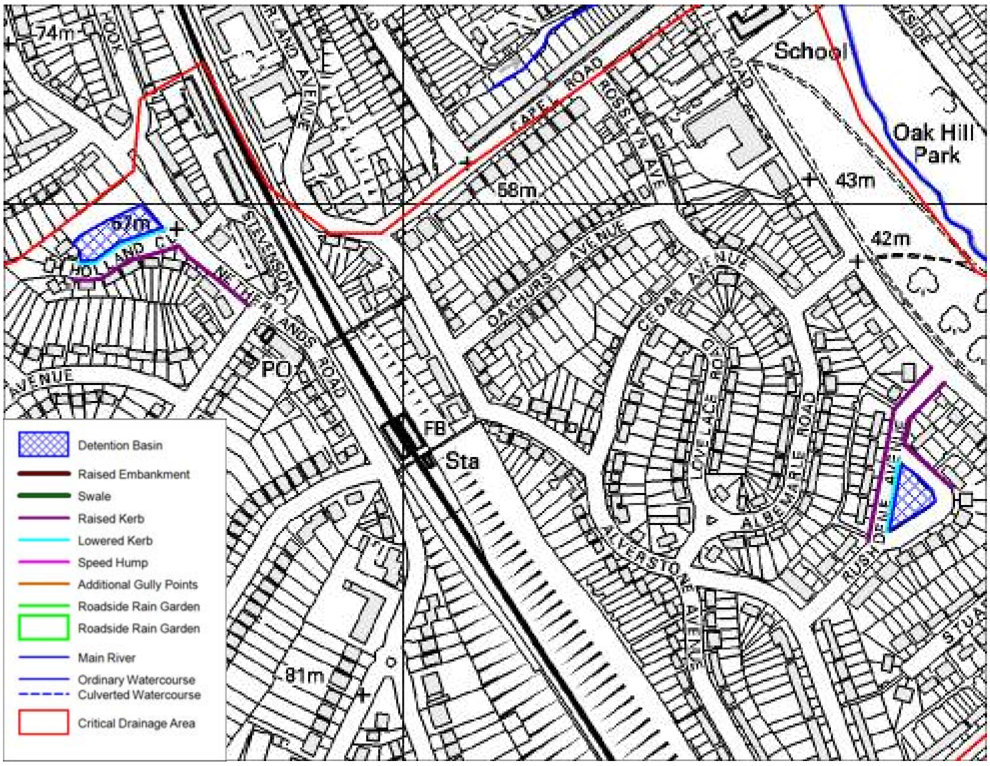


Figure E3-13 Oakleigh Park Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Raised Kerbs	£51k - 100k

Table E3-13 Oakleigh Park Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed detention basins should help to reduce localised ponding on either side of the railway line. It should also have benefits to the surrounding areas, as the surface water drainage system will have more capacity due to runoff entering the system at a slower rate. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.47 Long Lane – Group2_012

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. There are surface water flow paths across the north of the CDA, along the line of an existing watercourse, and south west across High Road and Central Avenue. The railway cutting at Church Lane is also at risk of flooding.

There are approximately 227 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, two properties fall within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety.

To mitigate the flood risk in this area, the following preferred option has been derived. Lowering the kerb of the slip road onto Pinkham Way will assist in diverting flows into green space rather than onto the road. A swale and detention basin in combination with raised kerbs along Old Farm Road will divert flow away from properties and into green space. Figure E3-14 below outlines the proposed locations of the combined preferred option for this CDA.

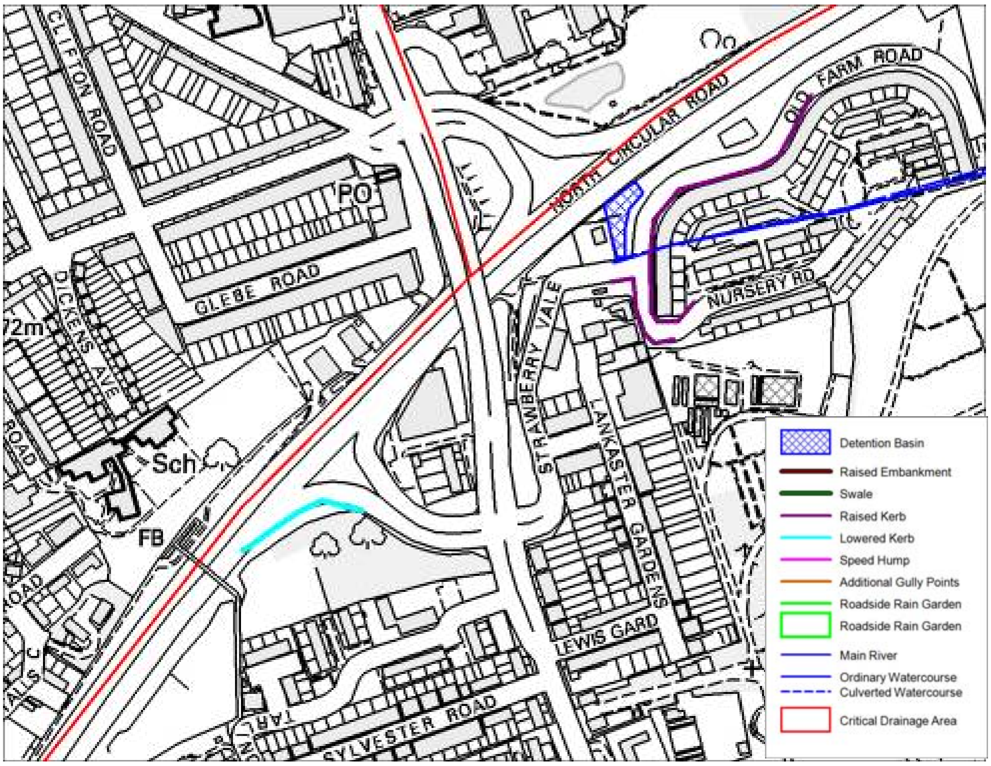


Figure E3-14 Long Lane Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Raised Kerbs, Swales	£26k - 50k

Table E3-14 Long Lane Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

This proposed scheme will help to reduce localised surface water ponding on the North Circular and on Long Lane. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

There is further opportunity to reduce flood risk in this area by incorporating SuDS measures into the regeneration proposals for East Finchley – Central Avenue to achieve betterment on the existing situation.

1.7.48 Broadfields Ditch – Group2_031

The Drain London mapping identified one main area of significant risk within this CDA. This area of risk has been discussed in Section E1. A predicted surface water flow route curves across the centre of the CDA, causing flooding at a number of properties. Flooding is most significant upstream of the A41 at the head of an existing watercourse flowing south into Deans Brook.

There are approximately 182 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, 26 properties fall within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety.

To mitigate the flood risk in this area, the following preferred option has been derived. Installation of roadside rain gardens along Springwood Crescent, Bushfield Crescent, Glengall Road, Wyre Grove and Warwick Avenue will help to store and slow surface water flow through the catchment. In conjunction with this measure, kerbs in these roads could also be raised at suitable locations to provide additional protection to properties. Figure E3-15 below outlines the proposed locations of the combined preferred option for this CDA.

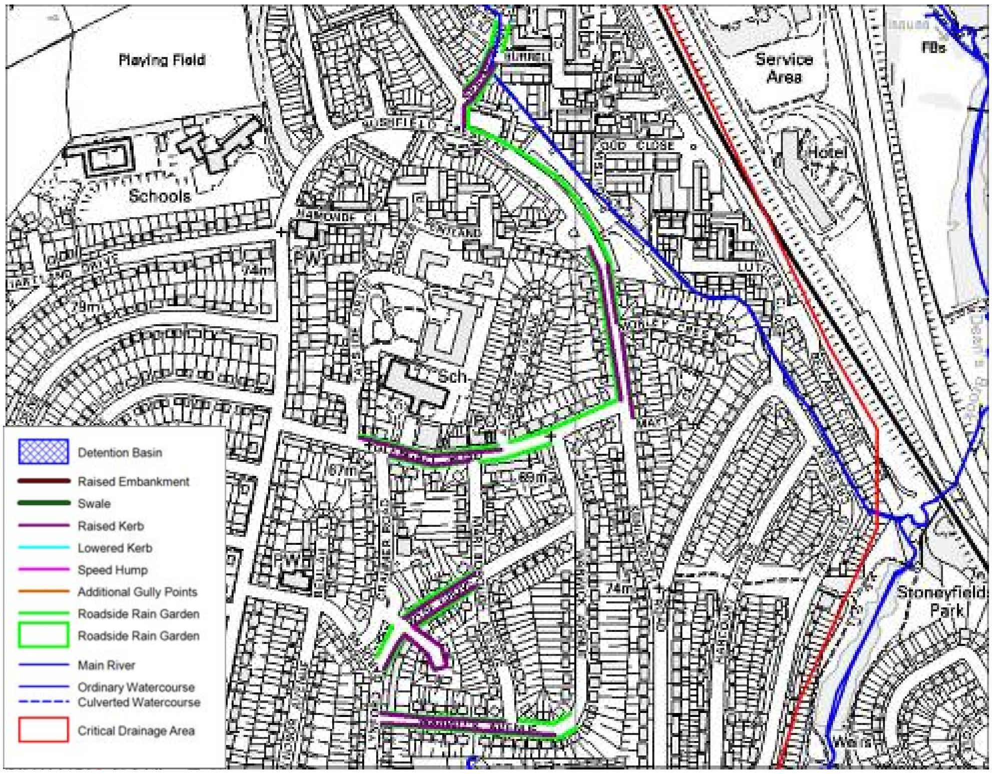


Figure E3-15 Broadfields Ditch Preferred Option

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Garden, Raised Kerbs	< £25k

Table E3-15 Broadfields Ditch Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

These proposed options will help to reduce localised surface water flood risk in this residential area. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.49 Sunnyhill Park – Group2_032

The Drain London mapping identified one main area of significant risk within this CDA. This area of risk has been discussed in Section E1. Surface water flows are constrained by the M1 embankment and consequently flood into adjacent properties. There is an overlap in flood risk between this CDA and Group2_033; any overlapping options to mitigate the flood risk in Group2_032 have been costed within this CDA.

There are approximately 212 non-deprived residential properties at risk of surface water flooding within this CDA. No non-deprived properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Creation of a swale adjacent to Wheatley Close and the M1 will help to provide extra storage and infiltration potential, thus helping to reduce adjacent flooding. In conjunction with this, additional storage could be provided by detention basins north and south of Wheatley Close, and at Longfield Avenue. Further property protection could be achieved by raising kerbs at Longfield Avenue and Rowlands Close to keep flows within the road. Figure E3-16 outlines the proposed locations of the combined preferred option for this CDA.

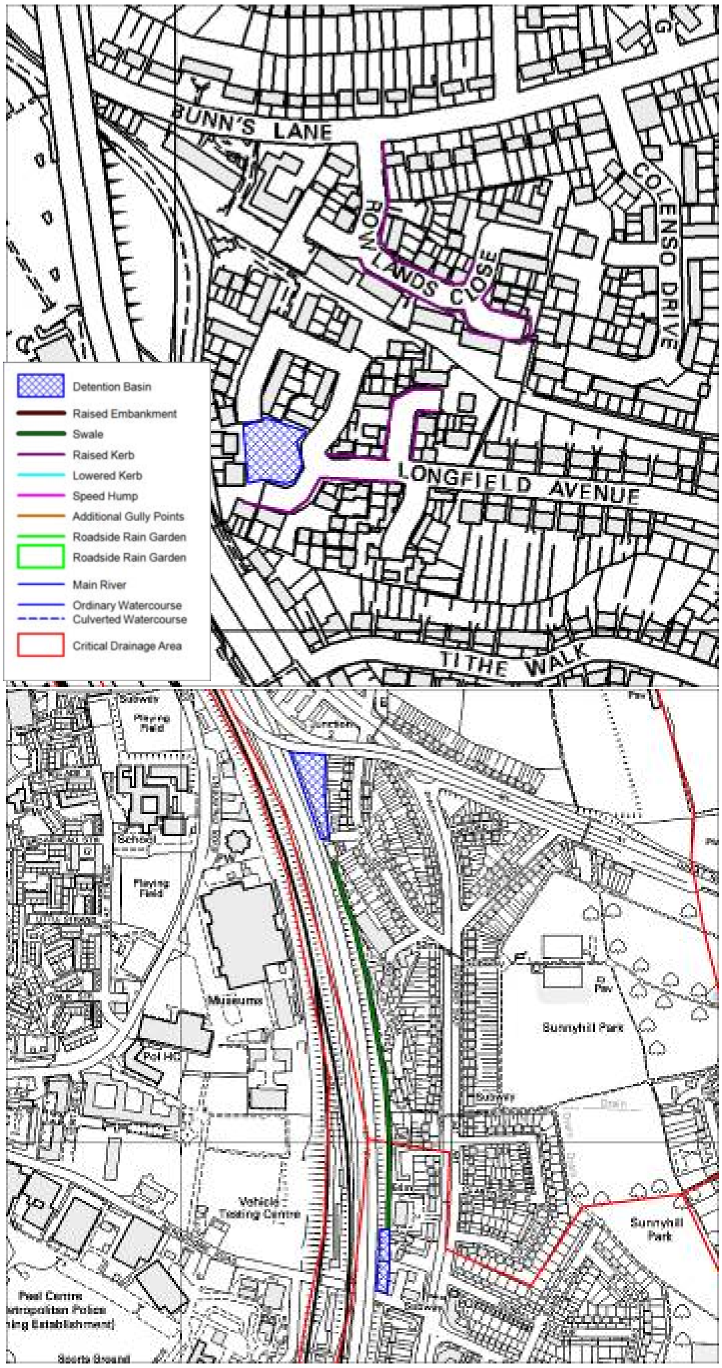


Figure E3-16 Sunnyhill Park Preferred Options

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Raised Kerbs, Swales	£251k – 500k

Table E3-16 Sunnyhill Park Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed detention basin and swale system adjacent to the M1 would help to significantly reduce surface water flood risk to the properties on Wheatley Close. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.50 Victoria Road – Group2_017

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. There is flooding predicted along Victoria Road and adjoining residential streets.

There are approximately 152 non-deprived residential properties at risk of surface water flooding within this CDA. No non-deprived properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Installation of raised kerbs on Aprey Gardens, First Avenue, Victoria Road and Albert Road will help to divert flow away from properties and contain it within the roadway. Establishing roadside rain gardens along Hillview Gardens, Boyne Avenue and Kings Close will also help to reduce and slow surface water flows. Figure E3-17 below outlines the proposed locations of the combined preferred option for this CDA.

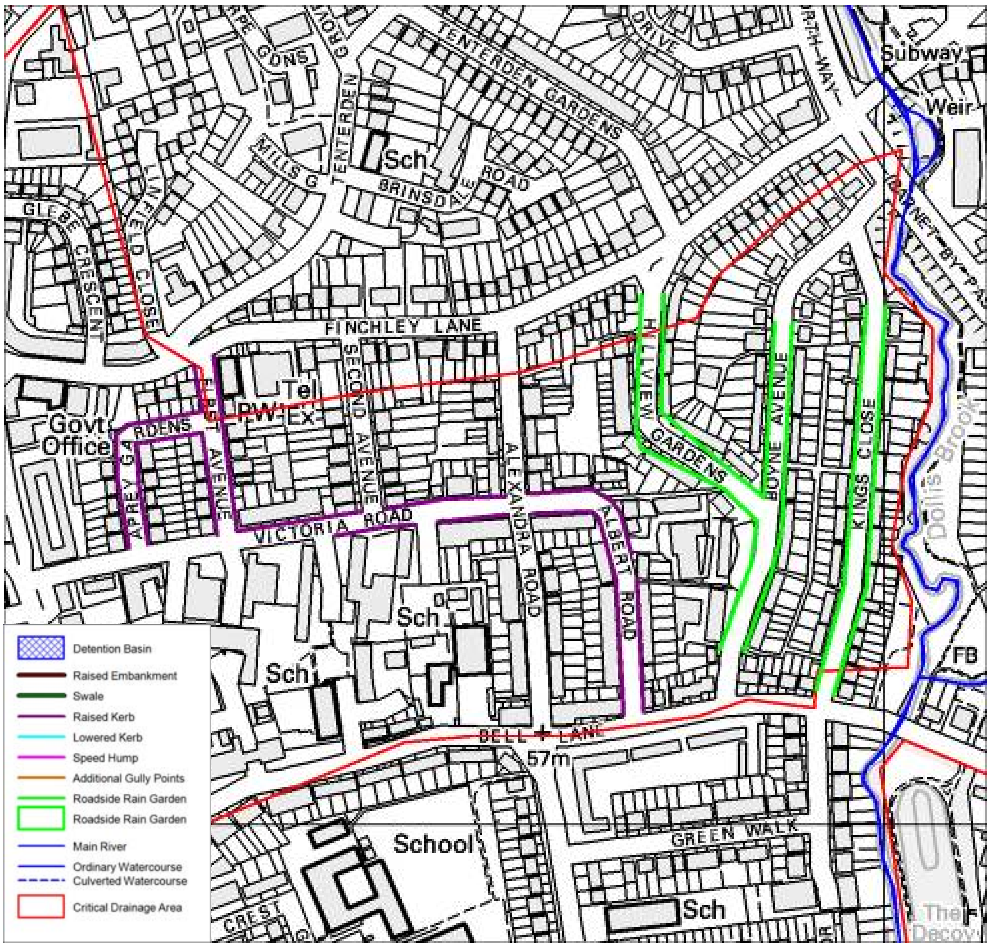


Figure E3-17 Victoria Road Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Garden, Raised Kerbs	< £25k

Table E3-17 Victoria Road Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed options will help to reduce the number of properties at risk of surface water flooding within this CDA. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.51 Church End Farm – Group2_033

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted on Aerodrome Road where it passes beneath the M1. There is also flooding predicted at the junction of Greyhound Hill and Watford Way and on the slip road from Colindeep Lane onto Watford Way.

There are approximately 134 non-deprived residential properties at risk of surface water flooding within this CDA. No non-deprived properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. The installation of four additional gully points along the Colindeep Lane slip road will help to prevent surface water accumulation in this topographic low point. There is an overlap in option resolution between Group2_032 and Group2_033, with a small Section of swale and a detention basin falling within Group2_033 to resolve surface water issues within Group2_032. The cost for these preferred options have been factored into Group2_032. Figure E3-18 below outlines the proposed locations of the combined preferred option for this CDA.

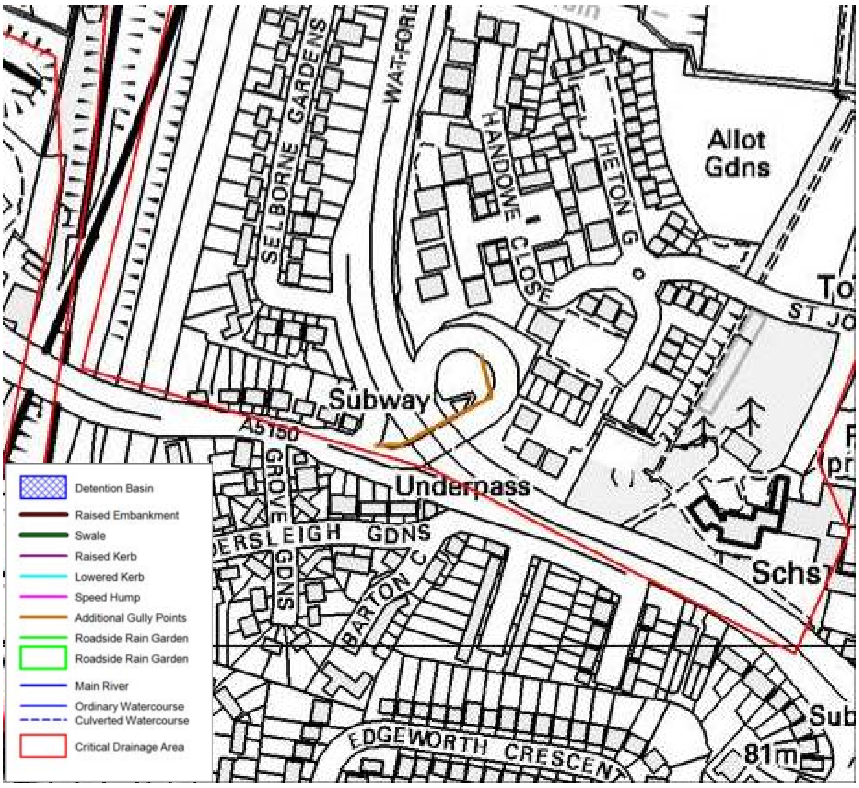


Figure E3-18 Church End Farm Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Additional Gully Points	< £25k

Table E3-18 Church End Farm Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The increase in gully entry points will improve drainage along the lower lying stretches of the Colindeep slip road. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.52 Lichfield Road – Group2_023

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted on Cricklewood Lane at Cricklewood Station, as surface water flows are unable to cross the railway. Surface water also flows down Lichfield Road and contributes to flooding at this location.

There are approximately 113 deprived residential properties at risk of surface water flooding within this CDA. There are approximately 58 deprived residential properties within the deep (>0.5m) surface water mapping which indicates significant risk to health and safety.

To mitigate the flood risk in this area, the following preferred option has been derived. Raising kerbs along Lichfield Road will contain flows and protect properties around the railway station. In addition, the installation of roadside rain gardens will help to reduce surface water runoff and ponding on Cricklewood Lane. Figure E3-19 below outlines the proposed locations of the combined preferred option for this CDA.

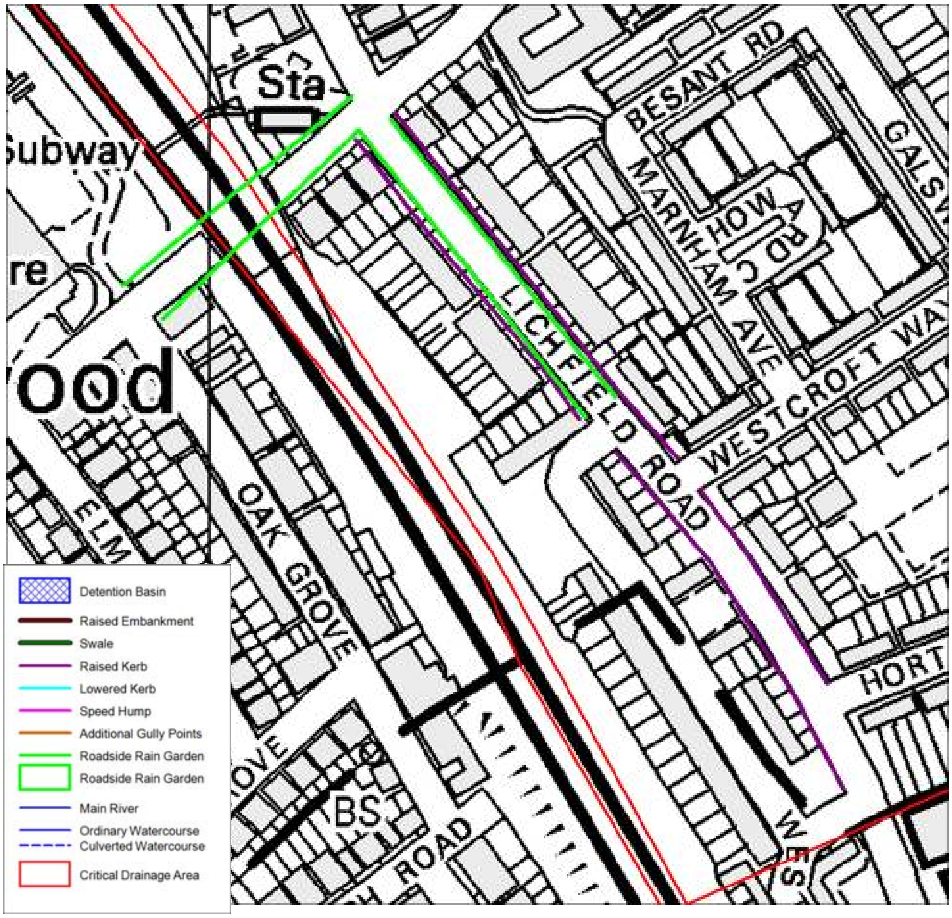


Figure E3-19 Lichfield Road Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Garden, Raised Kerb	< £25k

Table E3-19 Lichfield Road Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

Due to the complex nature of flooding in this area and the relative lack of opportunities in terms of appropriate green open spaces, the preferred option is one of mitigating the risks exhibited in Cricklewood and helping to reduce the impact as opposed to eliminating risk. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.53 Victoria Park – Group2_011

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. There is flooding predicted to properties behind Glebe Road, and surface water flow routes are shown along Woodlands Avenue and the properties on Queen's Avenue.

There are approximately 96 non-deprived residential properties at risk of surface water flooding within this CDA. No non-deprived properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Installation of roadside rain gardens at the end of each of the Avenues feeding onto Squires Lane will reduce the amount of surface water runoff and ponding. In addition, the construction of a small speed hump at the end of Dickens Avenue will help to protect properties along this narrow cul-de-sac. Figure E3-20 below outlines the proposed locations of the combined preferred option for this CDA.

Figure E3-20 Victoria Park Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Garden, Speed Humps	< £25k

Table E3-201 Victoria Park Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.54 Creighton Avenue – Group2_013

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. There is flooding predicted along Hereford and

Bedford Roads and adjacent properties. There is also flooding on the railway line in the south west of the CDA.

There are approximately 54 non-deprived residential properties at risk of surface water flooding within this CDA. No non-deprived properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. The installation of eight additional gully points along Hertford Road will improve the drainage along this road. This should help to reduce flood risk on the adjacent residential streets. Figure E3-21 below outlines the proposed locations of the combined preferred option for this CDA.

Figure E3-212 Creighton Avenue Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Additional Gully Points	< £25k

Table E3-21 Creighton Avenue Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.55 Brunswick Park – Group2_030

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted along the railway line and along the edge of Brunswick Park/Benfleet Way.

There are approximately 111 non-deprived residential properties at risk of surface water flooding within this CDA. No non-deprived properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. The creation of a swale system at Benfleet Way will help to accommodate surface water flows and prevent water from flooding adjacent areas. Figure E3-22 below outlines the proposed locations of the combined preferred option for this CDA.

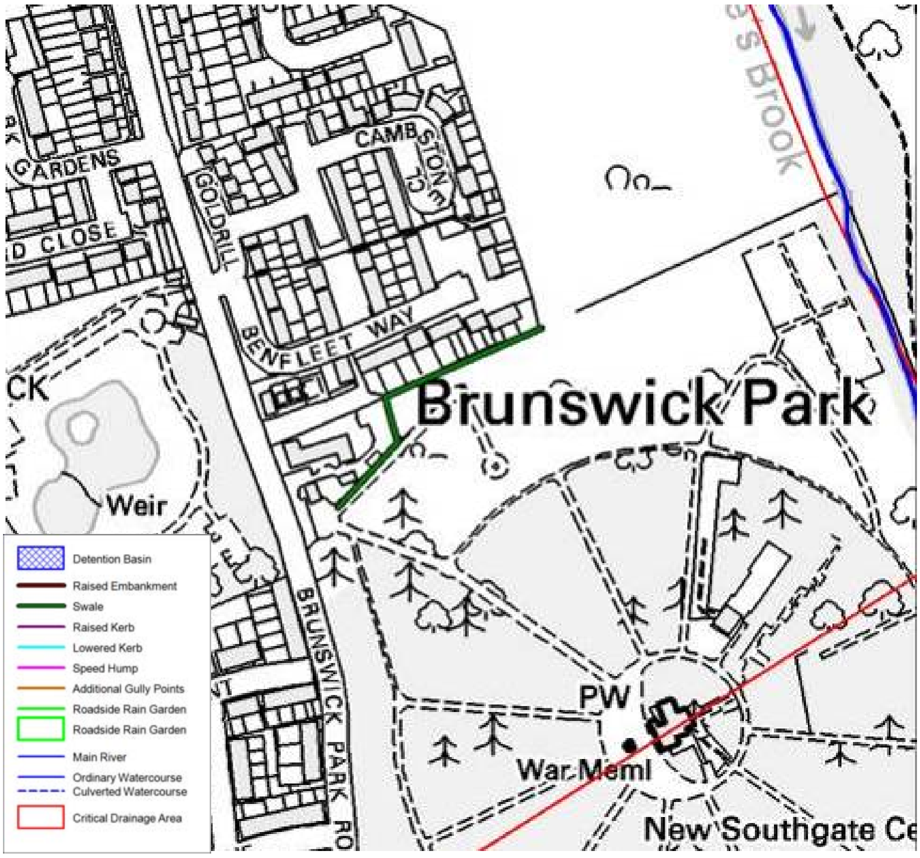


Figure E3-223 Brunswick Park Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Swales	< £25k

Table E3-22 Brunswick Park Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.56 Grahame Park – Group2_028

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted on Clayton Field and adjoining roads in the north of the CDA. There are also smaller, isolated areas of flooding on roads off Great Strand.

There are approximately 51 deprived and 43 non-deprived residential properties at risk of surface water flooding within this CDA. No properties are shown to fall within the deep (>0.5m) surface water mapping.

As development is currently underway in this area, no new options have been developed as part of this SWMP. The Colindale SWMP assessed the associated flood risk with the regeneration planned as part of the Colindale AAP. Options for reducing surface water flood risk were assessed and costed within this report.

1.7.57 Blundell Road – Group2_027

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted at properties on Blundell Road, South Road and Angus Gardens.

There are approximately 34 deprived and 98 non-deprived residential properties at risk of surface water flooding within this CDA. No properties are shown to fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Installation of roadside rain gardens on Blundell Road and Angus Gardens will help to slow overland flows through the CDA. In conjunction with this measure, kerb raising would be beneficial in directing flows and protecting properties. Figure E3-23 below outlines the proposed locations of the combined preferred option for this CDA.

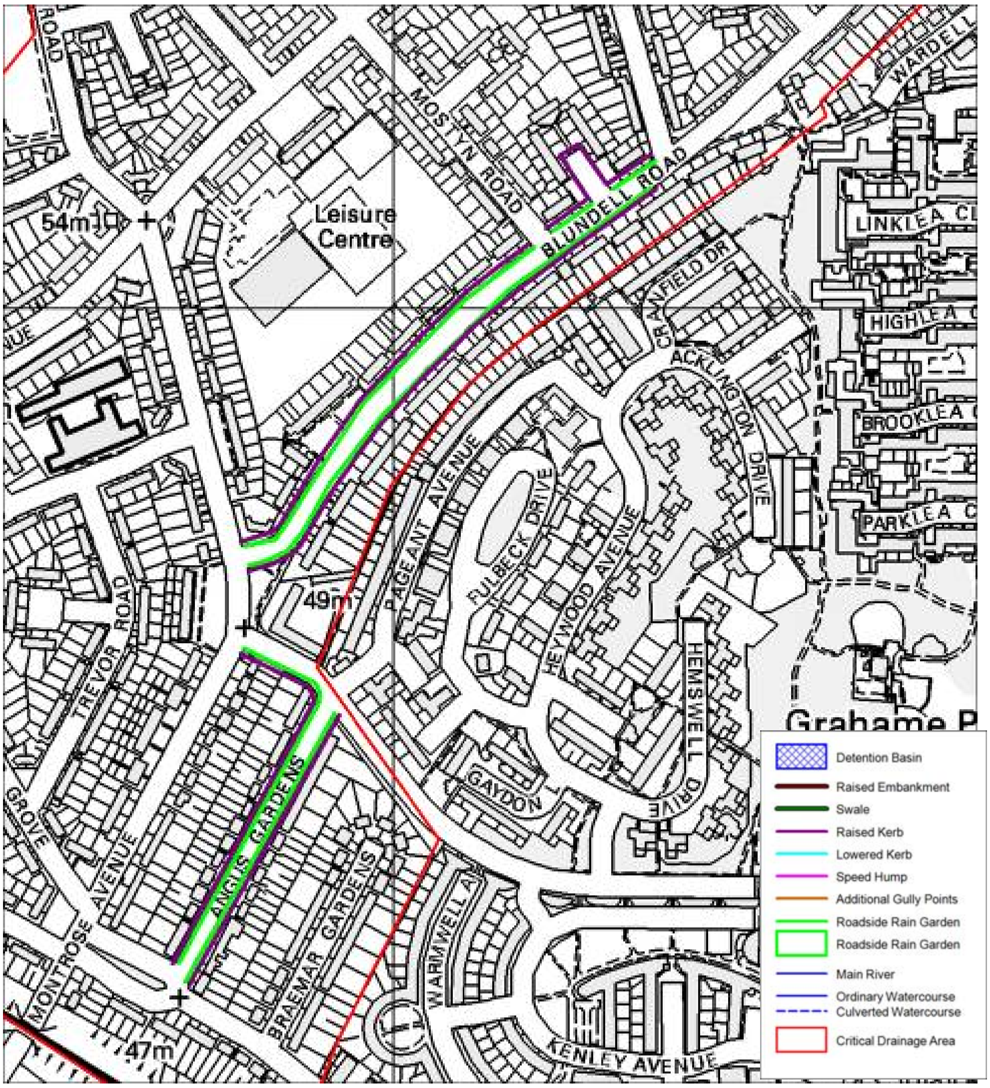


Figure E3-23 Blundell Road Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Gardens, Raised Kerbs	< £25k

Table E3-23 Blundell Road Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.58 Mill Hill – Group2_025

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. There is a surface water flow route through the centre of this CDA, the outlet of which is restricted by the disused railway line to the south. This causes flooding to adjacent properties.

There are approximately 49 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, six properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. The creation of roadside rain gardens on Derwent Avenue, Hale Drive, Delamere Gardens and Downhurst Avenue will slow overland flows through the CDA. In conjunction with this measure, some kerb raising at Hale Drive would be beneficial in directing flows and protecting properties. Figure E3-24 below outlines the proposed locations of the combined preferred option for this CDA.

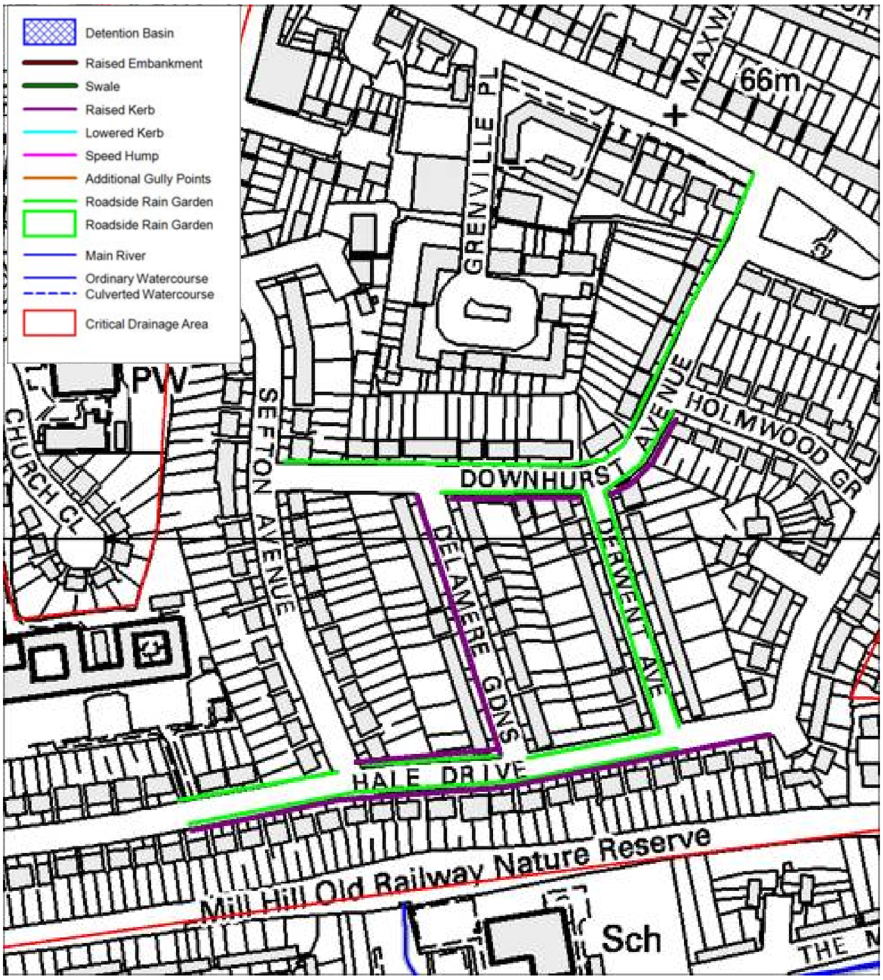


Figure E3-24 Mill Hill Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Gardens, Raised Kerbs	< £25k

Table E3-24 Mill Hill Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.59 Westchester Drive – Group2_016

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted to properties along Holders Hill Avenue and to properties on Downage.

There are approximately 86 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, seven properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Kerb raising on Garrick Place, Holders Hill Road and Holders Hill Avenue will assist in containing flows within the roadway to protect properties. In addition, the creation of roadside rain gardens on Downage will help to attenuate flows through the catchment. Figure E3-25 below outlines the proposed locations of the combined preferred option for this CDA.

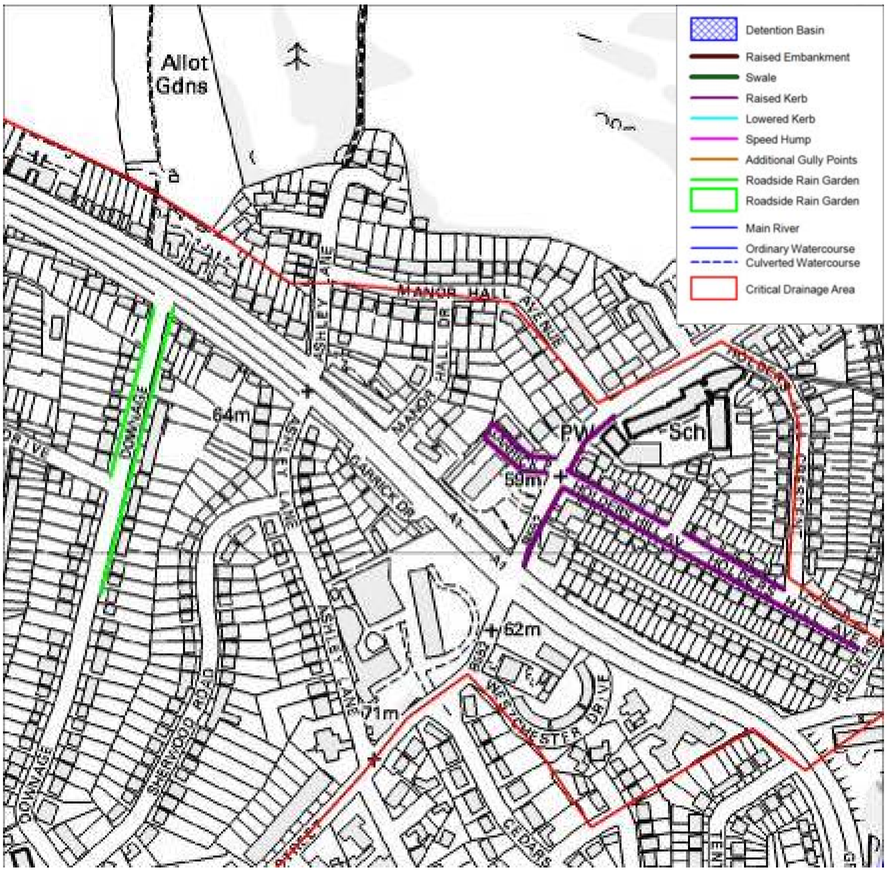


Figure E3-25 Westchester Drive Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Gardens, Raised Kerbs	< £25k

Table E3-25 Westchester Drive Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

This proposed option will help to contain surface water runoff within the road carriageways and to reduce localised surface water ponding. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.60 Ducks Island – Group2_003

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. There is a predicted overland flow route along Chesterfield and Alan Drives towards the Dollis Brook. Flooding is also predicted around Barnet Hospital.

There are approximately 264 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, only one property falls within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Kerb raising at Chesterfield, Mays Lane and Connaught Roads will help to contain flows within the carriageway and protect properties. In addition, kerb lowering to the south of Connaught Road will allow surface water runoff to enter the Dollis Brook. Figure E3-26 below outlines the proposed locations of the combined preferred option for this CDA.

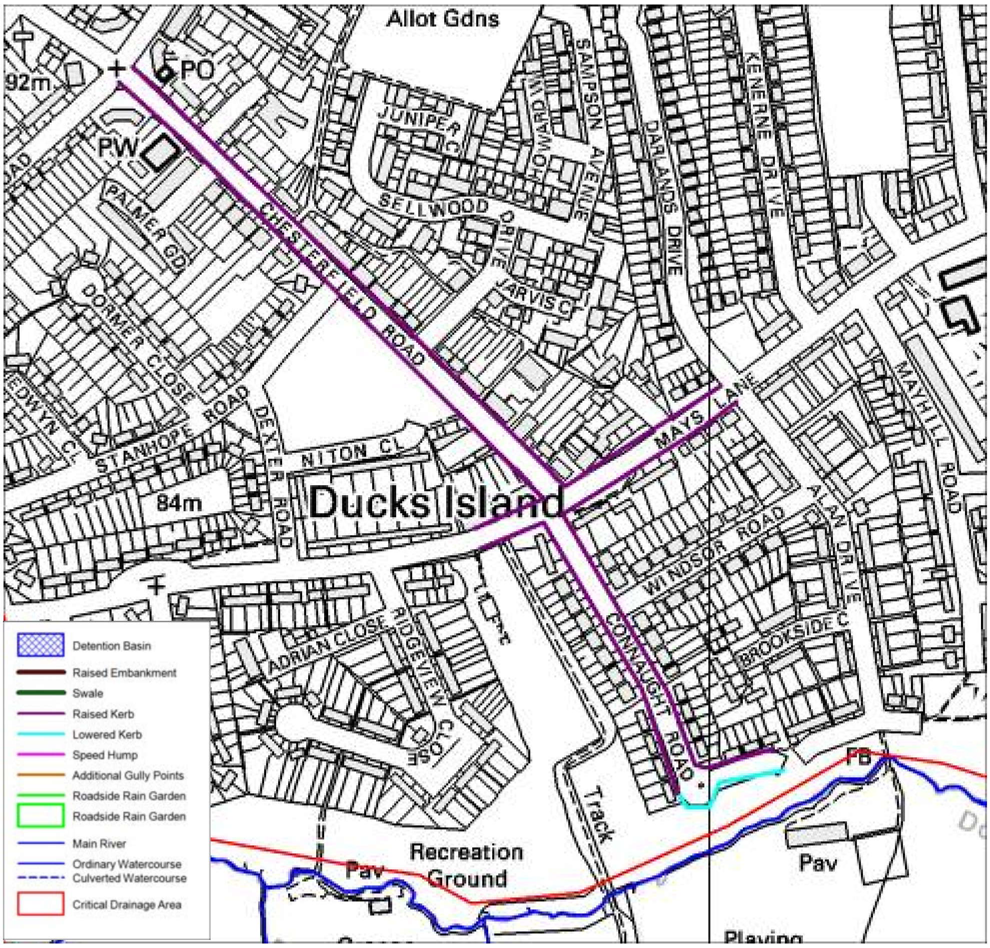


Figure E3-26 Ducks Island Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Raised Kerbs	< £25k

Table E3-26 Ducks Island Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed option will help to prevent shallow surface water runoff from entering properties within this CDA. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding. Further investigation into the potential for implementing source control measures in this area would be beneficial. Source control measures would help to minimise the risk posed to property in this area.

Barnet Hospital is shown to be at risk, however, there are no clearly defined flow paths affecting the hospital and as such the localised topography appears to be the issue. The model results are patchy with a number of non-contiguous flooded areas around this site. No options have been derived for this area but actions to raise awareness at the hospital site will be made in this SWMP Action Plan.

1.7.61 Pricklers Hill – Group2_006

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Deeper flooding is predicted at properties on Hillier Close. There is also some flooding to properties at Greenhill Park.

There are approximately 54 non-deprived residential properties at risk of surface water flooding within this CDA. Of these, six properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Raising kerbs along Cherry Hill and Hillier Close will contain flows within the carriageway, protecting properties. Figure E3-27 below outlines the proposed locations of the combined preferred option for this CDA.

Figure E3-27 Pricklers Hill Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Raised Kerbs	< £25k

Table E3-27 Pricklers Hill Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed raised kerbs would help to contain localised surface water ponding on Cherry Hill and Hilliers Close. This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

Further investigation should be made into the linear asset beneath the railway line to assess its condition and to ensure that an appropriate maintenance regime is in place.

1.7.62 Brent Terrace – Group2_022

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Deeper flooding is predicted along Brent Terrace.

There are approximately 36 deprived and 20 non-deprived residential properties at risk of surface water flooding within this CDA.

To mitigate the flood risk in this area, the following preferred option has been derived. Raising kerbs along Brent Terrace will help to contain flows within the highway carriageway, preventing flooding of property and infrastructure. Figure E3-28 below outlines the proposed locations of the combined preferred option for this CDA

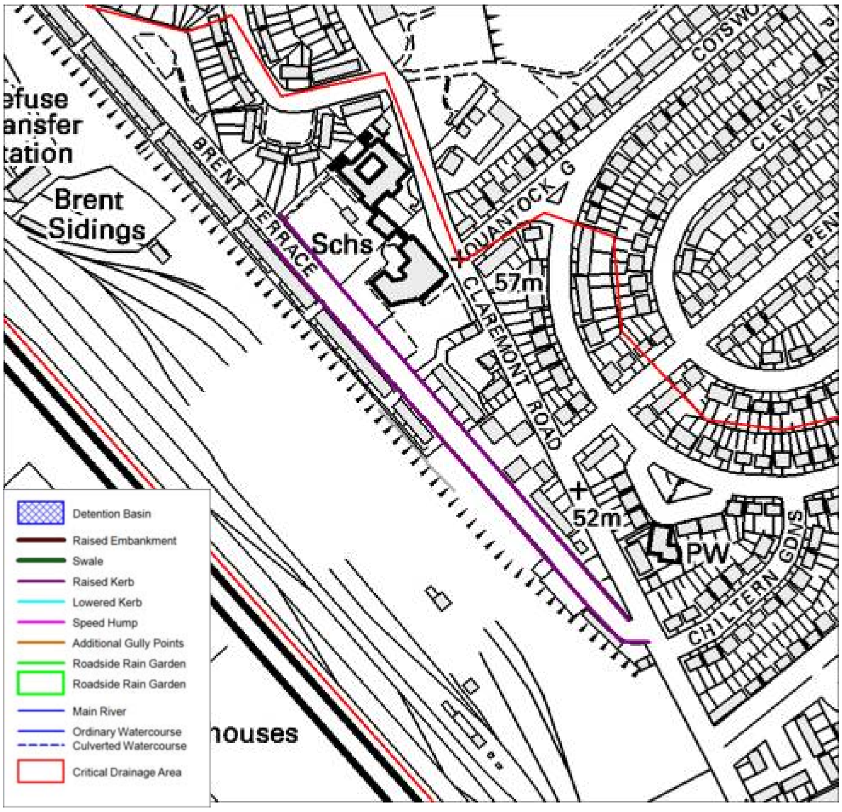


Figure E3-28 Brent Terrace Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Raised Kerbs	< £25k

Table E3-28 Brent Terrace Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

This option will not completely eliminate the risk posed to property but it should mitigate the risks and help reduce the deeper areas of ponding.

1.7.63 Edgware Station – Group2_024

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted on the railway lines around Edgware Station and the adjacent depot.

There are no residential properties at risk of surface water flooding within this CDA. To mitigate the flood risk in this area, the following preferred option has been derived. The use of kerb raising will assist in directing and controlling overland flow paths around the station. In addition, the installation of roadside rain gardens along Station Road would help to reduce the amount of overland flow in this location. Figure E3-29 below outlines the proposed locations of the combined preferred option for this CDA.

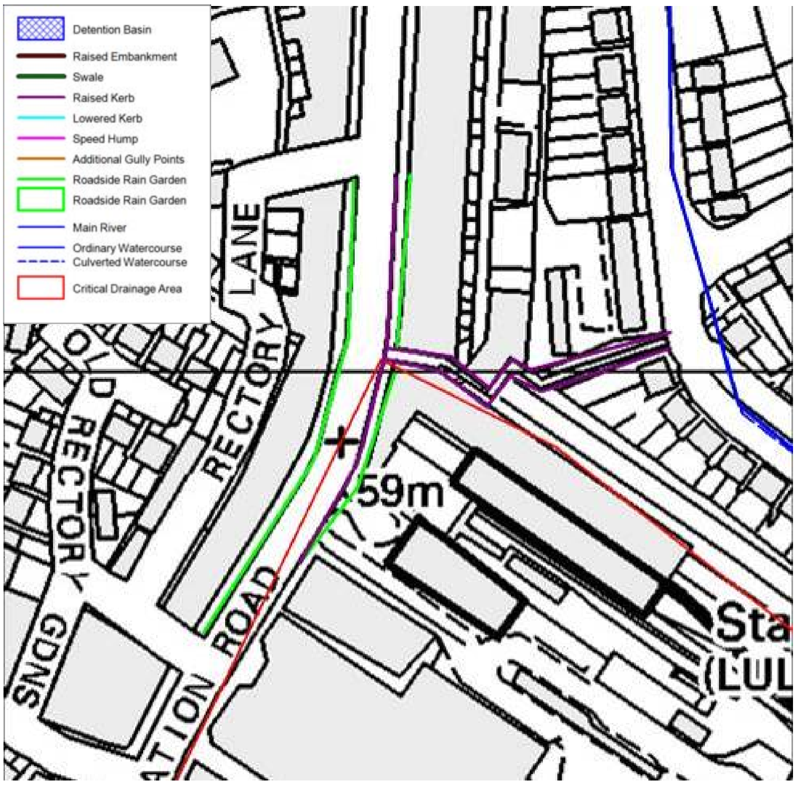


Figure E3-29 Edgware Station Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Roadside Rain Garden, Raised Kerbs	< £25k

Table E3-29 Edgware Station Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

This option will not completely eliminate the risk posed to property and infrastructure but it should mitigate the risks across the area and help to reduce the deeper areas of ponding.

1.7.64 Scratchwood – Group2_001

The Drain London mapping identified that the main line rail link into London from the North-West is at risk. This area of risk has been discussed in Section E1.

The main source of flooding in this area is surface water runoff from the field drain to the west. To prevent overland flow from these two sources reaching the railway cutting a continuous raised embankment around the railway line in this location has been proposed. Figure E3-30 below outlines the proposed locations of the combined preferred option for this CDA.

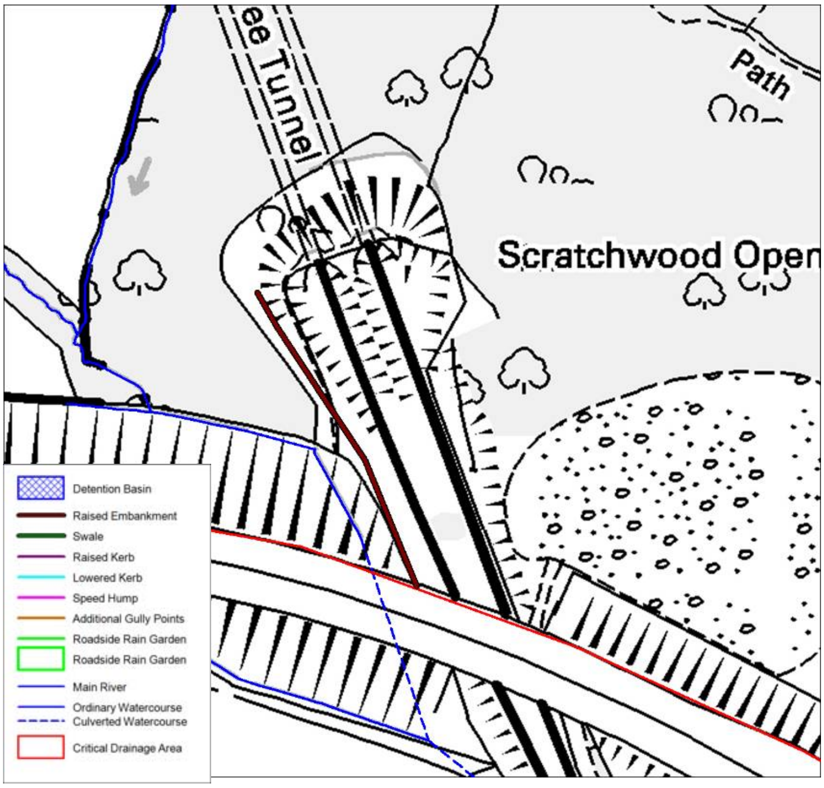


Figure E3-30 Scratchwood Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Raised Embankment	£51k – 100k

Table E3-30 Scratchwood Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

The proposed embankment will help to prevent runoff from interacting with the railway line in this location. This option will completely eliminate the risk posed to the infrastructure. Smaller scale bunds may be required to the east of the railway line, however, the 1 in 100 year rainfall event mapping does not indicate a clear flow path in this location.

1.7.65 Arkley – Group2_002

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted in open land and through Chesterfield Farm/Vale Farm and Cottage Farm.

There are 34 non-deprived residential properties at risk of surface water flooding within this CDA. No non-deprived properties fall within the deep (>0.5m) surface water mapping.

To mitigate the flood risk in this area, the following preferred option has been derived. Construction of a combination of swale and detention basin on open space north of the farms will assist in attenuating runoff from the rural area. Figure E3-31 below outlines the proposed locations of the combined preferred option for this CDA.

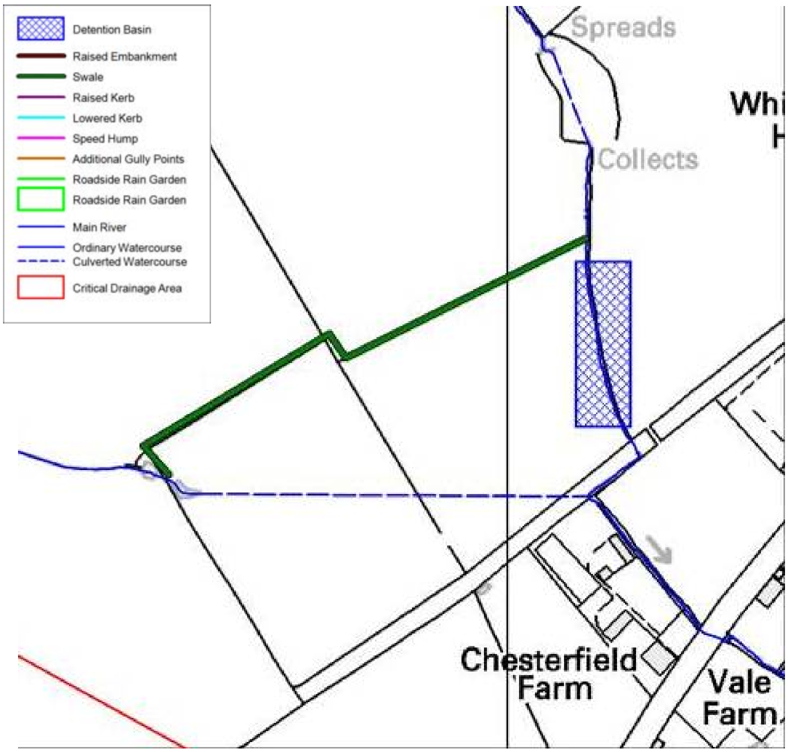


Figure E3-31 Arkley Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Detention Basin, Swales	£101k – 250k

Table E3-31 Arkley Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy. The proposed detention basins and swales would help to reduce localised surface water ponding within this CDA.

Further investigation into the affect an online storage area in this location would have on 'normal' flow would be required to ensure that it does not adversely impact the watercourse or cause issues in the residential area upstream.

1.7.66 Claremont Industrial Estate – Group2_021

The Drain London mapping identified several areas of significant risk within this CDA. These areas of risk have been discussed in Section E1. Flooding is predicted along Brent Terrace and on the edge of Claremont Way Industrial Estate.

There are no residential properties at risk of surface water flooding within this CDA. However there are two waste transfer stations and a cement works. To mitigate the flood risk in this area, the following preferred option has been derived. Kerb raising along both sides of Brent Terrace will help to contain surface water runoff within the road carriageway. Figure E3-32 below outlines the proposed locations of the combined preferred option for this CDA.

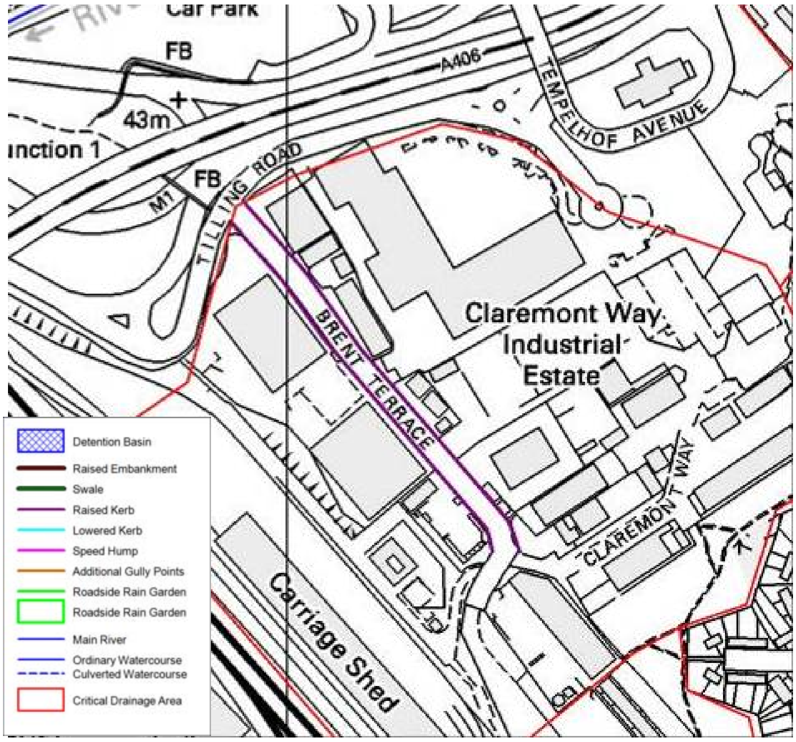


Figure E3-32 Claremont Industrial Estate Preferred Option Locations

The estimated capital expenditure of this option is summarised below:

Proposed Measures	Estimated Cost
Raised Kerb	< £25k

Table E3-32 Claremont Industrial Estate Preferred Option Costs

The costs outlined above are an approximate estimation for illustration purposes. A more detailed study of this particular area would be required to determine the most effective flood mitigation strategy.

Appendix F – Peer Review

Appendix G – Spatial Planner Information Pack

Background

PPS 25 sets out national planning guidance for development in relation to flood risk. It takes a risk based approach and categorises land uses into different vulnerabilities, which are appropriate to different flood zones.

PPS 25 applies to all forms of flood risk; however, surface water, groundwater and ordinary watercourse flood risks are generally less well understood than fluvial or coastal flood risk. In part this is due to the much faster response times of surface water flooding, a perception that the impacts are relatively minor and the highly variable nature of influences, e.g. storm patterns, local drainage blockages, interactions with the sewer system.

However, climate change models are predicting more frequent heavy storms and there is emerging evidence that this is already happening. It is also clear from the flooding that occurred in several parts of England in summer 2007 that surface water flooding can have major impacts. In the heavily urbanised area of London, the risks are significant and it is important that appropriate consideration is given to these risks when new development is proposed.

The planning system is a key tool in reducing flood risk, and with this additional information, this can apply to the surface water risk as well as fluvial and tidal risk.

Since April 2011, London Boroughs have been given the roles of Lead Local Flood Authorities (LLFAs) by the Flood and Water Management Act 2010. This means that each borough has new duties. The Planning Department has an important role to play in delivering these new duties and must ensure that it forms part of authority wide co-ordination of the LLFA role.

Whilst this document is titled a SWMP, it also identifies flood risk at ordinary watercourses and has been adapted to include consideration of groundwater flood risk through the identification of a map showing “Increased Potential for Elevated Groundwater (IPEG)”.

The Greater London Authority will examine the 33 SWMPs across London to update the Regional Flood Risk Appraisal during 2012.

Using the SWMP to update the borough SFRA

Most borough SFRAs have little or no historic analysis of surface water, groundwater and ordinary watercourse flood risk. The North London SFRA analysed flood risk from all sources, however, the report does not identify any specific events associated with non-Main River sources as there were very few historic records available. The report did use existing datasets to identify areas at risk of flooding from non-Main River sources.

The mapping within this SWMP (Figures D-9 – D18 in Appendix D) shows some areas that are vulnerable to extensive deep accumulations of water (>0.5m), these areas have a high certainty of flooding during extreme storms and the damage occurring is likely to be significant. The mapping also shows some small areas of potentially deep (>0.5m), these areas may have particular risks associated with them, but may also occur due to irregularities in mapping and modelling. The mapping also shows areas shallower flooding (<0.5m), some isolated and some more extensive flooding. Maps show general flow directions and approximate velocities (in the form of ‘hazard’ maps) as even relatively shallow water flowing at high velocities can be a threat to life and can cause damage.

For most boroughs the production of this SWMP will be a significant addition of new/updated data. Therefore, in due course, this should trigger a review of the SFRA. The SFRA should consider these risks in the following ways:

- Large areas of deep (>0.5m) flooding should be shown as Local Flood Risk Zones, unless there is evidence to suggest that these risks have been mitigated, for example by high capacity drainage or pumping infrastructure.
- Small, isolated areas of deep (>0.5m) flooding should be investigated to determine how likely they are to be at flood risk but do not need to be shown if there is no significant risk.
- Large areas of shallower flooding should be identified as Local Flood Risk Zones if they pose a significant risk, but do not need to be shown if the risks are relatively minor.
- Smaller isolated areas of shallower flooding should generally not be identified as Local Flood Risk Zones, unless there is a particular significant risk associated with that area, as it must be expected that most areas will be affected to some extent by rainwater.
- Routes of fast flowing water may be considered as Local Flood Risk Zones if they pose a significant risk.
- Areas of Increased Potential for Elevated Groundwater, should be shown where they are likely to pose a significant risk of flooding or where they are likely to affect the nature of future development, especially for the design and use of sub-surface spaces.

Identifying an area as a Local Flood Risk Zone, should mean that it is then treated in a similar way to Environment Agency Flood Zone 3, namely that a Flood Risk Assessment is required and measures should be taken to reduce the likelihood and impact of any flooding.

Where a Critical Drainage Area contributes significant amounts of surface water to a Local Flood Risk Zone, the SFRA should identify this and suggest strict application of sustainable drainage measures in line with the London Plan Sustainable Drainage Hierarchy.

Using the SWMP to update policies in Development Plan Documents

Ideally the review of the borough SFRA should be a pre-cursor to any significant change to the Core Strategy and development control policies. Therefore, reference to the SFRA should automatically update the approach to local flood risks. Where the SFRA has not been updated, the review of Development Plan Documents should consider the same steps outlined above for the SFRA review.

Using the SWMP to influence major areas of redevelopment

Where major development areas are proposed, either in the London Plan or within the Core Strategy DPD, these should be examined for:

- Local Flood Risk Zones that affects the area
- Increased Potential for Elevated Groundwater
- Contribution of run-off to Local Flood Risk Zones beyond the actual redevelopment area

Given the large scale of major developments, it is unlikely that the Local Flood Risk would prevent redevelopment taking place, but it may affect the location, uses, design and resilience of the proposals. Therefore, a Flood Risk Assessment needs to be undertaken and it should consider:

- the location of different types of land use within the site(s)
- the layout and design of buildings and spaces to take account of flood risk, for example by dedicating particular flow routes or flood storage areas
- measures to reduce the impact of any flood, through flood resistance/resilience measures/materials
- incorporating sustainable drainage and rainwater storage to reduce run-off to adjacent areas
- linkages or joint approaches for groups of sites, possibly including those in surrounding areas

Using the SWMP to influence specific development proposals

Where development is proposed in an area covered wholly or partially by a Local Flood Risk Zone, this should trigger a Flood Risk Assessment, as already required under PPS25.

Whilst some small scale developments may not be appropriate in high risk areas, in most cases it will be a matter of ensuring that the Flood Risk Assessment considers those items listed under major developments above and also considers some or all of the following site specific issues:

- Are the flow paths and areas of ponding correct, and will these be altered by the proposed development?
- Has the site been planned sequentially to keep major surface water flow paths clear?
- Has exceedance of the site's drainage capacity been adequately dealt with? Where will exceedance flows run off the site?
- Could there be benefits to existing properties at risk downstream of the site if additional storage could be provided on the site?
- In the event of surface water flooding to the site, have safe access to/egress from the site been adequately considered.
- Have the site levels been altered, or will they be altered during development? Consider how this will impact surface water flood risk on the site and to adjacent areas.
- Have inter-dependencies between utilities and the development been considered (for example, the electricity supply for building lifts or water pumps)?

Specific Locational Considerations

Within the London Borough of Barnet, the following major redevelopment areas have already been identified.

Opportunity Area	Relevant Boroughs
Colindale/Burnt Oak	Barnet
Cricklewood/Brent Cross	Barnet Brent
Mill Hill East (intensification area)	Barnet

Table E G-1 Summary of major redevelopment areas in LBB

Mapping Checklist

The Table E below indicates the SWMP maps which are of potential use to spatial planning, and indicates which maps may be suitable for replacing existing SFRA maps:

Issue	SWMP maps	Consider replacing existing SFRA maps?
Surface water flood risk	D-9 – D-18 (Appendix D)	Yes – more detailed methodology to that used for the SFRA.
Increased potential for elevated groundwater	Figure E3-3	Yes – more detailed methodology to that used for the SFRA.
Infiltration SUDs suitability map	D.7 (Appendix D)	Yes – provides a consistent initial infiltration SUDs screening process for all London Boroughs, but does not replace on-site assessments.
Recorded incidents of sewer flooding	D.5 (Appendix D)	Yes – similar method (based on postcode sector) but brings the records up-to-date to June 2010.

Table E G-2 SWMP maps of potential use to spatial planners

Appendix H – Resilience Forum and Emergency Planner Information Pack

Background

Presently, surface water flooding is less well understood than other sources of flooding, partly because surface water events tend to happen and disperse quickly meaning that there is a lack of accurate and consistent records and partly because they are not tied to readily identifiable features such as rivers or the sea. Therefore, this SWMP offers an opportunity to communicate up to date information about locations at risk from surface water flooding to those with an interest. Responses in an emergency will be informed by known surface water flooding locations, especially near public buildings and major transport routes and important infrastructure.

The purpose of this information pack is to assist in communicating surface water flood risk to the London Local Resilience Forum, and Emergency Planners within the London Resilience Partnership to enable them to ensure that incident management plans are updated based on the improved understanding of surface water flooding. SWMP mapping outputs and knowledge will be used to:

- Update Community Risk Registers (CRR);
- Update Multi-Agency Flood Plans (MAFP).

This pack is presented as a Frequently Asked Questions (FAQ) document and contains information that addresses the following points:

1 How can SWMP outputs improve Community Risk Registers?

2 How can SWMP outputs improve Multi-Agency Flood Planning?

3 How do SWMP outputs compliment the Flood Forecasting Centre's Extreme Rainfall Alert (ERA)?

4 Examples of Good Practice

In updating Multi-Agency Flood Plans, as well as the neighbouring boroughs, LBB also have a responsibility to partner with other key stakeholders and risk management authorities, who share the responsibility for decisions and actions. Ideally, the informal relationships established within the context of the Drain London programme should be formalised to ensure clear lines of communication and continued mutual cooperation through the development of a Memorandum of Understanding. This should include appropriate aspects for Surface Water Flood Risk Management.

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, Brent, Ealing, Hillingdon and Hounslow. The following list outlines the purpose of setting up this Group:

- To develop a collective understanding of flood risk across North West London,
- to discuss and help Boroughs with the LLFA requirements,
- to share best practice and develop resources within the North West,
- to provide the framework for management of flooding across the area and to identify how to communicate risks and responsibilities to the communities within the area – promoting the concepts of personal responsibility and the 'Big Society',

- to potentially develop a common approach to IT, GIS Systems and the management of asset registers across the North West,
- to identify opportunities for resource sharing (for example to potentially assist with the emerging requirements (over 2011/12) for the format and scope of the SUDS Approval Body),
- to track and help to reduce the risks and consequences across the catchment, and
- to identify annually, a short list of schemes, agreed by the Partnership to submit to the Regional Flood Defence Committee (RFDC) seeking EA levy monies to assist delivery (individual Boroughs can also pursue funding requests for other projects as part of their LLFA duties).

1. How can SWMP outputs improve Community Risk Registers?

Community Risk Registers (CRR) are prepared by Category 1 responders and are required as part of the Civil Contingencies Act (CCA) 2004. The CCA requires that Category 1 responders undertake risk assessments and maintain these risks in a CCR. In this context risks are defined as events which could result in major consequences, and they include risks from flooding.

Outputs from SWMP can be used to reduce the uncertainties associated with assessing the likelihood and impact of surface water flooding (see Community Risk Register HL18 for more information on current risk assessment). SWMP presents an opportunity for the identification of vulnerable sites and populations which may be at increased risk, and allows for risk-based prevention or mitigation actions to be taken.

2. How can SWMP outputs improve Multi-Agency Flood Plans?

Multi-Agency Flood Plans (MAFP) are specific emergency plans which should be developed by LRFs, to deliver a coordinated plan to respond to flood incidents. MAFPs recognise the need for specific flooding emergency plans, due to the complex nature of flooding and the consequences that arise. Guidance on producing a MAFP is available at http://www.ukresilience.gov.uk/media/ukresilience/assets/flooding_ma_planning_guidance_0208.pdf.

Outputs from SWMPs should inform the development of, or update, the MAFP.

The SWMP surface water mapping should be used as an initial indicator of a possible risk. A Flood Risk Assessment at a site shown as being at risk of surface water flooding should consider:

- Impacts on flood receptor sites
- The degree of receptor vulnerability
- In the event of surface water flooding to the site, has safe access to/egress from the site been adequately considered?

The Table E below indicates the SWMP maps which are of potential use to emergency planning, and indicates which maps may be suitable for updating existing MAFP maps:

Issue	SWMP maps	Consider updating existing MAFP maps?
Surface water flood risk	D.9– D.18 (Appendix D)	Yes – more detailed methodology to that used for the MAFP.
Increased potential for elevated groundwater	3.3	Yes – more detailed methodology to that used for the MAFP.

Table E H-1 SWMP maps of potential use to emergency planners

3. How do SWMP outputs compliment the Flood Forecasting Centre's Extreme Rainfall Alert (ERA)?

In 2008 the Met Office and the Environment Agency set up the Flood Forecasting Centre to provide services to emergency and professional partners. The Flood Forecasting Centre provides an Extreme Rainfall Alert (ERA) service to Category 1 and Category 2 responders. The ERA is issued at county level and is used to forecast and warn for extreme rainfall that could lead to surface water flooding, particularly in urban areas. It is designed to help local response organisations manage the impact of flooding via two products:

Guidance – issued when there is a 10% or greater chance or extreme rainfall;

Alert – issued when there is a greater than 20% chance of extreme rainfall.

The ERA cannot provide site-specific real-time surface water flood forecast, but does offer a county level alert of impending rainfall. The alert is based on the probability of rainfall occurring, rather than being a definitive forecast.

Surface water flooding has very short lead times and is hard to predict in real time because local topography and drainage infrastructure affect the direction of runoff and location of flooding. However, the assessment carried out as part of this SWMP study has taken an important step towards the likely flow pathways and locations of ponding of surface water. Used in parallel with the ERA, this can be used to improve emergency planning and responses for surface water flooding events.

4. Examples of Good Practice for Emergency Planners

Ensure that a programme of engagement on flood risk awareness is initiated within the Borough. Meet with key corporate communications teams to agree an approach to social change, education and awareness raising in line with the needs of the Borough.

Build trust - Public and stakeholder trust in authorities through **long term, transparent engagement.**

- Ensure there are key messages in the that encourage attitude and behaviour change with the public. This will help to address misconceptions that flooding results from a failure on someone's part.
- Educate the public to help them better understand where responsibilities lie, changes they can make to their own lifestyles, and actions they can take to physically reduce personal flood risk.
- Encourage communities towards creating their own community action/response plans to support wider ownership of risk and responsibilities

- Consider holding face to face interviews with at -risk families and groups to better inform your Community Risk Register. This will help both you and them to better understand risk and plan to manage it.
- Establish a **common baseline for flood data** and information in line with EA requirements. Set up a Borough '**One-Stop Shop'** to enable efficient information consolidation and data sharing. This will support efficient planning and updating of the MAFP.
- **Develop a surface water flooding response plan with vulnerable receptors as external partners**. Vulnerable receptors could include hospitals, schools and care homes. Identify these through Emergency Planning and other relevant forums and build into stakeholder engagement. This will assist with prioritisation decisions. For example 'early warning' processes, appropriate measures, funding and resourcing.
- Link the actions from the SWMP directly to the **Flood Risk Management Strategy** for the Borough such that a programme of work is visible.
- Link with the Planning Department's **Strategic Flood Risk Assessment** (SRFA) to ensure that Emergency Planners are involved in land use decisions for new development.
- Create a key facts and 'what to do' section for surface water flooding in **emergency handbooks**. Provide easy- to- reach contact points, and regularly update your website
- Work with other agencies, such as the **Environment Agency flood alert/warning schemes**, in the interests of cost effectiveness and good communication - but still own the responsibility for your borough. Use others' information to reinforce your own process.

Appendix I – Action Plan

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