London Borough of Bromley Strategic Flood Risk Assessment

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Quality information

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Executive Summary

The National Planning Policy Framework (NPPF) and accompanying Technical Guidance emphasise the responsibility of Local Planning Authorities (LPAs) to ensure that flood risk is understood and managed effectively and sustainably throughout all stages of the planning process.

This Strategic Flood Risk Assessment (SFRA) aims to facilitate this process by identifying the spatial variation in flood risk across the London Borough of Bromley (LBB) thus allowing an area-wide comparison of future development sites with respect to flood risk considerations. There are several sources of flood risk across the Borough, including: fluvial, pluvial, groundwater, sewer and artificial. These are summarised below.

The western half of Bromley is within the Ravensbourne catchment whereas the eastern part is within the Darent and Cray catchment. Fluvial flooding is largely contained to the north of the Borough, in close proximity to the Beck, River Ravensbourne, Kyd Brook and the River Cray. There are several key tributaries associated with these watercourses, as well as a network of ordinary watercourses which all contribute to fluvial flood risk in the Borough.

The EA historic flood maps show severe flooding in the 1960s across the full extent of the River Ravensbourne and to a lesser extent on the River Cray. Flooding occurred in the 1970s along the River Cray north of St Mary's Cray; however no flooding was reported along the River Ravensbourne during this event even though, based on the 1960s River Cray extent, it was likely to be a more extreme event. Although there are no 'formal' flood defences in Bromley, the lack of flooding in the 1970s on the River Ravensbourne may be partially due to the concrete lining and straightening of channels which is believed to have occurred in the 1970s following publication of the Ravensbourne Improvement Act 1961[1]. Nonetheless, a source of fluvial flood risk still exists for much of the developed areas in the north of the Borough, as indicated in the Flood Zone maps.

Surface water flooding occurs when high intensity rainfall generates runoff which flows and ponds in low-lying areas. It is generally associated with intense rain, saturated soils and an insufficient drainage capacity of the surface water system. Surface water flooding is becoming an increasing issue due to urban sprawl (increased impermeable area) and climate change (greater rainfall intensity). The Bromley Surface Water Management Plan (SWMP) (2011) estimated a total of 1,510 properties at risk of surface water flooding to depths > 0.5 m. Developers and planners must consider the use of Sustainable Drainage Systems (SuDS) in development to mitigate this source of flood risk and minimise the impact of climate change. Priority should be given to the re-use of rainwater and utilisation of infiltration SuDS in line with the SuDS hierarchy as set out in Policy 5.13 of the London Plan. The British Geological Survey (BGS) have prepared mapping based on the underlying geology indicating the suitability of land for the incorporation of infiltration SuDS.

There is a risk of groundwater flooding in areas of the Borough where there are permeable sub-surface soils underlain by aquifer containing geological formations. Areas of Thanet Sands (north) and Chalk (south) have medium to high permeability and therefore support the movement of groundwater. This is where the majority of recorded groundwater flood incidents have occurred. The BGS have prepared mapping based on the underlying geology and aquifer locations indicating the susceptibility of land to groundwater flooding. This mapping should be utilised by developers and planners to ensure development in these areas carry out detailed ground investigation and consider the risk of groundwater flooding, particularly to basement development.

The majority of the Borough has separated foul and surface water sewer systems, as a result sewer flooding predominantly arises when surface water enters the foul system via misconnection resulting in surcharge of contaminated surface water. This is a problem throughout the Borough and in attempt to rectify this Thames Water has installed holding tanks in many of the most affected locations.

The final source of flood risk is from reservoirs. There are no designated reservoirs within the Borough boundary; however, this does not mean to say there is no risk. As shown by the EA Reservoir maps, the flood

[1] AECOM has been unable to locate a copy of this act to review as part of this assessment. Its implications for the Ravensbourne River have been based on anecdotal evidence from the Environment Agency and London Borough of Bromley staff.

extents for the South Norwood Lake (Croydon) and Knockholt Lake (Sevenoaks) show that should a failure of these reservoirs ocurr then parts of Bromley will be affected by flooding. However, the risk of failure is very low due to the rigorous safety and inspection regimes in place for all designated reservoirs.

The Functional Floodplain (Flood Zone 3b) in Bromley is land classified as having a 5% annual exceedance probability (AEP) (1 in 20 Year) of flooding. All of the Environment Agency designated 'Main Rivers' within the Borough have some extent of Functional Floodplain; however, due to the surrounding topography and riverside development the extent varies. The Pool River in Beckenham, Chaffinch Brook in Elmers End and the River Ravensbourne in Bromley Town contain some of the more extensive areas of Flood Zone 3b (Functional Floodplain).

A spatial planning solution to flood risk management should be sought wherever possible. The maps and supporting information presented in this SFRA are intended to inform and facilitate the decision making process by LBB with regards to the NPPF risk-based approach to planning. This is based upon determining compatibility of various types of development within each flood zone, subject to the application of the Sequential Test and Exception Test (when needed). Guidance to undertaking these processes is included within the report.

The SFRA provides an overview of the risk of flooding across LBB and assists in the development of policy formulation, strategic planning, development control and flood risk management. It is recommended that policy options are expanded to include greater emphasis on floodplain management to promote appropriate use of the floodplain and making space for water. Existing corridors of land along the river frontage should be safeguarded and opportunities taken to set back development to enable sustainable and cost effective flood risk management, including upgrading of river assets. Flood awareness and robust emergency planning and response will additionally be critical to sustainable ongoing flood risk management.

In the future, climate change is anticipated to have an impact on all sources of flood risk within the Borough. It is important that planning decisions recognise the potential risk that increased runoff poses to property and plan development accordingly so that future sustainability can be assured. The EA published updated climate change allowances in February 2016, the hydraulic models which define flood risk from the River Ravensbourne and River Cray networks are in the process of being updated by the EA to include these allowances.

At the time of preparing this SFRA, the modelling has been partially completed for the River Ravensbourne and as such the 25% and 35% allowances for climate change have been included within this report. In the absence of the 70% allowance for climate change for the River Ravensbourne, the 0.1% AEP (1 in 1,000 Year) event flood extent has been used as an approximation of the maximum anticipated increase in flood risk as a result of climate change. The Environment Agency should be contacted during the preparation of site-specific flood risk assessments within the 0.1% AEP flood extent to determine the status of the 70% climate change allowance modelling and for guidance on assessing the risk of flooding from the River Ravensbourne over the duration of any proposed development.

The EA are currently in the initial stages of commissioning an update of the River Cray model as part of a wider model update package. To assess the change in fluvial flood risk as a result of climate change, the EA's 25%, 35% and 70% allowances have been run through the existing River Cray model and the results included within this assessment. The Environment Agency should be contacted during the preparation of a site-specific flood risk assessment within the 1% AEP with a 70% allowance for climate change event to ascertain the status of the planned updated modelling and for guidance on assessing the risk of flooding from the River Cray over the duration of any proposed development.

The report additionally contains specific recommendations for both the Borough and local developers, for effectively managing and mitigating flood risk, including guidance on the requirements for site specific Flood Risk Assessments and the implementation of Sustainable Drainage Systems.

The maps and supporting information presented in this SFRA are intended to inform and facilitate the decision making process by LBB with regards to the NPPF risk-based approach to planning. This is based upon

determining compatibility of various types of development within each Flood Zone, subject to the application of the Sequential Test and Exception Test (when needed).

As part of the Level 2 assessment supporting this SFRA, a high level assessment has been undertaken to determine structures within the Borough that could be classified as informal flood defences by the EA and be added to those already included in its Asset Information Management System (AIMS). Additionally, potential locations where the functional floodplain within the Borough could be extended or its functionality improved have been identified and assessed. Recommendations have been made for further work to explore these locations potential to improve the function floodplain within the Borough and reduce the risk of flooding from its rivers.

The findings of the SFRA have additionally been used to undertake an assessment of each of the allocated development sites across the Borough as part of its emerging Local Plan.

Contents

Abbreviations

Acronym	Definition
AEP	Annual Exceedance Probability
AIMS	Asset Information Management System
BGS	British Geological Survey
CDA	Critical Drainage Area
CFMP	Catchment Flood Management Plan
EA	Environment Agency
FCERM	Flood and Coastal Erosion Risk Management
FWMA	Flood and Water Management Act
FRA	Flood Risk Assessment
FWD	Flood Warnings Direct
GIS	Geographical Information Systems
LBB	The London Borough of Bromley
LFRMS	Local Flood Risk Management Strategy
LFRZ	Local Flood Risk Zone
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
m AOD	Metres Above Ordnance Datum. Elevations use Ordnance Datum, Newlyn
NPPF	National Planning Policy Framework
PFRA	Preliminary Flood Risk Assessment
RBMP	River Basin Management Plan
RBD	River Basin District
RFRA	Regional Flood Risk Appraisal
SFRA	Strategic Flood Risk Assessment
SoP	Standard of Protection
SPG	Supplementary Planning Guidance
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
TE2100	Thames Estuary 2100

Glossary

Term	Definition
Annual Exceedance Probability (AEP)	In flood risk terms, the AEP represents the probability of a particular return period event occurring in any given year. (e.g. 1 in 100 year return period event = 1% AEP – there is a 1% chance every year that this event will take place).
Aquifer	A source of groundwater comprising water-bearing rock, sand or gravel capable of yielding significant quantities of water.
Areas Benefiting from Defences	The area that is protected by a defence or defence system against flooding from a 1% (1 in 100) annual probability fluvial event and 0.5% (1 in 200) annual probability tidal event, assuming all defences remain intact and function perfectly.
Blue-green infrastructure	Combining green spaces and surface water management infrastructure within the urban environment to facilitate natural hydrological processes whilst minimising flooding, enhancing biodiversity, facilitating recreation and assisting adaption to climate change.
Brownfield Land	Previously developed land.
Catchment	The land (and its area) which drains (normally naturally) to a given point on a river, drainage system or other body of water.
Catchment Flood Management Plan	A high-level planning strategy through which the Environment Agency works with key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Critical Drainage Area	A discrete geographic area where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, Main River and/or tidal) cause flooding during severe weather, affecting people, property or local infrastructure.
Culvert	A channel or pipe that carries water below the level of the ground.
Exception Test	The Exception Test is required for certain development sites following application of the Sequential Test. The Exception Test must demonstrate that the development provides wider sustainability benefits to the community that outweigh flood risk, and that the site is safe from flood risk for its lifetime.
Flood Defence	Flood defence infrastructure, such as flood walls and embankments, intended to protect an area against flooding to a specified standard of protection (SoP).
Flood Map	A map produced by the Environment Agency providing an indication of the likelihood of flooding within all areas of England and Wales, assuming there are no flood defences.
Flood Risk Assessment	A study to assess the risk to an area or site from flooding from all sources, now and in the future, and to assess the impact that any changes or development on the site or area will have on flood risk to the site and elsewhere. It may also identify, particularly at more local levels, how to manage those changes to ensure that flood risk is not increased.
Flood Risk Management	The activity of understanding the probability and consequences of flooding, and seeking to modify these factors to manage flood risk to people, property and the environment in line with agreed policy objectives.

Term	Definition
Flood Warning	If a flood warning is issued in an area, it means flooding is expected and will cause disruption.
Flood Zone	A geographic area within which flood risk is within a particular range as defined by NPPF and its Practice Guidance.
Flood Zone 1	Land where flooding from rivers and the sea is very unlikely. There is less than a 0.1 per cent (1 in 1,000) chance of flooding occurring each year.
Flood Zone 2	Land which has between a one in 100 and one in 1,000 annual probability (chance) of river flooding (1% - 0.1%); or between a one in 200 and 1 in 1,000 annual probability (chance) of sea flooding (0.5% - 0.1%).
Flood Zone 3	Land which has a greater than one in 100 annual probability (chance) of river flooding (>1%); or greater than one in 200 annual probability (chance) of sea flooding (>0.5%).
Flood Zone 3a (High probability)	This is a subset of Zone 3 (above), which is not within the functional floodplain (Flood Zone 3b), as defined below. Therefore this land is typically expected to have an annual probability of flooding between 1 in 20 and 1 in 100 or (from fluvial sources) or 1 in 200 (from tidal sources) in any year.
Flood Zone 3b (Functional Floodplain)	Land where water has to flow or be stored in times of flood. Specifically, this land would flood with an annual probability of 1 in 20 (5 %) or greater in any year, or as otherwise agreed by the Local Authority and the Environment Agency.
Flooding Hotspot	Also known as flood prone areas. These are locations where concentrations of flooding incidents within a limited geographical context have appeared over time.
Floodplain	Area of land that borders a watercourse, an estuary or the sea, over which water flows in time of flood, or would flow but for the presence of flood defences where they exist.
Flood Resilience	Flood resilience involves design and construction of buildings and structures to reduce the impact of flooding so that, although flood water may enter the building, its impact is minimised, structural integrity is maintained, and repair, drying & cleaning are facilitated.
Flood Resistance	Flood resistance involves design and construction of buildings or other structures to prevent entry of flood water or minimising the amount that may enter.
Functional Floodplain	Refer to Flood Zone 3b definition.
Greenfield Runoff Rate	The greenfield runoff rate is the rate at which rainfall would runoff from an undeveloped, naturally permeable catchment.
Informal Flood Defence	A structure that has not been specifically built to retain floodwater, and is not maintained for this specific purpose but provides a level of flood protection.
Main River	A watercourse designated on a statutory map of Main Rivers, maintained by DEFRA, on which the Environment Agency has permissive powers to construct and maintain flood defences.
National Planning Policy Framework	The NPPF is a framework which aims to simplify and accentuate accessibility on current policy in planning of development of an area, particularly for local planning authorities and decision makers.

Term	Definition
Ordinary Watercourse	All rivers, streams, ditches, drains, cuts, dykes, sluices, sewers (other than public sewers) and passages through which water flows which do not form part of a Main River. Local authorities and, where relevant Internal Drainage Boards, have similar permissive powers on Ordinary Watercourses as the Environment Agency has on Main Rivers.
Overtopping	The process of water rising over the top of a barrier intended to contain it (e.g. sea defence).
Pathway	A route that enables a hazard to move from a 'source' to a 'receptor', as in the 'source-pathway-receptor' concept. A pathway must exist in order for a hazard to be realised. Pathways can be constrained in order to mitigate the risks.
Planning Policy Guidance	This document provides additional technical guidance to ensure the effective implementation of the planning policy set out in the National Planning Policy Framework.
Reservoir	A large raised structure, raised lake or other area capable of storing at least 25,000 cubic metres of water above natural ground level, created artificially or enlarged. This is defined by the Reservoirs Act, 1975.
Residual risk	The risk which remains after all risk avoidance, reduction and mitigation measures have been implemented.
Return Period	The long-term average period between events of a given magnitude which have the same annual exceedance probability of occurring.
Run-off	The flow of water from an area caused by rainfall.
Sequential Test	The aim of the sequential test is to steer new development toward areas with the lowest probability of flooding. Development should not be allocated or permitted if there are reasonably available sites appropriate for that development in areas of lower probability of flood risk.
Site Allocation	Location identified by the Local Planning Authority as likely to experience change or development in the short to medium term.
Standard of Protection	The design event or standard to which a building, asset or area is protected against flooding, generally expressed as an annual exceedance probability.
Strategic Flood Risk Assessment	An area-wide study, undertaken by one or more local authorities, to assess the risks that all sources of flooding poses to a Borough or District, both now and in the future. It incorporates the impacts of further land changes and climate change in the development of an area and if these factors impact the risk of flooding.
Surface Water Flooding	In this context, surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small water courses and ditches that occurs as a result of heavy rainfall.
Sustainability Appraisal	An integral part of the plan-making process which seeks to appraise the economic, social and environmental effects of a plan in order to inform decision-making that aligns with sustainable development principles.
Sustainable Drainage Systems	A sequence of management practices and control structures, often referred to as SuDS, designed to drain water in a more sustainable manner than some conventional techniques.

Term	Definition
TE2100	The Thames Estuary 2100 plan outlines how the Environment Agency is planning to manage tidal flood risk in the Thames estuary until the year 2100.
Tidal Surge	A local high rise in sea level caused by climatic conditions, creating wind and low atmospheric pressure. Tidal flooding is of greatest risk when tidal surges combine with high tides.
Vulnerability Classes	NPPF provides a vulnerability classification to assess which uses of land may be appropriate in each flood risk zone.

1 Introduction

1.1.1 The National Planning Policy Framework (NPPF) and accompanying Technical Guidance emphasise the responsibility of Local Planning Authorities (LPAs) to ensure that flood risk is understood and managed effectively using a risk-based approach throughout all stages of the planning process. As such, LPAs are required to undertake Strategic Flood Risk Assessments (SFRAs) to support the preparation of their Local Plan.

1.1.2 AECOM has been commissioned by the London Borough of Bromley (LBB) to review and revise the existing Strategic Flood Risk Assessment (SFRA) for the Borough, which was completed in 2008. The methodology followed in the study has been designed to comply with the NPPF and the accompanying Technical Guidance as well as guidelines from the Environment Agency (EA). The SFRA has been carried out in collaboration with a range of officers from LBB, the Environment Agency (EA) and Thames Water (TW). The results of this assessment are described in this report and are intended to inform strategic land use planning and decision making, from a flood risk perspective.

1.2 SFRA Aims and Objectives

1.2.1 The aim of this SFRA is to collate and analyse the most up-to-date flood risk information from all sources, to provide an overview of flood risk issues across Bromley. The resulting report and mapping is intended to be used by the LBB as evidence to inform the emerging Local Plan, ensuring flood risk is taken into account when considering development options and in the preparation of strategic land use policies. LBB consulted on its proposed submission Draft Local Plan at the end of 2016 in accordance with Regulation 19 of the Town and Country Planning (Local Panning) (England) Regulations 2012. This is intended to be the final statutory consultation before being submitted to the Secretary of State for independent examination.

1.2.2 In addition to providing an evidence base to support the Local Plan, the SFRA will enable LBB to:

- Determine the spatial variations in flood risk from all sources across the Borough;
- Prepare broad policies for the management of flood risk;
- Steer development towards areas of lowest flood risk, through the application of the Sequential Test and, where necessary, the Exception Test;
- Assist the decision making process on flood risk issues;
- Consider opportunities to reduce flood risk to existing communities through better management of surface water, provision for conveyance and storage for flood water;
- Identify the level of detail required for site-specific Flood Risk Assessments; and
- Determine the acceptability of flood risk in relation to emergency planning capability.

1.2.3 Based upon EA guidance, the key objectives of this SFRA are to:

- Provide maps showing the LPA area including Main Rivers, ordinary watercourses and flood zones, including the functional floodplain (defined by the 5% AEP (1 in 20 Year) flood event;
- Assess and map the distribution of flood risk from all sources across the Borough, including an assessment of the potential implications of climate change;
- Identify relevant flood risk management measures, including the location and standard of infrastructure and the coverage of flood warning systems;
- Undertake an appraisal of the current condition of flood assets and likely future flood management policy;
- Provide advice on the preparation of site-specific flood risk assessments for sites of varying risk across the flood zones, including information about the use of sustainable drainage techniques;
- Identify policies and practices required to ensure development satisfies the Exception Test;
- Provide meaningful recommendations to inform policy, development control and technical issues; and

- Provide advice on appropriate mitigation measures, including the likely applicability of sustainable drainage systems techniques for managing surface water run-off.

1.2.4 The Level 2 SFRA study additionally undertook an assessment of development within the Borough (contained in Chapter 4), including analysis of flood risk at key allocated development sites (Appendix G).

1.3 Using this SFRA

1.3.1 This SFRA is broadly divided into 6 sections, as described below:

- *Chapter 1* (this chapter) includes an overview of the aims and objectives of the updated SFRA, provides contextual background information about the Borough and summarises the methodology used to undertake this assessment;
- *Chapter 2* provides a brief overview of the legislative as well as national, regional and local planning policy context relevant to LBB and referenced in the preparation of this SFRA;
- *Chapter 3* presents a broad overview of flood risk from all sources across Bromley, including flood history and the anticipated impact of climate change;
- *Chapter 4* summarises the assessment undertaken as part of this SFRA to identify informal flood defences, establish opportunities to make better use of the functional floodplain and assess the risk of flooding to the LBB allocated development sites.
- *Chapter 5* summarises the NPPF risk-based approach to managing flood risk through planning, including step-by-step guidance on the application of the Sequential Test and the Exception Test. This is followed by specific recommendations to inform local planning policy, development control and emergency planning;
- *Chapter 6* provides guidance to developers in undertaking site-specific flood risk assessments and measures available for appropriately managing and mitigating flood risk; and
- *Chapter 7* summarises the key findings of the SFRA, including the primary recommendations for flood risk management in Bromley.

1.3.2 A number of appendices are also attached within this SFRA, as summarised below:

- *Appendix A* contains mapping summarising contextual information for Bromley and illustrating the spatial variability of flood risk across the Borough;
- *Appendix B* contains a map from the Bromley Surface Water Management Plan that shows recorded surface water flood incidents, produced by Halcrow in 2011;
- *Appendix C* provides more detailed information on commonly utilised SuDS techniques and their applicability;
- *Appendix D* provides a summary of the datasets collated throughout the SFRA preparation and describes each of the datasets contained within the SFRA maps;
- *Appendix E* summarises the known historical flooding records across the Borough, and;
- *Appendix F* summarises the key aspects to be considered to ensure that the SFRA is kept up-to-date.
- *Appendix G* outlines the risk of flooding to the allocated development sites within the Borough.
- *Appendix H* outlines several areas of the Borough where additional informal flood defences have been identified.
- *Appendix I* outlines several areas of the Borough where measures have been identified to improve the use of the functional floodplain.

1.3.3 While it is generally recommended that this SFRA be considered holistically, the key sections deemed to be most relevant to various parties are summarised below.

Development Control

1.3.4 A key objective of the SFRA is to collate, assess and map all forms of flood risk across LBB and use this information to steer new development towards areas of lowest flood risk, through the Sequential Test process. The spatial distribution of different sources of flood risk across the Borough is illustrated in the mapping contained in Appendix A, and further described in Chapter 3. These sections will provide a broad indication of the sources of flood risk impacting on any potential development sites, and the flood zone in which they are situated.

1.3.5 Chapter 5 summarises the Sequential Test process to be followed when establishing the compatibility of certain developments types within each flood zone, describing how the mapping and associated information should be used to assess planning applications.

Strategic Planning

1.3.6 The maps contained within Appendix A illustrate the spatial distribution of flood risk across Bromley, and are intended to inform strategic land use planning and development allocation. Greater detail on each source of flood risk is contained in Chapter 3.

1.3.7 Chapter 5 provides an overview of the NPPF risk based approach to sequential planning, which should inform development planning and site allocations. This is followed by specific recommendations for the Borough, intended to inform planning policy, development control and emergency planning.

Guidance for Developers

1.3.8 When considering proposed development, it is recommended that developers refer to the mapping contained in Appendix A to obtain an overall understanding of the different sources and level of flood risk which may affect their site. Further detail on any relevant sources of flooding can be found in Chapter 3.

1.3.9 Chapter 6 provides detailed guidance in undertaking site-specific flood risk assessments, depending on the Flood Zone and the type of development. This chapter also describes common measures which are available for appropriately managing and mitigating flood risk. Further detail on the applicability and use of different types of SuDS is provided in Appendix C.

1.3.10 Developers should also refer to Chapter 5 in order to understand the compatibility between different types of development and levels of flood risk, and how the Sequential Test will be used by LBB to assess planning applications.

1.4 Study Area

Location

1.4.1 The study area is defined by the administrative boundary of the London Borough of Bromley, illustrated on Map 001, Appendix A. The Borough covers an area of approximately 150 km^2 and is located on the periphery of Greater London. The north of Bromley borders with the London Boroughs of Lambeth, Southwark, Lewisham, Greenwich and Bexley. The west is bordered by the London Borough of Croydon and the Tandridge District in Surrey; the east is bordered by the Sevenoaks District in Kent.

1.4.2 Two river catchments cover the London Borough of Bromley and largely form the eastern and western halves of the Borough. The western half encompasses a large proportion of the Ravensbourne catchment and the eastern half a section of the Darent and Cray catchment. The Main Rivers in Bromley are shown on Map 001, Appendix A and listed below:

- The Pool River (northwest)

- Chaffinch Brook (northwest)
- The Beck (northwest)
- The Ravensbourne (northwest)
- River Quaggy (north)
- Kyd Brook (north)
- River Cray (northeast)

1.4.3 The Borough lies within the Thames River Basin District (RBD) and is covered generally by the Thames RBD River Basin Management Plan[2] (RBMP) and by two Catchment Flood Management Plans (CFMP): The Thames CFMP[3] and the North Kent Rivers CFMP[4]. It is located in the Environment Agency's Kent, South London and East Sussex (KSL) Operational Region. The water utility provider is Thames Water Utilities Ltd.

Land Use

1.4.4 Bromley is the largest Borough in Greater London by area, of which the majority is Metropolitan Green Belt. Due to its location on the outskirts of Greater London there is a comparably stronger rural and agricultural presence, particularly in the south of the Borough.

1.4.5 The population of Bromley was 309,392, in 2011[5]. Most of which live in the northwest of the Borough, with a cluster at Biggin Hill in the south. The principal settlements in the north of the Borough include: Beckenham, Bromley Town, Chislehurst and Orpington. The largest settlement in the south of the Borough is Biggin Hill, which includes London Biggin Hill Airport.

1.4.6 Although Bromley has no London Underground stations it does have many railway stations operated by London Overland, Thameslink, Southeastern and Southern Rail. Bromley also has several stops on the London Tramlink network. The two largest highways include the A20 on the northern and eastern boundary and the A232, which bypasses Princess Royal Hospital in the centre of the Borough where it becomes the A21 connecting to the M25.

Topography

1.4.7 The general topography of Bromley is illustrated on Map 002, Appendix A.

1.4.8 Westerham Heights is located on the southern boundary and is the highest point in London (245 m above Ordnance Datum (AOD)). The north of the Borough is much lower and flatter, sitting at approximately 30 m AOD in the northernmost area. There is a noticeable ridge of higher ground on which Orpington (approximately 75 m AOD) and Chislehurst (approximately 100 m AOD) are located.

River Network

1.4.9 As noted in Paragraph 1.4.2 there are several Environment Agency designated Main Rivers, the most extensive being The Beck, River Ravensbourne, Kyd Brook and the River Cray.

1.4.10 **The Beck** located in the northwest flows from Spring Park northward to join **Chaffinch Brook** outside of Beckenham to form the **Pool River** which eventually meets the Ravensbourne approximately 1.5 km north of the Borough boundary.

[2] Department for Environment, Food and Rural Affairs and the Environment Agency; Thames river basin district river basin management plan; February 2016; Accessible at: https://www.gov.uk/government/publications/thames-river-basin-district-river-basin-management-plan; Accessed on: 22nd February 2017
[3] Environment Agency Thames Catchment Flood Management Plan; December 2009; Accessible at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293903/Thames_Catchment_Flood_Management_Plan.pdf; Accessed on: 27th February 2017
[4] Environment Agency North Kent Rivers Catchment; December 2009; Accessible at: https://www.gov.uk/government/publications/north-kent-rivers-catchment-flood-management-plan; Accessed on: 27th February 2017
[5] Office for National Statistics; Census Data for Population 2011; Accessible at: https://www.ons.gov.uk/census/2011census; Accessed on 27th February 2017

1.4.11 **River Ravensbourne** rises at Caesar's Well four miles south of Bromley town centre and flows northward where it is joined by its tributaries: **Ravensbourne South Branch** and **Ravensbourne East Branch** on the southern outskirts of Bromley town centre. It then flows alongside the A21 towards Beckenham Place Park, on the other side of the Borough boundary. A further main tributary, **Spring Brook**, originates in Bromley however joins the Ravensbourne north of the Borough boundary.

1.4.12 **Kyd Brook** serves the central northern region, originating in open farmland and countryside upstream of Chislehurst where it is owned and managed by the National Trust. It flows northward becoming the **River Quaggy** in Sunridge Park before joining the Ravensbourne north of the boundary in the London Borough of Lewisham.

1.4.13 **River Cray** in the northeast of Borough originates in St Mary's Cray where rainwater permeates the chalk bedrock and forms a pond at the boundary between chalk and impermeable clay. It flows northward, exiting the Borough and joining the River Wantsunt in the London Borough of Bexley.

1.4.14 The River Network within the Borough is illustrated on Map 001, Appendix A.

Geology

1.4.15 The underlying geology across Bromley as specified by the BGS is illustrated on Map 003, Appendix A.

Bedrock

1.4.16 The southern high ground of the Borough is underlain by the White Chalk Subgroup, which is a sedimentary bedrock formation. This extends beneath the eastern half of Borough beyond Orpington but east of Chislehurst. The northern half of the Borough is predominantly Thames Group, formed of clay, silt, sand and gravel. Where the two rock types meet are ribbons of Lambeth Group formed of clay, silt, sand and gravel and the Thanet Formation formed of sand, silt and clay.

Superficial Deposits

1.4.17 The majority of the Borough bedrock is not overlain with superficial deposits and would be encountered immediately below made ground. However, the high ground in the south of the Borough is overlain with the Clay-with-flints Formation (Diamicton). Along the Ravensbourne and Cray River valleys are layers of River Terrace Deposits (undifferentiated). There is a small area of sand and gravel of uncertain age and origin in the northeast of the Borough, at Crystal Palace Park.

1.5 Methodology and Approach

1.5.1 This SFRA is a desk-based study undertaken using readily available information and existing datasets to enable the assessment of flood risk across the Borough. The information is presented in a suitable graphical format to facilitate the decision making process by LBB. The SFRA will be used to inform the application of the Sequential Test to local development sites and to identify if any require the application of the Exception Test.

1.5.2 The main activities undertaken in the preparation of this SFRA are summarised below:

- Organise and attend an inception meeting with LBB as well as a steering group meeting with key stakeholder organisations to establish the main objectives of the study (from each organisation's perspective), aid collaborative working and discuss available information and datasets;
- Liaise with LBB to request relevant datasets and information from stakeholders;
- Interrogate received data and review against the objectives of the SFRA to identify any gaps in the required information;
- Consult with key stakeholders to agree approach, and define datasets to be included within the SFRA;

- Assess flood risk from all sources, including sea, rivers (fluvial), land (overland flow and surface water), groundwater, sewers and artificial sources;
- Undertake updated hydraulic modelling of the River Cray to include the latest Environment Agency climate change allowances[6] published in February 2016; and
- Produce strategic flood risk maps, GIS deliverables and a technical report.

1.5.3 The key datasets selected for inclusion within this SFRA are summarised in Appendix D.

Consultation

1.5.4 The following stakeholders were engaged to provide data and information during this SFRA.

- *London Borough of Bromley* – LBB is the Local Planning Authority, with responsibility for strategic planning of future development, determination of planning applications and emergency planning, as well as development control within the Borough. Additionally, LBB have a role as the Lead Local Flood Authority, responsible for leading the management of flood risk from surface water, groundwater and ordinary watercourses. In particular, officers responsible for the areas of Planning and Flood Risk and Drainage were closely involved in the preparation of this SFRA.
- *Environment Agency* – The EA is responsible for taking a strategic overview of the management of all sources of flooding and erosion. The study area falls entirely in the Environment Agency's Kent, South London and East Sussex (KSL) Operational Region. The EA has discretionary powers under the Water Resources Act (1991) for all Main Rivers and their associated flood defences.
- *Thames Water* – Thames Water is responsible for management of the sewer system across the study area. This includes managing the risk of flooding from surface water, foul and combined sewer systems. In addition, private individuals may be responsible for drainage systems that operate prior to discharge either into a watercourse or into a public sewer.

1.5.5 There are a number of other organisations that play a role in effectively managing flood risk across the London Borough of Bromley. These include The Greater London Authority, Neighbouring London Boroughs, the London Fire Brigade, Network Rail, Transport for London, the Highways Agency and Natural England, among others.

[6] Environment Agency; Flood risk assessments: climate change allowances; February 2016; Accessible at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances; Accessed on: 22nd February 2017

2 Legislative and Planning Policy Framework

2.1.1 This section provides a brief overview of the legislative and national, regional and local planning policy context relevant to the Borough and referenced in the preparation of this SFRA. Hyperlinks providing further detail on each of the described documents are contained in the footnote references where possible.

2.2 National Policy

Flood and Water Management Act (2010)

2.2.1 The Flood and Water Management Act (FWMA)[7] was enacted in 2010, with the intention of enabling the provision of more comprehensive and effective flood risk management. The act formalises flood risk management responsibilities across a range of organisations including the EA, water companies and highways authorities, and requires cooperation across all groups. Unitary authorities, including LBB, are designated as Lead Local Flood Authorities (LLFA), with responsibility to lead and co-ordinate local flood risk management. As such, LBB's responsibilities include:

- Coordinate management of flooding from surface water, ground water and ordinary watercourses;
- Develop, maintain and implement Flood Risk Management Strategies;
- Investigate and record local flood events; and
- Establish and maintain a Flood Risk Asset Register.

2.2.2 The Act further required the preparation of a number of other studies and strategies, as described in the following sections.

National Strategy for Flood and Coastal Erosion Risk Management

2.2.3 In accordance with the Act, the EA has developed a National Strategy for Flood and Coastal Erosion Risk Management (FCERM) in England[8]. Developed around the notion of understanding risks, empowering communities and building resilience, this Strategy provides a framework for the work of all flood and coastal erosion risk management authorities.

Flood Risk Regulations

2.2.4 As well as the duties under the FWMA, LBB have legal obligations under the EU Floods Directive, which was transposed into UK Law through the Flood Risk Regulations 2009 ('the Regulations')[9].

2.2.5 The regulations set out duties for the EA and LLFAs in the preparation of a range of studies and mapping outputs. As such, LBB was required to produce a Preliminary Flood Risk Assessment (PFRA), Flood Risk Maps showing the extents and hazards of flooding in their area, Flood Risk Management Plans and to update the Surface Water Management Plan. These studies are summarised in the following sections.

[7] Flood and Water Management Act (2010) http://www.legislation.gov.uk/ukpga/2010/29/contents
[8] National Flood and Coastal Erosion Risk Management Strategy for England https://www.gov.uk/government/publications/national-flood-and-coastal-erosion-risk-management-strategy-for-england
[9] Flood Risk Regulations (2009) http://www.legislation.gov.uk/uksi/2009/3042/contents/made

National Planning Policy Framework and Guidance

2.2.6 The NPPF[10], published in March 2012, is a key part of the government's reforms to make the planning system less complex and more accessible. It presents a structure and context for planning within England, providing a framework for local authorities and residents to produce local and neighbourhood plans that reflect the needs and priorities of their communities. The Planning Practice Guidance[11] (PPG) supports the framework and is published online and regularly updated.

2.2.7 Within the core principles of NPPF, set out in Paragraph 17, it is stated that planning should: "Support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change."

2.2.8 Section 10 of the NPPF, titled Meeting the Challenge of Climate Change, Flooding and Coastal Change, establishes the principles for assessing and managing flood risk through the planning and development process, which is supported by the Technical Guidance document.

2.2.9 The overall approach of the NPPF to flood risk is broadly summarised in Paragraph 103:

2.2.10 "When determining planning applications, LPAs should ensure flood risk is not increased elsewhere and only consider development appropriate in areas at risk of flooding where, informed by a site-specific FRA following the Sequential Test, and if required the Exception Test, it can be demonstrated that:

- Within the site, the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location, and
- Development is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed, including by emergency planning; and it gives priority to the use of sustainable drainage systems."

2.2.11 This is achieved by delineating the probability of flooding in any area into three main Flood Zones, as defined by the NPPF. Flood Zone 3 is additionally delineated into Flood Zone 3a (high probability area) and Flood Zone 3b (the functional floodplain, where water has to flow or be stored in times of flood). Each of these Flood Zones is described in Table 2-1.

Table 2-1 - *Flood Zone Definitions (as defined in the NPPF)*

Flood Zone	Definition	Probability of Flooding
Flood Zone 1	At risk from flood event greater than the 1 in 1,000 year event (greater than 0.1% annual probability of flooding each year).	Low Probability
Flood Zone 2	At risk from a tidal flood event between the 1 in 200 and 1 in 1,000 year event (between 0.5% and 0.1% annual probability of flooding each year), or a fluvial flood event between the 1 in 100 and 1 in 1,000 year event (between 1% and 0.1% annual probability of flooding each year).	Medium Probability
Flood Zone 3a	At risk from a tidal flood event less than or equal to the 1 in 200 year event (greater than 0.5% annual probability of flooding each year), or a fluvial flood event less than or equal to the 1 in 100 year event (greater than 1% annual probability of flooding each year).	High Probability
Flood Zone 3b	At risk from a flood event less than or equal to the 1 in 20 year event or otherwise agreed between the Local Planning Authority and the Environment Agency.	Functional Floodplain

[10] The NPPF (2012) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf
[11] The PPG (2012) https://www.gov.uk/government/collections/planning-practice-guidance

2.2.12 Each LPA is responsible for preparing an SFRA to inform the allocation of development sites within their administrative areas in accordance with their established Sustainability Appraisal. The policy levels of this process in the context of flood risk and the position of the SFRA within the planning framework are shown in Figure 2-1 below.

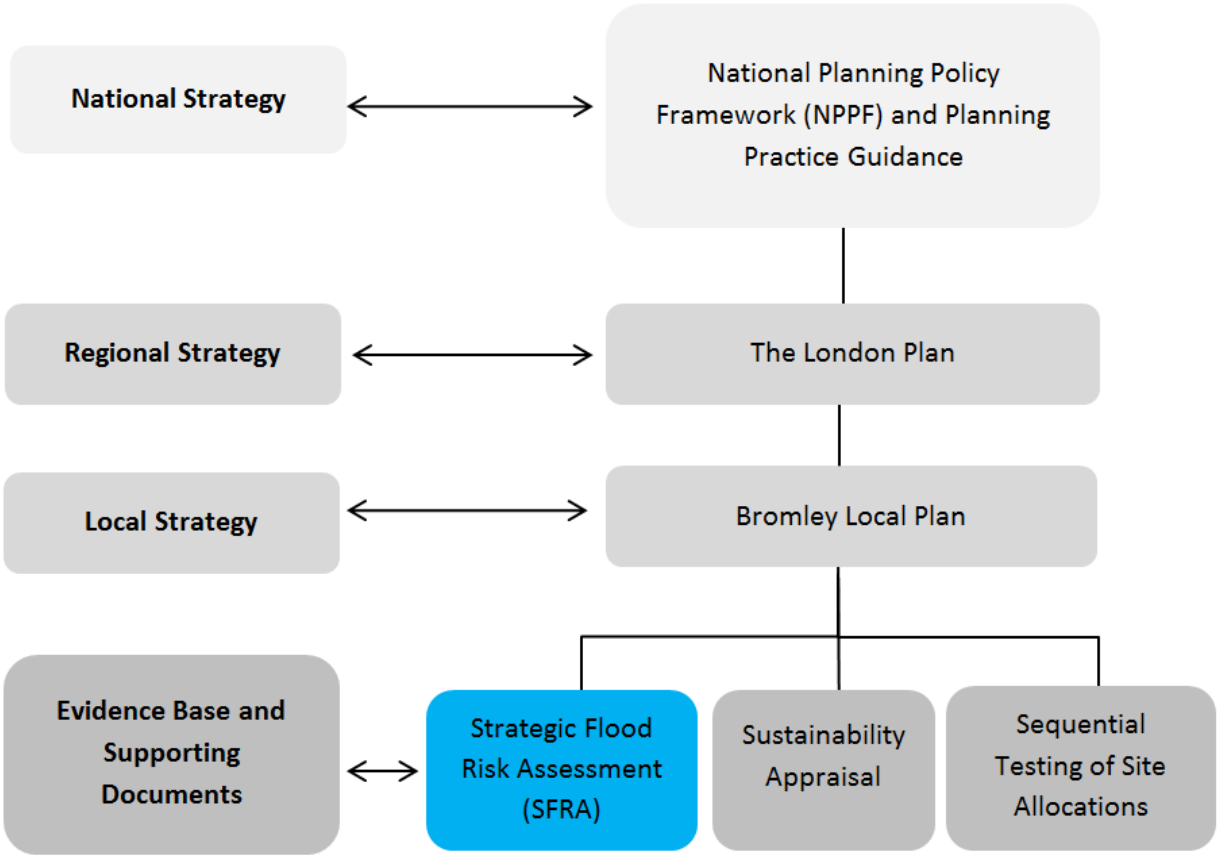

***Figure 2-1**: Overview of Policy Levels and Documents in the context of Flood Risk*

2.2.13 The NPPF is supported by Planning Practice Guidance, which provides additional information to facilitate the effective implementation of the planning policy, with specific sections relating to the management of flood risk.

2.2.14 Further detail regarding the application of the Sequential and Exception Tests is included in Section 5.1.

2.3 Regional Flood Risk Policy

London Plan

2.3.1 The London Plan, updated in March 2016[12], is the core planning and development guidance document for all of Greater London. Flood risk is considered in the London Plan under the section dealing with response to climate change. Policy statements 5.12 and 5.13 require developers to follow the guidance of NPPF, TE2100 and the SFRA in undertaking a site specific flood risk assessment. It also requires developers to follow the SuDS hierarchy when devising surface water management strategies, ensuring where possible surface water is attenuated and stored at source. A key recommendation is that all developments should aim to achieve greenfield runoff rates where possible.

2.3.2 Supplementary Planning Guidance (SPG) has been published to provide further guidance on policies within the London Plan, which cannot be addressed in sufficient detail within the main plan. The SPG

[12] The London Pan (March 2015) and London Regional Flood Risk Appraisal http://www.london.gov.uk/priorities/planning/london-plan

for Sustainable Design and Construction was published in April 2014[13], and provides further practical detail on flood risk and sustainable drainage.

2.3.3 To ensure clarity for stakeholders, it is important that LBB local policy is aligned with the minimum recommendations of the London Plan, particularly with respect to SuDS requirements.

[13] Supplementary Planning Guidance for Sustainable Design and Construction https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/supplementary-planning-guidance/sustainable-design-and

London Regional Flood Risk Appraisal

2.3.4 The first review of the London Regional Flood Risk Appraisal (RFRA) was released for public consultation in January 2014, providing underpinning evidence to the London Plan. The RFRA provides a broad overview of the different types of flood risk in London and provides a spatial analysis of tidal, fluvial and surface water flood risk against major development locations, key infrastructure assets and services. The RFRA contains 14 recommendations to be implemented by the EA and other agencies.

Thames Catchment Flood Management Plan

2.3.5 The LBB lies partially within the Thames Catchment Flood Management Plan[14], the plan was published by the EA in December 2009, and is one of the overarching flood risk management policy document for the Thames River Basin. It provides an overview of flood risk within the catchment and presents the EA's key strategic policy for sustainable flood risk management over the next 50 to 100 years. The Thames CFMP covers the catchment of the Ravensbourne within the LBB.

2.3.6 According to the Thames CFMP there are between 2,000 and 5,000 properties in LBB at risk of flooding in a 1% AEP fluvial flood from the River Thames. Bromley falls within Sub-area 9 of the Thames CFMP which is labelled 'London Catchments'. The preferred policy for this area of the catchment is Policy option 4: *'Areas of low, moderate or high flood risk where we are already managing the flood risk effectively but where we may need to take further actions to keep pace with climate change.'*

North Kent Rivers Catchment Flood Management Plan

2.3.7 The LBB lies partially within the North Kent Rivers CFMP[15], the plan was published by the EA in December 2009, and is one of the overarching flood risk management policy document for the Thames River Basin. It provides an overview of flood risk within the catchment and presents the EA's key strategic policy for sustainable flood risk management over the next 50 to 100 years. The North Kent Rivers CFMP covers the catchment of the River Cray within the LBB.

2.3.8 Bromley falls within Sub-area 1 of the North Kent Rivers CFMP which is labelled 'Shuttle and Upper Cray'. There are currently approximately 1,375 properties at risk of flooding from a 1% AEP river flood in this area, which is projected to rise to approximately 1,625 by 2100. The preferred policy for this area of the catchment is Policy option 5: '*areas of moderate to high flood risk where we can generally take further action to reduce flood risk.'*

Thames River Basin District Flood Risk Management Plan

2.3.9 Under the EU Floods Directive and UK Flood Risk Regulations, the EA is required to prepare FRMPs for all of England covering flooding from Main Rivers, the sea and reservoirs. The updated Thames River Basin District FRMP[16] was published by the EA in March 2016, setting out the proposed measures to manage flood risk within the District from 2015 to 2021 and beyond. The measures in the Thames FRMP have been formulated in line with agreed social, economic and environmental objectives and are grouped under 4 categories, summarised below.

- Preventing risk
    - Working with local planning authorities to ensure development takes place in the areas with the lowest risk of flooding;
    - Maintaining existing flood defences so that they continue to protect properties in future; and

[14] Thames Catchment Flood Management Plan https://www.gov.uk/government/publications/thames-catchment-flood-management-plan
[15] North Kent Rivers Catchment Flood Management Plan https://www.gov.uk/government/publications/north-kent-rivers-catchment-flood-management-plan
[16] Thames River Basin District Draft Flood Risk Management Plan https://www.gov.uk/government/publications/thames-river-basin-district-flood-risk-management-plan

- Carrying out a prioritised programme of mapping and modelling to ensure flood risk information remains up to date and fit for purpose.

· Preparing for risk:

- Working with communities to help them understand their risk and how to prepare effectively, improving emergency response; and
- Continuing to invest in improving real-time data and information to provide a quality flood warning service.

· Protecting from risk:

- Reducing the likelihood of flooding affecting people and property in specific locations or in locations that have flooded in the past; and
- Continuing to maintain watercourses that pose the most significant flood risk, responding quickly to incidents and clearing obstructions from screens and culverts during heavy rainfall.

· Recovery and review:

- Continuing to carry out investigations after flooding, produce recommendation reports and help communities to recover from floods more quickly.

Thames River Basin Management Plan

2.3.10 The Thames River Basin District Management Plan[17] was updated in 2015, and has been prepared under the European Water Framework Directive. The plan describes the river basin district, the pressures impacting the state of the water environment, and proposed actions to address these. The waterbodies within Bromley are covered by two separate catchments within the plan. This includes the Ravensbourne catchment and the Darent and Cray catchment.

2.3.11 The plan highlights several water management issues across the Basin, including physical river modification, flow regulation and a lack of natural river processes. This has led to a loss of habitat diversity and barriers for fish migration throughout the catchment. Water quality is also a significant issue across the catchments, with pollution pressures due to increased surface water run-off, storm sewage overflows, misconnections and effluent discharge. The plan identifies a series of actions to assist in improving water body status by addressing the water management issues highlighted. The key actions within the plan relevant to Bromley are:

- The Environment Agency investigation into the causes of urban diffuse pollution in the River Ravensbourne.
- The Environment Agency will work with partners to re-naturalise the River Ravensbourne through Harrow Lodge Park.
- The plan will address the key pressures in the catchment, and those waters in the worst state will be prioritised.
- Thames Water and the Environment Agency will investigate sewage misconnections into the River Darent and River Cray.
- Thames Water will assess options for improving groundwater abstraction in the Upper Cray once approved in the Periodic Review.

2.4 Local Planning Policy and Flood Risk Strategies

Local Plan

2.4.1 LBB is currently in the process of setting out the new Local Plan, which will set out the vision and objectives for the Borough to the 2030s and the strategic and more detailed policies used in determining local planning applications together with a policies map and specific site proposals. The emerging Local Plan has identified six key themes to focus the local plan:

[17] Thames River Basin District River Basin Management Plan https://www.gov.uk/government/publications/thames-river-basin-district-river-basin-management-plan

1. **Living in Bromley -** *'supporting strong, vibrant and healthy communities by providing the supply of housing required to meet the needs of present and future generations; and by creating a high quality built environment, with accessible local services that reflect the community's needs and support its health, social and cultural well-being.*
2. **Supporting Communities -** *'supporting communities are intrinsic to delivering the vision and objective for the Local Plan and supporting Bromley's Health and Wellbeing Strategy.'*
3. **Getting Around –** *'support the importance of accessibility to employment, shopping and services to residents, customers and the supply chain for businesses.'*
4. **Valued Environments –** *'ensure that change is appropriately managed to ensure the opportunities for the areas provide a successful transition to the town centre and a high quality residential environment whilst protecting and enhancing valued environments and ensuring that recreational opportunities are maximised to cater for the growing population within their Renewal Area.'*
5. **Working in Bromley –** *'deliver forecast significant employment growth and the business and Town Centre objectives.'*
6. **Environmental Challenges –** *'response to the current and future challenges of a range of environmental issues including: waste management, flood risk management, sustainable design and construction; and carbon reduction.'*

2.4.2 The policies relevant to this SFRA include those on current and future challenges of sustainable flood risk management, within the Environmental Challenges chapter. These policies should be considered to ensure that development in Bromley is both void of flood risk and is sustainable into the future. The two policies are detailed below, additional guidance can be found in the Supporting Text in the Draft Local Plan[18].

Draft Policy 115: Reducing Flood Risk

2.4.3 In order to address existing flood risk and to reduce the impact of new development, the Council will:

- Work with the Environment Agency, landowners and developers, based on the findings of the most recent SFRA and other Plans, to manage and reduce flood risk from all sources of flooding.
- Apply the sequential and exception tests to avoid inappropriate development in relation to flood risk.
- Implement sustainable drainage system (SuDS) across the Borough and work towards effective management of surface water flooding.
- Fully engage in flood risk emergency planning including the pre, during and post phases of a flooding event.
- Ensure the implementation of measures to mitigate flood risk across the Borough that are effective, viable, attractive and enhance the public realm and ensure that any residual risk can be safely managed.

2.4.4 To minimise river flooding risk, development in Flood Risk Areas (Environment Agency Flood Zones 2 and 3 and surface water flood risk hotspots) will be required to seek opportunities to deliver a reduction in flood risk compared with the existing situation.

2.4.5 In Flood Risk Areas the sequential test and exception test as set out in the NPPF and associated technical guidance should be applied. Flood Risk Assessments should be submitted in support of all planning applications in these areas and for major development proposals across the Borough.

2.4.6 All development proposals should reduce surface water run-off entering the sewerage network through the use of suitable SuDS as far as possible.

[18] Available at: http://bromley-consult.objective.co.uk/portal/pslp/dlp?pointId=3902688

Draft Policy 116: Sustainable Drainage Systems (SuDS)

2.4.7 All developments should seek to incorporate SuDS or demonstrate alternative sustainable approaches to the management of surface water as far as possible.

2.4.8 Applications for developments located within Flood Zones 2, 3a, and 3b and in Flood Zone 1 for areas identified as hotspots in Bromley's Surface Water Management Plan (SWMP), Preliminary Flood Risk Assessment (PFRA) and in the Strategic Flood Risk Assessment (SFRA), must be accompanied by a site-specific Flood Risk Assessment (FRA).

Local Flood Risk Management Strategy

2.4.9 As a LLFA, LBB has a statutory duty to develop, maintain, apply and monitor a strategy for local flood risk management. Bromley has published a Local Flood Risk Management Strategy[19] (LFRMS), which provides guidance and information for residents, businesses and developers regarding managing flood risk. The document outlines LBB's responsibilities as a LLFA and also clarifies the role of other organisations in managing flooding across the Borough. The LFRMS further provides an overview of the sources of flood risk across the Borough and outlines options for dealing with flooding.

2.5 Other Local Studies

Bromley Surface Water Management Plan

2.5.1 A Surface Water Management Plan (SWMP)[20] was produced for LBB as part of the Drain London Study in 2011, although was never made publically available. This study undertook an assessment of flooding from sewers, drains, groundwater and runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall. The plan outlines the preferred surface water management strategy for the Borough and includes an Action Plan that has been developed in conjunction with both LBB and other relevant Risk Management Authorities. As part of the Phase 2 Risk Assessment, direct rainfall modelling has been undertaken across the entire Borough for five specified return periods.

2.5.2 The main outputs of the Bromley SWMP have been considered in the preparation of this SFRA.

Preliminary Flood Risk Assessment

2.5.3 Under the Flood Risk Regulations, all LLFAs were required to prepare a Preliminary Flood Risk Assessment (PFRA). This study provides a high level summary of areas of significant flood risk, describing both the probability and consequences of past and future flooding.

2.5.4 The Bromley Preliminary Flood Risk Assessment[21] was produced in June 2011 as part of the Drain London study, drawing upon the data and information available from the SWMP. The assessment gives an overview of all local sources of flood risk. Boroughs must review the PFRA every six years and the next update of this document will be completed in June 2017 following completion of this SFRA.

Bromley SuDS Guidance

2.5.5 The Bromley Validation Guidance and Local Information Requirements for Planning Applications[22] (2015) is designed to help planners and developers understand what LBB expects to receive within an acceptable planning application. This includes guidance on the Foul Sewage and Surface Water

[19] Bromley Local Flood Risk Management Strategy http://www.bromley.gov.uk/downloads/download/681/local_flood_risk_management_strategy
[20] Bromley Surface Water Management Plan (2011*) Drain London*
[21] Bromley Preliminary Flood Risk Assessment http://webarchive.nationalarchives.gov.uk/20140328084622/http://cdn.environment-agency.gov.uk/flho1211bvkp-e-e.pdf
[22] Bromley Validation Guidance and Local Information Requirements for Planning Applications http://www.bromley.gov.uk/downloads/file/2362/validation_guidance_and_local_information_requirements_for_planning_applications

Drainage Assessment, Landscaping Scheme and Flood Risk Assessment, all of which recommend the inclusion of SuDS.

3 Flood Risk in Bromley

3.1 Overview

3.1.1 Fluvial flooding is the most prevalent risk across the Borough due to the Main Rivers that dissect the northern half of the Borough, including: The Beck, the River Ravensbourne, Kyd Brook and the River Cray.

3.1.2 A potential risk of flooding from other (non-river related) sources also exists within the Borough, including: surface water flooding as a result of intense rainfall and sewer surcharge due to over capacity of the drainage system. These flood issues are known to be a reoccurring problem for certain settlements, including: Bromley, St. Paul's Cray and Orpington.

3.1.3 Areas of the Borough are also susceptible to elevated groundwater levels, which may additionally interact with and exacerbate other sources of flood risk. It is expected that changing climate patterns will have a substantial impact of the level of flood risk from all sources within the Borough.

3.1.4 The various sources of flooding with the potential to affect the Borough have been analysed in the following Chapter.

3.2 Historic Flooding

3.2.1 Information on known and recorded historic flooding events within Bromley is shown in Maps 004a and 004b, Appendix A.

3.2.2 The EA holds the Historic Fluvial Flood Map, which includes past flood events in Bromley. However, some of the recorded historical events might have been as a result of issues that have now been addressed and, therefore, an indication of historical flooding affecting a particular location does not necessarily mean that the locality affected remains prone to flooding.

3.2.3 For all other sources of flooding, there is limited availability of records across the Borough. This is likely due to a historical lack of centralised recording of such flood incidents across the UK, and should not be interpreted as indicating a low probability of future flooding. Nonetheless there are some records of previous flooding, based on local knowledge and reports from affected areas.

3.2.4 A site specific FRA will be required to confirm whether any historical issues have been addressed and development in previously flooded sites can take place.

Historic Flooding from Rivers

3.2.5 The EA historic flood maps show severe flooding in the 1960s across the full extent of the River Ravensbourne and to a lesser extent on the River Cray. Flooding occurred in the 1970s along the River Cray north of St Mary's Cray; however no flooding was reported along the River Ravensbourne during this event even though, based on the 1960s River Cray extent, it was likely to be a more extreme event. Although there are no 'formal' flood defences in Bromley, the lack of flooding in the 1970s on the River Ravensbourne may be partially due to river alterations subsequent of the River Ravensbourne (Improvement and Flood Prevention) Act 1961[23]. This is believed to have led to concrete lining and straightening of channels which is reported to have occurred in the 1970s. Nonetheless, a source of fluvial flood risk still exists for much of the developed areas in the north of the Borough, as indicated in the Flood Zone maps.

[23] AECOM has been unable to locate a copy of this act to review as part of this assessment. Its implications for the Ravensbourne River have been based on anecdotal evidence from the Environment Agency and London Borough of Bromley staff.

3.2.6 The historic flood maps provided by the Environment Agency illustrate widespread flooding in the 1960s. According to these maps the 1965 flood event was particularly prevalent on the River Pool and River Chaffinch, northwest of Beckenham. The 1968 flood event was more extensive, with flood extents covering most of the length of all Main Rivers.

3.2.7 The mapping shows a comparatively restricted flood extent during the 1977 flood event, with only the River Cray experiencing flooding. Although the severity of each event is not known, the decrease in flooding could be at least partially attributed to an increase in culverted or straightened channels along the Main Rivers during the 1970s.

3.2.8 Following the wet winter of 2000-2001, some Ordinary Watercourses experienced flooding, leading to their designation as Main Rivers.

3.2.9 More recently, in December 2013, various properties were flooded on Magpie Hall Lane after the River Ravensbourne flooded next to St Luke's cemetery. During this event there was also flooding at the entrance of Nuffield Health Fitness and Wellbeing Centre, close to Hayes Lane.

Historic Flooding from Surface Water

3.2.10 In 1977 surface water flooding occurred close the River Cray at St Paul's Cray. According to the North Kent Rivers CFMP the River Cray flooded in summer 1897 due to an intense storm where over 1.5 inches (approximately 38 mm) of rain fell within 45 minutes over Chislehurst. The drainage system was unable to cope and low-lying areas were flooded.

3.2.11 More recently, heavy rain in summer 2012 caused localised flooding on Widmore Lodge Road and Homesdale Road in Bromley.

3.2.12 In winter 2013/14 heavy rainfall left many properties at risk and train stations inaccessible. At times of heavy rainfall during this period, flooding was particularly extensive at:

- Sparrows Den southwest of Hayes
- Borkwood Court in Orpington
- New Beckenham railway station
- Elmer's End Road including Goals Soccer Centre

3.2.13 The Bromley PFRA[24]identifies a further four locations susceptible to surface water flooding:

- The ditch running along the allotments at Westmoreland Road is too shallow and the current gradient does not permit the free movement of water. This increases the likelihood of highway flooding and the risk to seven private properties on a low spot along Westmoreland Road.
- Storm water running off the rural Shire Lane catchment flows along the highway valley line only to be held up by the A21 embankment; Ramus Wood Avenue and the Beechwood Estate sit at the base of the embankment. According to the Bromley PFRA flooding occurs here 2-4 times per year.
- Crofton Road, where the Main River crosses beneath (known as 'Butchers Corner') floods in extreme storms with reports of foul surcharge, despite recent major foul alleviation works by Thames Water.

[24] Bromley Preliminary Flood Risk Assessment (2011) http://webarchive.nationalarchives.gov.uk/20140328084622/http:/www.environment-agency.gov.uk/research/planning/135542.aspx

- Along Pickhurst Lane properties are at risk of flooding and there are reports of foul surcharge. Both the capacity of the public surface water sewer and the river culvert passing beneath the highway has been highlighted as potential problem areas.

3.2.14 The Bromley SWMP[20] contains a map of Surface Water Flooding Incidents (Appendix B) which demonstrates that there is a correlation between past surface water flood events and the extent of the 1% AEP (1 in 100 Year) event model results. The majority of recorded surface water flood incidents have occurred within the vicinity of the rivers as a result of intense rainfall. However, surface water flooding is not confined to watercourse areas; as shown by surface water flood records in Orpington and Biggin Hill.

Historic Groundwater Flooding

3.2.15 During winter 2013/14 there was flooding in the Cray Valley which was presumed to be due to a combination of groundwater, fluvial (ordinary watercourse) and pluvial (surface water) sources. During this period there was also flooding reported from residents at Bromley Common in areas that had previously flooded in 2008 but on this occasion it had encroached into properties. Furthermore, photographic evidence provided by residents near the River Pool shows areas flooded during the Christmas 2013 flood event. Flooding was also reported in Chislehurst.

3.2.16 LBB has confirmed locations where groundwater flooding occurred in 2014, these are located on Map 004a, Appendix A.

3.2.17 Flooding was recorded in gardens in West Wickham along Addington Road and in Courtfield Rise, Sparrow Den Playing Fields and along stretches of the highway as a result of elevated water tables due to months of prolonged rainfall. This flood location is underlain by the White Chalk Subgroup which has high permeability and therefore supports the movement of groundwater and hence flooding at the surface.

3.2.18 In Orpington along Borkwood Court, gardens were submerged and there was flooding in below ground parking facilities at Tesco and surrounding the pond in Priory Gardens. This area is also underlain with the White Chalk Subgroup and thus supports the movement of groundwater, which can lead to flooding at the surface.

3.2.19 LBB confirmed a history of groundwater flooding from Oaklands Lane at Biggins Hill through to Nash Lane including the Layhams Valley. It was reported that the route onto Gates Green Road from Jackass Lane, underlain by White Chalk, was flooded.

3.2.20 Groundwater flooding also occurred on Brookmead Way, to the southwest of St Mary Cray. This location is underlain partially by the White Chalk superficial deposit and partially by Thanet Sand bedrock. Groundwater typically occurs where the edges of rock formations outcrop and where valleys cut into the side of a hill, such as in this location.

Historic Sewer Flooding

3.2.21 General information on sewer flooding history has been provided by Thames Water, and is contained within Map 004b, Appendix A. This data indicates the total number of properties which have been impacted by sewer flooding (both externally and internally), per postcode area, over the previous decade. The dataset does not give exact locations of where flood incidents have occurred, only the numbers of properties affected in that area. The Thames Water DG5 dataset excludes severe weather events (usually defined as a rainfall event with a 3.33% AEP (1 in 30 Year)). The map shows low and relatively uniform occurrence of sewer flooding across the Borough in the past decade, suggesting that there are no particular areas of the Borough at significantly greater risk of flooding from this source.

3.2.22 Sewer flooding occurs in the absence of severe weather due to under capacity of the sewer system or localised blockage. There are no records of widespread flooding occurring from these causes however

there have been instances during periods of severe weather where surface water flooding has become contaminated with foul water, likely due to misconnection or localised combination of the two systems.

3.2.23 It should be noted that the flood records provided by Thames Water may not provide a complete and/or accurate account of flood events from this source in the Borough over the last 10 years. Some minor flooding incidents may go unreported, particularly if no property is affected.

Historic Flooding from Artificial Sources

3.2.24 Artificial sources are defined as manmade structures which hold significant volumes of water, such as reservoirs, canals, docks and manmade ponds and lakes.

3.2.25 There is no known history of flooding from artificial sources within the Borough.

3.3 Flood Risk from all Sources

Flooding from Rivers

3.3.1 Fluvial flooding occurs when water levels exceed the bank level of a watercourse, causing overtopping into adjacent areas. This can result from prolonged rainfall within the catchment, restrictions or blockages within the channels or high water levels preventing discharge at the outlet. This can also be impacted by saturated catchment conditions and high groundwater levels.

3.3.2 Part of Bromley is in the Ravensbourne catchment which may be impacted by flooding associated with The Beck, River Ravensbourne and the Kyd Brook, all of which flow in a northerly direction. Amongst other tributaries, The Pool system includes Chaffinch Brook, The Beck and the River Pool; the River Ravensbourne has a South and East Branch which join the system south of Bromley Town Centre. The Kyd Brook eventually becomes the River Quaggy before flowing out of the Borough.

3.3.3 The eastern half of the Borough is within the Darent and Cray catchment and may be impacted by flooding associated with the River Cray.

3.3.4 The Environment Agency's Risk of Flooding from Rivers and the Sea map is illustrated in Map 005, Appendix A, which delineates the probability of flooding into the Flood Zones, as defined in Table 2-1 (Section 2.2.11). Fluvial flood risk is prevalent in the north of the Borough only, with each main watercourse having some extent of Flood Zones 2 and 3 along its length.

3.3.5 The Environment Agency flood zones are defined based on an undefended scenario. Bromley does not contain any 'formal' flood defences (see 3.4.1) and therefore the Flood Zones mapped show the actual flood risk in the Borough. An assessment of the fluvial flood risk associated with the Main Rivers across the Borough is provided below.

The Pool

3.3.6 The Flood Zone mapping illustrates that Flood Zone 3b of The Beck is relatively confined to its immediate banks; however, there is wider spread flooding to the northwest of West Wickham associated with its tributaries. The Chaffinch Brook, which becomes the Pool River in New Beckenham, sits in the valley base where there is flatter topography; therefore flooding from the 5% AEP (1 in 20 Year) event results in a more extensive Flood Zone 3b. This has potential to inundate surrounding properties.

3.3.7 Flood Zone 3a for The Pool system follows a comparable outline to Flood Zone 3b; however additional flooding is predicted in Cator Park and around Worsley Bridge during this scenario. The extent of Flood Zone 2 is generally greater along the full length of the system within the Borough and further encompasses parts of Elmer's End and the area between Chesham Road and Ravenscroft Road.

River Ravensbourne

3.3.8 Flood Zone 3b of the River Ravensbourne is present in Keston Mark along a tributary of the East Branch of the Ravensbourne River. Flood Zone 3b is also apparent further downstream of the East Branch beyond Southborough. There is a narrow extent of Flood Zone 3b along much of the West Branch of the River Ravensbourne, particularly to the south and east of West Wickham. Where the two River Ravensbourne branches combine, Flood Zone 3b extends over a much greater area at the flat valley bottom, showing inundation around much of the railway line between Bromley South Station and Shortlands Station and beyond to Shortlands Golf Club.

3.3.9 Flood Zone 3a mapping predicts greater inundation near Shortlands golf course and adjacent property, as well as flooding along Hayes Road and Prince's Plain, northeast of Keston Mark. Flood Zone 2 is largely similar in extent to Flood Zone 3a along the western branch however shows a general increase in extent along the central and eastern branches.

Kyd Brook

3.3.10 The Kyd Brook has a relatively confined Flood Zone 3b extent, resultant of the steeper topography, with flooding predicted in only a few locations: Crofton Heath, Petts Wood, land close to Chislehurst Station and through Sundridge. Flood Zone 3a further extends northeast of Locksbottom along the culverted stretch of the Kyd Brook East Branch, across Shepperton Road and along the Crossway east of Willett Recreational Ground.

3.3.11 Flood Zone 2 shows additional predicted flooding around Chislehurst Station, Oaks Trees Gardens in Elmstead and Jersey Drive in Petts Wood.

River Cray

3.3.12 The Flood Zone mapping illustrates that the Flood Zone 3b of the River Cray is relatively confined to the watercourse. There is a small area of flooding north of Crayfields Business Park and in Riverside Gardens at St Mary Cray. Flood Zone 3a is more extensive, with much of St Mary Cray predicted to flood during the 1% AEP (1 in 100 Year) flood event. Under the 0.1% AEP (1 in 1,000 Year) (Flood Zone 2) flood event scenario, predicted flooding extends over Cray Avenue, Sevenoaks Way Industrial Estate and Cray Avenue Industrial Estate.

3.3.13 It should be noted that limited information is available on the level of flood risk associated with any ordinary watercourses. As Map 001, Appendix A indicates, there are numerous tributaries of the Main Rivers which are designated Ordinary Watercourses. In particular, Hayes and Coney Hall has numerous Ordinary Watercourses associated with the River Ravensbourne. As does Petts Wood in Chislehurst, associated with Kyd Brook. It is likely that the flood extents recorded in the EA historic flood maps had contribution from these smaller watercourses. To assess the risk of flooding from Ordinary Watercourses developers should cross examine the fluvial flood maps with the Risk of Flooding from Surface Water mapping (Map 006, Appendix A) as this illustrates runoff in topographic low points which often define the location of ordinary watercourses.

3.3.14 Furthermore, Bromley SWMP[20] states that some Public Surface Water Sewers listed on the Sewerage Undertakers Map of Sewers are arguably 'Piped Ordinary Watercourses'. These surface watercourse need to be investigated and mapped within an asset register, to ensure they are not overseen when undertaking maintenance works.

Flooding from Surface Water

3.3.15 The majority of the Borough is served by separate foul and surface water drainage systems; however, there are some combined systems in Penge and Anerley (northwest of the Borough). Here the surface water drains operate via gravity with most of their outfalls discharging into localised watercourses. If the water level is high in these local watercourses it becomes difficult for the surface water to discharge via gravity and sewers may back-up. Whereas in the south and east of the Borough a

significant portion of runoff drains in local soakaways, therefore this method of sewer back-up is less likely to occur.

3.3.16 Pluvial flooding occurs when high intensity rainfall generates runoff which flows over the surface of the ground and ponds in low lying areas, before the runoff enters any watercourse or sewer. It is usually associated with high intensity rainfall events and can be exacerbated when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with the flow. High intensity rainfall unable to discharge to ground, sewers or watercourses is the main mechanism of surface water flooding in the Borough; however it can be exacerbated by lack of maintenance of assets owned by Risk Management Authorities (RMAs) and/or riparian owners. Furthermore, this source of flooding can be compounded when combined with impermeable sub-soils or vast areas of open grassland. In the case of Bromley, chalk permeability at many locations within the Borough reduces the risk of surface water flooding as rainfall can drain away faster. However, this is constrained by significant development with associated hard standing areas which have increased volumes of runoff and led to the exceedance of the available pipe network capacity which has resulted in surface water flooding across some areas.

3.3.17 The Bromley Surface Water Management Plan undertook a comprehensive review of pluvial flood risk, including direct rainfall modelling and mapping across the Borough. As part of this study, the surface water flood risk was mapped and analysed. The SWMP identified a total of 20,400 properties at risk from some degree of surface water flooding.

3.3.18 Bromley has permeable ground with relatively small surface drainage systems within the urbanised areas, short duration and medium sized storms would result in only shallow flooding. However, with short duration and large sized storms the extent of damage is anticipated to be much more severe. The LLFA need to be concerned with the potential of these rain storm events and control development and manage highways accordingly. Flooding from highway drainage infrastructure often occurs as a result of limited inflow capacity of the road drains, which could be worsened by blockages.

3.3.19 The SWMP concluded that approximately 1,510 properties are at risk of flooding to a depth of 0.5 m or higher, of which approximately 4% are basement dwellings. Furthermore, the report identities 67 ‘Essential’, 4 ‘Highly Vulnerable’ and 16 ‘More Vulnerable’ public service buildings, such as hospitals, schools, post offices, etc. These vulnerabilities are defined in accordance with the NPPF Vulnerability Classification Table (Table 5-2). The surface water flood risk across the Borough is shown on Map 006, Appendix A.

Flooding from Groundwater

3.3.20 Groundwater flooding occurs as a result of the water table reaching the ground surface. This is most likely to occur in low-lying areas which are underlain by permeable rock (aquifers) and more likely to appear after periods of sustained rainfall. Groundwater flooding tends to occur sporadically in both location and time, and tends to last longer than fluvial, pluvial or sewer flooding. Groundwater flooding can also interact with other flood sources, exacerbating the risk of pluvial, fluvial or sewer flooding by reducing rainfall infiltration or discharge to sewers.

3.3.21 Within London, the primary mechanisms for elevated groundwater are associated with:

- Above average rainfall for a number of months in Chalk outcrop areas;
- Shorter period of above average rainfall in permeable superficial deposits;
- Permeable superficial deposits in hydraulic continuity with high river water levels;
- Interruption of groundwater flow paths; and
- Cessation of groundwater abstraction causing groundwater rebound.

3.3.22 Areas susceptible to groundwater flooding as defined by the British Geological Survey are illustrated in Map 007, Appendix A which corresponds with the underlying geology displayed in Map 003, Appendix A.

3.3.23 Much of the north of the Borough has medium permeability, predominantly where Thanet Sands or the Harwich Formation (sand and gravel) exist. This is where the majority of groundwater flood incidents occur as the bedrock permits movement of water. This is most likely to occur at the edge of the formation outcrop where a valley cuts into the side of a hill.

3.3.24 South Bromley has a greater extent of superficial deposit than the north (largely Clay-with Flint Formation). The areas around the superficial deposits are overlain by various chalk formations. Generally this results in soil with a high permeability, promoting the movement of groundwater.

3.3.25 Map 007, Appendix A displays the areas susceptible to groundwater flooding across the Borough. These are generally areas underlain by permeable substrate and therefore with the capacity to store groundwater. The SWMP indicates that there is elevated groundwater from permeable superficial soils located in the northwest of the Borough. It also highlights elevated groundwater from consolidated aquifers in West Wickham (including Courtfield Rise) and just north of Orpington.

3.3.26 Development in areas with a history of groundwater flood risk is likely to continue to be at risk since this is a particularly difficult source of flooding to prevent. Therefore a flood resilient building design is particularly important in these areas.

Flooding from Artificial Sources

3.3.27 Reservoirs, canals, water retention ponds and other artificial structures may have a potential flood risk associated with them. Generally, under normal circumstances, the flood risk posed is low; however, if a breach occurs, extensive flooding could be experienced.

3.3.28 There are no designated reservoirs located within Bromley; however, areas of the Borough are shown to be within the extent of flooding anticipated by breach of South Norwood Lake, which sits in the adjacent London Borough of Croydon and Knockholt Lake, which is in the neighbouring District of Sevenoaks, Kent.

3.3.29 Overtopping or failure of the South Norwood Lake would result in flooding from the Croydon boundary to the northwest of Beckenham and surrounding the River Pool. Overtopping or failure of Knockholt Lake results in a more confined flood extent from Sevenoaks, following the topographic low points and terminating in St Mary's Cray, at the source of Kyd Brook.

3.3.30 It should be noted that reservoir flooding is considered extremely unlikely. The EA is the enforcement authority for the Reservoirs Act 1975 in England and is responsible for ensuring regular inspection and maintenance.

3.3.31 Areas at residual risk of flooding from reservoirs (during a breach event) within the Borough are illustrated within Map 008, Appendix A.

Other Artificial Sources

3.3.32 Numerous small local ponds and water features are also present across the Borough; however, very limited information currently exists with regards to their capacity and connectivity and therefore an assessment of the flood risk posed by them will need to be made at a site specific level.

Flooding from Sewers

3.3.33 As the foul water sewer network is mostly separate from the surface drainage network across the Borough, flooding from this source arises if there is a sewer blockage or if surface water enters the foul network, as a result of a misconnection, resulting in it overflowing. Furthermore, when there are high water levels in receiving watercourses there is potential for sewer outfalls to rivers to become submerged during high water levels. When this happens, water is unable to escape into the watercourse and flows back along the sewer. Once storage capacity within the sewer itself is exceeded, the water will overflow into streets and houses.

3.3.34 Under current Thames Water standards, sewer systems are typically designed and constructed to accommodate a 3.33% AEP (1 in 30 Year) rainfall event. Therefore, during rainfall events of greater than a 3.33% AEP event, the surface water drainage network may be susceptible to surcharge and flooding. Additionally, drainage systems across London are of varying age and capacity, with many parts of the system thought to be designed to accommodate a 6.67% AEP (1 in 15 Year) return period rainfall event or less.

3.3.35 Thames Water are responsible for investigating and resolving frequent sewer flooding. Any properties with flood incidents occurring more than once every ten years are documented on the DG5 register and Thames Water aims to protect them through investment in new sewerage systems through the water company's asset investment programmes. Any sewer flooding as a result of extreme events is excluded from the DG5 resister.

3.3.36 Foul sewer surcharge is a problem for the Borough and to help mitigate this issue, Thames Water has installed off line holding tanks at the most affected locations, including: Corkscrew Hill, Tiepigs Lane and three locations in Crofton Road at Orpington. However, there are still reports of sewer surcharge at Crofton Road despite the installation of the holding tanks[20].

3.4 Flood Defences

3.4.1 There are two main categories of flood defences, formal and informal (de facto). Formal defences are specifically constructed to control floodwater. Informal defences include structures that have not necessarily been constructed for this purpose but do have an impact on retaining flood water, such as railway and road embankments or other linear infrastructure such as boundary walls and buildings.

3.4.2 As discussed in paragraph 3.2.10 there are no formal flood defences with the Borough. However, there are a number of informal flood defences. These are assets that have been built for other purposes but as a result have acted to reduce flood risk.

3.4.3 The responsibility for operational maintenance of watercourses lies with the Riparian Owner. Therefore it is important to ensure Riparian Owners are aware of their responsibilities and undertake the necessary maintenance work on any critical assets as failure to do so could result in flooding. The LLFA has the enforcement power to ensure all Riparian Owners maintain any Ordinary Watercourses contained within their land. The EA are responsible for the management of all Main Rivers.

3.4.4 In Bromley, the informal flood defences are embankments and walls built for other purposes (e.g. railways) but have the dual benefit of flood risk reduction. These assets are listed in Table 3-1.

Table 3-1 *List of Informal Flood Defences in Bromley (source: AIMS)*

Type	Location
Embankment	On the River Pool, bordering the HSBC Group Sports Ground
Rail Embankment	Off Clock House Road
Rail Embankment	Off Links Way next to The Beck
Rail Embankment	South of Chinbrook Meadows
Embankment	In Hollydale Recreational Ground
Rail embankments	Adjacent to Kyd Brook and the River Quaggy in Chrislehurst
Embankments	Along the River Cray in St Paul's Cray

Future Policy

Thames CFMP

3.4.5 The Thames Catchment Flood Management Plan covers the Ravensbourne area where the policy is to 'keep pace with climate change'. The general policy approach for the sub-area is to continue to maintain the existing defences where it is appropriate to do so and to replace flood defences in conjunction with redevelopment. Opportunities to remove culverts and other structures that cause

significant conveyance problems will be explored; this work has already begun in the Ravensbourne catchment. As there are no existing formal flood defences in Bromley this largely does not apply. However, any development in the vicinity of the informal flood defences should ensure their integrity is maintained.

North Kent Rivers CFMP

3.4.6 The North Kent Rivers Catchment Flood Management Plan covers the Upper Cray area where the policy is to 'generally take further action to reduce flood risk'. The general policy for the sub-area is to encourage the uptake of flood resilience measures by people living within the floodplain.

3.5 Impact of Climate Change

3.5.1 Climate change is anticipated to have a significant impact on temperature, rainfall and seasonal changes within London. The latest predictions are for warmer and drier summers, and wetter winters, with appreciable changes anticipated by the 2020s[25]. Within London the following impacts are anticipated:

- *By the 2020s* - increase in summer mean temperature of 1.5°C, decrease in mean summer rainfall of 6% and increase in mean winter rainfall of 6% (from a 1961–1990 baseline).
- *By the 2050s*- increase in mean summer temperature of 2.7°C, increase in mean winter rainfall of 15% and decrease in mean summer rainfall of 18%.
- *By the 2080s* - increase in mean summer temperature of 3.9°C, an increase of 20% in mean winter rainfall and decrease in mean summer rainfall of 22%.

3.5.2 The expected impacts of Climate Change on various sources of flooding across the Borough are broadly described in Table 3-2-2 below.

Table 3-2 - *Anticipated Impact of Climate Change on Flood Risk within the Borough*

Source	Anticipated Impact within Bromley
Groundwater Flooding	Increased frequency and intensity of rainfall events is anticipated, which could lead to further groundwater flooding in the Borough due to raised groundwater levels and associated spring flows
Surface Water and Sewer Flooding	Increased storm intensity, frequency and duration is anticipated to further exacerbate pressure on existing drainage and sewer systems, potentially leading to more frequent localised flooding incidents.
Fluvial Flooding	Changing rainfall patterns are likely to increase peak river flows, thereby resulting in higher levels of fluvial flood risk from the Main Rivers across the north of the Borough.

Climate Change Allowances

3.5.3 In February 2016, the EA updated national climate change allowances to be used in the assessment of future flood risk and support the NPPF risk based approach. The updated allowances covered the following aspects:

- Peak river flow by river basin district;
- Peak rainfall intensity;
- Sea level rise; and
- Offshore wind speed and extreme wave height.

[25] UK Climate Projections (2009) http://ukclimateprojections.metoffice.gov.uk/

3.5.4 The range of allowances provided for river flow, rainfall intensity and sea levels are based on statistical percentiles, representing the range of possible climate change scenarios, which give rise to the central (50th percentile), higher central (70th percentile) and upper end (90th percentile) estimates of impacts.

3.5.5 The allowances provided are additionally based on a range of time periods, representing the anticipated impact over the next 100 years. The percentile and time period to be used are dependent on the proposed development location, vulnerability and design life. The range of different climate change scenarios should be considered in the analysis of flood risk.

3.5.6 The EA has provided detailed online guidance[26] on the use of these allowances for site specific flood risk assessments and reference should be made to this source for the most up to date guidance. Table 3-3 indicates the climate change allowances for peak river flow for the Thames Basin, which includes LBB.

Table 3-3 *Peak River Flow Allowances (use 1961 to 1990 baseline)*

River Basin District	Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Thames	Upper End	25%	35%	70%
	Higher Central	15%	25%	35%
	Central	10%	15%	25%

3.5.7 Table 3-4 demonstrates which climate change allowance should be applied in each flood zone for each type of development.

Table 3-4 *Climate Change Allowances for Development Classifications in each Flood Zone*

NPPF Vulnerability Classification	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Essential Infrastructure	Higher Central	Upper End	Upper End
Highly Vulnerable	Higher Central	Not Permitted	Not Permitted
More Vulnerable	Central and Higher Central	Higher Central and Upper End	Not Permitted
Less Vulnerable	Central	Central and Higher Central	Not Permitted
Water Compatible	None	Central	Central

Climate Change in Bromley

Ravensbourne Model

3.5.8 The impact of climate change has been taken into account as a part of the hydraulic modelling work undertaken for the Borough by the EA. For the Ravensbourne catchment, the model results have been provided for the 25% and 35% allowance for climate change, which corresponds to the Higher Central estimate for the 2080s and the Central estimate for the 2080s, as reflected in Map 009, Appendix A. To gain a full understanding of the potential impact of climate change the Upper End (70% allowance) estimate for the 2080s should be modelled; this is currently being processed by the EA. These

[26] Climate change allowances for Flood Risk Assessment https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

allowances have been modelled by the EA as they cover the majority of climate change scenarios outlined in Table 3-3.

3.5.9 In the absence of the 70% allowance for climate change for the River Ravensbourne, the 0.1% AEP (1 in 1,000 Year) event flood extent has been used as an approximation of the maximum anticipated increase in flood risk as a result of climate change. The Environment Agency should be contacted during the preparation of site-specific flood risk assessments within the 0.1% AEP flood extent to determine the status of the 70% climate change allowance modelling and for guidance on assessing the risk of flooding from the River Ravensbourne over the duration of any proposed development.

3.5.10 Map 009, Appendix A displays the flood extent with climate change allowances included. With an additional 25% allowance for climate change there is additional flood inundation at Elmer's End associated with Chaffinch Brook, between Ravenscroft and Chesham Road affiliated with the Pool River and in central Beckenham along The Beck. With an additional 35% the flood zone is generally larger across the catchment, in particular: northeast of Kent House Station, around Langley Park School and land adjacent to Shepperton Road.

Cray Model

3.5.11 For the Shuttle and Upper Cray catchment, the model results have been generated by AECOM for the 1% AEP flood event with 25%, 35% and 70% allowances for climate change, which corresponds to the Central, High Central and Upper End estimates for the 2080s. AECOM has modelled these events using the EA existing hydraulic model. The results have been deemed suitable to provide an indication of the increase in flood risk as a result of climate change; however, it is recommended that a full review of the hydraulic model is undertaken to determine if a model update is required to represent the latest understanding of flood risk along its route. These allowances have been modelled as they cover the majority of climate change scenarios outlined in Table 3-3 and in agreement with the EA.

3.5.12 Map 009, Appendix A displays the flood extents including the allowance for climate change. When a 25% allowance for climate change is modelled, there is further flooding predicted at St Pauls Cray Recreational Ground, Sevenoaks Way and the High Street. When a 35% allowance for climate change is modelled, there is further flooding predicted at Cray Valley Bowls Club, Springvale Retail Park and Nugent Retail Hub. When the 70% allowance for climate change is modelled, there are widespread increases in predicted flood extents along the full length of the channel, predominantly around Crayfields Business Park, Riverside School and Cray Avenue.

4 Detailed Assessment

4.1 Informal Flood Defences

4.1.1 An informal flood defence is a structure that has not been specifically built to retain floodwater, and is not maintained for this specific purpose but provides a level of protection. As part of the Level 2 assessment undertaken to support this SFRA, the EA Asset Information Management System (AIMS) database has been reviewed to identify structures within the Borough that could be included within it and defined as an informal flood defence.

4.1.2 Along with the EA AIMS dataset, LiDAR data to inform topography, OS Mastermap data to inform land use and EA hydraulic model results for the River Ravensbourne and River Cray have been used to identify potential informal defences.

4.1.3 Four potential structures that could be considered for inclusion within the AIMS dataset as informal flood defences have been identified and are summarised in Table 4-1. Further details of the assessment undertaken are included in Appendix H .

Table 4-1 - Potential informal flood defences to be included in the EA AIMS dataset

Name	Location
Kent House Station railway embankment	Kent House Station, Beckenham, BR3 1JD NGR: 535989,169984
Richmal Crompton Fields	Richmal Crompton Fields, Bromley, BR2 8LP NGR: 542694, 166290
Glebe Way Highway Embankment	Glebe Way, West Wickham, BR4 0RL NGR: 538504, 165883
Crayfields Industrial Park, Main Road	Main Road, Orpington, BR5 3HP NGR: 547387, 169430

4.2 Functional Floodplain

4.2.1 As part of the Level 2 assessment of this SFRA, potential locations where the functional floodplain within the Borough could be extended or its functionality improved have been identified and assessed. The two river systems within the LBB, the River Ravensbourne and River Cray, become heavily urbanised in the downstream London Boroughs of Lewisham and Bexley. Within the LBB, however, they have a slightly more rural setting with parks and open space of one or both banks in many places. These open spaces, where the rivers can freely flood, are crucial for the prevention of flooding of the downstream urban areas.

4.2.2 Four locations within the Borough have been identified as potentially suitable for further investigation by the Environment Agency (EA), it is envisaged that these areas could be considered within future modelling and flood alleviation optioneering studies commissioned by the EA. These locations were filtered from a larger group by considering topographic or land use restrictions which would limit potential for functional floodplain storage.

4.2.3 The locations identified are summarised in Table 4-2 and further details of the assessment undertaken is included in Appendix I .

Table 4-2 Areas with potential to enhance the functional floodplain within the London Borough of Bromley

Name	Location
Langley Golf Course	Hawksbrook Lane, Beckenham, BR3 3SR NGR: 538271,167276
Rail Embankment Churchfields Recreational Ground	Clock House Road, Beckenham, BR3 4JY NGR: 536164,168964
HSBC Sports Ground	Lennard Road, Beckenham, BR3 1QN NGR: 536439,170426
Cegas Sports Ground	Worsley Bridge Road, Beckenham, BR3 1RL NGR: 537060,171229

4.3 Allocated Development Sites

4.3.1 As a part of the emerging Local Plan, LBB has identified 44 allocated development sites, as shown on Map 013, Appendix A, and described in Table 4-3.

4.3.2 An assessment page has been created for each of these sites, contained in Appendix J. The site assessments provide an overview of the various sources of flood risk, utilising the strategic datasets collated during this SFRA. Key recommendations for managing flood risk are provided for each site.

Table 4-3 Allocated Development sites and Flood Zone Classification

Site ID	Site Name	Flood Zone(s)
1	Bassetts Campus	1
2	Gasholder Station Bromley	2
3	Bromley Valley Gym	1
4	Depot Bruce Grove	1
5	Land and buildings, south of Bickley Station	1
6	Banbury House	1
7	18-44 Homefield Rise, Orpington	1
8	Small Halls, York Rise	1
9	Orchard Lodge	1
10	Opportunity Site G & Bromley South Railway Site	1
11	Hill Car Park & Adjacent Sites	1
12	Land adjacent to Bromley North Station	1
13	Bromley Civic Centre Site A	1
14	Bromley Civic Centre Site B	1
15	Bromley Civic Centre Site C	1
16	1 Westmoreland Road	2

Site ID	Site Name	Flood Zone(s)
24	Bromley Education Trust (BET)	1
25	James Dixon Primary School, William Booth Road	1
26	Harris Primary Academy Kent House	1
27	Scotts Park Primary School	1
28	Land at Bushell Way, Chislehurst	1
29	Land adjacent to Edgebury Primary School	1
30	Midfield site inc.primary school & alt provision	1
31	Wickham Common Primary School	1
32	Keston Mobile Park, Layhams Road	1
33	Mead Green, Layhams Road	1
34	Meadow View	1
35	Old Maidstone Road	1
36	Land at 148 Croydon Road, Keston	2
37	St Joseph's Place, Layhams Road	1
38	Millies View, Layhams Road	1
39	Land adj 1 Vinsons Cottages (Rosedale)	1

Site ID	Site Name	Flood Zone(s)
17	Turpington Lane Allotments	1
18	St Hugh's Playing Field	1
19	Langley Park School for Boys and Girls	2
20	Castlecombe Primary School and Youth Centre	1
21	Edgebury Primary School	1
22	St. Mary Cray Primary School	1
23	Oaklands Primary School	1

Site ID	Site Name	Flood Zone(s)
40	Southview, Trunks Alley	1
41	Travelling Showpersons Yard, Layhams Road	1
42	Land at junction of Sheepbarn Ln and Layhams Rd	1
43	Star Lane, St Paul's Cray - Boundary amended	1
44	Archies Stables, Cudham Lane North	1
45	Strategic Outer London Development Centre	1

5 Managing Flood Risk

5.1 Risk Based Approach to Planning

5.1.1 The NPPF approach aims to ensure that flood risk is considered at all stages of the planning process, and to avoid inappropriate development in areas of greatest flood risk; steering development towards areas of lower risk.

5.1.2 Development is only permissible in areas at risk of flooding in exceptional circumstances where it can be demonstrated that there are no reasonably available sites in areas of lower risk, the sustainability benefits outweigh flood risks and, the development will be safe for its lifetime without increasing flood risk elsewhere. Such development is required to include mitigation/management measures to minimise risk to life and property should flooding occur.

5.1.3 Building on these principles, the NPPF and Technical Guidance have established a process for the assessment of flood risk, with each stage building upon the previous assessment with a refinement of the evidence base. Utilising a Source – Pathway – Receptor approach, the source of flooding, the spatial distribution of flood risk and the vulnerability of development types are assessed to inform decision making through each of the key stages of the Flood Risk Management Hierarchy, as outlined in the Technical Guidance and shown in Table 5-1 below.

Table 5-1 - *Flood Risk Management Hierarchy and the SFRA Process*

Stage	Approach
Level 1 SFRA	Assessment (broad scale and comprehensive)
Sequential Test Across Planning Area	Avoidance
Level 2 SFRA (if required)	Detailed Assessment (Growth Area or Site Specific)
Sequential Approach at Site	Avoidance
Control and Improvement	Through Design (e.g. SuDS)
Mitigate Remaining Risks	Flood Resilient Design and Construction

Applying the Sequential Test

5.1.4 As described in the NPPF, the aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. As such, development should not be permitted in areas of flood risk, where there are reasonably available sites appropriate for the proposed development in areas with a lower probability of flooding. The Sequential Test should be carried out on all development sites and can be applied at all levels and scales of the planning process, both between and within Flood Zones.

5.1.5 The approach seeks to prevent the allocation of sites that are inappropriate on flood risk grounds by considering the vulnerability of the type of development proposed and how compatible the intended use is with the level of flood risk at the site. Five vulnerability classifications are defined; these are listed below and further defined in Table 5-2.

- Essential Infrastructure;
- Highly Vulnerable;
- More Vulnerable;
- Less Vulnerable, and
- Water Compatible.

Table 5-2 *Flood Risk Vulnerability Classifications (from Table 2 in the NPPF Technical Guidance)*

Appropriate Use Classification	Examples of Classification
Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons need to remain operational in times of flood. • Wind turbines.
Highly Vulnerable	• Police stations, ambulance stations and fire stations and command centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent.
More Vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable	• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for shops, financial, professional and other services, restaurants and cafes, hot food takeaways, offices, general industry, storage and distribution, non–residential institutions not included in "more vulnerable", and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place).
Water Compatible Development	• Flood control infrastructure. • Water and Sewage transmission infrastructure and pumping stations. • Sand and gravel working. • Docks, marinas and wharves. • Navigation facilities. • Ministry of Defence, defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

5.1.6 Table 5-3 illustrates the types of development that are considered as suitable within areas of varying perceived flood risk. This utilises the Flood Zones defined in Table 2-1 (Section 2.2.11), and delineated for the Borough in Map 005, Appendix A.

Table 5-3 - *Flood Zones and Development Compatibility (from Table 3 in the NPPF Technical Guidance)*

Flood Zone	Description	Annual probability of river or sea flooding	Appropriate uses
Zone 1	Low Probability	1 in 1,000 (<0.1% AEP)	· All uses
Zone 2	Medium Probability	1 in 100 – 1 in 1,000 (river) (1-0.1% AEP) 1 in 200 – 1 in 1,000 (sea) (0.5-0.1% AEP)	· Water Compatible · Less Vulnerable · More Vulnerable · Essential Infrastructure · Highly Vulnerable*
Zone 3a	High Probability	1 in 100 or greater (river) (>1% AEP) 1 in 200 or greater (sea) (>0.5% AEP)	· Water Compatible · Less Vulnerable · More Vulnerable* · Essential Infrastructure*
Zone 3b	The Functional Floodplain	1 in 20 or greater (5% AEP) or land which is designed to flood in an extreme (0.1% AEP) flood.	· Water Compatible · Essential Infrastructure*

Note: *only if Exception Test is passed

5.1.7 This SFRA provides the tools to undertake the Sequential Test by presenting information to identify the variation in flood risk across the Borough, allowing an area-wide comparison of future development sites with respect to flood risk considerations. The flow diagram presented as Figure 5-1 illustrates how the Sequential Test process should be applied to identify the suitability of a site for allocation, in relation to the flood risk classification.

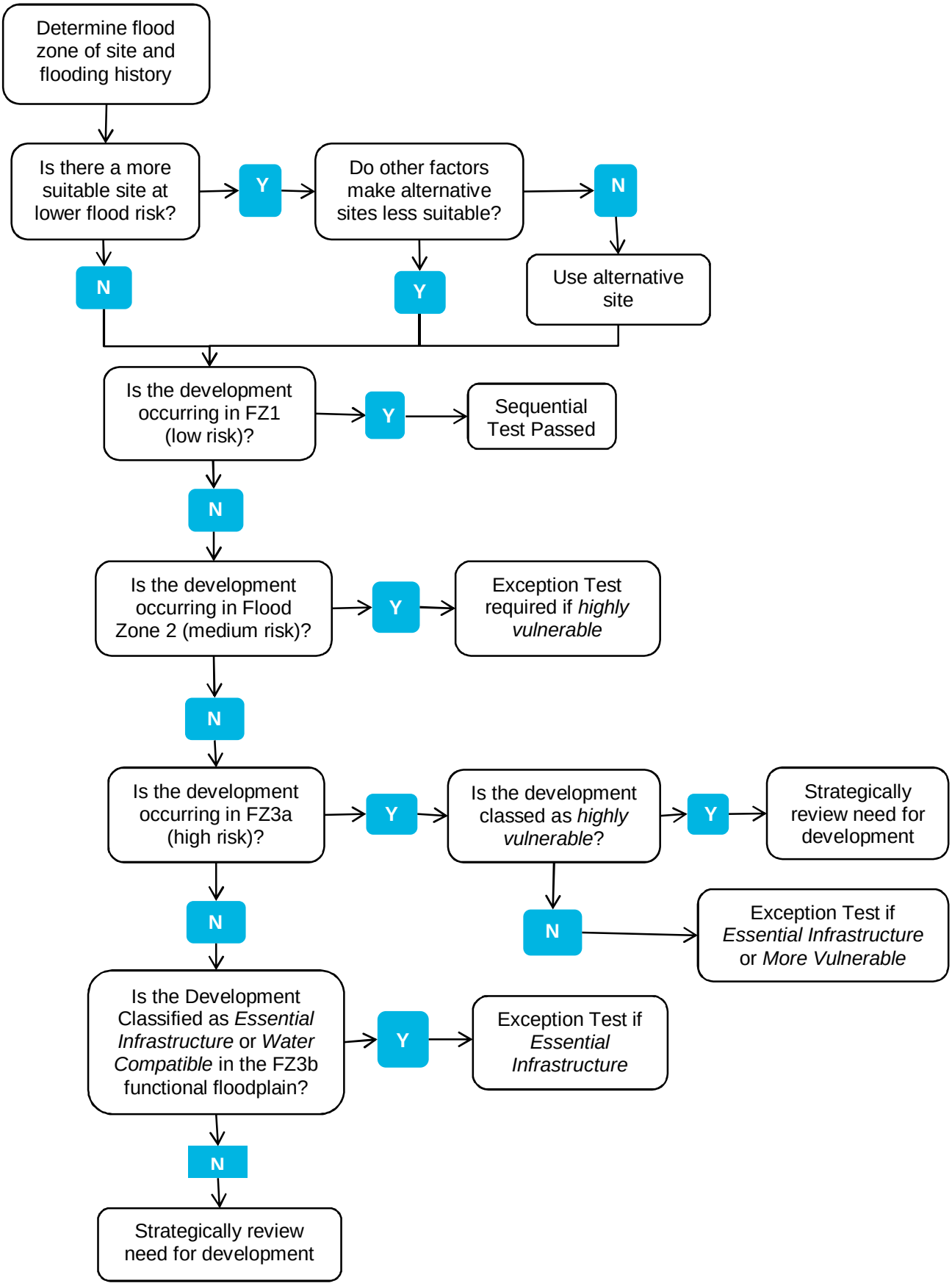

Figure 5-1: *Sequential Test Process - Schematic*

5.1.8 If, following the application of the Sequential Test, a proposed site allocation does not meet the criteria of acceptability, that site might qualify for the application of an Exception Test. This test considers both the development safety and the benefit of the site to the wider sustainability objectives of the Borough in order to establish whether the development can be deemed acceptable. This test is further described below.

5.1.9 It should be noted that, while the focus of the Sequential Test is on tidal and fluvial flood risk (through use of the NPPF Flood Zones), some areas of the Borough could be at risk of flooding from other sources. Consequently all sources of flooding must be considered in the location of new development. If the development is not deemed water compatible, and the site is found to be impacted by a recurrent flood source (other than fluvial), the site and flood sources should be investigated further irrespective of a requirement for the Exception Test.

Exception Test

5.1.10 The Exception Test is an additional test to be applied by decision-makers following application of the Sequential Test. The Exception Test has two elements as shown below, both of which must be satisfied for development in a flood risk area to be considered acceptable.

5.1.11 The Exception Test provides a method of managing flood risk while still allowing necessary sustainable development to occur. The test is only appropriate for use when there are large areas in Flood Zones 2, 3a and 3b, where the Sequential Test alone cannot deliver acceptable sites, but where some continuing development is necessary for wider sustainable development reasons. The flow chart presented in Figure 5-1 and Table 5-3 demonstrates the methodology to determine whether an Exception Test is required for proposed site allocations.

5.1.12 In order to pass the Exception Test, the NPPF Planning Practice Guidance identifies the following considerations that need to be demonstrated/fulfilled to the satisfaction of the LPA:

- That the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Sustainability Appraisal Report where one has been prepared; and
- A site-specific flood risk assessment (FRA) must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, reducing flood risk overall.

5.1.13 Satisfying the Exception Test involves consideration of the reasons behind the selection of the site for development, from the sustainability appraisal, as well as consideration in planning and design, such that the site will remain safe and operational in the event of flooding. This may involve demonstrating:

- A sequential approach is taken to development site layout, such that within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;
- Buildings are designed to be appropriately flood resilient and resistant, with essential services remaining functional in the event of flooding, and quick recovery following a flood;
- Provision of safe means of access and egress during a flood event; and
- Emergency evacuation procedures are developed, to be utilised following receipt of a flood warning.

5.1.14 Further detail on undertaking site specific flood risk assessments, including measures to safely mitigate and manage flood risk, are provided in Chapter 6.1.

5.1.15 Both parts of the Exception test must be satisfied in order for the development to be considered acceptable in terms of flood risk. There must be robust evidence in support of every part of the test.

5.2 Recommendations for Policy and Practice

5.2.1 Adopting a holistic approach to flood risk management should help ensure that flooding is taken into account at all stages of the planning process. To aid this holistic approach, it is recommended that all key recommendations set out in this report are considered and incorporated into the emerging Bromley Local Plan.

5.2.2 Future development and redevelopment, as set out in the Local Plan offers the opportunity to reduce the current level of flood risk. This includes making the urban environment more resilient and with a layout that offers added options for managing future flood risk and the impacts of climate change. As such, it is recommended that policy options are expanded to include greater emphasis on active floodplain management. This may include promoting more appropriate use of floodplain areas (Flood Zone 3), making space for water, improved flood preparedness and enhanced emergency planning and response measures.

5.2.3 Specific recommendations for LBB are detailed in the following sections.

Strategic Planning

5.2.4 When considering strategic spatial planning across the Borough, flood risk should be an early and primary consideration. A sequential approach should be taken to allocating strategic development areas in regions of lowest flood risk, taking into account vulnerability of land use. Consideration should also be given to strategic allocation of open space and preserving and expanding river corridors to create space for flooding to be managed effectively.

5.2.5 In particular, the following specific recommendations are made:

- Ensure the Sequential Test is undertaken for all strategic land allocations and check that the vulnerability classification of the proposed land use is appropriate to the Flood Zone classification;
- Pursue potential opportunities to move existing development from within the floodplain to areas with a lower risk of flooding. This should include consideration of the vulnerability of existing developments and whether there is potential for land swap with lower vulnerability uses.
- Identify opportunities to create space for water through appropriate location, layout and design of development, in order to accommodate climate change and assist in managing future flood risk. This can be achieved by restoring floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for storage. Equally, existing flood storage areas should be identified, conserved and protected against loss through redevelopment.
- Safeguard existing corridors of land along the Main Rivers and their tributaries and promote the setting back of development to enable sustainable and cost effective flood risk management, including upgrading of river walls and embankments. As a minimum, an 8 m buffer strip should be maintained along fluvial corridors.
- Consider opportunities to improve the riverside frontage to provide amenity space and environmental enhancement. Floodplain management could reduce the impact of flooding to existing properties and other assets located in the floodable areas on the river side.
- The consultation and initial investigation associated with detailed site specific flood risk assessments should be undertaken at an early stage for major development locations to ensure opportunities to reduce flood risk are identified early and maximised wherever possible.
- Ensure that developments at risk of flooding are designed to be flood compatible and/or flood resilient and maximise the use of open spaces within these developments to make space for water during times of flooding. Opportunities should be sought to identify a safe route for any exceedance flow of floodwaters and a suitable storage or discharge location, to avoid any risk to people.
- Strategic development allocations should specifically consider the issues of water supply and drainage infrastructure to service development proposed, taking into account regional constraints. An early and integrated approach should be taken to holistically assessing and

planning for the flood risk, water supply and drainage requirements and constraints in these areas.

- Look for opportunities to de-culvert and open up the channel. This process has already begun along the River Ravensbourne.

Development Control

5.2.6 In consulting on and determining development applications, LBB must ensure that all new developments have considered flood risk management from the planning stage. In general, this means that:

- Development is located in the lowest possible risk area from a flood risk perspective;
- New development is flood-proofed to a satisfactory level/standard and does not increase flood risk elsewhere; and
- Surface water is managed effectively on site using the SuDS hierarchy and the latest guidance and best practice.

5.2.7 When a proposed development is located within an area perceived to be at risk of flooding, then a suitably detailed FRA should determine the level of risk to the development and identify options to mitigate the flood risk to the development, site users and surrounding area. In particular, development located adjacent to flood assets is required to demonstrate that these will be maintained over the lifetime of the development. The requirements for site specific flood risk assessments and their contents are further detailed in Chapter 6. Planning applications should be considered and assessed in line with the sequential approach detailed in Section 5.1. Specific recommendations and considerations for development planning are provided below:

- If development is to be constructed with less vulnerable uses on the ground level, covenants need to be put in place to prevent future alteration of these areas to 'more vulnerable' uses without further consideration of the associated flood risk.
- Single storey residential development should not be considered in high flood risk areas as they offer no opportunity for safe refuge.
- NPPF does not permit basement dwellings to be located within Flood Zone 3a, and as such these should not be permitted in any areas at risk of flooding. This would include the excavation of basements under existing dwellings.
- Flood risk should be managed through emergency planning, site design and protection measures.
- Where development within flood risk areas is necessary due to wider sustainability/regeneration objectives, flood resistance and resilience practices should be followed in the construction and operation of the buildings to minimise the impact of flooding.
- Finished floor levels of all residential accommodation should be raised above the 1% AEP (1 in 100 Year) plus Climate Change level, with an allowance for freeboard (300 mm). Potential access and egress routes should also be considered and recommendations made for emergency response by occupants in the event of a breach occurring.
- Flood risk from all sources should be considered when identifying the perceived level of flood risk affecting a site. Robust consideration of surface water flood risk is particularly important in certain regions of the Borough, particularly in the north in the vicinity of the existing river network.
- Opportunities should be taken to identify sites where developer contributions could be used to fund future flood risk management schemes, improvements to surface water drainage systems or flood assets in adjacent areas. However, it should be noted that developer installed defences should not wholly justify development in locations with inappropriate levels of flood risk.
- Existing flood storage areas within development areas should be identified, conserved and protected against loss through redevelopment.
- An 8 m buffer strip should be maintained along fluvial river corridors, to ensure maintenance of the channel can be undertaken. As such, any new development should be avoided in existing buffer areas. A pragmatic approach should be adopted for existing development in these areas.
- For developments adjacent to Main Rivers, particular consideration should be given to facilitating the recommendations of the Thames CFMP and the North Kent Rivers CFMP in maintaining,

enhancing and replacing flood assets, future flood risk management and safeguarding riverside land.

Flood Defences

5.2.8 The SFRA has explained that there are currently no formal flood defences within the Borough. There are however several informal structures (walls, embankments) which reduce flood risk in addition to their primary purpose. The impact of these structures has been incorporated into the flood maps and therefore shows the actual fluvial flood risk with the assets in place. Local policy should continue to maintain and expand assets that are effective in managing current and future flood risk and promote wider sustainability.

5.2.9 The Thames CFMP and the North Kent Rivers CFMP address flood management in the area and suggest that flood management should generally be developed to reduce flood risk, especially to keep pace with climate change. This includes encouraging the uptake of flood resilience measures by people living within the floodplain. Additionally, opportunities to remove culverts and other structures that cause significant conveyance problems should be explored. Flood risk management should attempt to reduce risk whilst keeping the rivers natural characteristics as this provides a more sustainable method of flood risk management.

Sustainable Drainage Systems

5.2.10 Sustainable Drainage Systems must be included in new developments as a way to manage surface water flood risk, improve water quality and increase amenity and biodiversity. This is significant in the north of the Borough, where higher levels of pluvial flood risk are anticipated to interact with the more urbanised areas.

5.2.11 Runoff rates from new development must be restricted to greenfield runoff rates wherever possible. Robust justification must be provided for any sites where this is not achievable and an alternative discharge rate agreed with LBB.

5.2.12 Limiting the volume and rate of discharge for surface water entering the foul and combined surface water networks, is of importance within the Borough to help ensure the sewage network has the capacity to cater for population growth and the effects of climate change.

5.2.13 In line with the Sustainable Drainage Hierarchy, set out in Policy 5.13 of the London Plan (and repeated in Section 6.3), surface water should be prevented and controlled at source wherever possible through rainwater harvesting and infiltration techniques. Managed discharge of surface water to adjacent surface water bodies should also be considered. However, controls would need to be implemented to avoid any adverse harm to biodiversity and ecological habitat within receiving waters. Sustainable drainage should be delivered in accordance with the London Plan, the emerging Sustainable Design and Construction SPG, the emerging London Sustainable Drainage Action Plan and CIRIA guidance C753.

5.2.14 Presently, there is a tendency for required attenuation volumes to be accommodated below ground. However, preference should be given to the installation of blue-green surface infrastructure wherever possible, as opposed to hardscape or underground solutions, due to the wider benefits for biodiversity, amenity and microclimate.

5.2.15 The underlying geology within certain areas in Bromley is likely to impose constraints on the implementation of infiltration SuDS in many areas across the Borough. This is likely to necessitate the installation of lined systems to provide attenuation and reduction of runoff rates, requiring reuse of runoff or discharge to local surface water bodies or drainage systems. Site specific assessment of geological conditions should be undertaken as a part of the drainage strategy for new developments.

5.2.16 Greater detail and recommendations for SuDS within the Borough are contained in Section 6.3.

Emergency Planning

5.2.17 It is strongly recommended that emergency planning strategies are put in place in areas deemed at actual and/or residual risk of flooding to ensure adequate preparation and response during flood events. Where a new development or change of land use is proposed, flood evacuation plans should be developed through liaison with the emergency planners and the emergency services.

5.2.18 Additionally, following production of this SFRA, it is recommended that emergency planning strategies should be reviewed to determine the suitability of refuge centres and evacuation routes based on the updated flood risk mapping produced.

5.2.19 Emergency Planning can be broadly split into three phases, all of which should be considered in managing flood risk across the Borough:

- Before a flood – raising flood awareness, ensuring no inappropriate use of the floodplain/flow paths, preparing suitable flood emergency plans and communicating them to the wider community;
- During a flood – Flood alerts and communication, rescuing occupants, providing safe refuge and alternative accommodation; and
- After the flood – providing support to help people recover and return to their homes and businesses.

5.2.20 Consideration of emergency planning is even more critical when it relates to vulnerable sites and essential infrastructure, as further described below.

Vulnerable Sites

5.2.21 The Vulnerable sites (as defined by the National Receptors Database) in Bromley are shown in Appendix A, Map 012a, 012b and 012c, which show vulnerable site locations in comparison with fluvial flood zones, risk of surface water flooding and groundwater vulnerability respectively.

5.2.22 Emergency service authorities responsible for hospitals, ambulance, fire and police stations as well as prisons should ensure that emergency plans, in particular for facilities in flood risk areas, are in place and regularly reviewed so that they can cope in the event of a major flood. These plans should put in place cover arrangements through other suitable facilities, if deemed needed.

5.2.23 The NPPF classifies police stations, ambulance stations, fire stations and command centres as Highly Vulnerable buildings. It is essential that all establishments related to these services are located in the lowest flood risk zones to ensure that in the event of an emergency those services vital to the rescue operation are not impacted by flood water. Furthermore, development control policies should seek to locate more vulnerable uses such as schools and care homes in areas at the lowest risk of flooding to minimise the impact of a flood on their vulnerable users.

5.2.24 Allied to this, nominated rest and reception centres should also be identified within the study area and compared with the outputs of this SFRA to ensure that these centres are not at risk of flooding, so that evacuees will be safe during a flood event. Developments that would be suitable for such uses would include leisure centres, churches, schools and community centres.

5.2.25 On occasions where development of vulnerable sites within flood risk areas is unavoidable, necessary measures should be implemented to ensure the site is as safe as possible.

Critical Infrastructure

5.2.26 In the event of a flood incident, it is essential that the evacuation and rescue routes to and from any proposed development remain safe. Essential infrastructure located in Flood Zone 3a or 3b must be operational during a flood event to assist in the emergency evacuation process.

5.2.27 Relevant transport authorities and operators should examine and regularly review their infrastructure including their networks, stations, and depots, for potential flooding locations and to identify the need for any flood risk reduction measures. For large stations and depots, solutions should be sought to store or disperse rainwater from heavy storms in a sustainable manner.

Water Environment

5.2.28 It is recommended that LBB take a holistic approach to flood risk management across the Borough within the wider context of the water cycle and local environment. Within Bromley, a large extent of waterbodies are designated as heavily modified (as defined by the Water Framework Directive), with an absence of natural river processes leading to lost habitat diversity and poor water quality.

5.2.29 Additionally, it is anticipated that growing population numbers and changing climate patterns will place increased pressure on already stressed water resources across Greater London. New development can assist in alleviating this water scarcity by incorporating water efficiency measures such as grey water recycling, rainwater harvesting and water use minimisation technologies. This will also have a substantial benefit on the sewer system which will receive less wastewater from properties, potentially freeing up capacity during flood events.

5.2.30 Consideration should be given to maximising the benefits of surface water management infrastructure, enhance the urban environment for the benefit of communities and biodiversity. Through high quality design and installation, such infrastructure can contribute to multi-functional benefit in the following areas:

- Provision of habitat and biodiversity - when adequately planned, the delivery of diverse, high quality green spaces can provide valuable habitat to a range of flora and fauna.
- Recreation and community - provision of space for recreation and contribution to community health, wellbeing and social cohesion. Water features can create a sense of place.
- Microclimate adaptation - Reducing the impact of the urban heat island effect by providing shading to protect against radiations, reducing local temperatures through evapotranspiration and reducing heat absorbed and then released by surfaces.
- Public realm - street greening and the delivery of effectively landscaped open spaces can substantially improve the amenity value of neighbourhoods.

Consultation and Coordination

5.2.31 For future flood risk management within the Borough to be successful, it is essential that relevant partners and stakeholders, who have responsibility for flood risk management assets, work collaboratively to reduce flood risk.

5.2.32 In particular, LBB should continue to work with the EA and others to ensure ongoing maintenance and improvement of watercourses. This will include ensuring that the recommendations of the CFMPs and London Plan are implemented in new and existing developments, to keep communities safe from flooding in a changing climate and improving the local environment.

5.2.33 Similarly, opportunities should be sought to reduce the risk of flooding from surface water and sewer surcharge through consultation with Thames Water, to determine key areas for maintenance and locations that would benefit from flood alleviation schemes.

5.2.34 It is further recommended that LBB continues to collaborate with stakeholders to maintain and expand upon the existing understanding of flood risk across the Borough and, in particular, to confirm the impact of revised climate change allowances on understanding of fluvial flood risk.

6 Guidance for Developers

6.1 Site Specific Flood Risk Assessment

6.1.1 The aim of a site specific Flood Risk Assessment (FRA) is to assess the flood risk to and from a proposed development, and demonstrate that it will not be at risk of flooding during the design event during the lifetime of the development. This includes assessment of mitigation measures required to safely manage flood risk and demonstration that the proposed development will not increase flood risk elsewhere. All sources of flood risk will need to be considered.

6.1.2 This section presents the recommendations for site specific FRAs prepared for submission with planning applications to LBB, following the approach recommended by:

- The EA, particularly its flood risk standing advice[27];
- NPPF and Technical Guidance;
- CIRIA C753 The SuDS Manual[28];
- CIRIA report 624, Development and Flood Risk: Guidance for the construction industry[29]; and
- LBB's Validation Guidance and Local Information Requirements for Planning Applications[30].

6.1.3 FRA reports are usually undertaken by the developer and submitted as part of the planning application process. However, there are instances where a LPA might wish to commission a detailed, site-specific FRA to further understand the level of risk associated with a strategic site, and to inform decision making. An example of this would be where new flood defences or improved Standard of Protection (SoP) to existing assets is considered for a site, and the resultant flood reduction benefits, loss of floodplain storage and downstream implications need to be understood.

6.1.4 A site specific flood risk assessment is required in the following circumstances:

- Proposals of 1 hectare or greater in Flood Zone 1;
- Proposals for new development (including minor development and change of use) in Flood Zones 2 and 3;
- Proposals for new development (including minor development and change of use) in any critical drainage areas (as designated by the EA or the LLFA); and
- Where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding.

6.1.5 A FRA should demonstrate that the proposed development is safe from flooding from all sources, including the provision of safe access and egress, and that the development does not increase flood risk elsewhere. The flood risk assessment should consider the latest climate change guidance and allowances.

6.1.6 Proposals for the sustainable management of surface water should also be presented through a suitable drainage strategy incorporating SuDS techniques and demonstrating betterment in terms of runoff rates, amenity and biodiversity, as further described in Section 6.3.

6.1.7 If a detailed FRA is required, it must be undertaken by a suitably qualified professional. Assessments should be on a site by site basis making use of local knowledge. However, an initial assessment of flood risk can be made by consulting the mapping section of this SFRA.

6.1.8 FRAs should also be appropriate to the scale, nature and location of the development. Table 6-1 presents the different levels of site-specific FRA (as defined in CIRIA publication C624) and identifies typical sources of information that can be used.

[27] Available at: https://www.gov.uk/guidance/flood-risk-assessment-standing-advice
[28] Available at: http://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx
[29] Available At: http://www.ciria.org/ItemDetail?iProductCode=C624D&Category=DOWNLOAD
[30] Available At: http://www.bromley.gov.uk/downloads/file/2362/validation_guidance_and_local_information_requirements_for_planning_applications

Table 6-1 - *Levels of Site Specific Flood Risk Assessment (CIRIA C624)*

Level	Requirements	Typical Sources of Information
Level 1 Screening Study	The Level 1 FRA should identify whether there are any flooding or surface water management issues related to a development site that may warrant further consideration. This should be based on readily available existing information.	Typical sources of information include: • LBB SFRA, SWMP and PFRA; • Flood Map for Planning (Rivers and Sea); • Local flood risk policy documentation (such as Flood Risk Management Plan, Catchment Flood Risk Management Plan and Local Flood Risk Management Strategy); • EA Standing Advice; and • NPPF Tables 1, 2 and 3.
Level 2 Scoping study	The Level 2 FRA should be undertaken if the Level 1 FRA indicates that the site may lie within an area that is at risk of flooding, or the site may increase flood risk due to increased run-off. This study should confirm the sources of flooding which may affect the site. The study should include: • An appraisal of the availability and adequacy of existing information; • A qualitative appraisal of the flood risk posed to the site, and potential impact of the development on flood risk elsewhere; and • An appraisal of the scope of possible measures to reduce flood risk to acceptable levels. The scoping study may identify that sufficient quantitative information is already available to complete a FRA appropriate to the scale and nature of the development.	Typical sources of information include those listed above, plus: • Local policy statements or guidance, Local Flood Risk Management Strategy; • Catchment Flood Management Plan; • Data request from the EA to obtain result of existing hydraulic modelling studies relevant to the site and outputs such as maximum flood level, depth and velocity; • Consultation with EA/LBB/sewerage undertakers and other flood risk consultees to gain information and to identify in broad terms, what issues related to flood risk need to be considered including other sources of flooding; • Historic maps; • Interviews with local people and community groups; • Walkover survey to assess potential sources of flooding, likely routes for floodwaters, the key features on the site including flood defences, their condition; and • Site survey to determine general ground levels across the site, levels of any formal or informal flood defences.
Level 3 Detailed study	To be undertaken if a Level 2 FRA concludes that further quantitative analysis is required to assess flood risk issues related to the development site. The study should include: • Quantitative appraisal of the potential flood risk to the development; • Quantitative appraisal of the potential impact of the development site on flood risk elsewhere; and • Quantitative demonstration of the effectiveness of any proposed mitigations measures.	Typical sources of information include those listed above, plus: • Detailed topographical survey; • Detailed hydrographic survey; • Site-specific hydrological and hydraulic modelling studies which should include the effects of the proposed development; • Monitoring to assist with model calibration/verification; and • Continued consultation with the LBB, EA and other flood risk consultees.

Flood Risk Assessments for Flood Zone 1

6.1.9 Site specific flood risk assessments are required in Flood Zone 1, if a proposed development is:

- 1 hectare or greater in size;
- Within a Critical Drainage Area (as designated by the EA); or
- Where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding.

6.1.10 The following recommendations are made for site specific FRAs in Flood Zone 1.

- The developer should check whether the site has been identified as at risk from other (non-river related) flood sources by referring to the relevant maps within this SFRA. If so, a more detailed assessment of this risk over the lifetime of the development must be made.
- Assess the flood risk from all sources, including an assessment of the effects of climate change over the lifetime of the development.
- A drainage impact assessment must be carried out by a suitable professional to identify the impact of the proposed development on surface water drainage and recommend the approach to controlling runoff to the required discharge rates, through the use of SuDS. Where possible, runoff should be reduced to Greenfield Rates, in accordance with the recommendations of the London Plan. If the development is adjacent to a river, it must be set back an appropriate distance from the watercourse and development must enhance the river form and habitat. If culverted, the development should not build over the culvert and the developer should seek opportunities to de-culvert the watercourse as part of the development.
- The FRA must show that flood risk will be reduced overall.

6.1.11 The NPPF Technical Guidance (Table 3) confirms that all types of development are deemed suitable in Flood Zone 1.

6.1.12 If the site is on a ‘dry island’, surrounded by Flood Zone 2 or 3, the developer must also show that safe access and egress will be possible during a flood event.

Flood Risk Assessments for Flood Zones 2 and 3

6.1.13 A FRA must be undertaken for any proposed developments in flood zones 2 and 3. It is strongly recommended that the Sequential Test, and, depending on the vulnerability of the development (refer to Table 5-2), the first part of the Exception Test, be satisfied before the FRA is commenced.

6.1.14 If the development is within Flood Zone 2 or 3, the flood risk will be greater, and therefore the following recommendations and comments are made in addition to those that apply to sites in Flood Zone 1.

- Demonstrate, through the application of the Sequential Test, that there are no other suitable alternative sites in Flood Zone 1 for development.
- Show that flood risk will be reduced, and that suitable methods of mitigation will protect the development against the following (whichever are applicable):
  - 1% AEP fluvial event plus climate change over the lifetime of the development.
  - 0.5% AEP tidal event plus climate change over the lifetime of the development.
- Show that safe access can be provided to an appropriate level for the type of development.
- Show that flow routes are preserved and floodplain storage capacity is not reduced.
- The residents and occupiers of commercial buildings should be made aware their home / business is located in an area of flood risk, and should be encouraged to sign up to the EA Floodline Warnings Direct service (if available in this location).
- Any future development which includes or is immediately adjacent to a flood defence must additionally demonstrate that the flood defence will be fit for the lifetime of the development. This may require a survey of defences, proposals for required remedial works and / or complete replacement of defences.

6.1.15 If in Flood Zone 3, the Flood risk assessment must also confirm whether the development is located in Flood Zone 3a or 3b. It should be noted that only planning applications for essential infrastructure or water compatible development will be considered in Flood Zone 3b. Within Flood Zone 3b it must additionally be demonstrated that the development will:

- Remain operational and safe for users in times of flood;
- Result in no net loss of floodplain storage;
- Not impede water flows; and
- Not exacerbate flood risk elsewhere.

6.2 Reducing Residual Flood Risk

6.2.1 The minimum acceptable standard of protection against flooding for new property within flood risk areas is 1% AEP for fluvial flooding, with allowance for climate change over the lifetime of the development. The measures chosen will depend on the nature of the flood risk. Some of the more common measures are broadly outlined in this section.

Reducing Flood Risk through Site Layout and Design

6.2.2 Flood risk should be considered at an early stage in determining the layout and design of a development, providing an opportunity to reduce flood risk within the site. The NPPF and Technical Guidance state that a sequential, risk-based approach should be applied in order to locate more vulnerable land uses (such as residential use) to higher ground, while more flood-compatible development (e.g. parking, recreational space) can be located in areas at the highest risk of flooding within the site.

6.2.3 Low-lying waterside areas, or areas along known surface water flow routes, can be used for recreation, amenity and environmental purposes, allowing the preservation of flow routes and flood storage, and at the same time providing valuable social and environmental benefits contributing to other sustainability objectives. Landscaping should ensure safe access to higher ground from these areas, while avoiding the creation of isolated islands as water levels rise.

Modification of Ground Levels

6.2.4 Modifying ground levels to raise land above the required flood levels may be a potential means of reducing flood risk at certain sites, particularly where the risk is entirely from tidal flooding and the land does not provide conveyance for flood waters. However, in most areas of fluvial flood risk, conveyance or flood storage would be reduced by raising land above the floodplain, thereby adversely impacting on flood risk downstream. As such, compensatory flood storage must be provided to account for any land raising in the floodplain. Where the site is entirely within the floodplain it is not possible to provide compensatory storage at the maximum flood level so this will not be a viable mitigation option.

6.2.5 For proposed sites shown to be at risk of flooding from the 1 in 100 year plus Climate Change event, localised topography raising must be balanced with suitable floodplain compensation storage at another location (to be agreed with the EA). Such locations need to be sited in areas that currently do not flood (i.e. not part of the floodplain) and ideally within the redline application boundary.

6.2.6 Hydraulic modelling is likely to be required to demonstrate that the floodplain compensation design is technically robust, that there is no increase in flood risk off-site and that flood flow paths are not altered in such a way as to cause increase of flooding elsewhere. Consideration should also be given to surface water ponding, which may be increased due to changes in local topography.

Raised Defences

6.2.7 Construction of raised floodwalls or embankments can divert floodwaters away from new development or reduce the rate of flood inundation following a residual event. However, this should not be regarded

as a preferred option for new development, as a residual risk of flooding will remain. Additionally, it is essential to ensure that diversion of flood waters does not increase flood risk to people or properties in other areas. Compensatory storage must be provided where raised defences remove storage from the floodplain. Temporary or demountable defences are not acceptable flood protection for new development unless flood risk is residual only.

Upstream Flood Storage

6.2.8 Flood storage areas can be an effective way of attenuating floodwater for management of flood risk in surrounding areas. The basic function of these techniques is increased flood storage, through installation of features including pools, ponds, ditches and river restoration schemes. These features can provide habitat for local wildlife, contributing to local ecology and biodiversity, while additionally providing open space for recreational and amenity benefit. It is important that ongoing maintenance of flood storage areas is considered at an early stage to avoid future exacerbation of flood risk to surrounding areas as a result of poor upkeep.

Developer Contributions to Flood Defences and Risk Management Infrastructure

6.2.9 Riparian developments are required to renew or otherwise adequately maintain flood defences to the required standard of protection, over the lifetime of the development, accounting for the effects of climate change. In some cases, it may be necessary for the developer to make a contribution to the improvement of flood defences, or flood alleviation schemes for the benefit of both the development and the local community. Developers should also assess other existing assets (e.g. bridges, culverts, embankments) and renew them to last (as a minimum) the lifetime of the development.

6.2.10 Proposed developments which are adjacent to Main Rivers must demonstrate that sufficient access is provided to existing river assets to enable ongoing maintenance and, where appropriate, improvement has been considered. Where possible, development should be set back from the edge of Main Rivers and watercourses to enable future sustainable and cost effective flood risk management, including upgrade of river walls and embankments.

Building Design and Finished Floor Levels

6.2.11 Where developing in flood risk areas is unavoidable, the most common method of mitigating flood risk to occupants is to ensure that habitable floor levels are raised above the estimated design flood level, with an allowance for freeboard. This significantly minimises the risk of damage to the building interior, furnishings and electrical installations during flood events. Floor levels should ideally be raised by the following recommended amounts, as a minimum:

- In areas at fluvial flood risk:
  - 300 mm above the 1% AEP event plus climate change water level;
  - or 600 mm above the 1% AEP water level.

6.2.12 This additional height that the floor level is raised is referred to as the ‘freeboard’.

6.2.13 Making the ground floor use of a building water compatible (for example a garage), may also provide an effective means of raising living space above likely flood levels.

6.2.14 Constructing a building on stilts is not considered an acceptable means of flood mitigation for new development. However, this may be considered in special circumstances if replacing an existing solid building, as it can improve flow routes. In these cases, safe access and egress must be provided and covenants established to ensure the ground floor use is not changed at a later stage.

Flood Resistance and Resilience

6.2.15 There may be certain circumstances under which flood risk to a development is unavoidable, for example:

- Proposed water compatible uses;
- Alterations to existing buildings;
- Where building floor levels have been raised but there is still a remaining risk under the 0.1% AEP event.

6.2.16 In such cases (and for existing development in the floodplain), additional measures may be implemented to reduce damage during a flood and increase the speed of recovery. These measures should not be relied on as the only mitigation method.

6.2.17 Flood resistance measures aim to prevent floodwater from entering a property and causing damage. These measures may be temporary, such as demountable flood barriers and door flood guards for individual properties. If installed correctly and in advance of a flood event, these measures can provide effective protection. On a smaller scale, temporary snap-on covers for airbricks and vents can also be fitted to prevent entry of flood water. However complications can arise regarding the time for transportation and installation of defences and therefore a reasonable duration between flood warning and onset of flooding is generally required. This may be mitigated by the use of automatic barriers that do not require manual assembly.

6.2.18 The use of temporary resistance measures is considered appropriate for existing properties, however is not recommended for new development. This is because most temporary measures require intervention to function effectively, along with continued maintenance, which cannot be guaranteed. Permanent flood resistance measures, such as the use of low permeability materials to prevent water ingress are therefore recommended for new development.

6.2.19 Flood resilience measures aim to reduce the consequences of flooding events and ensure that buildings can be swiftly returned to normal use. This means that design provision is made for conveyance of flood waters through the building, avoiding the risk of structural damage and allowing rapid re-occupancy.

6.2.20 This includes interior design to reduce damage caused by flooding and may include:

- Designing structural capability to handle levels of water pressure associated with anticipated depths of flooding.
- Use of appropriate construction materials for surfaces, walls and floors which retain structural integrity during flooding and have good drying and cleaning properties. This may include vinyl and ceramic tiles, pressure treated timber, glass block, or metal. Alternatively sacrificial materials can be used for internal and external finishes (such as gypsum plasterboard which may be removed and replaced following flooding).
- Consideration given for appropriate water entry points into properties including doors, windows and air bricks.
- Placement of electrical circuitry and appliances above predicted levels of flooding with power cables carried down from the ceiling (not up from the floor level).
- Appropriate design of plumbing fittings, including toilets, with non-return valves to minimise the risk of contamination of floodwaters.

6.2.21 Flood resilience measures are most appropriate for less vulnerable uses where temporary disruption is acceptable and suitable flood warning is received.

6.2.22 The measures implemented should be specific to the nature of flood risk and the type of development proposed and, as such, will be informed and determined by the FRA. Further detailed guidance on

flood resilient construction techniques is provided within readily available publications from CIRIA (2010)[31] and DCLG (2007)[32].

6.3 Sustainable Drainage Systems (SuDS)

6.3.1 Implementing SuDS aims to recreate more natural drainage systems within the urban environment. These features celebrate the presence of water, enriching the urban environment, while providing valuable function for flood alleviation and biodiversity enhancement. Within developments, SuDS measures look to maximise permeable surfaces in an effort to increase the amount of water that is attenuated, treated and processed within the natural hydrological cycle.

6.3.2 Incorporating SuDS features will assist in absorbing runoff generated within development sites, reducing flooding, improving water quality, providing irrigation for vegetation and improve amenity. Such features can also contribute to a range of wider benefits, including provision of habitat for biodiversity, recreational opportunities, improved air quality and amelioration of the urban heat effect. All new developments within the Borough must incorporate SuDS to provide attenuation and management of rainfall runoff unless there is a valid reason to justify that they are not suitable. SuDS features are also suitable for retrofit on many sites, with a number of well-regarded SuDS retrofit schemes installed across Bromley. Sustainable drainage should be delivered in accordance with the SuDS Hierarchy, below:

- Store rainwater for later use;
- Use infiltration techniques, such as porous surfaces in non-clay areas;
- Attenuate rainwater in ponds or open water features for gradual release;
- Attenuate rainwater by storing in tanks or sealed water features for gradual release;
- Discharge rainwater direct to a watercourse;
- Discharge rainwater to a surface water sewer/drain;
- Discharge rainwater to the combined sewer.

6.3.3 Within Bromley, sewer capacity is constrained in certain areas, and minimising the volume and rate of discharge entering the foul and combined surface water networks is of critical importance to help ensure ongoing capacity to cater for population growth and the effects of climate change. Where infiltration is not achievable, managed discharge of surface water to adjacent surface water bodies should also be considered. However, controls would need to be implemented to avoid any adverse harm to biodiversity and ecological habitat within receiving waters.

6.3.4 Runoff rates from new development should be restricted to greenfield runoff rates wherever possible. Where this is not achievable, robust justification will be required, and an alternative reduction in runoff agreed through consultation with LBB.

6.3.5 SuDS schemes should be in accordance with the LBB SuDS Guidance, the London Plan and associated Sustainable Design and Construction SPG and the London Sustainable Drainage Action Plan.

6.3.6 Appendix C provides a brief summary of the main SuDS techniques that could be suitable for implementation within LBB. Detailed guidance on the selection, design, construction and maintenance of SuDS is provided in the LBB SuDS Guidance and the CIRIA SuDS Manual[33]. However, it should additionally be noted that the field of sustainable drainage is rapidly developing; therefore reference should be made to the latest guidance and best practice in developing site drainage strategies.

6.3.7 The selected SuDS scheme will be dependent on various factors including (but not limited to) topography, geology (soil permeability), and available area. This should be based on a comprehensive understanding of the catchment hydrological processes (i.e. nature and capacity of the existing

[31] Flood resilience and resistance for critical infrastructure (2010) http://www.ciria.org/Resources/Free_publications/Flood_resilience.aspx
[32] Improving the Flood Performance of New Buildings - Flood Resilient Construction (2007) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7730/flood_performance.pdf
[33] The SuDS Manual http://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx

drainage system). The design, construction and maintenance regime of such a scheme must be carefully defined, including the need and responsibility for ongoing inspection and maintenance to avoid future exacerbation of flood risk as a result of poor upkeep.

6.3.8 Many SuDS measures are designed to promote infiltration of runoff into the ground beneath, promoting recharge of the water table and reducing runoff. However, implementation of infiltration SuDS within Bromley may be constrained by geological conditions, including contaminated land. Site specific assessment of geological conditions should be undertaken to confirm that infiltration SuDS are suitable. Where sites lie within or close to source protection zones further restrictions may apply, and guidance should be sought from the EA.

6.3.9 Map 010, Appendix A contains information on the likely suitability of infiltration SuDS across the Borough. This map delineates four subsurface categories across the Borough, in which infiltration is likely to be of varying suitability, based upon a range of hydrogeological indicators. Further detail on the four categories is included in Table 6-2 below.

Table 6-2 - *SuDS Infiltration Suitability category descriptors*

Category	Description
Highly suitable	The subsurface is likely to be suitable for free-draining infiltration SuDS.
Probably suitable	The subsurface is probably suitable for infiltration SuDS although the design may be influenced by the ground conditions.
Potentially suitable for bespoke designs	The subsurface is potentially suitable for infiltration SuDS although the design will be influenced by the ground conditions.
Unlikely to be suitable	There is a very significant potential for one or more geo-hazards associated with infiltration.

6.3.10 If subsurface conditions are not suitable to facilitate infiltration in a certain area, selected SuDS features will need to be focused on surface water storage and attenuation, and appropriately lined so as to transport water to an area where it can be safely disposed.

6.4 Managing Flood Risk from Other Sources

Surface Water and Sewer Flooding

6.4.1 New development should seek to improve on-site drainage infrastructure to reduce flood risk. The site flood risk assessment and drainage strategy should demonstrate that the development will not increase flood risk elsewhere, and that LBB's drainage requirements regarding runoff rates and SuDS are met. SuDS are a highly effective way of managing surface water flood risk, as described in Section 5.3 and Appendix C, and should be incorporated on all development sites.

6.4.2 When redeveloping existing buildings, the installation of some flood-proofing and resilience measures can be used to protect against both surface water and sewer flooding. Non-return valves prevent water entering the property from drains and sewers. These valves can be installed within gravity sewers or drains, within the property's private sewer, upstream of the public sewer system. These need to be carefully installed and must be regularly maintained.

Groundwater

6.4.3 Groundwater flooding has a unique flooding mechanism, as it may emerge from below ground level and for this reason many conventional flood defence and mitigation methods are not suitable. Flood risk may be reduced through building design, by ensuring that floor levels are raised sufficiently above

the water table. Site design would also need to preserve any flow routes followed by the groundwater overland and make sure flood risk is not increased downstream. Proposed basement areas are likely to be particularly susceptible to groundwater flooding in certain areas. This may be mitigated through waterproof construction; however, consideration should be given to the potential impact on subterranean flow or water tables. When redeveloping existing buildings, it may be acceptable to install pumps in basements as a resilience measure. However, for new development this is unlikely to be considered an acceptable solution.

6.4.4 Site specific ground investigation is also likely to be required in locations where below ground development is proposed or there is known groundwater flood risk.

Artificial Sources

6.4.5 The flooding mechanism associated with flood risk from artificial sources is primarily related to breach or failure of structures (reservoir, lake, canal, flood storage areas, etc.). Due to the nature of this mechanism, it is difficult to foresee the location or extent of these problems and therefore it is important that the site specific FRA takes into consideration the integrity and history any relevant artificial structures and makes recommendations/provisions aimed at reducing the level of risk from these sources where applicable.

6.5 Making Development Safe

Safe Access and Egress

6.5.1 Emergency access and egress is required for developments during times of flooding to enable the evacuation of occupants and facilitate the emergency response. An emergency access and egress route is a path that is ‘safe’ for use by occupiers without the intervention of emergency services or others. A route can only be completely ‘safe’ in flood risk terms if it is dry at all times.

6.5.2 The FD2320/21 Defra/EA Flood Risks to People Report provides requirements for maximum flood depth and velocity to quantify whether an evacuation route should be deemed safe, where the requirements for safe access and egress from new developments are as follows in order of preference:

- Safe, dry route for people and vehicles;
- Safe, dry route for people;
- If a dry route for people is not possible, a route for people where the flood hazard (in terms of depth and velocity) is low and should not cause risk to people; and
- If a dry route for vehicles is not possible, a route for vehicles where the flood hazard (in terms of depth and velocity) is low to permit access for emergency vehicles.

6.5.3 Provision of safe access and egress may involve raising access routes to a suitable level above flood levels. As with land raising, it is imperative that any assessment takes into consideration the volume of floodwater potentially displaced.

Flood Warning and Evacuation

6.5.4 Emergency and evacuation plans should be in place for all properties at residual risk of flooding. Those developments which house vulnerable people (i.e. care homes and schools) will require more detailed plans.

6.5.5 Advice should be sought from the LBB Emergency Planning Team when producing an emergency evacuation plan for developments as part of an FRA. Those preparing detailed emergency evacuation plans for vulnerable developments should undertake consultation not only with LBB‘s Emergency Planning team but also the emergency services, so they know what is expected of them in the event of an emergency.

6.5.6 The EA operates a flood warning service in certain areas at risk of both fluvial and tidal flooding. The Flood warning system helps residents in these areas to prepare for flooding to minimise its potential consequences.

6.5.7 All homes and businesses within Flood Zone 2 and 3 are eligible for the EA's Floodline Warnings Direct (FWD) service, and should be encouraged to sign up to it. It is recommended that the developers make new owners of the property aware of this so they can sign up to FWD.

6.5.8 Areas of the Borough which are subject to flood warnings and alerts are illustrated in Map 011 Appendix A.

6.6 Making Space for Water

Opportunities for River Restoration and Enhancement

6.6.1 All new development close to watercourses should consider the opportunity to improve and enhance the water environment. Developments should look at particular opportunities for river restoration and enhancement. Restoration can take place on various scales, from small enhancement measures to full river restoration. Options include backwater creation, de-silting, in-channel habitat enhancement, removal of in-stream structures (e.g. weirs), and restoration of banks among others.

6.6.2 These measures have the potential of reducing the costs of any hard engineering structures, reducing flood risk, improving water quality and increasing biodiversity. Social benefits are also gained by increasing green space and access to the river.

6.6.3 In particular, there should be a presumption against further culverting of watercourses and constructing over culverts. All new developments with culverts running through their site should seek opportunities to de-culvert rivers, for flood risk management and conservation benefit.

6.6.4 These measures are supported by the European Water Framework Directive (WFD) a comprehensive river basin management planning system which aims to protect and improve the ecological health of waterbodies across Europe. In the UK, the EA is the authority charged with implementation of the Directive, and must meet certain targets aimed at restoring water bodies towards good condition. In line with the objectives of the directive, opportunities for waterbody improvement must be considered across all development proposals incorporating watercourses.

Buffer Strips

6.6.5 Developers must aim to set back development from the edge of adjacent waterways, in order to provide a buffer strip to 'make space for water' and allowing additional capacity to accommodate the effects of climate change. This is also necessary in areas where flood defences or other engineered structures are present in order to provide a corridor for maintenance and improvement works. As a minimum, development should be set back:

- 5 metres from ordinary watercourses;
- 8 metres from fluvial Main Rivers; and

6.6.6 An Environmental Permit[34] will be required from the EA for all works within 8 metres of Main Rivers. It should be noted that although planning consent may be granted in the absence of the correct Environmental Permit being obtained, this does not negate the need to obtain a permit from the EA prior to commencement of construction works within 8 metres of a Main River.

[34] Available at: https://www.gov.uk/topic/environmental-management/environmental-permits

Designing for Exceedance

6.6.7 The capacity of existing drainage systems is limited, and can be overwhelmed by rainfall events of intensity above the design capacity, possibly leading to surcharge and flooding. In order to manage and minimise the impacts of such events, developers should seek opportunities to identify a safe route for any exceedance flow and suitable storage or discharge location, so that this does not put people or property at risk.

6.6.8 As exceedance is expected to occur infrequently, such measures should ideally provide other benefits. An example of this is blue-green urban corridors, which provide ecological, recreational and functional benefits under the small rainfall events, whilst offering an effective and safe means of managing extreme events when these do occur.

7 Summary

7.1 Overview

7.1.1 The NPPF and accompanying Guidance emphasise the responsibility of LPAs to ensure that flood risk is understood and managed effectively and sustainably throughout all stages of the planning process. This SFRA aims to facilitate this process by identifying the spatial variation in flood risk across the Borough, allowing an area-wide comparison of future development sites with respect to flood risk considerations.

7.1.2 The north of the Borough is dissected by four Main Rivers: The Pool, the River Ravensbourne, Kyd Brook and the River Cray. There are no formal flood defences within the Borough; however, channelisation and alterations to the watercourses over the years has resulted in reduced flood risk. Nonetheless, there are still considerable areas at fluvial flood risk within the north of the Borough.

7.1.3 A potential risk of flooding from other (non-river related) sources exists throughout the Borough, including sewer surcharge, and surface water flooding as a result of heavy rainfall and limited capacity of drainage infrastructure. This is particularly known to be an issue where groundwater levels are already high due to the location of permeable aquifers beneath the surface. It is expected that changing climate patterns will have a substantial impact on the level of flood risk from all sources within the Borough.

7.1.4 This SFRA identifies the floodplain areas associated with the Main Rivers and presents Flood Zone Maps that delineate the flood zones outlined in the NPPF. These maps provide the necessary information to facilitate the NPPF risk-based approach to planning. This process determines the compatibility of various types of development within each flood zone, subject to the application of the Sequential Test and the Exception Test when required.

7.2 Key Recommendations and Next Steps

7.2.1 Adopting a holistic approach to flood risk management should help ensure that flooding is taken into account at all stages of the planning process. To aid this holistic approach, it is recommended that all key recommendations set out in this report are considered and incorporated into the emerging Bromley Local Plan.

7.2.2 Given the extent of Main Rivers in the north of the Borough, development in this region must be considerate of flood risk and undertake measures to ensure its level is not increased. It is recommended that policy options are expanded to include greater emphasis on floodplain management to promote appropriate use of the floodplain and making space for water. Existing corridors of land along the river frontage should be safeguarded and opportunities taken to set back development to enable sustainable and cost effective flood risk management, including upgrading of river walls and embankments. Flood awareness and robust emergency planning and response will additionally be critical to sustainable ongoing flood risk management.

7.2.3 In the future, climate change is anticipated to have an impact on all sources of flood risk within the Borough. It is important that planning decisions recognise the potential risk that increased runoff poses to property and plan development accordingly so that future sustainability can be assured.

7.3 Maintenance of this SFRA

7.3.1 In order for this SFRA to serve as a practical planning tool now and in the future, it is imperative that the SFRA is adopted as a ‘living document’ and is reviewed periodically in light of emerging policy directives and an improving understanding of flood risk within the Borough.

7.3.2 Appendix F lists a series of recommendations ensuring that the SFRA is kept up-to-date and maintained. This will allow the SFRA to follow emerging best practice and developments in policy and climate change predictions.

References

2011 Census http://www.ons.gov.uk/ons/guide-method/census/2011/index.html

CIRIA C697, 2015, The SuDS Manual.
http://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx

CIRIA C624, 2004: Development and flood risk, guidance for the construction industry.

Communities and Local Government, 2007, Improving the Flood Performance of New Buildings

Communities and Local Government, 2012, The National Planning Policy Framework
https://www.gov.uk/government/publications/national-planning-policy-framework--2

Communities and Local Government, 2012, Technical Guidance to the National Planning Policy Framework
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6000/2115548.pdf

DEFRA/Environment Agency, October 2005, Flood Risk Assessment Guidance for New Development, R&D Technical Report FD2320/TR2

DEFRA/Environment Agency, March 2006: Flood Risks to People Phase 2, FD2321/TR2

DEFRA/Environment Agency, May 2007: Improving the Flood Performance of New Buildings, Flood Resilient construction.

Environment Agency, 2007: Thames Region Catchment Flood Management Plan
https://www.gov.uk/government/publications/thames-catchment-flood-management-plan

Environment Agency, 2009: North Kent Rivers Catchment Flood Management Plan

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293893/North_Kent_rivers_Catchment_Flood_Management_Plan.pdf

Environment Agency, May 2011, National Flood and Coastal Erosion Risk Management Strategy for England
https://www.gov.uk/government/publications/national-flood-and-coastal-erosion-risk-management-strategy-for-england

Environment Agency, October 2014, Thames River Basin District Draft Flood Risk Management Plan
https://consult.environment-agency.gov.uk/portal/ho/flood/draft_frmp/consult?pointId=3063510

Environment Agency, 2009, Thames River Basin District Management Plan

Environment Agency, February 2015, Climate change allowances for Flood Risk Assessments
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Environment Agency, Flood Risk Standing Advice https://www.gov.uk/guidance/flood-risk-assessment-standing-advice

Flood Risk Regulations, 2009, http://www.legislation.gov.uk/uksi/2009/3042/contents/made

Flood and Water Management Act, 2010, http://www.legislation.gov.uk/ukpga/2010/29/contents

Greater London Authority, April 2014, Sustainable Design and Construction, The London Plan Supplementary Planning Guidance https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/supplementary-planning-guidance/sustainable-design-and

Greater London Authority, March 2015, The London Plan http://www.london.gov.uk/priorities/planning/london-plan

London Borough of Bromley, 2015, Our Borough, Our Plan
http://www.towerhamlets.gov.uk/Documents/Planning-and-building-control/Strategic-Planning/Local-Plan/18112015_local_plan_engagement_document_v12_6_publication.pdf

Bromley, Draft Local Flood Risk Management Strategy
http://www.towerhamlets.gov.uk/Documents/Environmental-protection/Monitoring/Draft-Local-Flood-Risk-Management-Strategy.pdf

Bromley, Surface Water Management Plan (2011) Drain London

Bromley, 2011, Preliminary Flood Risk Assessment
http://www.towerhamlets.gov.uk/Documents/Environmental-protection/Monitoring/DLT2-GP4-TowerHamlets-PFRA.pdf

Met Office, 2009, UK Climate Projections http://ukclimateprojections.metoffice.gov.uk/

Appendix A Flood Risk Mapping

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Appendix D Mapping and Dataset Summary

Appendix E Flood History Register

Appendix F SFRA Management Guide

Appendix G Allocated Development Site Assessments

Appendix H Informal Flood Defence Identification

Appendix I Potential Floodplain Enhancement Options

Appendix J Surface Water Flood Risk Hot Spot Identification and Guidance

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