URS

Lambeth Strategic Flood Risk Assessment

Final Report

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Prepared for:
London Borough of Lambeth

UNITED KINGDOM & IRELAND

Lambeth

Rev	Date	Details	Prepared by	Checked by	Approved by
1	March 2013	Draft SFRA	Joanne Somerton Senior Flood Risk Specialist Tom Edwards Senior Consultant	Jon Robinson Operations Director	Jon Robinson Operations Director
2	March 2013	Final SFRA	Tom Edwards Senior Consultant	Jon Robinson Operations Director	Jon Robinson Operations Director

URS Infrastructure & Environment UK Limited
6 – 8 Greencoat Place
London
SW1P 1PL

Tel: +44 (0)20 7798 5200
Fax: +44 (0)20 7798 5001
www.ursglobal.com

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ABBREVIATIONS

Acronym	Definition
CFMP	Catchment Flood Management Plan
CLG	Communities and Local Government
DEM	Digital Elevation Model
DPD	Development Plan Documents
EA	Environment Agency for England and Wales
FRR	Flood Risk Regulations
FWMA	Flood and Water Management Act
FRA	Flood Risk Assessment
GIS	Geographical Information Systems
IDB	Internal Drainage Board
LB	London Borough
LBL	The London Borough of Lambeth
LDDs	Local Development Documents
LDF	Local Development Framework
LDS	Local Development Scheme
LFRMS	Local Flood Risk Management Strategy
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LLP	Lambeth Local Plan
LPA	Local Planning Authority
mAOD	Metres Above Ordnance Datum. Elevations use Ordnance Datum, Newlyn.
NPPF	National Planning Policy Framework
ODPM	Office of the Deputy Prime Minister
PFRA	Preliminary Flood Risk Assessment
PPS25	Planning Policy Statement 25: Development and Flood Risk
RBMP	River Basin Management Plan
RFRA	Regional Flood Risk Appraisal
RPG	Regional Planning Guidance
RSS	Regional Spatial Strategy
SAR	Synthetic Aperture Radar
SAC	Special Area of Conservation
SA	Sustainability Appraisal
SDP	Strategic Development Plan
SFRA	Strategic Flood Risk Assessment
SPD	Supplementary Planning Document
SPG	Supplementary Planning Guidance
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan

GLOSSARY

Term	Definition
Alluvium	Sediments deposited by fluvial processes / flowing water.
Attenuation	In the context of this report - the storing of water to reduce peak discharge of water.
Aquifer	A source of groundwater comprising water-bearing rock, sand or gravel capable of yielding significant quantities of water.
Breach	An opening – For example in the sea defences
Brownfield	Previously developed land, usually of industrial land use within inner city areas.
Catchment Flood Management Plan	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Culvert/culverted	A channel or pipe that carries water below the level of the ground.
Drift Geology	Sediments deposited by the action of ice and glacial processes
EA Flood Zone 1	Low probability of flooding
EA Flood Zone 2	Medium probability of flooding. Probability of fluvial flooding is 0.1 – 1%. Probability of tidal flooding is 0.1 – 0.5 %
EA Flood Zone 3a	High probability of flooding. Probability of fluvial flooding is 1% (1 in 100 years) or greater. Probability of tidal flooding is 0.5%(1 in 200 years)
EA Flood Zone 3b	Functional floodplain
Estuary	A tidal basin , where a river meets the sea, characterised by wide inlets
Exception Test	The exception test should be applied following the application of the sequential test. Conditions need to be met before the exception test can be applied.
Flood defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floodplain	Area adjacent to river, coast or estuary that is naturally susceptible to flooding.
Flood Resilience	Resistance strategies aimed at flood protection
Flood Risk	The level of flood risk is the product of the frequency or likelihood of the flood events and their consequences (such as loss, damage, harm, distress and disruption)
Flood Risk Assessment	Considerations of the flood risks inherent in a project, leading to the development actions to control, mitigate or accept them.
Flood storage	A temporary area that stores excess runoff or river flow often ponds or reservoirs.
Flood Zone	The extent of how far flood waters are expected to reach.
Fluvial	Relating to the actions, processes and behaviour of a water course (river or stream)
Fluvial flooding	Flooding by a river or a watercourse.
Freeboard	Height of flood defence crest level (or building level) above designed water level
Functional Floodplain	Land where water has to flow or be stored in times of flood.
Freeboard	Height of flood defence crest level (or building level) above designed water level.
GIS	Geographic Information systems – A mapping system that uses computers to store, manipulate, analyse and display data.
Greenfield	Previously undeveloped land.
Groundwater	Water that is in the ground, this is usually referring to water in the saturated zone below the water table.
Highly Vulnerable Developments	Developments that are at highest risk of flooding.
Hydraulic Modelling	A computerised model of a watercourse and floodplain to simulate water flows flows in rivers too estimate water levels and flood extents.
Hydrodynamic Modelling	The behaviour of water in terms of its velocity, depth and hazard that it presents.
Infiltration	The penetration of water through the grounds surface.

Term	Definition
Infrastructure	Physical structures that form the foundation for development.
Inundation	Flooding.
LiDAR	Light Detection And Ranging – uses airborne scanning laser to map the terrain of the land.
Local Development Framework (LDF)	The core of the updated planning system (introduced by the Planning and Compulsory Purchase Act 2004). The LDF comprises the Local Development Documents, including the development plan documents that expand on policies and provide greater detail. The development plan includes a core strategy, site allocations and a proposals map.
Local Planning Authority	Body that is responsible for controlling planning and development through the planning system.
Main River	Watercourse defined on a 'Main River Map' designated by DEFRA. The environment Agency has permissive powers to carry out flood defence works, maintenance and operational activities for Main Rivers only.
Mitigation measure	An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere.
Overland Flow	Flooding caused when intense rainfall exceeds the capacity of the drainage systems or when, during prolonged periods of wet weather, the soil is so saturated such that it cannot accept any more water.
Overtopping	Water carried over the top of a defence structure due to the wave height exceeding the crest height of the defence.
Reach/ Upper reach	A river or stream segment of specific length. The upper reach refers to the upstream section of a river.
Residual Flood Risk	The remaining flood risk after risk reduction measures have been taken into account.
Return Period	The average time period between rainfall or flood events with the same intensity and effect.
Risk	The probability or likelihood of an event occurring.
River Catchment	The areas drained by a river.
SAR	Synthetic Aperture Radar - a high resolution ground mapping technique, which uses reflected radar pulses.
Sequential Test	Aims to steer vulnerable development to areas of lowest flood risk.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Solid Geology	Solid rock that underlies loose material and superficial deposits on the earth's surface.
Source Protection Zone	Defined areas in which certain types of development are restricted to ensure that groundwater sources remain free from contaminants.
Standard of Protection	The flood event return period above which significant damage and possible failure of the flood defences could occur.
Storm surge	A high rise in sea level due to the winds of the storm and low atmospheric pressure.
Sustainability	To preserve /maintain a state or process for future generations.
Sustainable drainage system	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations meeting their own needs.
Tidal	Relating to the actions or processes caused by tides.
Topographic survey	A survey of ground levels.
Tributary	A body of water, flowing into a larger body of water, such as a smaller stream joining a larger stream.
1 in 100 year event	Event that on average will occur once every 100 years. Also expressed as an event, which has a 1% probability of occurring in any one year.
1 in 100 year design standard	Flood defence that is designed for an event, which has an annual probability of 1%. In events more severe than this the defence would be expected to fail or to allow flooding.

1. INTRODUCTION

1.1 Planning Context

The National Planning Policy Framework[1] (NPPF) and accompanying Technical Guidance[2] 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. The NPPF requires LPAs to undertake Strategic Flood Risk Assessments (SFRAs) to support the preparation of their Local Plan.

The NPPF and Technical Guidance were published in March 2012 and replace Planning Policy Statement 25 (PPS25) Development and Flood Risk[3], however they do not supersede the PPS25 Practice Guidance[4]. Accordingly, this SFRA has been prepared in accordance with the principles set out in the NPPF and supporting guidance.

The NPPF and supporting guidance require LPAs to undertake SFRAs and to use their findings, and those of other studies, to inform strategic land use planning including the application of the Sequential Test which seeks to steer development towards areas of lowest flood risk prior to consideration of areas of greater risk.

Following the publication of the NPPF and new regional policies such as the Mayor's Vauxhall Nine Elms Battersea Opportunity Area Planning Framework, London Borough of Lambeth (LBL) is currently reviewing its planning policies to provide an up to date Development Plan. The new Lambeth Local Plan (LLP) will support growth and change within the Borough and will guide development over the next 15 years.

The new LLP will also reflect updates in council strategies. This includes recent area based work such as the Vauxhall Supplementary Planning Document (SDP), the draft Brixton SDP and the revised draft Waterloo SDP. The LLP is scheduled to go out to public consultation in March 2013 with the aim of adopting the LLP in early 2015.

A review of the flood risk related policies contained within the Draft Local Plan is provided in Section 2.3.

1.2 The Lambeth Study Area

The Study Area is defined by the administrative boundary of Lambeth. The Study Area includes typically heavily developed areas in the north, interlinked with small sections of open space more commonly found in the southern extent of the study area.

The Study Area is bound to the north by the Tidal River Thames which flows from east to west. The River Graveney / Norbury Brook, tributaries of the River Wandle, cross the south western extent of the Borough. These tributaries run through urban areas where the natural watercourse has historically been heavily modified.

The River Effra, now a sewer along its entire course, flows through the Study Area in a northerly direction passing through Herne Hill, Brockwell Park, Brixton and onto Kennington before flowing out into the Thames. The River Effra is described as a lost river of London and due to its culverted nature is referred to as a sewer for the purposes of this study.

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[1] Communities and Local Government. 2012. *National Planning Policy Framework*. Available at: http://www.communities.gov.uk/documents/planningandbuilding/pdf/2116950.

[2] Communities and Local Government. 2012. '*Technical Guidance to the National Planning Policy Framework'*. TSO: London. Available at: http://www.communities.gov.uk/publications/planningandbuilding/nppftechnicalguidance

[3] Communities and Local Government. 2010. *'Planning Policy Statement 25: Development and Flood Risk,* TSO: London.

[4] Communities and Local Government. 2009. *'Planning Policy Statement 25: Development and Flood Risk Practice Guide'*. TSO: London. Available at: http://www.communities.gov.uk/documents/planningandbuilding/pdf/pps25guideupdate.pdf

A detailed Study Area Plan is illustrated in Figure 1 Appendix A.

1.3 SFRA Overview

URS/Scott Wilson produced Level 1 and Level 2 SFRA documents for LBL in 2008, which were produced in accordance with PPS25, and in conjunction with the Environment Agency. The Level 1 SFRA provides an overview of all sources of flooding, including fluvial, tidal, groundwater, surface water and sewers, throughout Lambeth's administrative area.

Following completion of the SFRA in 2008, several changes to flood risk policy and guidance have been introduced including, but not limited to, the Flood Risk Regulations (FRR) 2009, the Flood and Water Management Act 2010 and the National Planning Policy Framework (NPPF) 2012.

In addition to the revised policy and guidance documents that have recently been released, many of the data sets used to inform the 2008 SFRA have since been updated, and/or improved through the use of new modelling approaches.

The availability of new policy guidance and improved flood risk data sets makes this an appropriate time at which to update the existing SFRA documents to ensure they remain up to date and fit for purpose.

1.4 Aims and Objectives of the 2013 SFRA

The aim of this study is to provide a full SFRA for the London Borough of Lambeth to inform policies regarding realistic approaches to managing flood risk in accordance with the NPPF and supporting guidance.

The aim of the London Borough of Lambeth SFRA will be met through the following objectives:

Level 1 SFRA

- To provide an assessment of the impact of all potential sources of flooding in accordance with NPPF, including an assessment of any future impacts associated with climate change and sea level rise;
- Enable planning policies to be identified specific to local flooding issues;
- Provide information required to apply the Sequential Test for identification of land suitable for development in line with the principles of the NPPF;
- To provide baseline data to inform the Sustainability Appraisal of the Development Plan Documents (DPDs) with regard to catchment-wide flooding issues which affect the Study Area;
- Provide sufficient information to allow the London Borough of Lambeth to assess the flood risk for specific development proposal sites, thereby setting out the requirements for site specific Flood Risk Assessments (FRAs);
- Provide recommendations of suitable mitigation measures including the objectives of Sustainable Drainage Systems (SuDS);
- Enable the London Borough of Lambeth to use the SFRA as a basis for decision making at the planning application stage;

- Where necessary, provide technical assessments to demonstrate that development located in flood risk areas are appropriate and in line with the requirements of the exception test;
- Present sufficient information to inform the London Borough of Lambeth of the acceptability of flood risk in relation to emergency planning capability;
- To inform on specific flood risk issues and suitability for development of Waterloo and Vauxhall as outlined in the London Plan and Waterloo and Vauxhall Opportunity Area Framework documents and the Current Lambeth Local Plan. This will provide sufficient information to allow the application of the Exception Test.

Level 2 SFRA

- An appraisal of the current condition of flood defence infrastructure and of likely future policy with regard to its maintenance and upgrade;
- An appraisal of the probability and consequences of failure of flood risk management infrastructure, including an appropriate allowance for climate change;
- Mapping to illustrate the distribution of flood risk across flood zones to enable a sequential approach to site allocation within flood zones;
- Identify policies and practices required to ensure development satisfies the Exception Test;
- Guidance on the preparation of FRAs for sites of varying risk across the flood zone.

1.5 SFRA Structure

The SFRA has been completed in two stages as recommended in NPPF supporting guidance. This provides the local planning authority with tools throughout the LLP and SFRA process sufficient to inform decisions regarding development sites. The two stages are:

- Level 1 SFRA – Study Area Flood Source & Data Review to enable application of the Sequential Test.
- Level 2 SFRA – refines information on the probability of flooding in the Waterloo and Vauxhall Opportunity Areas including development Site Assessments for Exception Testing.

The Sequential and Exception Tests are discussed in more detail in Chapter 8 and 9.

1.6 Neighbouring Strategic Flood Risk Assessment Status

Local Authority areas do not follow river catchment boundaries and therefore sometimes share neighbouring river catchments. Details of neighbouring boroughs SFRAs are provided below with their status at the time of writing to allow users to cross reference catchments where necessary:

- London Boroughs of Wandsworth, Merton, Sutton and Croydon SFRA – completed in Summer 2008.
- London Borough of Southwark SFRA – updated version published February 2008

Both the London Borough of Wandsworth SFRA and The London Borough of Southwark SFRA consider the residual risk of flooding from the River Thames through the application of various breach scenarios.

2. POLICY REVIEW AND UPDATES

Since the LBL Level 1 and Level 2 SFRAs were completed, updates to national planning policy and flood risk have emerged. This section highlights the main updates and the impacts they have on the SFRA.

2.1 National Policy

National Planning Policy Framework

The NPPF consists of a framework within which councils and local people can produce local and neighbourhood plans that reflect the needs and priorities of their communities.

PPS25 was revoked by the new NPPF. Section 10 of the NPPF provides national policy in relation to development and flood risk, and retains key elements of PPS25. It is supplemented by an accompanying Technical Guide and the PPS25 Practice Guide, which previously supported PPS25. The retention of the PPS25 Practice Guide is an interim measure pending a wider review of guidance to support planning policy.

The overall approach to flood risk is broadly summarised in NPPF Clause 103:

"When determining planning applications, local planning authorities 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."*

Table 1 of the NPPF includes statements on policy aims, and reaffirms the need for developers and Local Planning Authorities to seek opportunities to:

- *Reduce the overall level of flood risk in the area and beyond through the layout and form of the development,*
- *Relocate existing development to land with a lower probability of flooding,*
- *Create space for flooding, and*
- *Apply appropriate sustainable drainage systems."*

Planning Policy Statement 25: Development and Flood Risk (March, 2010)

PPS25 has been revoked and replaced by the NPPF in March 2012. However due to the timescales often involved in producing and finalising planning documents the following section has been retained for future reference.

Limited amendments to PPS25 were proposed to clarify how certain aspects of PPS25 are applied to ensure the policy is fully effective. The proposed amendments affected tables D.1

(Flood Zones)[5] and D.2 (Flood Risk Vulnerability Classification)[6] in Annex D to PPS25. A consultation on these amendments was held between August and November 2009.

Following public consultation, the Government has decided to make some limited amendments in relation to essential infrastructure, emergency services facilities, certain facilities requiring hazardous substances consent, wind turbines and the text supporting the definition of 'Functional' Floodplain.

The revised version of PPS25 incorporating amendments covered by the consultation process was released late March 2010. A summary of the amendments that affect planning relevant to this document is provided in Table 2-1.

Table 2-1: Previous and amended text within PPS25.

Location of Amended Text	Pre-March 2010 text within PPS25 (where available)	Amended Text released post-March 2010 within PPS25
Table D1: Flood Zones – Zone 3b The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. SFRAs should identify this Flood Zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes).	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their SFRAs areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain.

Tables D.1 (Flood Zones) and D.2 (Flood Risk Vulnerability Classification) in Annex D to PPS25 now form part of the NNPF Technical Guidance.

PPS25: Development and Flood Risk Practice Guide (DCLG, 2009)

Appendix B of this Practice Guide now contains a checklist to help developers and applicants to prepare an appropriate, site-specific FRA in accordance with the policy in PPS25, and the advice in the Practice Guide.

[5] Department for Communities and Local Government. March 2010. Planning Policy Statement 25: Development and Flood Risk (PPS25). Pg.28.
[6] Department for Communities and Local Government. March 2010. Planning Policy Statement 25: Development and Flood Risk (PPS25). Pg. 31.

The Flood and Water Management Act

Following the devastating national floods of 2007, one of the recommendations from Sir Michael Pitt's review[7] was that "the role of local authorities should be enhanced so that they take on responsibility for leading the co-ordination of flood risk management in their areas".

The Flood and Water Management Act (2010)[8] brings in new roles and responsibilities for local authorities. In particular, the Act defines the role of Lead Local Flood Authority (LLFA), which will include Unitary Authorities or County Councils. The LLFA will be encouraged to bring together relevant bodies and stakeholders to effectively manage local flood risk. These Flood Risk Management Authorities may include County, City and District/Borough Councils, Internal Drainage Boards (IDBs), highways authorities, water companies and the Environment Agency.

The new responsibilities that the Act assigns to LLFAs include:

- Coordinated management of flooding from surface water, ground water and ordinary watercourses;
- Development and maintenance and implementation of Flood Risk Management Strategies;
- Investigation and recording of local flood events; and
- Establishment and maintenance of a Flood Risk Asset Register.

The Act gives LLFAs the role of SuDs Approval Body (SAB) which allows each Council to be responsible for adopting and maintaining SuDS. This will mean that planning applications which have drainage implications should be approved by the SAB before work can commence.

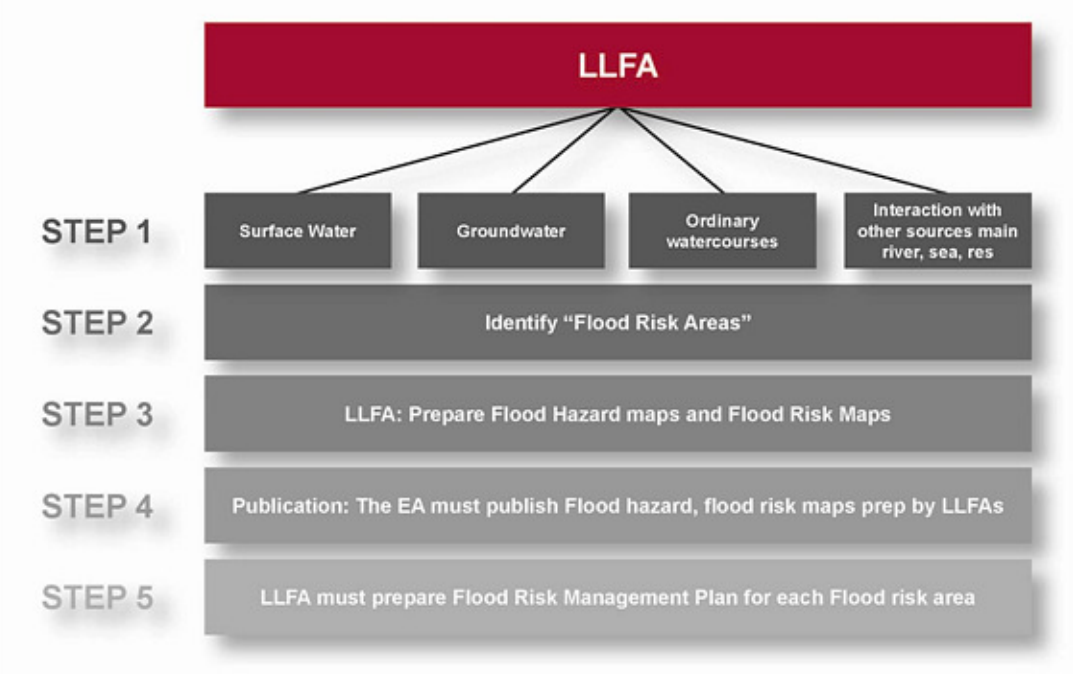
The Flood Risk Regulations (December 2009)

The Flood Risk Regulations[9] came into force on the 10th December 2009 and sets out duties for the Environment Agency and LLFAs in the preparation of a range of reports and mapping outputs.

The Flood Risk Regulations (2009) transpose the EU Floods Directive (2007/60/EC) into UK Law. One of the main impacts on Local Authorities in the UK is that they are required to complete Preliminary Flood Risk Assessment (PFRAs), produce Flood Risk Maps showing the extents and hazards of flooding in their area and finally, produce Flood Risk Management Plans (see Figure 2-1).

[7] Sir Michael Pitt. June 2008. The Pitt Review: Lessons learned from the 2007 floods. http://www.environment-agency.gov.uk/research/library/publications/33889.aspx
[8] The National Archives. HM Government. 2010. The Flood and Water Management Act. http://www.legislation.gov.uk/ukpga/2010/29/contents
[9] The Flood Risk Regulations. 2009. http://www.legislation.gov.uk/uksi/2009/3042/contents/made

Figure 2-*1: LLFA PFRAs*



Lambeth are the Lead Local Flood Authority for the Borough and are responsible for preparing the following:

- A Preliminary Flood Risk Assessment report for flooding from sources other than that from the sea, main rivers and reservoirs, this was produced in June 2011;
- Determine whether, in the opinion of the lead local authority, there is a significant flood risk in its area and identify the part of the area, if any, where this risk exists (for sources other than that from sea, main rivers and reservoirs); and
- Where LLFA identify a relevant flood risk area there is a requirement to prepare flood hazard and flood risk maps for these areas for publication by the Environment Agency before 22nd December 2013. In addition, for these areas, a flood risk management plan must be prepared for publication by the Environment Agency by 22nd December 2015.

Although the outputs of reports and mapping from the requirements of the Flood Risk Regulations may not be available for the purposes of this study, it is important to use the findings from these when updating the SFRA in the future.

2.2 Regional Policy

Some regional and local policy relevant to the SFRA still refers to PPS25, however the NPPF and its Technical Guidance does not change the appropriateness of the technical content of PPS25.

The London Plan: Spatial Strategy for Greater London

The London Plan[10] was adopted in July 2011. This replaced the London Plan (consolidated with alterations since 2004[11]) which was published in February 2008. The Plan sets out an

[10] Greater London Authority, (2011); The London Plan: Spatial Strategy for Greater London

integrated economic, environmental, transport and social framework for the development of London for the next 20-25 years. Policies of relevance to flood risk within the context of the SFRA include:

- *Policy 2.18 Green Infrastructure* – the promotion of SuDS will improve water resources, flood mitigation and reduce flood risk;
- *Policy 5.3 Sustainable Design and Construction* – promotes high standards of design in new developments to improve environmental performance. This includes avoiding impacts from natural hazards (such as flooding);
- *Policy 5.11 Green Roof and Development Site Environs* – major developments should include roof, wall and site planting in their design to achieve sustainable urban drainage by absorbing rainfall and thereby reduce flooding;
- *Policy 5.12 Flood Risk Management* – development proposals must comply with PPS25 and have regard to measures proposed in the Thames Estuary 2100 Plan and Catchment Flood Management Plans. Developments, which are required to pass the PPS25 Exceptions Test, will need to address flood resilient design and emergency planning;
- *Policy 5.13 Sustainable Drainage* – Developments should utilise SuDS, aim to achieve greenfield run-off rates and manage surface water run-off close to source;

Supplementary Planning Guidance (SPG) – Sustainable Design and Construction

In May 2006 Supplementary Planning Guidance (SPG) was published by the GLA on Sustainable Design and Construction[12]. One area, Section 2.4, relates to reducing water pollution and flooding.

Section 2.4.4 indicates that the essential standards for reducing water pollution and flooding require that all developments use SuDS wherever practical and achieve 50% attenuation of the undeveloped site's surface water run-off at peak times. The 'undeveloped site' is taken to be the site as it existed prior to the construction of the Proposed Development (i.e. the existing site). The Mayor's preferred standards would achieve 100% attenuation of the undeveloped site's surface water run-off at peak times.

The SPG also highlights the need for all developments to conform to the Sequential Test of PPS25, and identifies that development should incorporate safe access routes above the flood levels likely during the lifetime of the development and adopt the principles of flood resilient design.

The Mayor's Water Strategy

A water strategy was developed by the Mayor of London and was published in October 2011[13]. It identifies ways in which present water resources could be used more effectively, in order to tackle problems such as water supply, waste water generation and flood risk. Policies of relevance to flood risk issues for the SFRA are:

1. *Action 18,* which encourages the use of green roofs, rainwater harvesting, grey water recycling and sustainable drainage to relieve the pressures on the drainage systems, thereby reducing flood risk and water demand.

[11] Greater London Authority, (2008); The London Plan – Spatial Development Strategy for Greater London – Consolidated with Alterations since 2004
[12]Greater London Authority, (May 2006); Supplementary Planning Guidance – Sustainable Design and Construction
[13] Greater London Authority, (2011); The Mayor's Water Strategy

2.3 Local Planning Policy

London Borough of Lambeth Local Plan

LBL is currently reviewing its planning policies to provide an up to date Local Plan .The new Lambeth Local Plan will be a partial review of the Council's Core Strategy which was adopted in 2011 after extensive consultation. The new Plan will reflect recent national, regional and local policies, such as the NPPF.

The new Plan will also reflect updates in council strategies. This includes recent area-based work - such as the Vauxhall SPD, and the revised draft Waterloo SPD. The Plan is out for consultation between March and April 2013 and LBL aim to adopt the finalised Plan early in 2015. The Plan is currently available in draft format.

The Plan will set out the long-term spatial planning vision for the Borough and an overall strategy for future development through Strategic Objectives (SO) and Strategic Policies (SP). Objectives and Policies of relevance to the SFRA are:

- *Strategic Objective 6: Tackling and adapting to Climate Change – to enable Lambeth to adapt to the effects of climate change, including flood risk, through the design of the built environment, retention of existing trees, urban greening, and SuDS; and*
- *Policy EN4 – Sustainable design and construction: Development will be required to be resilient to climate change by including appropriate climate change adaptation measures.*
- *Policy EN5 – Flood Risk states:*

a) The Council will seek to minimise the impact of flooding in the borough through;

i. Applying a sequential, risk based approach to the location of development to avoid, where possible, flood risk to people and property and manage any residual risk, taking account of the impacts of climate change over the lifetime of the development;

ii. steering development towards areas of lowest flood risk, both across Lambeth and within the development site boundary, through the application of the Sequential Test in accordance with the NPPF, taking the vulnerability of the proposed uses into account, as set out in the Lambeth Strategic Flood Risk Assessment (SFRA);

iii. ensuring development does not increase flood risk and where possible reduces flood risk; and

iv. permitting appropriate development in Flood Zones 1,2, 3a and 3b subject to meeting the criteria set out in Annex 6.

b) All development in Flood Zones 2, 3a and 3b defined in the SFRA, or identified as at risk of flooding from other sources, should contribute positively to actively reducing flood risk through avoidance, reduction management and mitigation;

c) A Flood Risk Assessment (FRA) will be required for major development proposals within Flood Zone 1, all development within Flood Zones 2, 3a and 3b , or where the development may be subject to other sources of flooding. The FRA should be proportionate with the degree of flood risk posed to and by the proposed development; consider the impact of climate change on flood risk to and from the development using the latest government guidance; and take account of the advice and recommendations set out in the SFRA and Local Flood Risk Management Strategy (LFRMS);

d) *FRAs must consider the risks of both on and off site flooding to and from the development for all sources of flooding including fluvial, tidal, surface runoff groundwater, ordinary watercourse, sewer and reservoir;*

e) *For all developments, it must be demonstrated that the development will be safe, and where required, it will reduce fluvial, tidal, surface runoff and groundwater flood risk and manage residual risks through appropriate flood risk measures, including the use of Sustainable Drainage Systems (SuDS) in accordance with policy EN6. Measures to mitigate flooding from sewers should be discussed with Thames Water Utilities Ltd. and be included in development proposals for which this is risk;*

f) *Basement proposals (excluding self-contained dwellings in Flood Zone 3) shall incorporate appropriate mitigation measures to ensure the development is safe from all forms of flooding and does not increase flood risk elsewhere;*

g) *For developments adjacent to the River Thames and River Graveney, maintenance, remediation and improvements to the flood defence walls will be required where these are in poor condition. Developments adjacent to defences and culverts should demonstrate that their development will not undermine the structural integrity or detrimentally impact upon its intended operation.*

- Policy EN6 – Sustainable drainage systems and water management states development proposals should:

  i. *Maximise opportunities for restoring river channels, flood flow pathways and floodplains to their natural state and managing surface runoff aboveground and as close to the source as possible to reduce flood risks downstream; and consider sustainable water management through Water Sensitive Urban Design (WSUD);*

  ii. *Provide compensatory storage to ensure that there is no loss in flood storage capacity where flood storage is removed, as set out in the Strategic Flood Risk Assessment (SFRA);*

  iii. *Ensure that the layout and design does not have a detrimental impact on floodwater flow routes across the site;*

  iv. *Demonstrate that there will be no increase in either the volume or rate of runoff leaving the site by incorporating Sustainable Drainage Systems (SuDS) in line with the London Plan drainage hierarchy and National SuDS Standards to maximise amenity and biodiversity benefits and improve the quality of water discharges. Details submitted to the Council to demonstrate compliance with this policy should follow the design principles within the National SuDS Standards and the current SuDS Manual and guidance identified within the Council's SFRA or Local Flood Risk Management Strategy (LFRMS);*

  v. *Seek to improve the water environment in line with the requirements of the European Water Framework Directive 2000 and its associated legislation and the Thames River Basin Management Plan;*

  vi. *Minimise water consumption and the pressure on the combined sewer network, through incorporating water efficiency measures including rainwater harvesting, grey water recycling and other innovative technologies where appropriate; and*

  vii. *Demonstrate that the local public sewerage network has adequate capacity to serve the development.*

Waterloo Area Supplementary Planning Document

The Waterloo Area Supplementary Planning Document[14] (SPD) was originally adopted by the Council on 8 June 2009 but was supplementary to policies in the Unitary Development Plan. As national and regional policy has changed these policies needed refreshing

The SPD will coordinate improvements to the area with high quality public realm, new homes, effective transport links and accommodation for businesses and will be critical to delivering the core objectives of Lambeth Council.

The SPD states that;

- *The Council will work in partnership with the Environment Agency to manage and mitigate flood risk;*
- *Development proposals within flood risk areas are required to demonstrate how they will mitigate and manage flood risk through appropriate measures;*
- *Flood Risk Assessments should accompany planning applications in Flood Zone 3a;*
- *Development must comply with the exception tests in national policy in Planning Policy Statement 25 (Flooding) and with London Plan policy;*
- *On sites adjacent to the river Thames, remediation and improvements to the flood defence walls will be required where these are in poor condition. When developing within 16m of the tidal flood defence, developers need to make a statutory application to the Environment Agency for land drainage consent;*
- *Measures to mitigate flooding from groundwater and sewers should be included in development proposals for which this is a risk.*

Vauxhall Area Supplementary Planning Document

The Vauxhall Area Draft Supplementary Planning Document[15] (SPD) was approved by the Council in January 2013.

The purpose of this SPD is to translate the London Plan, the Council's Core Strategy and the Vauxhall Nine Elms Board Opportunity Area Planning Framework (OAPF) strategic ambitions to a level of detail capable of interpretation at a neighbourhood scale.

The SPD states that;

- *The revised National Policy Planning Framework of 2011, places further emphasis on the need for sustainability, insisting on sustainable development as central to the environment, social and economic success of the country as the core principle underpinning planning;*
- *Developments will be expected to minimise surface water run off, following the London Plan sustainable drainage hierarchy, including through the use of SUDS.*

[14] Lambeth Borough Council (2012) Waterloo Area Supplementary Planning Document.
[15] Lambeth Borough Council (2012) Vauxhall Area Draft Supplementary Planning Document

2.4 Additional Local and Regional Guidance and Planning Documents

London Regional Flood Risk Appraisal

The London Regional Flood Risk Appraisal[16] (RFRA) was published in October 2009, in support of the Draft Replacement London Plan. The document seeks to ensure that the overall flood risk in Greater London does not increase. The RFRA contains 19 recommendations to be implemented by the Environment Agency and other agencies.

Thames Estuary 2100 Plan (TE2100)

The Environment Agency has produced a long-term flood risk management plan for London and the Thames estuary which was published in November 2012. The TE2100[17] is a Flood Risk Management strategy that aims to provide a 100-year flood management plan that will be adaptable to varying flood risk and changing social and economic conditions, also to optimise the current flood defence infrastructure. The document will influence planning decisions, shape regional local authority policies in the future and provide guidance on flood risk management activities.

The Plan primarily looks at tidal flooding, though other sources of flooding including high river flows as a result of heavy rainfall and surface water flooding are considered.

The Thames Estuary is broken down to form 23 policy units. For each of the 23 policy units in the TE2100 Plan area there is a recommend flood risk management policy. The LBL is located within Action Zone 2 – Central London. TE2100 gives the two policy units within this zone a 'Policy 5' flood risk management strategy.

TE2100 Policy 5 is defined as *"Take further action to reduce the risk of flooding (now or in the future)."*

The Policy acknowledges that to keep up with climate change and reduce flood risk further, the Environment Agency and other key stakeholders will need to do more to manage and reduce both the likelihood and consequence of flooding, providing a level of flood risk management which is higher still than the standard currently provided.

Thames River Basin Management Plan

In December 2009, the Environment Agency published river basin management plans (RBMPs) covering all the water environments of England and Wales. The plans outlined what would be done to protect and improve the water environment, including mitigating the effects of floods. The plans are produced in a series of six year planning cycles. The Environment Agency is now reviewing and updating the Thames RBMP, and will publish the revised documents in December 2015.

Thames Catchment Flood Management Plan

The role of CFMPs is to establish flood risk management policies which will deliver sustainable flood risk management for the long term. The Thames CFMP identifies flood risk management policies to assist all key decision makers in the catchment. CFMPs are used to inform planning and decision making by key stakeholders such as the Environment Agency and regional and local planning authorities.

[16] Greater London Authority , (2009); London Regional Flood Risk Appraisal
[17] Environment Agency, (EA), (2012); Thames Estuary 2100 Plan (TE2100)

Lambeth Preliminary Flood Risk Assessment

A Preliminary Flood Risk Assessment (PFRA) is required as part of the Flood Risk Regulations which implement the requirements of the European Floods Directive. A PFRA was produced for the LBL as part of the Drain London study and draws upon new data and information regarding surface water flooding. The assessment gives an overview of all local sources of flood risk. Boroughs must review the PFRA every six years.

Lambeth Surface Water Management Plan

A Surface Water Management Plan (SWMP) was produced for the LBL as part of the Drain London study. The plan outlines the preferred surface water management strategy for the borough and includes consideration of flooding from sewers, drains, groundwater and runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall based on probabilistic 2 – dimensional modelling. This information improves greatly on data which has previously been provided at a national scale by the Environment Agency.

In addition, the SWMP contains an Action Plan that has been developed in conjunction with both the borough and relevant other Risk Management Authorities. This data and actions and associated policy interventions feeds directly into the operational level of the borough across many departments, in particular into spatial and emergency planning policies and designations and into the management of local authority controlled land.

The SWMP has identified 14 Critical Drainage Areas (CDAs) within or crossing the administrative boundary of the LBL. These are defined within the SWMP as "*a discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure.*"

Local Flood Risk Management Strategies

The FWMA 2010 requires each LLFA to produce a Local Flood Risk Management Strategy which is currently being developed by Lambeth. The SWMP, PFRA, and SFRA for Lambeth, and their associated risk maps will provide the necessary evidence base to support the development of LFRMS which is currently being produced.

3. DATA COLLECTION & REVIEW

As outlined in Chapter 1, the objective of the Level 1 SFRA is to collect, collate and review the information available relating to flooding in the Study Area. The information is then presented in a format to enable the London Borough of Lambeth to apply the NPPF Sequential Test to their growth areas and to identify potential development sites which require the application of the Exception Test through a Level 2 SFRA.

Further investigations were required as part of the Level 1 SFRA to determine the variation in residual risk across areas protected by flood defences. Additional hydrodynamic modelling has been completed to ensure that the sequential test for development plans in defended areas take residual flood risk into account.

Gaps in the data/information have also been identified in order to ascertain additional requirements needed to meet the objectives the Level 2 SFRA, where required.

A comprehensive record of all the data collected through the production of the SFRA is presented in the document register included in Appendix C.

3.1 Tasks

The sequence of tasks undertaken in the preparation of the Level 1 SFRA was, in order:

- Inception meeting with the London Borough of Lambeth;
- Established the local stakeholders;
- Contacted stakeholders requesting data/information;
- Collated and reviewed data and populated data register;
- Presentation of available relevant information on flood sources and flood risk;
- Reviewed received data against the SFRA objectives; and
- Identified gaps in data.

3.2 Stakeholder Consultation

In the preparation of this Level 1 SFRA the following stakeholders were contacted to provide data and information:

- The London Borough of Lambeth;
- Thames Water;
- Environment Agency, Thames Region.

The study area falls entirely in the Environment Agency's Thames Region. The Environment Agency's Thames Region has discretionary powers under the Water Resources Act (1991) for all Main Rivers and their associated flood defences within the study area.

Thames Water is responsible for storm water and foul water management across the study area. In addition, private individuals may be responsible for drainage systems that operate prior to discharge either into a watercourse or into a public sewer.

3.3 Data/Information Requested

Information and data requested from the stakeholders was integrated with URS's GIS system where possible to facilitate a review. The information and data requested from the identified stakeholders was based on the following categories:

- Terrain Information e.g. LiDAR, SAR, river cross-sections;
- Hydrology e.g. the main and ordinary watercourses;
- Hydrogeology e.g. groundwater vulnerability zones;
- Flood Defence e.g. flood banks, sluices;
- Reservoirs Act (1975) Water Bodies within the study area;
- Environment Agency Flood Levels e.g. at flood monitoring points;
- Environment Agency Flood Zone Maps;
- Local Authority Information e.g. Local Development Schemes and allocation sites;
- Historical flooding, and;
- Sewer flooding problems.

All data was registered and its accuracy and relevance reviewed to assess confidence levels for contribution to the SFRA (Table 3.1). Details of the data collected at the time of production, is presented in Appendix B.

Table 3.1: Method for qualitative confidence ranking of data received

		RELEVANCE		
		1 - VERY RELEVANT	2 - PARTLY RELEVANT	3 - NOT RELEVANT
ACCURACY	1 - EXCELLENT	VERY GOOD	GOOD	GOOD
	2 - GOOD	GOOD	GOOD	FAIR
	3 - FAIR	GOOD	FAIR	FAIR
	4 - POOR	FAIR	FAIR	POOR
	5 - VERY POOR	FAIR	POOR	VERY POOR

3.4 Data Presentation

GIS Layers

Using GIS the collected data was analysed and interrogated to produce visual flood risk statistics for the Borough as a whole. Broadly, the layers can be classified into Planning Policy, Information and Flood Risk categories. Table 3.2 below summarises the main GIS layers used in the SFRA.

Table 3.2: GIS Layers included in Lambeth SFRA

Planning Policy	Information	Flood Risk
London Borough of Lambeth Administrative Boundary	Main River Network	Flood Zone maps (Tidal and Fluvial)
Potential site allocations	Ordinary Watercourse Network	Functional Floodplain for the River Graveney
Other land use pressures (Areas of Outstanding Natural Beauty/ Sites of Special Scientific Interest)	Flood Defence Locations	Hydraulic model extents
	Flood Warning Areas	Historic Groundwater flood records

4. THE LEVEL 1 SFRA

This section describes the available data and methodology used in the production of mapping deliverables for the project.

4.1 Requirements of National Planning Policy Framework

NPPF and its accompanying Technical Documents require Strategic Flood Risk Assessments to present sufficient information on all flood sources to enable local planning authorities to apply the Sequential Test in their administrative areas. In order to apply the Sequential Test information is required on the probability (High, Medium and Low) associated with flooding from the different flood sources. This information should be presented graphically where possible as a series of figures and/or maps.

In addition, the assessment of probability should also account for the effects of climate change on a flood source for the lifetime of any development that would be approved through the emerging Local Plan.

For all but tidal and fluvial flood sources the current lack of data makes definition of robust classifications of probability unreliable. For example to define high, medium and low probabilities for groundwater flooding within the study area based on one reported incident (with no corresponding record of the severity of that flood) is not robust. Consequently for flood sources other than fluvial and tidal, where only anecdotal evidence of flooding is available, subjective assessments of probability have been made where the data allows.

However in some cases, definitions of probability are not practical or are unreliable; in these situations the flood risk from a particular source should be considered as 'medium' until proven otherwise and should be investigated through a site specific assessment of flood risk submitted as part of a planning application. Details of the requirements for flood risk assessments are presented in Section 18.

4.2 Tidal Flooding Data

Flooding to low lying land from the sea and tidal estuaries is caused by storm surges and high tides. Where tidal defences exist, they can be overtopped or breached during severe storms, which may become more likely with climate change.

Requirements

The northern boundary of the Study Area is defined by the tidal River Thames. As part of the Level 1 SFRA, the NPPF requires definition of the following tidal Flood Zones:

Table 4.1: Tidal Flood Zone Definitions (as defined in the NPPF, Table 1)

Flood Zone	Definition	Probability of Flooding
Flood Zone 1	At risk from flood event greater than the 1 in 1000 year event (greater than 0.1% annual probability of flooding each year)	Low Probability
Flood Zone 2	At risk from flood event between the 1 in 200 and 1 in 1000 year event (between 0.5% and 0.1% annual probability of flooding each year)	Medium Probability
Flood Zone 3a	At risk from flood event less than or equal to the 1 in 200 year event (greater than 0.5% 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	Functional

Flood Zone	Definition	Probability of Flooding
	20 year event or otherwise agreed between the Local Planning Authority and the Environment Agency (greater than 5% annual probability of flooding each year)	Floodplain

Climate Change

The NPPF requires that an increase in sea level be applied when mapping tidal systems under a climate change situation. Allowances for the regional rate of sea level rise; up to the year 2115 is shown in Table 4.2 below.

Table 4.2: Recommended contingency allowances for net sea level rise (as defined in NPPF Table 4)

Administrative Region	Net Sea Level Rise (mm/yr) Relative to 1990			
	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
East of England, East Midlands, London, SE England (south of Flamborough Head)	4.0	8.5	12.0	15.0

(N.B for deriving sea levels up to 2025 4.0mm should be applied back to the 1990 base sea level. From 2026 to 2055, the increase in sea level in this period is derived by adding the number years on from 2025 (to2055), multiplied by 8.5mm. Subsequent time periods 2056 to 2085 and 2086 to 2115 are treated similarly).

Data Sources used for SFRA mapping

The Environment Agency Flood Zones have been defined based on flood outlines generated by hydraulic models or outputs from the Environment Agency's National Generalised Model. No further adjustments have been made to this data. Where hydraulic models are not available the Environment Agency's Flood Map has been used as a default.

The Environment Agency has invested significant funds in the construction and development of a 1D hydraulic model of the River Thames. The model simulates the fluvial flow from the upstream catchment in conjunction with the tidal levels experienced in the lower estuary, and the operation of the Thames Barrier during extreme tidal events. The model has been used to simulate a full range of return period events and provide estimated water levels along the length of the Thames estuary. The Environment Agency has provided the peak tidal flood levels for the 1 in 200 year and 1 in 1000 year return period flood events, calculated in 2005.

The Environment Agency has confirmed that the Thames hydraulic model has also been used to simulate flood events incorporating increased fluvial flows and tide levels to represent the predicted effects of climate change. Results show that the modelled climate change flood levels for extreme events are slightly lower than present day levels within the study area.

This unexpected result is based on the assumption that the Barrier will be closed more frequently due to increased sea levels anticipated during climate change scenarios. Increased use of the Barrier will allow fewer high tides to flow upstream into central London each year therefore the estimated extreme water levels within the study area do not increase with climate change.

Therefore the present day tidal floodplain (2005) uses the highest water levels and will produce the 'worst case' tidal outlines with respect to a potential breach scenario in the Thames defences.

The extent of the functional floodplain is defined by the 1 in 20 year flood event, taking into account the presence of existing flood defences. The study area therefore does not contain any tidal functional floodplain as the defences located on The Thames provide a significantly higher standard of protection.

Breach Modelling

Hydraulic breach modelling has been undertaken by the Environment Agency at four strategic locations along the Thames river frontage within the study area. There are also two additional breach locations located in LB Wandsworth's Nine Elms area, which are relevant to the study area.

The Environment Agency's breach locations are shown on Figure 4 in Appendix A, and further details are in Table 4-3 below. The locations have been chosen to highlight low points behind defences and aim to give a broad variation in flood risk throughout the north of the Study Area.

Table 4.3 Environment Agency Modelled Breach Locations

Reference	Description	National Grid Coordinates	
		Easting	Northing
Berm12	Oxo Tower	531320	180510
Berm13	Hungerford Bridge	530670	180120
Berm14	Lambeth Palace	530550	179120
Berm15	Fire Brigade Headquarters	530500	178710
Berm16	New Covent Garden Market	529980	177840
Berm17	Prescot Wharf	529600	177650

Each model has been used to simulate a breach in the defences occurring at the same time as a 1 in 200 year and a 1 in 1000 year tidal water level curve. The model outputs have been used to create flood depth and hazard maps included in Appendix A. Figures 5 and 6 present the maximum flood depth and flood hazard category for the 1 in 200 year event respectively, based on a composite of the model results from all six breaches being considered.

During production of the original SFRA in 2008, additional work was also undertaken to determine the breach risk along the entire River Thames frontage based on an analysis of topographic levels and peak tidal levels. It should be noted that this riverside analysis has not been updated to reflect the 2013 SFRA revision; therefore this will need to be reviewed independently for site specific assessments.

The Lambeth/Thames frontage has been divided into 8 sections or reaches. Within each section, the frontage has been assigned a category based on the assumed breach level and potential peak depth of flow, being RC-1 to RC-4. Areas assigned RC-1 have lower potential peak depths if there were a breach, while RC-4 areas have higher potential peak depths, (see Section 5.6)

This information can then be used to determine the requirements for site specific FRAs. Full details of the methodology used for the assessment is contained within Appendix C and the mapping outputs are shown as Figures H1- H19.

Assessment

Where breach modelling has not been carried out, the residual risk of flooding will need to be determined by carrying out a site specific FRA. The riverside analysis in Appendix C provides further information on areas not covered by the breach models in this study. See Chapter 18 for site specific FRA guidance.

Mapping

The following GIS mapping outputs have been produced in relation to Tidal Flooding:

- Environment Agency Indicative Floodplain map – Figure 2.

The extent of tidal Flood Zones whilst ignoring the presence of the existing flood defence structures within the north of the study area has been illustrated using Environment Agency data as shown in Figure 2.

- Location of Environment Agency Flood Defences – Figure 3.

The location of Environment Agency flood defences and standard of protection is shown in Figure 3. This plan shows the study area as being defended from a 1 in 1000 year tidal flood event under normal circumstances.

- Location of Hydraulic Analysis Breach Locations – Figure 4.

Hydraulic breach modelling has been undertaken at four strategic locations along the river frontage agreed with the Environment Agency as shown in Figure 4.

- Breach model outputs – Figure 5 and 6.

Breach model outputs have been used to create composite flood depth and hazard maps shown in Figures 5 and 6 for the 1 in 200 year event. Figure 7 also shows a composite of the maximum extent of inundation for all six breach locations.

4.3 Fluvial Flooding Data

The extent of fluvial flooding from rivers and streams in the Study Area has been mapped in GIS using existing Environment Agency data. No additional hydraulic modelling has been undertaken as part of this study.

Requirements

As part of the Level 1 SFRA, the NPPF requires definition of the following fluvial Flood Zones across the Study Area:

Table 4.4: Fluvial Flood Zone Definitions (as defined in NPPF, Table 1)

Flood Zone	Definition	Probability of Flooding
Flood Zone 1	At risk from flood event greater than the 1 in 1000 year event (greater than 0.1% annual probability of flooding each year)	Low Probability
Flood Zone 2	At risk from flood event between the 1 in 100 and 1 in 1000 year event (between 1% and 0.1% annual probability of flooding each year)	Medium Probability
Flood Zone 3a	At risk from 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 (greater than 5% annual probability of flooding each year)	Functional Floodplain

Climate Change

The Flood Zones should be defined considering the effects of climate change. For fluvial systems NPPF requires an increase of 20% in peak flows to be used when mapping climate change flood zones up to 2115.

However, the Environment Agency's fluvial modelling studies do not provide climate change mapping for all necessary flood return periods, therefore the Environment Agency has recommended that surrogate flood outlines relating to higher return periods could be used for the climate change scenario, in accordance with the precautionary principle.

Data Sources used for SFRA mapping

The Environment Agency has completed a hydraulic modelling study of the River Wandle catchment, which includes the River Graveney. Table 4.5 identifies the sources of data used to map the fluvial Flood Zones required by the NPPF.

Table 4.5: Fluvial Flood Zone Mapping Data Sources

Scenario		River Graveney
Current Flood Zones (2013)	**Flood Zone 2**	River Wandle/Graveney hydraulic model 1 in 1000 year event results
	Flood Zone 3a	River Wandle/Graveney hydraulic model 1 in 100 year event results
	Flood Zone 3b	River Wandle/Graveney hydraulic model 1 in 20 year event results
Climate Change Flood Zones (2115)	**Flood Zone 2**	Not required
	Flood Zone 3a	River Wandle/Graveney hydraulic model 1 in 100 year climate change event results
	Flood Zone 3b	River Wandle/Graveney hydraulic model 1 in 100 year event results

The current Flood Zones have been prepared using the best available data from appropriate hydraulic models and following the precautionary principle as detailed throughout the NPPF.

Mapping

The following GIS mapping outputs have been produced in relation to Fluvial Flooding:

- Figure 2 – Environment Agency Indicative Flood Zone Map

The extent of the fluvial Flood Zones within the study area is presented in the Flood Zone Map.

It should be noted that mapping has not been produced for the climate change scenario however the suggested surrogate outlines can be viewed on the present day flood zone map.

4.4 Sewer Flooding Data

In urban areas, rainwater is frequently drained into surface water sewers or sewers containing both surface and waste water known as 'combined sewers'. Flooding can result when the sewer is overwhelmed by heavy rainfall, becomes blocked or is of inadequate capacity.

Requirements

Areas at risk from sewer flooding have been determined through review of the records from the DG5 registers provided by Thames Water.

As per fluvial flooding, areas with high, medium and low probability should be defined based on the available data. The definition of functional floodplain is not required for flooding from sewers.

Due to the lack of resolution of the data and the relatively short period for which the records are available (≤10 years), definition of flooding probability cannot currently follow the same approach as that used for fluvial or tidal flooding. Therefore based on the available data it has been plotted showing the areas that have been most and least affected by sewer flooding over the last 10 years.

Foul, surface and combined water flooding incidents have been plotted in combination to provide a cumulative frequency of all forms of sewer flooding incidents within Lambeth.

Each data set has been split into six bands, however these can broadly be delineated into three categories of high, medium and low probability of flooding. The following criteria have been used to give a basis on assessing the sewer flooding across Lambeth. These bands have been selected using the natural break in the numbers as outlined below.

Cumulative Sewer Flooding Incidents

High Probability - > 51 properties affected within the previous 10 year period

Medium Probability - between 11 and 50 properties affected within the previous 10 year period

Low Probability - <10 properties affected within the previous 10 year period

Climate Change

Climate change is estimated to result in milder wetter winters and increased summer rainfall intensity. This combination will increase the pressure on existing sewer systems effectively reducing their design standard, leading to more frequent flooding.

The current data does not enable a robust assessment of the effects of climate change on sewer flooding to be undertaken. Therefore in the absence of accurate data the effects of climate change should be taken to result in an increase in the flooding probability of each post code area by one category. For example where a post code area is currently identified to have a low probability, accounting for the effects of climate change the area has been defined as medium probability.

Data Sources used for SFRA mapping

Records of sewer flooding were obtained from Thames Water through a query of their DG5 registers. In order to fulfil statutory commitments set by OFWAT, water companies must maintain verifiable records of sewer flooding, which is achieved through their DG5 registers. Water companies are required to record flooding arising from public foul, combined or surface water sewers and identify where properties suffered internal or external flooding.

The data provided by Thames Water is limited to postcode data, resulting in the coverage of relatively large areas by comparatively limited and isolated recorded flood events. The data also only covers the last ten years of record.

It should be noted that the flood records provided by Thames Water may not be a complete and accurate record of flood events in the city over the last 10 years. Some minor flooding incidents may go unreported, particularly if no property is affected by such flooding.

LBL has prepared a Surface Water Management Plan which assesses the risk of flooding from sewers and surface water in greater detail, and it is recommended that the Council refer to this document for further information on flooding from these sources.

Mapping

The following GIS mapping outputs have been produced in relation to Sewer Flooding Data:

- Figure 8 Cumulative Sewer Flooding

4.5 Surface Water Flooding / Overland Flow Data

Intense rainfall that is unable to soak into the ground or enter drainage systems can quickly run overland and result in local flooding. This is exacerbated by highly impermeable urban development or low permeability soils and geology (such as clayey soils).

In developed areas, this flood water can be polluted with domestic sewage where foul sewers surcharge and overflow. Overland flow paths should be taken into account in spatial planning for urban developments.

LBL has prepared a Surface Water Management Plan which assesses the risk of flooding from sewers and surface water in greater detail, and it is recommended that the Council refer to this document for further information on flooding from these sources.

4.6 Groundwater Flooding Data

Groundwater flooding occurs when water levels in the ground rise above surface elevations. Groundwater flooding may take weeks or months to dissipate, as groundwater flow is much slower than surface water flow and water levels therefore take much longer to fall.

Requirements

The NPPF states that an assessment of the risk of groundwater flooding needs to be considered; however, a quantified assessment of risk from groundwater flooding is difficult to undertake, especially on a strategic scale. This is due to lack of groundwater level records, the variability in geological conditions and the lack of predictive tools (such as modelling) that can be used to make assessments of groundwater flow and risk of groundwater flooding following rainfall events.

Data Sources used for SFRA mapping

The Environment Agency's Areas Susceptible to Groundwater Flooding (AStGWF) dataset has been provided in combination with recorded incidents of groundwater flooding within the study area.

The AStGWF output is a strategic scale map showing groundwater flood areas on a 1km square grid, designed to broadly indicate areas which could be more susceptible to groundwater flood emergence. The location of aquifers and the underlying geology is used to classify each 1km grid square, using a proportion of the square which could be susceptible to emergence in 25% bandings.

The Environment Agency's records of groundwater flooding incidents between 2000 and 2010 have also been presented in tandem with the AStGWF to provide some form of validation, and highlight areas where this increased susceptibility has resulted in recorded flooding occurring.

Lambeth has prepared a Surface Water Management Plan which assesses the risk of flooding from sewers and surface water in greater detail, and also explores links to groundwater flooding. It is recommended that the Council refer to this document for further information on flooding from these sources.

Mapping

The following GIS mapping outputs have been produced in relation to Groundwater flooding:

- Figure 9 – Groundwater Flooding

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5. FLOOD MAPPING AND APPLICATION

5.1 Introduction

The following section is intended for use in conjunction with the flood zone and hazard zone mapping presented in Appendix A of this report. The flood zone maps should be used to complete the Sequential Test, identifying the particular flood zones and flood risks to individual allocation sites. The hazard and depth maps provided for the tidal areas in this Level 1 provide a greater level of detail on the variation of residual flood risk from tidal flooding.

5.2 Flood Zone Mapping

The strategic flood zone mapping for the London Borough of Lambeth in this SFRA study area have been produced in accordance with the NPPF using hydraulic modelling outputs provided by the Environment Agency.

The fluvial outlines for the River Graveney include Flood Zone 3b outputs. The tidal floodplain areas associated with the River Thames do not have a Flood Zone 3b or functional floodplain associated with them, as they are classed as defended and would not flood during a 1 in 20 year event.

The flood zone maps should be used as part of the Sequential Test to determine the level of flood risk associated with potential development allocations. Guidance on applying the Sequential Test is detailed in the Chapter 7.

5.3 Breach Modelling

The tidal floodplain areas in the London Borough of Lambeth are associated with the River Thames and classified as defended. Therefore the associated flood risk with these areas is that of a residual nature, i.e. the flood risk as a result of a failure or breach in the flood defences.

To provide the London Borough of Lambeth with further detail on the variation of the tidal residual risk, hydraulic breach modelling was undertaken along the River Thames frontage by the Environment Agency. Six relevant breach locations have been considered, and further detail on the specific modelling methodology can be obtained from the Environment Agency.

Assumptions

The hazard and depth maps indicate the associated outputs from a number of specific breach events. These hazard classifications do not indicate a change in flood probability. **It is essential to remember, when using the hazard zone maps, that they represent hazard arising from one or more specific breach locations, and that hazard will almost certainly vary spatially if the breach locations are in different local areas.** Further issues in this respect should also be considered:

- Not all possible breach locations in a given area have been considered. Necessarily, the modelling study had to be limited to those locations thought most likely to lead to flood risk for specific development areas;
- Breach width and depth, though based on Environment Agency guidance, are arbitrary and do not necessarily represent the actual dimensions of a breach in a given location;
- Changes in inundation extent or hazard zone are non-linear to changes in breach location;

- In agreement with the Environment Agency climate change has not been modelled. The climate change tidal levels would result in lower water levels than at present. The reasons for this are presented in Section 4.2 in relation to the River Thames data.

Flood cell mapping has been produced to present the combined results of all breaches within the London Borough of Lambeth. Figure 7 shows the potential inundation extent from all the breach locations during the 1 in 200 year event across the area.

Limitations

To obtain a complete analysis of residual risk a breach location would be required every 50m along the River Thames frontage, which is clearly not practical. Instead the Environment Agency's strategic locations have been utilised, which provide appropriate coverage throughout LBL where potential allocations are likely to require further information as part of the Exception Test.

Areas that are shown between the breaches as white areas are not necessarily free from flooding. The depth and hazard maps represent composite mapping which presents the greatest flood depth and hazard associated with all six breach locations.

All proposed development sites in Flood Zone 2 and 3 would be subject to a Flood Risk Assessment. Therefore it would be recommended that any sites within 500m of the defences conduct a breach assessment as part of their FRA unless they are covered by one of the six locations modelled or they can demonstrate the local topography and flow paths would not result in inundation of their site. The riverside topography mapping described in Section 5.6 below should initially be reviewed to determine the requirements for site specific FRAs.

5.4 Depth Mapping

These maps show the water depth in metres associated with a breach event at a specific location. The depth varies across the flood cell in relation to ground levels; lower ground levels are more likely to experience deeper flooding in the event of a breach.

5.5 Hazard Mapping

Hazard mapping presents the results of breach modelling within each flood cell in accordance with FD2320, and includes an appropriate debris factor for an urban environment.

5.6 Riverside Topographic Assessment

The riverside topographic assessment mapping provides additional information regarding the potential of a breach occurring along LBL's River Thames frontage. It should be noted that the riverside assessment was completed for the original 2008 SFRA, and has not been revised for the 2013 SFRA update.

Where areas have been identified as having potentially 'high' or 'medium' depths of flow through a breach or where ground levels are lower (RC-4 and RC-3) future site specific flood risk assessments should consult the Environment Agency to determine the requirement for 2D breach modelling. In areas of 'No' or 'Low' depths of flow through a breach, or where ground levels are higher (RC-1, RC2), site specific flood risk assessments should focus on topographic site levels and analyse potential flow paths to the site from the River Thames.

Cross sections were assessed every 20 metres of the River Thames frontage, and the broad crested weir equation applied to calculate potential volumes and depths on site which are presented in Appendix C. Whilst these give an indication of potential flood depth they are

not as accurate as breach modelling, and should be used as a guide only. In areas where significant potential flood depths are identified, site specific FRA's should consult the Environment Agency to determine the requirement for 2D breach modelling.

Table 5.1 provides an outline regarding the level of assessment required for an FRA for each category, Figures H3 – H19 included in Appendix C show the categorisation along the River Thames frontage.

Table 5.1: Risk categories and additional guidance

Risk Category	Additional breach modelling required?
RC-1	**No**
RC-2	**No**. Flow path assessment required based on topography
RC-3	**Yes**. Site specific breach model required if not covered by modelled locations
RC-4	**Yes**. Site specific breach model required if not covered by modelled locations

6. FLOOD RISK IN THE LONDON BOROUGH OF LAMBETH

This chapter identifies the main sources of flooding within the London Borough of Lambeth Study Area.

6.1 Tidal Flooding

Tidal flooding is the primary source of flooding within the Study Area.

The River Thames

The Tidal River Thames runs along the northern boundary of The London Borough of Lambeth from Nine Elms and Vauxhall in the west to the Oxo Tower in the east. The 3.2km frontage is actively defended by raised embankments and hard defences that protect the Study Area from large scale flood events.

The tidal limit of The River Thames is situated at Teddington Weir approximately 15km upstream of the Study Area. Lambeth is therefore potentially at risk from tidal flooding from the Thames.

The Thames Barrier, located in Woolwich Reach lies approximately 25km downstream of the Study Area and is the main structure of the Thames tidal defence system. When closed, the barrier prevents extreme storm surges from flowing up the estuary and flooding central London.

The Thames Barrier has also been used to control the risks of fluvial flooding to the upper stretches of the Thames, by closing during low tides to increase the storage capacity of the Thames for fluvial waters during extreme events. However, it is a tidal structure and therefore has limited use for the prevention of fluvial flooding in West London. In the future, as climate change increases the frequency of barrier closures, this type of use may not be possible owing to operational constraints and the needs of the river and its users. Over the next 20 to 30 years, another way to reduce fluvial flooding may have to be found.

As discussed in section 4.2, the Environment Agency has constructed a 1D hydraulic model of the River Thames in order to provide estimated water levels throughout the Thames estuary and to simulate a climate change situation. Results show that the estimated extreme water levels within the study area do not increase with climate change.

Flood defences of the River Thames protect areas within the floodplain up to a 1 in 1000 (0.1%) annual probability event which is the highest standard of protection in the country. There is still some risk however that these defences may fail or overtop.

Breach Analysis

Breaching of flood defences can occur in any situation where there is defence with a raised crest height above adjacent land levels.

A fluvial breach in a flood defence will result in a dispersal of floodwater from the channel resulting in a lowering of water levels and a flow through the breach. In addition to the flood risk associated with the breach event, there is an implied flood hazard. The highest hazard exists in the period immediately following a breach and usually but not necessarily in the areas closest to the breach. Floodwater flowing through a breach will be of high velocity and volume dissipating rapidly across large low lying areas, possibly affecting evacuation routes.

Hard defences may fail through the slow deterioration of structural components such as the rusting of sheet piling, erosion of concrete reinforcement and toe protection or the failure of ground anchors. Such deterioration is often hard to detect so that failure when it occurs is

often sudden and unexpected. Failure is more likely when the structure is under maximum stress such as during extreme tide when pressures on the structure are at its most extreme.

The Environment Agency regularly monitor the condition of Environment Agency owned flood defences and has a rolling 5 year maintenance of flood defences however, maintenance is usually carried out under a priority scale. The Environment Agency work under permissive powers under the Water Resources Act 1991 and land drainage byelaws and do not guarantee that defences will be maintained every 5 years.

As discussed in Section 4.2, the Environment Agency has undertaken breach modelling at six relevant locations within the north of the Study Area including Vauxhall and Waterloo to determine the variation in residual flood risk (i.e. the risk of flood in the event of a failure of breach in the flood defence). The results are illustrated in Figures 5, 6 and 7, Breach Depth, Hazard and Flood Extent mapping respectively.

It is essential to remember, when using the flood depth and hazard zone maps that they represent hazard arising from one or more of the six specific breach locations, and that hazard and depth will almost certainly vary spatially if the breach locations are in different local areas. Further issues in this respect should also be considered:

Not all possible breach locations in the London Borough of Lambeth have been considered and the four breach locations were chosen as locations thought most likely to lead to flood risk and to give a broad coverage of the Lambeth frontage.

Breach width and depth, though based on Environment Agency guidance, are arbitrary and do not necessarily represent the actual dimensions of a breach in a given location.

Changes in inundation extent or hazard zone are non-linear to changes in breach location.

The East London Strategic Flood Risk Assessment (Entec 2005) assumed a 500m buffer zone, to include the zone of rapid inundation, however, due to the location of the Waterloo mainline embankment running through Lambeth, a 500m buffer zone would not be realistic in this situation as the raised embankment will act as a barrier to potential floodwaters. It is not considered appropriate to specify an arbitrary riverine buffer zone in Lambeth, as it is likely to misrepresent the spatial variability of risk.

Overtopping

Overtopping occurs when water passes over a flood defence. Low levels of overtopping may arise even when the defence crest level is higher than the water level due to the actions of winds, wave and spray.

When flow exceeds the capacity of the channel to convey that flow, the water in that channel will rise until the point is reached where the banks of the channel are overtopped. Water will then spill over the channel banks and onto adjoining land.

No assessment of risk associated with overtopping has been made as part of this study. Development proposals adjacent to The River Thames flood defences should include a FRA containing assessment of overtopping risk.

6.2 Fluvial Flooding

Apart from the River Thames, the Study Area contains one watercourse that generally flows in a northerly direction, to discharge to the River Thames at Wandsworth.

The key main rivers within the study area are:

- The River Thames (as discussed in Section 6.1);
- The River Graveney.

River Graveney

A 1km stretch of the River Graveney, a tributary to the River Wandle runs through the Streatham / Norbury area to the southern extent of the Borough. The Graveney joins the Wandle at South Wimbledon. The source of the River Graveney is located in the vicinity of Selhurst and the upper reaches are often referred to as the Norbury Brook.

The watercourse is canalised throughout the study area having artificial banks and bed as illustrated in Figure 6.1 below:

Figure 6.1: Typical section of the River Graveney

Source Hidden London – Lambeth ***www.hidden-london.com/streathamvale.html***

The Environment Agency holds a model of the River Wandle which includes its tributary, the River Graveney.

Hydraulic models enable the estimation of accurate floodplain extents and flood depths based on detailed topographic data of river channels including structures (bridges, culverts etc) and flood defences. The floodplain extents are compiled using rigorously developed statistically derived flow estimates.

The Environment Agency's River Wandle Hydraulic model has been updated in recent years and final outputs were produced in March 2010. The Environment Agency has provided the current modelled flood levels and flood extents for the River Graveney. The modelled flood extents are illustrated in Figure 2.

The Environment Agency have also provided details of flooding instances on the Graveney from their flood records database for the years; 1968, 1973, 1977,1978,1981,1983 and 1987. Details are included in Table 6.1 below:

Table 6.1: Environment Agency records of Flooding on the River Graveney

Year	No of flood events	Location	Post code	Source	Description
06/08/1981	1	138 Abercairn Rd	SW16	Graveney	Garage & garden flooded - water level 0.5 inch below front door
06/08/1981	1	132 - 136 Abercairn Rd	SW16	Graveney	Gardens flooded
06/08/1981	1	140 Abercairn Rd	SW16	Graveney	Garage & garden flooded - water level 0.5 inch below front door

The River Effra is described as a lost River of London and is treated as a sewer for the purposes of this study. It is therefore described in Section 6.4.

Environment Agency Flood Zone Maps

The Environment Agency has provided an extract of their Flood Map for the study area (Figure 2, Appendix A). The Flood Map shows the estimated extent of Flood Zones 2 (area with a 1 in 1000 or greater annual probability of flooding) and Flood Zone 3 (area with an annual probability of less than or equal to 1 in 100 fluvial flood risk or 1 in 200 tidal flood risk) (ignoring the presence of flood defences) for all main rivers and/or watercourses with identified critical drainage problems. The Flood Map gives a good indication of the areas at risk of flooding within the Study Area. However, it does not provide detail on individual properties.

The Flood Map has been developed by the Environment Agency using a combination of detailed 2-D modelling information based on LiDAR topography and outputs from the Environment Agency's National Generalised Model. The National Generalised Model outputs are derived from less accurate topographic data (Synthetic Aperture Radar (SAR) or LiDAR data) and national data for river flows.

The Flood Map does not provide information on flood depth, speed or volume of flow. It also does not show flooding from other sources, such as groundwater, direct runoff from fields or parkland, or overflowing sewers.

Planning

- Any planning application for a site within Flood Zones 2, 3a or 3b, or greater than 1Ha in any Flood Zone would require a FRA;
- During preparation of a flood risk assessment, consultation with the Environment Agency is likely to identify that hydraulic modelling will be required. As a minimum the Flood Risk Assessment should confirm the extent of Flood Zones 3a and 3b relative to the development. Further planning considerations are included in Section 2;
- Refer to http://www.environment-agency.gov.uk/research/planning/33098.aspx for Environment Agency standing advice on flood risk.

6.3 Sewer Flooding

Sewer flooding generally results in localised short term flooding caused by intense rainfall events overloading the capacity of sewers. Flooding can also occur as a result of blockage, poor maintenance or structural failure.

A large network of sewers is located in the study area. Modern sewer systems are typically designed to accommodate rainfall events with a 1 in 30 year return period. Older sewer systems were often constructed without consideration of a design standard therefore some areas of The London Borough of Lambeth may be served by Victorian sewers with an effective design standard of less than 1 in 30 years. Much of the London sewer network is a combined system with storm and foul drainage served by a single sewer. As a result sewer flooding events where they occur can often be frequent, although the scale of consequence is generally small.

In addition, as flood risk has increased in importance within planning policy, a disparity has emerged between the design standard of conventional sewer systems (typically 1 in 30 years), and the typical flood design standard (1 in 100 year) that should be considered for residential development. This has resulted in drainage inadequacies for the flood return periods considered for new developments, often resulting in potential flood risk from surface water/combined sewer systems.

In future climate change will increase the potential risk from sewer flooding as summer storms become more intense and winter storms more prolonged. This combination will increase the pressure on existing sewer systems effectively reducing their design standard, leading to more frequent localised flooding incidents.

Thames Water has supplied data based on a four figure post code to show sewer flooding instances over the last ten years. Figure 8 Appendix A illustrates Thames Water sewer flooding data.

LBL has prepared a Surface Water Management Plan which assesses the risk of flooding from sewers and surface water in greater detail, and it is recommended that the Council refer to this document for further information on flooding from these sources.

Effra Sewer

The River Effra is a 'lost river' of London and for the purposes of this study is referred to as a sewer.

The sewer flows entirely underground. It rises to the south of the Lambeth study area near Crystal Palace, and flows in a northerly direction through Norwood Cemetery, Dulwich, Herne Hill, Brockwell Park, Brixton, Kennington to flow out into the Thames by Vauxhall Bridge.

The approximate route of this sewer is shown on Figure 3, Appendix A. The route has been identified through local knowledge and reference to the London County Council Sewer record.

In 1985, to overcome problems of damp and occasional flooding in the basements of Dulwich Road, in South Brixton a storm relief sewer was built, running from Burbage Road to Clapham. Following very heavy rainfall events, surplus water is now allowed to overflow

into this sewer which runs forty feet below Brixton Water Lane, and later, when the tide is low enough, it can be released into the Thames.[18][19]

The outlet for the Effra sewer empties into the Thames by Vauxhall Bridge as illustrated in Figure 6.2 below:

Figure 6.2: Effra Sewer outlet at Vauxhall Bridge

Source wikipedia http://en.wikipedia.org/wiki/River_Effra

Due to the culverted nature of the watercourse, the River Effra produces flood risk with characteristics of sewer flooding.

Planning

- It is essential that any new development takes account of known sewer flooding problems to ensure that the development is not put at risk and that the development does not worsen an existing problem. Future development if not adequately planned can increase the flood risk from sewer flooding and in some cases cause new flood problems to occur. Potential increases in surface water or sewage discharge from new development must be adequately managed and mitigation measures introduced where required. Further planning considerations are included in Section 2.

6.4 Surface Water Flooding / Overland Flow

Surface water flooding typically arises as a result of intense rainfall, often of short duration, that is unable to soak into the ground or enter drainage systems. There is therefore an inherent link between sewer flooding and overland flow/surface water flooding.

This source of flooding can be compounded when combined with impermeable sub-soils, significant areas of development with associated hard standing areas or areas of open grassland. As the majority of the study area is heavily developed, the risk of surface water flooding is increased.

The London Plan Supplementary Planning Guidance outlines the Mayors “essential” and “preferred standards” to include the importance of the use of SUDS wherever practical and the need to “achieve 50% attenuation of the undeveloped site’s surface water runoff at peak times” as an essential standard and “achieve 100% attenuation of the undeveloped sites surface water runoff as peak times” as a preferred standard.

[18] River Effra - Wikipedia
[19] Vauxhall Society Newsletter January 1987, www.vauxhallsociety.org

Lambeth has prepared a Surface Water Management Plan which assesses the risk of flooding from sewers and surface water in greater detail, and it is recommended that the Council refer to this document for further information on flooding from these sources.

Planning

- Overland flow paths should be taken into account in spatial planning for urban developments. Local topography and built form can have a strong influence on the direction and depth of flow. The design of development down to a micro-level can influence or exacerbate this.

- Where an area is identified as being at risk from overland flow, site specific flood risk assessments should consider localised flow paths to establish the risks to the site. Further planning considerations are included in Section 2.

6.5 Groundwater Flooding

The Solid and Drift deposit geology of the study area consists of London Clay for the majority of the Study Area.

The Environment Agency has provided as a GIS layer containing groundwater flooding records throughout the study area, however these records have only been collated between the years of 2000 and 2010. As with all historic flooding records the evidence is rather anecdotal, and in some cases simply refers to water being present within the basement of a building. This situation could be caused by a number of other flood sources such as a leaking or burst water pipe in the vicinity of the building.

The short length of the data record is a cause for concern and reduces confidence in the conclusions drawn from analysis. However, continued data collection will provide more confidence in drawn conclusions in future SFRA revisions.

There is limited information regarding historical instances of groundwater flooding. Local knowledge provided by Lambeth has noted that instances of groundwater flooding have been reported on Ferndene Road adjacent to Ruskin Park in Central Brixton and Dulwich Road adjacent to Brockwell Park. This data should be used with caution as it is anecdotal and may not be solely caused by groundwater flooding, surface water and/or overland flow may also be contributing.

The presence of London Clay throughout the study area suggests that the risk of groundwater flooding should typically be relatively low. However groundwater flooding risks are often highly localised, and dependent upon geological interfaces between permeable and impermeable subsoils. It is therefore essential that an understanding of site specific ground conditions is achieved through site survey and/or review of detailed borehole data.

Planning

- Where an area is identified as being at risk from groundwater flooding, site specific flood risk assessments should consider localised groundwater levels and geology to establish the risks to the site. Further planning considerations are included in Section 2.

6.6 Artificial Flood Sources (Infrastructure failure)

Artificial sources include any water bodies not covered by the previous categories. This typically includes canals, lakes, reservoirs etc. Due to the heavily urbanised nature of the study area, there are very few artificial flood sources in the area. There are two reservoirs located in the Borough, the first at Brixton Hill on Waterworks Road and the second on Wavertree Road. Both of these are operated by Thames Water but no details have been

provided. The London Borough of Lambeth has confirmed that there are no records of flooding associated with these structures.

7. NPPF SEQUENTIAL TEST GUIDANCE

7.1 What is the Sequential Test?

As set out in the NPPF, the aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. The sequential test should be carried out on all development sites. It can be applied at all levels and scales of the planning process, both between and within Flood Zones.

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 of that development outweigh the risks from flooding and, the development will be safe for its lifetime without increasing flood risk else where. Such development is required to include mitigation/management measures to minimise risk to life and property should flooding occur.

7.2 Development Vulnerability Classifications

The NPPF classifies developments according to their vulnerability. Five vulnerability classifications are defined, these are:

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

Full definitions are provided in Table 2 of the Technical Guidance to the NPPF including the types of development that fall under these classifications (reproduced as Table 7.1 below).

Table 7.1: Flood Risk Vulnerability Classification (from Technical Guidance to the NPPF, Table 2)

Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes), which has to cross the area at risk, and strategic utility infrastructure, including electricity generating power stations and grid and primary substations, and 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 plants. • Sewage treatment plants (if adequate pollution control measures are in place).
Water-compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel workings. • Docks, marinas and wharves. • Navigation facilities. • MOD 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 and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

The NPPF also stipulates where the differing types of vulnerable development may be appropriate based on flood risk. This is presented in Table 3 of Technical Guidance to the NPPF, which is reproduced in Table 7.2 below.

Table 7.2: Technical Guidance to the NPPF, Table 3, Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Risk Vulnerability Classification		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	1	✓	✓	✓	✓	✓
	2	✓	✓	Exception Test Required	✓	✓
	3A	Exception Test Required	✓	✗	Exception Test Required	✓
	3B	Exception Test Required	✓	✗	✗	✗

✓ – Development is appropriate ✗ – Development should not be permitted

7.3 How should the SFRA be used to apply the Sequential Test?

A Level 1 SFRA is designed to be sufficiently detailed to allow the application of the Sequential Test on the basis of Table 1 of the *Technical Guidance to the NPPF* (reproduced as Tables 4.1 and 4.4 in this report) and Figure 3.1 (reproduced as Figure 7.1 below).

The NPPF acknowledges that some areas will (also) be at risk of flooding from sources other than tidal and fluvial. Consequently all sources of flooding must be considered when looking to locate new development. The other sources of flooding requiring consideration when situating new development allocations include:

- Overland Flow;
- Groundwater;
- Sewers; and
- Artificial Sources.

These sources (as sources of flooding) are typically less well understood than tidal and fluvial sources. Consequently data often only exists as point source data or through interpretation of local conditions. In addition there is conflicting guidance on suitable return periods to associate with floods arising from these sources. For example modern surface water drainage systems are constructed to a 1 in 30 year standard. Any rainfall event in excess of the 30 year return period would be expected to result in some minor flooding through insufficient capacities. When assessing these sources through the Sequential Test, if a location is recorded as having experienced repeated flooding from the same source this should be investigated further in a site specific flood risk assessment.

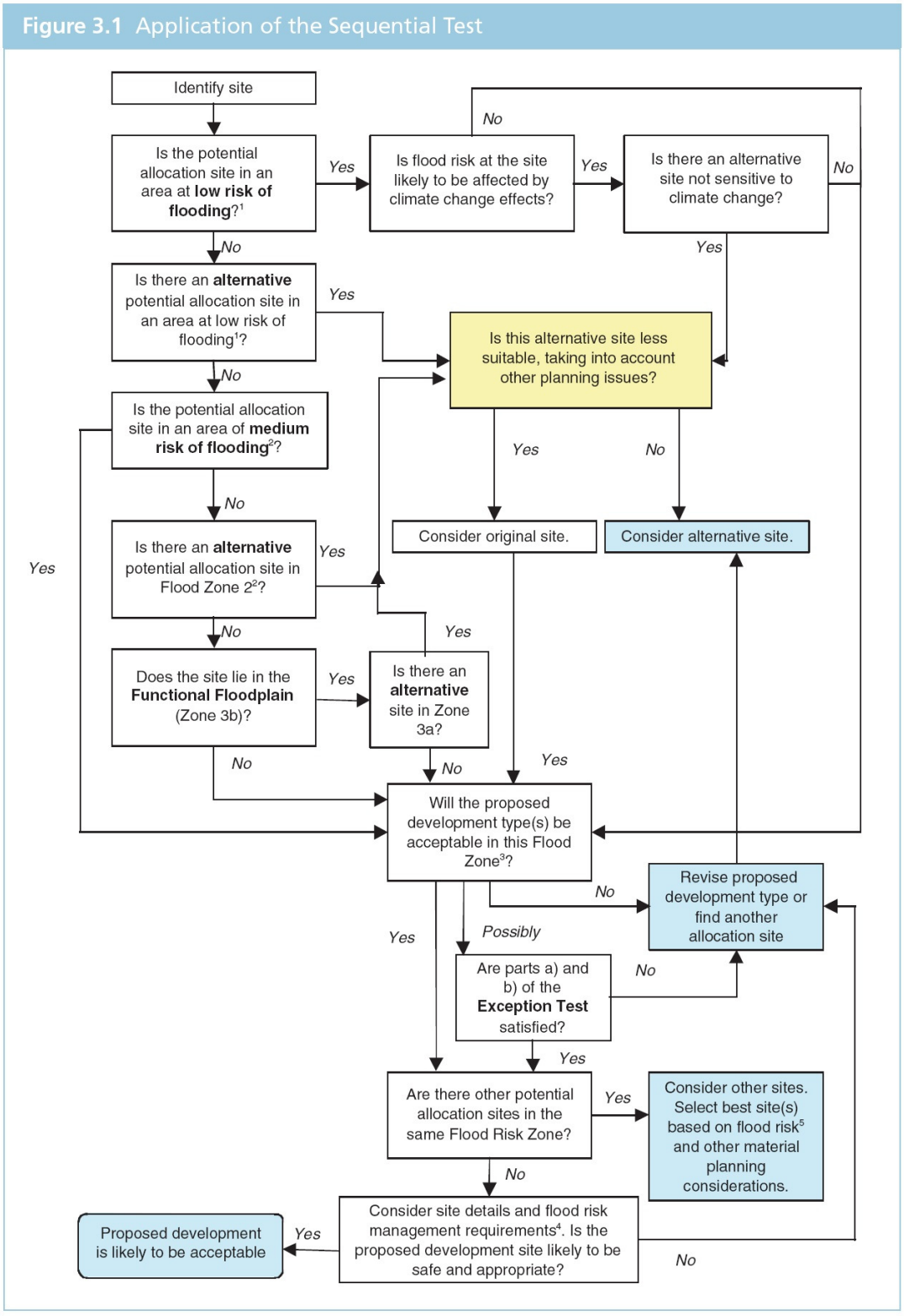
7.4 Undertaking the Sequential Test

Using the information documented and mapped within this Level 1 SFRA, the Sequential Test should be undertaken by the LPA and accurately documented to ensure decision processes are consistent and transparent.

The Level 1 SFRA mapping provides the tools by which the LPA can undertake the Sequential Test. This is achieved by presenting information to identify the variation in flood risk across the London Borough of Lambeth, allowing an area-wide comparison of future development sites with respect to flood risk considerations.

The following flow diagram (Figure 7.1), taken from the Practice Guide Companion to PPS25 (p67) illustrates how the Sequential test should be undertaken. The full process is described fully in PPS25, A Practice Guide Companion, 'Living Draft'.

Figure 7.1: Application of the Sequential Test (adapted from Figure 3.1 of PPS25: Practice Guide, A 'Living Draft')



7.5 Recommended stages for LBL application of Sequential Test

The sequence of steps presented below in tandem with Figure 7.1 is designed to guide the London Borough of Lambeth and developers through the Sequential Test:

1. The developments (i.e. housing, hospitals, industrial etc) that need to be accommodated by the Borough should be assigned a vulnerability classification (Table 7.1). Where development is mixed, this should be moved to the higher classification.
2. The Flood Zone classification of all development sites should be determined based on a review of the Environment Agency Flood Zones for fluvial and tidal sources. This should consider the effects of climate change on flood zone definition for the design life of any development that the site may be suitable for, i.e.:
   - 60 years – up to 2075 for commercial / industrial developments; and
   - 100 years – up to 2115 for residential developments

Where these span more than one Flood Zone, all zones should be noted.

3. Identify existing flood defences serving the potential development sites. However, it should be noted that for the purposes of the sequential test, flood zones ignoring defences should be used.
4. In the first instance the 'highly vulnerable' developments should be located in those sites identified as being within Flood Zone 1. If the 'highly vulnerable developments' cannot be located in Flood Zone 1, because the identified sites are unsuitable or there are insufficient sites in Flood Zone 1 then sites in Flood Zone 2 can then be considered. If sites in Flood Zone 2 are inadequate then the London Borough of Lambeth may have to identify additional sites in Flood Zones 1 or 2 to accommodate development, or seek opportunities to locate the development outside their administrative area. In Accordance with the NPPF 'highly vulnerable' uses would not be permitted in Flood Zone 3.
5. Once all 'highly vulnerable' developments have been allocated to a development site, the London Borough of Lambeth can consider those development types defined as 'more vulnerable'. In the first instance 'more vulnerable' development should be located in any unallocated sites in Flood Zone 1. Where these sites are unsuitable or there are insufficient sites, sites in Flood Zone 2 can be considered. If there are insufficient sites in Flood Zone 1 or 2 to accommodate the 'more vulnerable' development types, sites in Flood Zone 3a can be considered. However, any 'more vulnerable' developments in Flood Zone 3a will require application of the Exception Test (See Section 8). 'More vulnerable' developments are not appropriate in Flood Zone 3b – Functional Floodplain.
6. Once all 'more vulnerable' developments have been allocated to a development site, the Borough would consider those development types defined as 'less vulnerable'. In the first instance 'less vulnerable' development should be located in any remaining unallocated sites in Flood Zone 1, continuing sequentially with Flood Zone 2 then 3a. Less vulnerable development types are not appropriate in Flood Zone 3b – Functional Floodplain.
7. 'Essential infrastructure' developments should also be preferentially located in the lowest flood risk zones, however this type of development can be located in Flood Zones 3a and 3b, where necessary, through application of the Exception Test.
8. Water compatible development typically has the least flood risk constraints and it is therefore recommended to consider these types of development last when allocating development sites.
9. For decisions made through Stages 4, 5 and 6 it will also be necessary to consider the risks posed to the site from other flood sources and where comparable development sites in the same flood zone may be more suitable due to:

- flood risk management measures,
- the rate of flooding,
- flood water depth, or,
- flood water velocity.

10. Where the development type is highly vulnerable, more vulnerable, less vulnerable or essential infrastructure and a 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. This should be discussed with the Environment Agency to establish the appropriate time for the assessment to be undertaken, (i.e. Exception Test through a Level 2 SFRA or through a site specific flood risk assessment).
11. It is recommended that the Borough complete the Proforma, included in Appendix K (2008 SFRA version) to assist in completion of the Sequential Test to provide a transparent framework and justification of sites that may need to be Exception Tested.
12. The potential growth areas and development sites identified by Lambeth are presented in Figure 11 in relation to flood risk. This provides a starting point for consideration of the Sequential Test.

8. NPPF EXCEPTION TEST GUIDANCE

8.1 What is the Exception Test?

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.

The Exception Test is only appropriate for use when there are large areas in Flood Zones 2 and 3, where the Sequential Test alone can not deliver acceptable sites, but where some continuing development is needed for wider sustainable development reasons, taking into account the need to avoid social or economic blight and the need for essential civil infrastructure to remain operational during floods.

For the Exception Test to be passed:

a) It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA; and,

b) A site specific FRA must demonstrate that the development will be safe for its lifetime, without increasing flood risk elsewhere and, where possible, reducing flood risk overall.

Both parts of this 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.

A significant proportion of LBL is located within Flood Zone 3a of the River Thames; therefore it is likely that the requirements of the Exception Test will need to be satisfied for 'more vulnerable' e.g. residential, development in this area.

For this reason, the breach modelling has been undertaken during this Level 1 SFRA to enable the London Borough of Lambeth to take into account the variation in flood depth and hazard within Flood Zone 3a when allocating development sites. The breach modelling information should be used at this early stage to determine whether more appropriate locations are available within Flood Zone 3a, with a lower depth of flooding and associated hazard.

Further details of how to undertake the Exception Test are contained within the SFRA Level 2 report (Section 14).

9. FLOOD RISK MANAGEMENT

All new development should have flood risk management factored in at the planning stage to include the rigorous application of NPPF. Over the longer term (mid to end of the century) plans will include landscaping for flood storage and flood resilience. This chapter describes how flood risk management can be applied within the Borough.

9.1 Flood Defences

Flood defences are typically engineered structures designed to limit the impact of flooding. Flood defences take several forms including bunds/embankments, canalised channels, culverts and flood storage areas.

Information on flood defences throughout the study area has been provided by the Environment Agency as a GIS layer of the National Flood and Coastal Defence Database (NFCDD), listing details of structures and flood defences. The NFCDD aims to provide the following information:

- The location, composition and condition of fluvial and tidal defences and watercourses referenced to identified risk areas;
- The types of asset (i.e. property, infrastructure, environmental) at risk within identified risk areas and including those protected by fluvial, tidal and coastal defences;
- The extent of floods related to different flooding scenarios (e.g. different return periods and different types of flood event such as overtopping or embankment failure).

The locations of all NFCDD flood defences in the study area are presented in Figure 3, Appendix A.

The Environment Agency Flood Zone Map defines the extent of flooding ignoring the presence of defences and the fact that their presence can not always be assured. The reason for this approach is to make an allowance for residual flood risk in the event of a failure or breach/blockage/overtopping of the flood defences. This conservative approach over time will reduce reliance on flood defences and raises the awareness of flood risk in defended areas to help ensure that it is managed appropriately as part of development proposals.

The Environment Agency has also provided topographic survey drawings of some flood defences from their data archives which vary significantly in age, format, level of detail and coverage. A full review of these drawings has not been undertaken as it is currently beyond the scope of this study.

Existing flood defences in the Study Area

The NFCDD identifies a significant number of flood defences throughout the study area, which are classified as either tidal or fluvial defences. The Thames Tidal Defences, incorporating the Thames Barrier were designed to protect London from a tidal flood with a magnitude of 1 in 1000 years to the year 2030. So far sea level rise has not exceeded predicted rates and the defences are therefore providing a greater level of protection than 1 in 1000 years.

Many of the fluvial defences have a design standard less than 50 years; therefore a flood event of this magnitude would be expected to result in flooding despite the presence of a flood defence.

With this in mind the efficient operation of channels and culverts is paramount if the existing standard of flood defence is to be maintained for the Study Area. This requires maintenance by the defence owners which include the Environment Agency, Local Authorities and riparian owners or by the responsible drainage authority where appropriate remedial action does not take place.

Future proposals for Flood Defence in the Study Area

The Environment Agency is currently undertaking a comprehensive programme of study referred to as Thames Estuary 2100 (TE2100), to establish the best approaches to manage flood risk with respect to different climate change scenarios. A number of measures have been identified that could be implemented depending on the increase in sea level rise and storm surge that may be experienced over the next 100 years. TE2100 will recommend local policies that set the strategic direction of flood risk management, and high level, estuary-wide options to ensure these local policies are achieved.

TE2100 will be recommending options that place more emphasis on floodplain management, in addition to flood defence. These options will include more appropriate use of the floodplain, making space for water, better flood awareness and flood-preparedness and improved emergency planning and response measures.

It is recommended that progress of the TE2100 project should be closely monitored and this study should be updated to reflect the latest findings.

9.2 Flood Warning

The Environment Agency operates a flood warning service in certain areas at risk of both fluvial and tidal flooding.

The Environment Agency operate four types of flood warning to use when warning the public, media and partner organisations of impending flooding as described below. They are referred to as 'Flood Warning Codes' and are used as appropriate to indicate the impact of flooding in a given area.

Severe Flood Warning
Severe flooding. Danger to life.

Flood Warning
Flooding is expected. Immediate action required.

Flood Alert
Flooding is possible. Be prepared.

Warning no longer in force
Flood warnings and flood alerts that have been removed in the last 24 hours.

The Environment Agency issue flood warnings to the public and professional partners including emergency services, local authorities, utility companies and the media. Warning messages are sent to people registered to receive flood warnings on the Environment Agency's Floodline Warnings Direct service via automated voice messages to land line and mobile phones, fax, pager, SMS, email. Warnings may also be broadcast by the media, an agreement to this affect is in place with LBC radio, 1152am and DAB in this area.

There is also an emergency Floodline number (0845 988 1188) and a quick dial number for specific areas.

The Flood warning system helps residents in flood warning areas to prepare for flooding, through obtaining sand bags, moving valuables upstairs and where necessary evacuating the property to minimise the potential consequences of flooding.

It should be noted that flood warnings are not possible for Flood Defence failure. Figure 10, Appendix A illustrates the flood warning areas within the study area.

9.3 Lead Time

The greater the lead time, i.e. from when the Flood Warning is issued to the onset of property flooding, may mean there is increased preparation time to prepare for flooding and evacuation. The Environment Agency endeavour to give a 2 hour lead time when issuing Flood Warnings, however, this may not always be possible due to the characteristics of some rivers which react more quickly.

Should a defence structure breach or fail then inundation can be rapid, resulting in rapid inundation for areas local to the breach. On the other hand, during tidal events, should a breach occur early in the tidal cycle, the lead time could be a lot slower. Typically, areas immediately adjacent to a breach location will flood quicker than areas setback from the flood defence.

9.4 Residual Risk

Residual risks, as defined in the NPPF, are 'those remaining after applying the sequential approach and taking mitigating actions'. In a flood risk context, this residual risk pertains to the flood risk that remains after flood avoidance and alleviation measures have been put in place.

An example of residual risk relevant to the study area is overtopping or breaching of the floodwalls located along the banks of the River Thames. It is possible that the defences could be breached due to collision of river traffic, terrorist action and/or hydrostatic water pressure during high tides. The defences could also be overtopped if the Thames Barrier failed to close and a storm surge travelled up the estuary into Central London. As sea level rises over time, the Barrier will have to close with increasing frequency, and not just in response to surge tides. With operational constraints limiting the number of closures in any one year, the risk of overtopping will increase.

While breaching of the Thames flood defences has been covered as part of this study, the probability of overtopping has not due to the presence of the Thames Barrier.

Residual risk management therefore aims to prevent or mitigate the consequences of flooding that can occur despite the presence of flood alleviation measures.

Application of the Sequential Test aims to preferentially develop or relocate potential development sites into areas with low flood risk. Where this is not realistically possible, some development sites may be located in higher flood risk areas, such as Flood Zones 2 and 3. As a result, such developments will require residual risk management to minimise

the consequences of potential flooding, e.g. following a breach or overtopping of local defences.

Ensuring properties are defended to an appropriate design standard reduces flood risk. However, further options are also available should the residual risk to a development prove unacceptable. Details of potential residual risk management options are contained in Appendix D.

9.5 Emergency Planning

Emergency planning is the responsibility of the London Borough of Lambeth. Specific details of the emergency plans throughout the study area have not been made available during this study as they are highly confidential documents for security reasons. However, it is understood that the London Borough of Lambeth has emergency plans in place to respond to any incident that occurs within their administrative area.

Emergency Planning can be broadly split into three phases:

- Before a flood – raising flood awareness, ensuring no inappropriate use of the floodplain, ensuring emergency access and egress routes are available, protecting vital infrastructure, ensuring adequate flood resilience measures are employed;
- During a flood – Flood warning, rescuing occupants, providing safe refuge and alternative accommodation;
- After the flood – providing support to help people recover and return to their homes and businesses.

During a flood the main function of the Boroughs would be to provide temporary accommodation to any displaced people until such time that they are in a position to return to their homes or their insurance companies can arrange temporary accommodation for them. This shelter is provided in the form of rest centres, and provides a warm dry place to sleep and basic facilities including shower, food, etc.

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. In addition future development control polices should seek to locate more vulnerable institutes such as schools and care homes in areas of the lowest risk to minimise the potential for flood casualties.

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 allocated centres are not at high 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.

It is becoming increasingly important to manage the use of the floodplain and the LBL should encourage the construction of new facilities to be developed outside the floodplain. Floodplain management and emergency response activities must have a focus on key infrastructure such as the underground network and properties that are below sea level.

Essential infrastructure located in Flood Zone 3a or 3b must be operational during a flood event to assist in the emergency evacuation process.

9.6 Potential Evacuation and Rescue Routes

In the event of a flood incident, it is essential that the evacuation and rescue routes to and from any proposed development remain safe.

Chapter 13 of Document FD2320 "FRA Guidance for New Development" produced by the Environment Agency and Defra concentrates on safe access and egress. Table 13.1 included in this report illustrates danger to people based on flood depth and velocity and shows that the Environment Agency deem evacuation routes safe if they fall within the white cells of the table, being lower depth and velocity for a 1 in 100/200 year design event.

Where flood risk during an extreme event is to be assessed (1 in 1000 year); the Environment Agency should inform the borough of potential risk. This allows the Borough to consult with the emergency services over the suitability of the access route. If potential evacuation routes are likely to become inundated so that safe access/egress would not be possible, then the proposed development should be relocated.

A key consideration in relation to the presence and use of evacuation routes is the vulnerability and mobility of those in danger of being inundated. Development for highly vulnerable users e.g. disabled or the elderly should be located away from high-risk areas. The Sequential Test does not however differentiate between the vulnerability of the end users of the site, only the vulnerability of the intended use of the site. A proposed residential development for highly vulnerable end users (elderly, physically impaired etc) will still fall under the 'More Vulnerable' classification in Table 2 of the Technical Guidance to the NPPF and the Sequential and Exception Tests will apply accordingly. Where development for highly vulnerable end users cannot be avoided, safe and easy evacuation routes are essential.

Table 2 of the Technical Guidance to the NPPF (Table 7-1) classifies 'Highly Vulnerable' developments, of those that should be taken into consideration in the event of an emergency are:

- Hospitals; Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels;
- Student halls of residence; and,
- Non-residential uses for health service, nurseries and educational establishments.

Situations may arise in an emergency where the occupants of the above institutions cannot be evacuated (such as prisons). Therefore particular significance must be given to these development types when looking to allocate them. These allocations should be assessed against the outputs of the SFRA to develop robust emergency plans.

Consideration needs to be made to basement only properties as they provide no means of escape from flood waters and no alternative dry accommodation after a flood. Their occupants will be at a high risk from even shallow flooding and means of escape is essential. Agreements should be made with occupants and emergency planning teams as to appropriate actions.

10. SUSTAINABLE DRAINAGE SYSTEMS

10.1 What are SuDS?

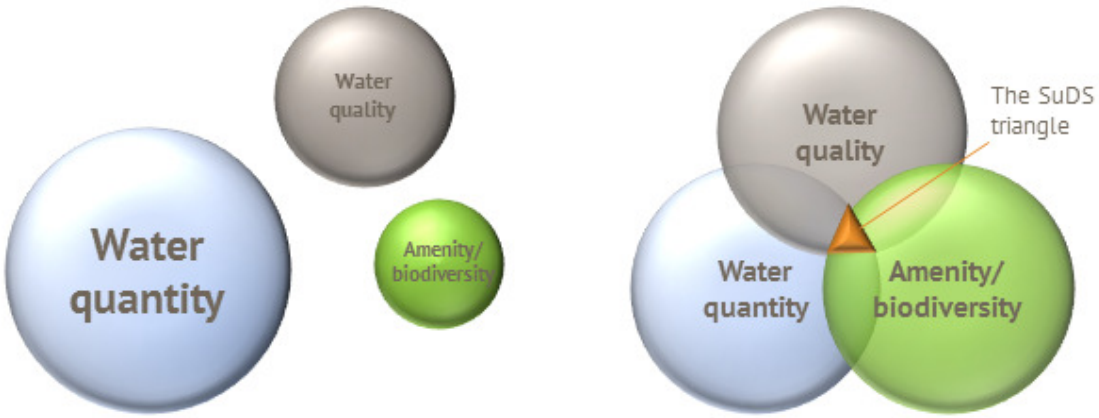
Drainage systems can contribute to sustainable development and improve urban design, by balancing the different issues that influence the development of communities. Approaches to manage surface water that take account of water quantity (flooding), water quality (pollution) and amenity issues are collectively referred to as Sustainable Drainage Systems (SuDS).

SuDS mimic nature and typically manage rainfall close to where it falls. SuDS can be designed to slow water down (attenuate) before it enters streams, rivers and other watercourses, they provide areas to store water in natural contours and can be used to allow water to soak (infiltrate) into the ground or evaporated from surface water and lost or transpired from vegetation (known as evapotranspiration).

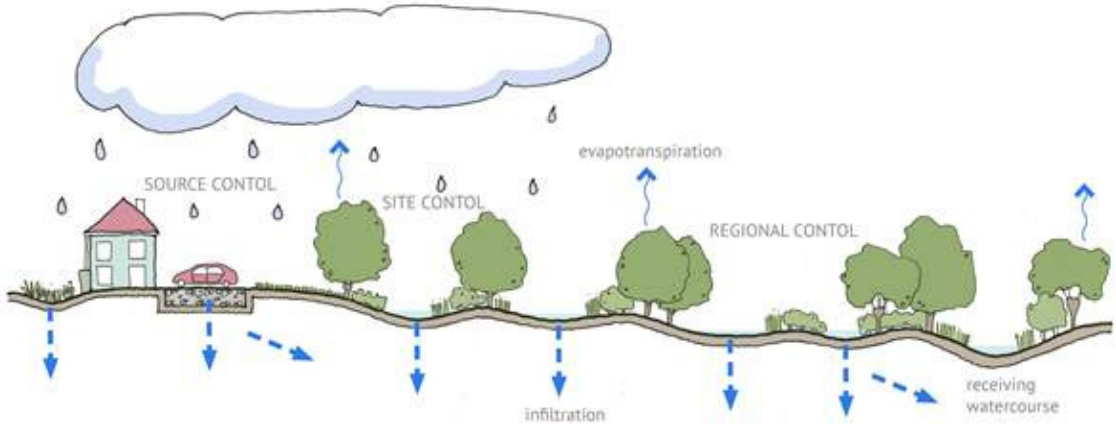
SUDS are technically regarded a sequence of management practices, control structures and strategies designed to efficiently and sustainably drain surface water, while minimising pollution and managing the impact on water quality of local water bodies.

SuDS are more sustainable than traditional drainage methods because they:

- Manage runoff volumes and flow rates from hard surfaces, reducing the impact of urbanisation on flooding
- Protect or enhance water quality (reducing pollution from runoff)
- Protect natural flow regimes in watercourses
- Are sympathetic to the environment and the needs of the local community
- Provide an attractive habitat for wildlife in urban watercourses
- Provide opportunities for evapotranspiration from vegetation and surface water
- Encourage natural groundwater/aquifer recharge (where appropriate)
- Create better places to live, work and play.



A useful concept used in the development of sustainable drainage systems is the SuDS management train (sometimes referred to as the treatment train), illustrated below. Just as in a natural catchment, drainage techniques can be used in series to change the flow and quality characteristics of the runoff in stages.



The management train starts with prevention (preventing runoff by reducing impermeable areas), or good housekeeping measures for reducing pollution; and progresses through local source controls to larger downstream site and regional controls.

Runoff need not pass through all the stages in the management train. It could flow straight to a site control, but as a general principle it is better to deal with runoff locally, returning the water to the natural drainage system as near to the source as possible.

Only if the water cannot be managed on site should it be (slowly) conveyed elsewhere. This may be due to the water requiring additional treatment before disposal or the quantities of runoff generated being greater than the capacity of the natural drainage system at that point. Excess flows would therefore need to be routed off site.

End of pipe solutions where runoff is directly discharged to a wetland or pond should be avoided. SuDS design requires a balancing of different options, often depending on the risks associated with each course of action. The risks of an area flooding have to be balanced with the costs of protecting the area from different levels of floods.

The management train concept promotes division of the area to be drained into sub-catchments with different drainage characteristics and land uses, each with its own drainage strategy. Dealing with the water locally not only reduces the quantity that has to be managed at any one point, but also reduces the need for conveying the water off the site.

When dividing catchments into small sections it is important to retain a perspective on how this affects the whole catchment management and the hydrological cycle.

10.2 Why use SuDS?

Traditionally, built developments have utilised piped drainage systems to manage surface water and convey surface water run-off away from developed areas as quickly as possible. Typically these systems connect to the public sewer system for treatment and/or disposal to local watercourses. Whilst this approach rapidly transfers surface water from developed areas, the alteration of natural drainage processes can potentially impact on downstream areas by increasing flood risk and reducing water quality.

Due to the difficulties associated with upgrading sewer systems it is uncommon for sewer and drainage systems to keep pace with the rate of development/re-development and the increasingly stringent drainage discharge restrictions that are being placed upon them. As development continues and/or urban areas expand these systems can become inadequate to deal with the volumes of surface water that is generated, resulting in increased flood risk and/or pollution to watercourses. Allied to this are the implications of climate change and increasing rainfall intensities.

SuDS also have wider sustainability advantages by creating opportunities for landscaping and incorporation of habitats for wildlife.

The London Plan Sustainable Design and Construction Supplementary Planning Guidance outlines the Mayors "essential" and "preferred standards" to include the importance of the use of SUDS wherever practical and the need to "achieve 50% attenuation of the undeveloped site's surface water runoff at peak times" as an essential standard and "achieve 100% attenuation of the undeveloped sites surface water runoff as peak times" as a preferred standard;

10.3 SuDS Techniques

SuDS techniques can be used to reduce the rate and volume and improve the water quality of surface water discharges from sites to the receiving environment (i.e. natural watercourses or public sewers etc). Various SuDS techniques are available and operate under two main principles:

- Infiltration;
- Attenuation

The design of SuDS measures should be undertaken as part of the drainage strategy and design for a development site. A ground investigation will be required to assess the required volume of on-site storage. Hydrological analysis should be undertaken using industry approved procedures, to ensure robust design storage volume is obtained.

During the design process, liaison should take place with the Local Planning Authority, the Environment Agency and if necessary, the water undertaker to establish a satisfactory design methodology and permitted rate of discharge from the site.

The application of SuDS is not limited to a single technique per site. Often a successful SuDS solution will utilise a combination of techniques, providing flood risk, pollution and landscape/wildlife benefits. In addition, SuDS can be employed on a strategic scale, for example with a number of sites contributing to large scale jointly funded and managed SuDS. It should be noted, each development site must offset its own increase in runoff and attenuation cannot be 'traded' between developments.

10.4 Where can SuDS be utilised?

SuDS can be used anywhere, though consideration needs to be given to the points below. As long as the basic principles of the SuDS management and treatment trains are applied there is no reason why they will not work, and successfully deliver the flood mitigation benefits alongside additional benefits such as amenity, bio-diversity and water quality.

- Land use characteristics;
- Site characteristics;
- Catchment characteristics;

- Quantity and quality performance requirements;
- Amenity and environmental requirements.

The underlying ground conditions of a development site can determine the type of SuDS approach to be used. This will need to be determined through ground investigations carried out on-site.

10.5 Retro-fit SuDS

Lambeth believe and can evidence that SuDS can be retro-fitted, and all developments will be expected to implement SuDS measures as standard.

The use of SuDS should be reviewed on a site by site basis as often a combination of available SuDS methods may provide the best solution.

10.6 Further Information

The above information is intended to provide an introduction to the use of SuDS. The options available for the provision of SuDS is not limited to those presented here and new techniques are frequently developed.

The Surface Water Management Plan prepared by Lambeth includes revised and updated details of SuDS techniques and principles.

10.7 Expected Standards

Lambeth will expect as the absolute minimum that the requirements of the National Standards are met, it will also be expected that designs will as a minimum be in accordance with the current version of the SuDS manual, with particular reference being made to the London SuDS guidance. Where proprietary products are proposed they must be used in accordance with the manufacturers guidance.

It is expected that SuDS designs will be submitted with proprietary software design outputs, it should be noted that although these outputs will be accepted to support any designs, they will not be accepted solely on the basis that the SuDS proposed will work.

11. THE LEVEL 2 SFRA

11.1 Introduction

NPPF emphasises the active role Local Planning Authorities (LPAs) should have in ensuring flood risk is considered in strategic land use planning. NPPF encourages LPAs to undertake a Strategic Flood Risk Assessment (SFRA) as part of their evidence base for the Local Development Framework (LDF) process and to use their findings to inform strategic land use planning.

Where decision-makers are unable to allocate all proposed development and infrastructure in accordance with the Sequential Test (i.e. steer development to areas at lowest risk of flooding), it is necessary to increase the scope of the Level 1 SFRA to provide information necessary for application of the Exception Test (Level 2 SFRA).

The Level 1 Report identified that the entire Waterloo Opportunity Area and a large proportion of the Vauxhall Opportunity Area is located in Flood Zone 3a, being an area benefiting from tidal flood defences.

11.2 Aim of Level 2 SFRA

The aim of this study is to provide supplementary information to the Level 1 SFRA, to inform on specific flood risk issues and suitability for development of Waterloo and Vauxhall as outlined in the London Plan and Waterloo Opportunity Area Framework documents and the Lambeth Local Plan (LLP). This will provide sufficient information to allow the application of the NPPF Exception Test.

11.3 Level 2 SFRA Objectives

The aim of the London Borough of Lambeth Level 2 SFRA will be met through the following the guidance set out in NPPF Technical Guidance with the following specific objectives:

- An appraisal of the current condition of flood defence infrastructure and of likely future policy with regard to its maintenance and upgrade;
- An appraisal of the probability and consequences of failure of flood risk management infrastructure, including an appropriate allowance for climate change;
- Mapping to illustrate the distribution of flood risk across flood zones to enable a sequential approach to site allocation within flood zones;
- Identify policies and practices required to ensure development satisfies the Exception Test;
- Guidance on the preparation of FRAs for sites of varying risk across the flood zone.

11.4 Specific Overview

Correspondence with the London Borough of Lambeth has confirmed that Waterloo and Vauxhall should be the focus for the Level 2 SFRA. Both Waterloo and Vauxhall are located in Flood Zone 3a.

The location of the Waterloo and Vauxhall Opportunity Areas are shown in Figure 11 Appendix A.

Waterloo

Lambeth's Local Plan identifies the Waterloo area as a key part of Central London, with strong movement and activity relationships with adjoining areas across and along the river. The area consists of four distinct character areas: The Riverside; Railway; Residential and Lower Marsh.

The London Plan identifies potential for an additional 1.900 dwellings within the area during the period 2011 to 2031.

The Waterloo Opportunity Area is approximately 39 hectares in size (including the River Thames) and is located wholly within the London Borough of Lambeth, in Flood Zone 3a.

Vauxhall

Vauxhall is part of the Mayor's Vauxhall, Nine Elms and Battersea (VNEB) Opportunity Area Planning Framework (OAPF) which promotes 'the optimum level of development for the area'.

The OAPF includes significant development throughout the VNEB area; which is anticipated to result in approximately 3,500 new homes and 8,000 new jobs within Vauxhall, which is located in Flood Zone 3a, 2 and 1.

At Vauxhall, good public transport coupled with strong traffic management, easier pedestrian movement, major environmental improvement and scope for intensification should create a stronger sense of local identity and increase housing and commercial capacity.

12. FLOOD DEFENCES

12.1 Condition and Standard of Protection

Figure 3 illustrates the location of flood defences in the Waterloo and Vauxhall areas. Flood defences reduce the risk of flooding, but do not eliminate flood risk completely. The reduction in flood risk that the defence provides depends on the standard of protection (SoP) and the performance and reliability of the defences.

The Environment Agency has provided details of the flood defences that are in place along the banks of the River Thames in Lambeth to include the areas of Waterloo and Lambeth. The defences are designed to protect areas behind the defences up to a 1 in 1000 (0.1%) annual probability flood event. This is the highest standard of protection provided in the country.

All defences within the Lambeth Study area including Waterloo and Vauxhall are defined as 'Hard defences', consisting of flood defence walls and/or armoured slopes. They are privately maintained and the Environment Agency carry out regular maintenance inspections.

No details are included in the NFCDD database provided by the Environment Agency regarding the condition of defences.

12.2 Likely Future Policy

The whole of Lambeth is covered by the Thames Region Catchment Flood Management Plan (CFMP). This document is produced by the Environment Agency to provide an overview for managing the long-term flood risk within the catchment over the next 50 to 100 years.

The Thames CFMP outlines strategic action plans for six catchment types in the Thames Region. Waterloo and Vauxhall fall into 'developed floodplain with built flood defences'. In this area the Environment Agency's key messages are:

- That at present it is still possible and effective to maintain flood defences;
- Climate change will mean that existing defences will become less effective in the future.

The Environment Agency are committed, in conjunction with the Local Authority, to maintain river assets at this location through asset management plans. In the long term investigations will be made into options to mitigate the effects of climate change and sea level rise on Flood Defences.

The Environment Agency's TE2100 Flood Risk Management Policy has split the Thames Estuary into a number of units, each is being investigated in detail to find out what the current and future flood risk will be and how well it is currently being managed. TE2100 is currently consulting on a number of options to manage flood risk in the Central London Estuary Zone. Those applicable to Vauxhall and Waterloo are listed below:

- **Manage flood walls and embankments**
  - Raise defence levels over time by 0.5m to a maximum of 1.0m;
  - Install temporary defences at times of forecast high river flow and tide levels;

- Some defences may be set back to make space for water and to improve access to the river – this can provide an opportunity to improve the riverside environment and restore historic or architectural features.

- **Barriers, Barges and Pumping stations**

  - The Thames Barrier will continue to provide protection against increasing sea level and could either be upgraded or potentially be replaced by a structure further down the estuary towards the end of the century;

  - Over the next 20 – 30 years we may need to find another way to reduce freshwater flooding rather than using the Thames Barrier.

13. FLOOD SOURCES

13.1 Flooding without defences

The Environment Agency Flood Zone maps provide predictions of flood extent across Lambeth without the provision of flood defences. These Flood Zones clearly show that the whole of the Waterloo Opportunity Area is located in Flood Zone 3 and the majority of Vauxhall Opportunity Area is located in Flood Zone 3, with some areas in Flood Zones 2 and 1. The flood maps provide a good indication of the areas at risk of flooding within the study area, however, they do not provide detail on individual properties.

Further details on Environment Agency Flood Zone maps can be found in Section 6.3.

13.2 Flooding with Defences

Waterloo and Vauxhall both have a substantial frontage to the River Thames; the Opportunity Areas are located behind flood defences. They are therefore at residual risk of flooding through failure or overtopping of the defences.

According to the Environment Agency, both Opportunity Areas are defended to a 1 in 1000 year return period event by defences that are in good condition, strengthened with concrete and sheet piling and that are maintained and inspected regularly by the Environment Agency. This means that the risk of failure of the Thames Tidal Defences is very low. However, to fulfil the purposes of the Level 2 SFRA process an assessment of the level of residual risk must be made.

Breach modelling

Flooding to low lying land from the sea and tidal estuaries is caused by storm surges and high tides. Where tidal defences exist, they can be breached during severe storms.

The Environment Agency has undertaken two-dimensional hydraulic modelling to simulate breach flood events to determine and illustrate the areas at highest, medium and low risk in order that a sequential approach to site allocation within a flood zone can be applied.

Further detail on the specific modelling methodology applied can be obtained from the Environment Agency.

All defences within the Lambeth study area are defined as 'Hard defences', consisting of flood defence walls located along the River Thames. The Thames Tidal Defences are to the 1 in 1000 year standard, therefore they would not overtop during a 1 in 20 year water level. As such there is no functional floodplain on the landward side of defences associated with the tidal floodplain in this area.

The breach analyses have been undertaken for the present day 1 in 200 year flood event. Due to increased use of the Thames Barrier in the future, consideration of a climate change scenario is not required by the Environment Agency.

This unexpected result is based on the assumption that the Thames Barrier will be closed more frequently due to increased sea levels anticipated during climate change scenarios. Increased use of the Thames Barrier will allow fewer high tides to flow upstream into central London each year therefore the estimated extreme water levels within the study area do not increase with climate change.

Taking this into account and, in agreement with the Environment Agency and the Council, no climate change scenarios have been included in the breach modelling.

13.3 Depth Maps

The main outputs from 2D modelling are depth, velocity and flow direction information. Depth and velocity are used to determine hazard whilst velocity and direction of flow indicate the rate and onset of flooding. Composite depth maps have been provided within this SFRA for the six relevant breach locations. These maps show the maximum depth experienced during all modelled scenarios. The depth information is presented in metres; therefore to determine the surface water level of the flood depth this should be added to the topographic height to produce a water level in mAOD.

13.4 Hazard Maps

Flood hazard is a function of the instantaneous flood depth and velocity. Therefore, the maximum flood hazard for a given location could be experienced at any stage of the flood. Near the breach where velocities are high the highest hazard is likely to be achieved at the time of peak velocity. Further from the breach the maximum hazard will depend on local factors affecting both the depth of floodwaters and velocities at each instant. At the very fringes of the flood extent the maximum hazard occurs nearer the peak water depth towards the end of the simulation.

As the flood hazard is time and location dependant a hazard calculation is performed on every output time step for every element in the model domain. The maximum hazard attained is then recorded for each element.

The flood hazard for each element is categorized as either low, medium or high. The assigned category is determined by a relationship between water depth and flow velocities as illustrated in Figure 16.2 below, in accordance with the FD2320[20] methodology.

$$HR = d \times (v + 0.5) + DF$$

Where: HR = *(flood) hazard rating;*

d = *depth of flooding (m);*

v = *velocity of floodwaters (m/sec); and*

DF = *debris factor (= 0, 0.5, 1 depending on probability that debris will lead to a significantly greater hazard)*

The breach analysis described above provides data to aid the identification of risk of flooding from failure of local flood defences.

Flood Hazard mapping uses a combination of flood depth and velocity to create a hazard rating for people that may be affected by flooding. This helps to define the distribution of risk within a flood zone and allows planners to make more detailed consideration of the Sequential Test and NPPF vulnerability classifications on specific site allocations.

[20] http://www.defra.gov.uk/science/project_data/DocumentLibrary/FD2321/FD2321_3436_TRP.pdf

In most flood events the maximum hazard of a flood at a certain location is not experienced at the peak of the flood but before the maximum floodwater level occurs. This is the point at which the greatest flood depths and velocities typically occur. To assess the maximum flood hazard during a flood event, the hazard level at every time step during the breach model simulations is assessed.

Zone of Rapid Inundation

This refers to an area in the locality of a breach event or source of flooding, where a residual flood hazard would be highest as a result of high velocities and initial floodwater dispersal from a potential breach event.

Flood inundation animations were previously supplied to the London Borough of Lambeth and Environment Agency to provide further detail with regards the main flood routes and speed of inundation relating to each particular breach event.

The East London SFRA (Entec 2005) assumed a 500m buffer zone, to include the zone of rapid inundation, however, due to the location of the Waterloo mainline embankment running through Lambeth, a 500m buffer zone would not be realistic in this zone as the raised embankment will act as a barrier to potential floodwaters. Therefore, it is not considered appropriate to specify an arbitrary riverine buffer zone in Lambeth, as it is likely to misrepresent the spatial variability of risk.

It is essential to remember when using flood depth and hazard maps that they represent hazard arising from one or more of the six specific breach locations and that hazard and depth will almost certainly vary spatially if the breach locations are in different local areas.

The following issues should also be considered:

- Not all possible breach locations in the London Borough of Lambeth have been considered and the six breach locations were chosen as locations thought most likely to lead to flood risk and give a broad coverage of the Lambeth frontage;
- Breach width and depth, though based on Environment Agency guidance are arbitrary and so not necessarily represent the actual dimensions of a breach in a given location;
- Changes in inundation extent or Hazard Zone are non-linear to changes in breach location.

13.5 Riverside Topographic Assessment

The original 2008 SFRA analysed the riverside topography to determine the potential consequences of a breach in the defences occurring. This information has been provided to supplement the breach modelling and provide an indication of residual risk for the entire Borough. It should be noted that this assessment has not been revised for the 2013 SFRA update.

LiDAR data was analysed and compared with peak flood levels to estimate the flow of water through a theoretical breach at any point along the river frontage. The results were then used to classify the riverside into categories of increasing residual risk from RC-1 (topography above 1 in 1000 year tidal flood level) to RC-4 (topography more than 1m below the 1000 year level).

The full methodology and mapping is presented within Appendix C, Figure H1 – H19.

13.6 Surface Water Flooding

The Level 1 SFRA outlined instances of Sewer flooding from the Thames Water DG5 register and local knowledge was used to pinpoint instances of surface water flooding.

Due to the resolution of Thames Water DG5 data using 5 figure postcodes, there is a need to better understand the risk of surface water flooding posed by extreme rainfall events.

As part of Lambeth's Surface Water Management Plan, a surface water modelling exercise has been completed for the study area, including the Opportunity Areas of Waterloo and Lambeth. The modelling provides an indicative view of potential problem areas where surface water may collect during a rainfall event.

The SWMP provides a significant insight into surface water and sewer flooding problems within Lambeth, and provides full details of the modelling methodology applied and analysis of results. It is recommended that LBL refer to the SWMP for further details of surface water flooding risks to major development areas such as Vauxhall and Waterloo.

13.7 Other sources of flooding

The River Graveney, a tributary to the River Wandle flows through the south of the Borough. It is understood from the London Borough of Lambeth that there are no allocations proposed in the vicinity of the River Graveney therefore further information to inform the Exception Test process is not required at this stage so this has not been explored further in this Level 2 SFRA.

Groundwater flooding has not been highlighted as an issue in either Waterloo or Vauxhall. Therefore, no further analysis of these risks has been undertaken as part of the Level 2 SFRA.

14. THE SEQUENTIAL APPROACH TO SITE ALLOCATIONS WITHIN FLOOD ZONES.

14.1 The Sequential Test

The Level 1 SFRA has shown that the opportunity area of Waterloo resides wholly within Flood Zone 3a having a high probability of flooding and Vauxhall partly resides in Food Zones 3a, 2 and 1.

Development is only permissible in areas at risk of flooding such as Waterloo and Vauxhall where it can be demonstrated that there are no reasonably available sites in areas of lower risk and that the benefits outweigh the risks from flooding i.e. the development must pass the Exception Test.

In Vauxhall, where there are no reasonably available sites in Flood Zone 1, decision makers should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should decision makers consider sites in Flood Zone 3, taking into account flood risk vulnerability and applying the Exception Test where necessary.

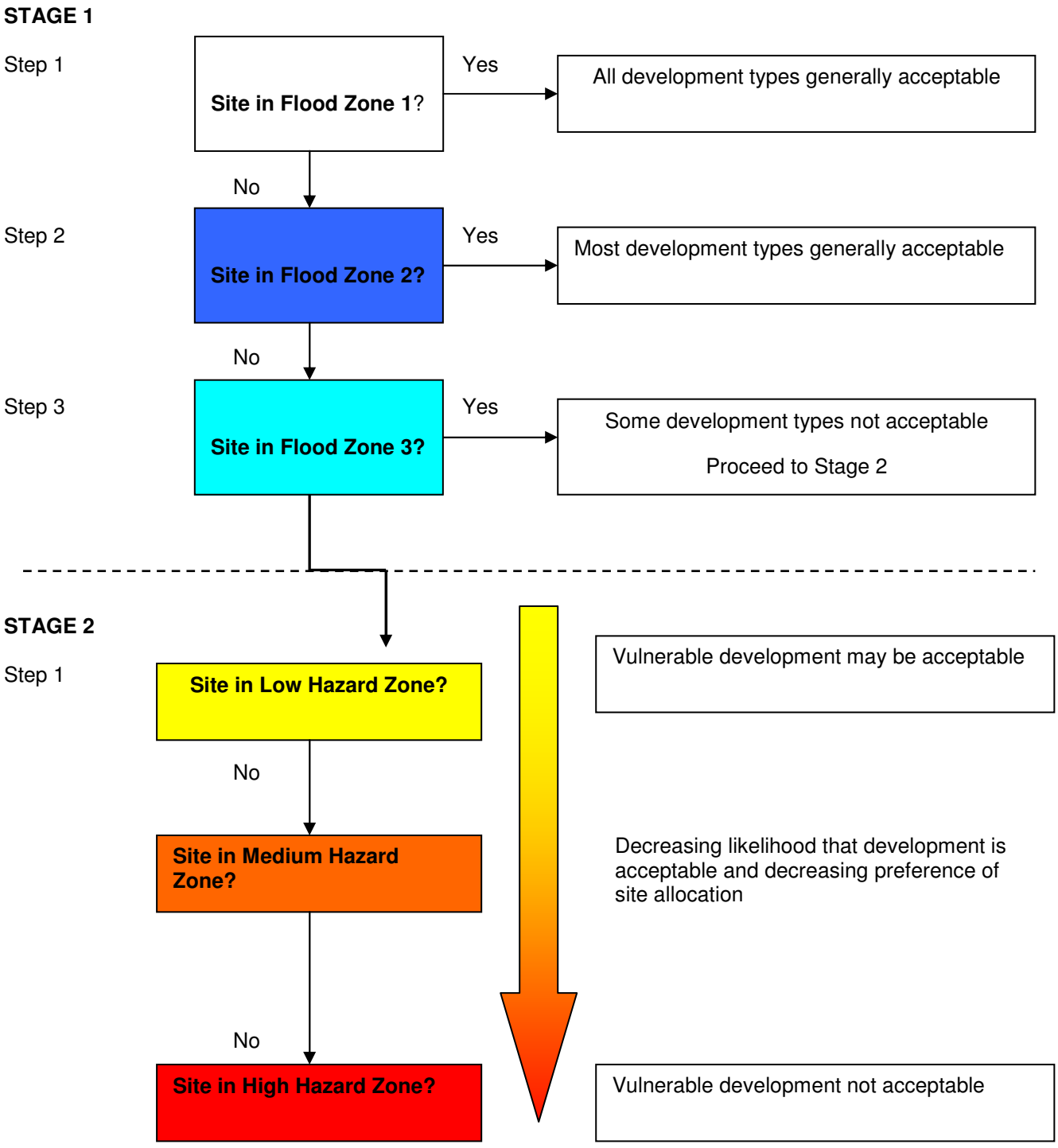
In the situation of Waterloo, the whole development opportunity area resides in Flood Zone 3a. In this case new development should be directed to areas at lowest probability and associated hazard of flooding within the flood cell and the flood vulnerability should be matched to the flood risk of the site e.g. higher vulnerability uses should be located on parts of the site with the lowest probability of flooding. The same method should be applied to Vauxhall which partly resides in Flood Zones 3a, 2 and 1.

The production of Hazard maps allows an appreciation of differing levels of hazard within the flood zones, allowing a sequential approach to be taken for the master planning of these Opportunity Areas as illustrated in Figure 14.1 below.

Stage 1 of Figure 14.1 represents the NPPF Sequential Test. Steps 1 to 3 are to be followed, with each, from a flood risk point of view, being less desirable than the previous for a given development type (i.e. Flood Zone 2 is less desirable than Flood Zone 1). As the user progresses through the steps, they must be confident that a site of lesser flood risk is not available for the specific development under consideration.

Stage 2 of Figure 14.1 represents the additional Hazard Zone test. To move to Stage 2 the user must again be confident that no site of a lesser flood risk is available for the specific development under consideration. As with Stage 1, each step represents, from a flood risk point of view, a less desirable site than the previous step.

Figure 14.1: Suggested Sequential Test for Waterloo and Vauxhall



As can be seen from the above schematic, the interrogation of Hazard Zone information is a series of further steps beyond the usual procedure of applying the NPPF Sequential Test. It is intended that the Hazard Zone classification of low-medium-high remains subjective and is inherently relative to a specific site.

A planning authority's decision to allocate development land within areas where Hazard Zone maps have been produced in this SFRA should examine all of the following:

- The vulnerability of the proposed development type to flooding;
- The residual risk to the development and;
- The options for managing the residual risk.

In the case of Waterloo, Stage 2 will always be required as the whole Opportunity Area resides in Flood Zone 3a. In Vauxhall, Stage 2 may not always be required if the master planning can undertake the sequential approach to the location of more vulnerable development types into areas of lower flood risk.

14.2 Development Vulnerability

In order to determine the suitability of land for development in flood risk areas the developments vulnerability must first be established. Table 2 'Flood Risk Vulnerability Classification' contained in the Technical Guidance to the NPPF should be used to do this (see Table 7.1).

The vulnerability of the proposed development usages are listed for both Waterloo and Vauxhall in Table 14.2 overleaf.

Table 14.2: Development Vulnerability in Waterloo and Vauxhall

Proposed Development	Vulnerability Classification	Exception Test Required?
Underground station	Essential transport Infrastructure	Yes, If in Flood Zone 3a
Overland Station	Essential transport Infrastructure	Yes, If in Flood Zone 3a
Residential	More Vulnerable	Yes, If in Flood Zone 3a
Food Shopping	Less vulnerable	No, Permitted in FZ 1, 2 and 3a
Retail	Less Vulnerable	No, Permitted in FZ 1, 2 and 3a
Office Use	Less vulnerable	No, Permitted in FZ 1, 2 and 3a
Public open space	Water – compatible	No, Permitted in FZ 1, 2 and 3a
Public car parking	Less Vulnerable/water – compatible	No, Permitted in FZ 1, 2 and 3a
Educational use	More Vulnerable	Yes, If in Flood Zone 3a
Leisure	Less Vulnerable	No, Permitted in FZ 1, 2 and 3a

Flood Zone 3b is classified as functional floodplain. The entire frontage of Lambeth is defended to a 1 in 1000 year event so there is no tidal functional floodplain in the Borough. Therefore notes relating to vulnerability within Flood Zone 3b have been omitted from the above table in relation to the Opportunity Areas of Waterloo and Lambeth.

'More vulnerable' development such as residential or educational uses should, according to the Sequential Test, only be permitted in Flood Zone 3a if the Exception Test is passed.

In accordance with Technical Guidance to the NPPF Table 1, developers and Local Authorities proposing to develop in Flood Zones 2 and 3 should seek opportunities to:

- Reduce flooding by considering the layout and the form of the development and the appropriate application of sustainable drainage techniques;
- Relocate existing development to land in zones with a lower probability of flooding; and
- Create space for flooding to occur by restoring functional floodplains and flood flow pathways and by identifying, allocating and safeguarding open space for storage.

The use of SuDS should be encouraged for all development in Waterloo and Vauxhall. Suitable SuDS techniques are discussed further in Section 10 of this report.

The nature of development in Waterloo and Vauxhall means that all development would be on brownfield sites. The hazard mapping offers the opportunity to use the sequential approach in locating development, locating the more vulnerable types to the lower flood Hazard Zones.

While the restoration of functional floodplains is not applicable to Waterloo or Vauxhall, flood flow pathways should be identified and maintained as part of site development layouts through specific flood risk assessments.

14.3 The Exception Test

For the Exception Test to be passed two criteria must be satisfied:

- It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA; and
- A site specific 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 reduce flood risk overall.

For successful application it is important that the arguments presented for justification through the Exception Test are in line with policies set out in the Local Plan and supported by reference to other national policies such as Planning Policy 3: Housing, which advocates the development of brownfield sites.

This Level 2 SFRA aims to provide information to assist in completion of site-specific FRAs, to demonstrate Part 2 of the Exception Test.

15. FLOOD RISK IN WATERLOO

15.1 Tidal Flood Risk

Breach modelling results

Of the six breach modelling locations considered in this study, two are located within the Waterloo Opportunity Area, along Queens Walk. Table 15.1 details the grid reference along with a brief description of the breach location and the River Thames water levels at each location, for the 1 in 200 and 1 in 1000 year events. Figure 2 and Figure 11 show the Environment Agency Flood Zones for the Waterloo area.

Table 15.1 Waterloo Opportunity Area Breach Locations

Reference	Location of Breach	Description	1 in 200 year Water Level (mAOD)	1 in 1000 year Water Level (mAOD)
Berm 12	531320 180510	Oxo Tower	4.97	5.00
Berm 13	530670 180120	Hungerford Bridge	4.98	5.02

As part of the SFRA, mapping showing the maximum flood depth and flood hazard from a composite of all breach locations was produced as Figure 5 and 6 respectively. These figures show the results for the 1 in 200 year flood event.

Figure 12 shows the tidal breach flood depth and flood hazard data centred on the Waterloo Opportunity Area. The following section provides details on the general flooding mechanisms from each separate breach location, however it should be noted that this has been based upon modelling completed for the original SFRA in 2008. The specific flood depths and hazards referred to have been reviewed in conjunction with the Environment Agency's latest modelling data, however Figure 12 should also be reviewed alongside this summary.

The flood hazard demonstrates the FD2320 categories of 'risk to people' and should be used to assess potential egress/access routes. This forms a key part of the Exception Test process, where the hazard category and potential egress/access conditions help to determine the 'safe' classification of the proposed development.

Flood Depth

Berm 13

Under both the 1 in 200 and 1 in 1000 year return period breach events, flood waters predominantly flow in a southerly direction, with only limited flooding to the north of the railway line running from Waterloo and Charing Cross. Floodwaters extend as far south as the A3203 and the easterly extent is in line with the Imperial War Museum to King Edward Walk and Morley Street.

Significant flooding to a depth between 1m and 2m is largely confined to land directly behind the breach including:

- Office blocks located in between York Road and Belvedere Road;

- The County Hall;
- Waterloo train station, and;
- Low lying areas around St Thomas's hospital

Berm 12

At the breach location in the vicinity of The Oxo Tower, the presence of low lying land behind the flood defences results in an area of significant flood depth up to1.5m. Following a flood defence breach at this location, flood water generally flows in a southerly direction. However the railway embankment acts as a significant flow barrier and reduces the impact of flooding to the south.

Significant flooding, to a depth of 1.5m is restricted to a central swathe behind the breach including:

- Residential and office areas on land north of the railway line to the A3200 Stamford Street;
- Land south of the railway line to 'The Cut' including Southwark tube.

Flood Hazard

Berm13 and 12

Figure 12 shows that the distribution of flood hazard is similar to the distribution of high flood depths. This confirms that the velocity of floodwaters within the study area is relatively low, as would be expected for a relatively flat area such as Waterloo. As there are no significant changes in topography gradient present, this does not result in sudden changes flood flow velocities.

The derivation of the flood hazard is therefore governed by the flood depth present within the study area. The maximum flood hazard is therefore anticipated to occur at the time of maximum depth.

A site specific FRA using detailed topographic surveys and potential development layouts should clarify and discuss the potential velocities and depths of flood flows from the River Thames during breach scenarios.

Summary

The Waterloo Opportunity Area Planning Framework outlines many potential sites for regeneration. It is recommended that site specific assessment should review the potential for lower levels of developments to be inundated by floodwater using the subways and underpasses as flood flow paths.

The Waterloo Station developments should consider the potential egress/access routes from the concourse. An emergency evacuation plan taking flood risk into consideration should be used to assess potential routes and contingency measures for evacuation. For example one of the main dry routes out of this flood cell is actually the railway line which is on a raised embankment. As such during times of a flood a suitable contingency measure may be to allow evacuation along this route.

For sites in Waterloo not covered by a breach assessment, the riverside analysis presented in the SFRA can be used to provide an indication of likely flood depths and hazard.

16. FLOOD RISK IN VAUXHALL

16.1 Tidal Flood Risk

The Environment Agency Flood Zone Maps (Figure 2 and Figure 11) show that the majority of Vauxhall (over 75%) resides within Flood Zone 3a. The remainder of the Opportunity Area, located in the southern extent consists of Flood Zone 2 and Flood Zone 1.

Breach modelling results

Breach modelling has been carried out at the Fire Brigade Headquarters, approximately 0.6km north of Vauxhall Bridge, and at New Covent Garden Market, approximately 0.4km south of Vauxhall Bridge. Table 16.1 details the grid reference for each breach location along with a brief description of the location and the River Thames water levels at each location, for the 1in 200 and 1 in 1000 year events.

Table 16.1 Vauxhall Opportunity Area Breach Location

Reference	Location of Breach	Description	1 in 200 year Water Level (mAOD)	1 in 1000 year Water Level (mAOD)
Berm 15	530500 178710	Fire Brigade Headquarters	4.99	5.03
Berm 16	529980 177840	New Covent Garden Market	5.01	5.04

As part of the SFRA, mapping showing the maximum flood depth and flood hazard from a composite of all breach locations was produced as Figure 5 and 6 respectively. These figures show the results for the 1 in 200 year flood event.

Figure 13 shows the tidal breach flood depth and flood hazard data centred on the Vauxhall Opportunity Area. The following section provides details on the general flooding mechanisms from each separate breach location, however it should be noted that this has been based upon modelling completed for the original SFRA in 2008. The specific flood depths and hazards referred to have been reviewed in conjunction with the Environment Agency's latest modelling data, however Figure 13 should also be reviewed alongside this summary.

The flood hazard demonstrates the FD2320 categories of 'risk to people' and should be used to assess potential egress/access routes. This forms a key part of the Exception Test process, where the hazard category and potential egress/access conditions help to determine the 'safe' classification of the proposed development.

Flood Depth

Berm 15 and Berm 16

Flooding from the breach located at the Fire Brigade Headquarters, 0.6km north of Vauxhall Bridge leads to flooding in an easterly and northerly direction from the point of breach. Flooding extends to the north of the Vauxhall Opportunity Area in the vicinity of Lambeth Bridge.

Some flooding is shown on the northern extent of the Vauxhall Opportunity Area to include the A3036 Albert Embankment, Glasshouse Walk, Tinworth Street and Vauxhall Walk, where flood depths are typically in the region of 0.5m.

Flooding from the breach located at New Covent Garden Market, 0.4km south of Vauxhall Bridge leads to flooding in a southerly and westerly direction from the point of breach. Only the southern extent of the Vauxhall Opportunity Area is shown to be flooded from this breach, with typical flood depths of approximately 0.5m. The flood extent extends to the south of the railway embankment, which provides some partial flood protection.

Approximately 50% of the centre of the Vauxhall Opportunity Area, located around the railway station is shown to remain free from flooding during the breach scenarios considered. This is due to the topography of the area, as ground levels generally rise in the vicinity of the station. Ground levels along the riverside area are also generally higher than areas in the far north and south of the Opportunity Area, therefore the potential consequences of a flood defence breach at this location are likely to be limited.

Flood Hazard

Figure 13 shows that the distribution of flood hazard is similar to the distribution of high flood depths. This confirms that the velocity of floodwaters within the study area is relatively low, as would be expected for a relatively flat area such as Vauxhall. As there are no significant changes in topography gradient present, this does not result in sudden changes flood flow velocities.

The derivation of the flood hazard is therefore governed by the flood depth present within the study area. The maximum flood hazard is therefore anticipated to occur at the time of maximum depth.

The flood hazard rating in the north of the area is typically Low/Moderate, however there are some pockets of Significant hazard located within low lying areas in the vicinity of Lambeth Bridge. In the far south of the area pockets of Significant hazard are located on Wandsworth as flood water ponds against the southern extent of the railway embankment.

A site specific FRA using detailed topographic surveys and potential development layouts should clarify and discuss the potential velocities and depths of flood flows from the River Thames.

Summary

The Vauxhall Opportunity Area Planning Framework outlines many potential sites for regeneration. It is recommended that site specific assessment should review the potential for developments to be inundated by flowpaths beneath the railway embankment, to ensure all potential flood flow routes are assessed.

The proposed development plans should consider the potential egress/access routes from the sites, and emergency evacuation plans taking flood risk into consideration should be used to assess potential routes and contingency measures for evacuation.

For sites in Vauxhall not covered by a breach assessment, the riverside analysis presented in the SFRA can be used to provide an indication of likely flood depths and hazard.

17. POLICY AND PRACTICE

17.1 Overview

To ensure a holistic approach to flood risk management and ensure that flooding is taken into account at all stages of the planning process, the findings of this report needs to be incorporated into the London Borough of Lambeth's Local Plan. This will help to ensure that flood risk is taken into account at all levels of the planning process.

In accordance with NPPF, a specific policy on flood risk should be included in the London Borough of Lambeth Core Strategy to ensure:

- Development is located in the lowest risk area where possible;
- New development is flood-proofed to a satisfactory degree and does not increase flood risk elsewhere;
- Surface water is managed effectively on site;

The Level 2 SFRA highlights high residual flood risk in the development opportunity area of Waterloo. Therefore a sequential approach needs to be undertaken as part of the master planning process for this area, to place higher vulnerability uses in lower residual risk areas.

Application of the Sequential Test should ensure that more vulnerable property types are not permitted in areas at high risk of flooding. Where there are valid reasons for a development type which is not entirely compatible with the level of flood risk the LPA or developer needs to demonstrate that both elements of the Exception Test are passed.

When proposing development behind flood defences, the impact on residual flood risk to other properties should be considered. New development behind flood defences can increase the residual flood risk should defences be breached or overtopped by disrupting flow paths and or the displacement of flood water. If conveyance routes that allow flood water to pass back into a river following failure of a flood defence are blocked, this may potentially increase flood risk to existing properties.

As discussed in Section 4.2, increased use of the Thames Barrier is anticipated to mitigate against the risk of increased tide levels in the Thames due to climate change. That said in order to promote good practice and encourage sustainable development the following measures could be used in development areas behind flood defences such as Waterloo and Vauxhall:

- Redevelopment must ensure that residual flood risk is reduced in areas benefiting from flood defence measures through effective mitigation;
- The natural floodplain must be used upstream and downstream of areas benefiting from flood defences in order to accommodate additional floodwater.

The SFRA has highlighted the importance of flood defences in the London Borough of Lambeth. Future policy should seek to address how these defences are to be maintained by the current owners (TfL or private ownership), to ensure that they are maintained to the current high level of protection.

If development is to be constructed with less vulnerable uses on the ground level, agreements need to be in place to prevent future alteration of these areas to 'more vulnerable' uses without further study into flood risk.

Single storey residential development should not normally be considered in high flood risk areas as they offer no opportunity for safe refuge areas on upper floors.

The London Borough of Lambeth has a presumption against the location of any new basements in their Borough and as such these would not be permitted in any areas at risk of flooding. This would include the excavation of basements under existing dwellings.

Developers and Local Authorities proposing to develop in Flood Zones 2 and 3 should seek opportunities to:

- Reduce flooding by considering the layout and the form of the development and the appropriate application of sustainable drainage techniques;
- Relocating existing development to land in zones with a lower probability of flooding; and
- Create space for flooding to occur by restoring functional floodplains and flood flow pathways and by identifying, allocating and safeguarding open space for storage.

17.2 Flood Risk

Area Wide Recommendations

1. Ensure the Sequential Test is undertaken for all land allocations to reduce the flood risk to the allocation and ensure that the vulnerability classification of the proposed development is appropriate to the Flood Zone classification;
2. FRAs should be undertaken for all developments within Flood Zones 2 and 3 to assess the risk of flooding to the development and identify options to mitigate the flood risk to the development, site users and surrounding area;
3. In Flood Zone 1, NPPF states that FRAs are required for residential development sites greater than 0.5 ha or with 10 dwellings or more. For commercial developments in Flood Zone 1, FRAs are required for sites greater than 1 ha or with more than 1000m^2 floor space. Furthermore, for a development in Flood Zone 1 which is less than 1.0 ha and has a critical drainage problem, a FRA is also required;
4. FRAs are required for all developments identified as at risk from other sources of flooding;
5. Identify sites where developer contributions could be used to fund future flood risk management schemes. However, it should be noted that developer defences should not wholly justify development in unsuitable locations;
6. Look at opportunities to make space for water to accommodate climate change in order to assist in managing future flood risk;
7. An 8m and 16m metre buffer strip must be maintained along fluvial and tidal river corridors respectively, to ensure that maintenance of the channel can be undertaken;
8. Flood defences provide flood protection and should continue to be maintained;
9. Promote flood resilience at the individual property level;
10. Continue to maintain those assets that are effective in managing current and future flood risk; and

11. Take opportunities to reduce the dependency on assets that do not contribute to effective flood risk management;

London Borough of Lambeth Recommendations

Proposed developments located within the River Graveney floodplain should be accompanied by a flood risk assessment including detailed topographic surveys and comparison to recently revised flood levels to enable accurate flood level estimation and consideration of potential flood flow paths.

Residual flood risk should be managed through emergency planning, site design and protection measures. The key residual flood risks are overtopping/breach of the tidal Thames.

NPPF does not permit basement dwellings to be located within Flood Zone 3a. The London Borough of Lambeth has a presumption against the location of any new basements in their Borough and as such these would not be permitted in any areas at risk of flooding. This would include the excavation of basements under existing dwellings.

Finished floor levels of all residential accommodation should be raised above the residual flood level occurring on the site in defended areas. Potential access & egress routes should also be considered and recommendations made for appropriate actions of future occupants in the event of a breach occurring.

The groundwater, surface water and historic flood mapping should be reviewed to determine the risk of flooding from sources other than fluvial and/or tidal. When a proposed development is located within an area with an identified flood risk, then a flood risk assessment should determine the actual risk to the development and recommend appropriate mitigation measures. The flood risk assessment must demonstrate to the satisfaction of the Environment Agency that the development will not exacerbate the existing flooding situation, and improve existing conditions where possible.

Consultation should be undertaken with the Environment Agency's Thames Estuary 2100[21] (TE2100) project team to develop suitable policies in line with the wider strategy and aims of The Thames Catchment Flood Management Plan (CFMP) set out for the Graveney policy unit[22].

Potential opportunities to move existing development from within the floodplain to areas with a lower risk of flooding should be maximised. This should include consideration of the vulnerability of existing developments and whether there is potential for land swaps with lower vulnerability uses.

[21] The Thames Estuary 2100 (TE2100) project is an Environment Agency run project with the aim of developing a tidal flood risk management plan for the Thames estuary until the end of the century. The plan will recommend the flood risk management measures required in the estuary, when these will be needed and where they will be needed. This will be based on climate changes and sea level rises. More information can be found at www.environment-agency.gov.uk/te2100/

[22] (The Thames CFMP separates the Wandle, Graveney and Beverley Brook into three separate policy units, each with specific objectives and action plans)

17.3 Flood Mitigation

Area wide Recommendations

General flood mitigation policies should address the following issues:

1. Where a development borders an area benefiting from flood defence, opportunities should be sought for the maintenance of these flood defences to be partly funded by the development for its lifetime;
2. Opportunities should be sought to de-culvert rivers, where possible, to return them to a natural system, reducing back up of flows and under capacity where this does not exacerbate the flooding elsewhere;
3. River channel restoration should be undertaken where possible to return the river to its natural state and restore floodplain to reduce the impact of flooding downstream;
4. Emergency planning strategies should be put in place in order to direct people to safety during times of flood;
5. Current emergency planning strategies should be reviewed to determine the suitability of refuge centres and evacuation routes based on the flood zone mapping produced in this study;
6. Opportunities should be sought to reduce the risk of flooding from the sewer network through consultation with Thames Water to determine key areas for maintenance and flood alleviation schemes; and
7. Where development within flood risk areas is absolutely necessary flood proof construction methods should be utilised to reduce the impact of flooding.

17.4 TE2100 Considerations

TE2100 is currently consulting on the following options to manage flood risk in the central London estuary zone:

Manage the walls and embankments

- Raise defence levels over time by 0.5m to a maximum of 1.0m;
- Install temporary defences at times of forecast high river flow and tide level;
- Some defences may be set back to make space for water and to improve access to the river – this can provide an opportunity to improve the riverside environment and restore historic or architectural features;
- Making space for water (flood storage and/or habitat creation);
- Ensure that urban drainage facilities are improved to avoid local flash flooding and discharge of sewage to the Thames;
- Take local opportunities to enhance the habitats alongside the river and on the floodplain through making space for water.

Barriers, barrages and pumping stations

- The Thames Barrier will continue to provide protection against increasing sea level and could potentially be supplements by a structure further down the estuary towards the end of the century.

Manage the floodplain

- Increase the number of people who sign up to Flood Warnings Direct;
- Floodplain management and emergency response activities must have a focus on key infrastructure such as the underground network and other properties that are below sea level;
- All new development to have flood risk management factored in at planning stage including rigorous application of PPS25;
- Emergency planning would include refuge areas in vulnerable areas.

17.5 Sustainable Drainage

Area wide Recommendations

1. Sustainable Drainage Systems must be included in new developments as a way to manage surface water;
2. NPPF requires the use of SuDS as an opportunity of managing flood risk, improving water quality and increasing amenity and biodiversity;
3. Flood risk assessments should be undertaken for all developments in Flood Zone 2 and 3. Sites in Flood Zone 1 also require flood risk assessments if they are residential developments sites greater than 0.5 ha or greater than 10 dwellings and commercial development sites greater than 1 ha or with a floor area greater than 1000 m^2, to ensure that flood risk is not increased to other properties due to increased site runoff;
4. Runoff rates from new development on greenfield sites should be restricted to greenfield runoff rates as required by the London Plan. The London Plan aims for an essential standard of 50%, and desirable 100% standard for attenuation of current runoff rates when considering redevelopment, including an appropriate allowance for climate change;
5. Runoff rates should be restricted to greenfield runoff rates in areas known to have a history of sewer flooding;
6. Sustainable Drainage Systems should be considered in line with the Management Train hierarchy set out in The SUDS Manual, C697, whereby 'Prevention' techniques are considered initially. Adopted techniques should also be located in accordance with the restrictions set out in Policy and Practice for the Protection of Groundwater;

London Borough of Lambeth Recommendations

In areas where surface water flooding has been identified as a higher risk in the Waterloo and Vauxhall areas, Flood Risk Assessments should ensure suitable SUDS techniques are incorporated as part of redevelopment.

Where there are potential overland flow paths from higher ground, or infrastructure such as roads and sewers where surface water flow routes may exist, buildings should be designed to run parallel to such routes, siting building so they do not obstruct flows.

Where basements are proposed in areas of Flood Zone 1 and 2 the risk of surface water flooding should be considered, with potential mitigation to include raising thresholds and including storage for surface water in such developments.

17.6 Water Environment

As populations increase and climate change leads to changes in weather patterns, the prospect of droughts may increase. New development can tackle this by incorporating water efficiency measures such as grey water recycling, rainwater harvesting and water use minimisation technologies. In doing so, knock-on benefits could be felt by the sewer system which will receive less wastewater from properties, potentially freeing up capacity during flood events.

In addition, increasing people's awareness of the water environment around them, its importance and its hazards, will contribute to their understanding of where floods come from and what individuals can do to limit the consequences of flooding and resource shortages.

London Borough of Lambeth Recommendations

1. Consult the Environment Agency regarding the potential for future management regime of the River Wandle catchment including the potential for any flood alleviation schemes, upgrading and/or replacement of existing flood defences;

2. Ensure that proposed developments can be accommodated by the existing resource provision. Where a development cannot be met by current resources, ensure that the phasing of development is in tandem with resource infrastructure investment;

3. Encourage new developments to adhere to the principles of water sensitive urban design by integrating surface water, groundwater, wastewater management and water supply designs in order to minimise environmental impacts whilst providing additional recreational and aesthetic benefits.

4. For large schemes suggest a water strategy is carried out to determine there is sufficient water resources for the proposed increase in demand.

17.7 Development Management

- If development is to be constructed with less vulnerable uses on the ground level, agreements need to be in place to prevent future alteration of these areas to 'more vulnerable' uses without further study into flood risk;

- Single storey residential development should not normally be considered in flood risk areas as they offer no opportunity for safe refuge areas on upper floors;

- Where a development is applying for a change of use, flood evacuation plans should be developed through liaison with the emergency planners and the emergency services. For lower to higher vulnerability properties a FRA would be required;

- The Council should ensure new development in an area known to suffer surface water flooding does not increase the discharge to the existing drainage system either though

restricting site discharge rates and/or through capital contributions to improvements works of the existing drainage infrastructure.

17.8 Environmental

- Consider the potential benefits an appropriately designed Sustainable Drainage System could have for the biodiversity, amenity value, water quality and resource value of a development and/or surrounding area;
- Consider the vulnerability and importance of local ecological resources when determining the suitability of drainage strategies/SuDS.

18. LONDON BOROUGH OF LAMBETH SITE SPECIFIC FRA GUIDANCE

18.1 Introduction

The NPPF and the Technical Guidance to the NPPF places the primary responsibility for assessing the flood risk to and from any property with the landowner. However, site specific flood risk assessments are generally prepared by prospective developers.

The assessment of flood risk is a fundamental consideration regardless of the scale or type of development. Understanding the flood risk to, and arising from, a development is key to managing the risk to people and property thereby reducing the risk of injury, property damage or even death.

Opportunities to manage flooding whilst providing development exist through an understanding and mitigation of the risk. This includes the location, layout and design of developments to enable the management of flood risk through positive planning. Positive planning needs to consider the risks to a development from local flood sources but also the consequences a development may have on increasing flood risk to others. Early identification of flood risk constraints can ensure developments maximise development potential whilst achieving the principles of sustainability.

Site specific FRAs are required to assess the flood risk posed to proposed developments and to ensure that, where necessary, appropriate mitigation measures are included in the development. This section presents the recommendations for site specific FRAs prepared for submission with planning applications to The London Borough of Lambeth.

The site specific FRA guidance presented in the following sections has been developed based on:

- the requirements outlined in the NPPF and The Technical Guidance to the NPPF;
- a review of the policies contained within the draft Lambeth Local Plan; and
- the information gathered through and findings of the Level 1 and Level 2 SFRA process.

When is a Flood Risk Assessment Required?

When deciding if a FRA is required the Standing Advice from the Environment Agency http://www.environment-agency.gov.uk/research/planning/33098.aspx/ should be referred to as this outlines when the Environment Agency should be consulted.

When informing developers of the requirements of a FRA for a development site, consideration should be given to the position of the development relative to flood sources, the vulnerability of the proposed development and its scale.

In the following situations a Flood Risk Assessment should always be provided with a planning application:

- The development site is located in **Flood Zone 2 or 3**;
- The proposed development comprises 10 or more residential dwellings and/or the site area is greater than 1 hectare (even if the site is located in **Flood Zone 1**). This is to ensure surface water generated by the site is managed in a sustainable manner and does not increase the burden on existing infrastructure and/or flood risk to neighbouring property);
- The floor space of proposed non-residential development is greater than 1000 m^2 or the site area is greater than 1 hectare;

- The development site is located in an area known to have experienced flooding problems from any flood source; and,

- The development is located within 20m of top of bank of a main river watercourse regardless of Flood Zone classification.

The Majority of proposed development areas in the London Borough of Lambeth are located in defended Flood Zone 3a. The tidal Thames flood defences provide protection up to a 1 in 1000 year flood event. While flood risk due to breach in these defences is very slim, it should still be considered in new development proposals by referring to hazard and depth maps. These should be used as part of a FRA to sequentially steer development proposals and vulnerability classifications to areas at least risk of flooding should a breach occur.

What does a Flood Risk Assessment Require?

Annex E of The Practice Guide Companion to PPS25 presents the minimum requirements for flood risk assessment. These include:

- The consideration of the risk of flooding arising from the development in addition to the risk of flooding to the development;

- Identify and quantify the vulnerability of the development to flooding from different sources and identify potential flood risk reduction measures;

- Assessment of the remaining 'residual' risk after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular development;

- The vulnerability of those that could occupy and use the development, taking account of the Sequential and Exception Tests and the vulnerability classification, including arrangements for safe access;

- Take consideration of the ability of water to soak into the ground may change with development, along with how the proposed layout of development may affect drainage systems; and

- Fully account for current climate change scenarios and their effect on flood zoning and risk.

The Practice Guide Companion to PPS25 advocates a staged approach to site specific flood risk assessment with the findings from each stage informing the next and site master plans, iteratively throughout the development process.

The staged approach comprises of three stages:

- Level 1 Screening Study;

- Level 2 Scoping Study;

- Level 3 Detailed Study.

Level 1 - Screening Study

A level 1 Screening Study is intended to identify if a development site has any flood risk issues that warrant further investigation. This should be based on existing information such as that presented in the Level 1 SFRA. Therefore this type of study can be undertaken by a development control officer in response to the developer query or by a developer where the

Level 1 SFRA is available. Using the information presented in the Level 1 SFRA and associated GIS layers a development control officer could advise a developer of any flooding issues affecting the site. This should include a review of local structures that could potentially become blocked during a flood event. A developer can use this information to further their understanding of how flood risk could potentially affect their development.

Level 2 - Scoping Study

A Level 2 Scoping Study is predominately a qualitative assessment designed to further understanding of how the flood sources affect the site and the options available for mitigation. The Level 2 FRA should be based on existing available information to further a developers understanding of the flood risk and how they affect their development. This type of assessment should also be used to inform master plans of the site raising a developer's awareness of the additional elements the proposed development may need to consider.

Level 3 – Detailed Study

Where the quality and/or quantity of information for any of the flood sources affecting a site is insufficient to enable a robust assessment of the flood risks, further investigation will be required. For example it is generally considered inappropriate to base a flood risk assessment for a residential care home at risk of flooding from fluvial sources on Flood Zone maps alone. In such cases the results of hydraulic modelling are preferable to ensure details of flood flow velocity, onset of flooding and depth of floodwater is fully understood and that the proposed development incorporates appropriate mitigation measures.

At all stages, the Local Planning Authority, and where necessary the Environment Agency and/or the Statutory Water Undertaker should be consulted to ensure the Flood Risk Assessment provides the necessary information to fulfil the requirements for Planning Applications.

18.2 Site Vulnerability

The sequential approach should be applied within development sites to locate the most vulnerable elements of a development in the lowest risk areas e.g. residential developments should be restricted to areas at low hazard and parking open space etc can be placed on lower ground in areas at identified as high hazard.

Potential development sites shown in Figures 11, 12 and 13 illustrate flood zone, depth and hazard risks to each site in order that the Sequential Test can be applied within each development boundary

18.3 Infrastructure Failure Flood Risk Areas

The majority of development areas in the London Borough of Lambeth reside in defended Flood Zone 3a, being a residual risk from tidal flooding of the River Thames.

Artificial sources of flooding within a 1km radius of the any site should be considered in order to assess the residual risk of the River Thames. Flooding may occur as a result of the defences being overwhelmed and/or as a result of failure and therefore an assessment of flood flow routes should be included.

The Practice Guide to PPS25 recommends that where developments are proposed in a defended flood area, the potential cumulative impact of loss of storage at the allocation sites on flood risk elsewhere within the flood cell should be considered. Such assessments should be appropriate to the scale and nature of the proposed development and flood risk. Should the potential impact be unacceptable, mitigation should be provided. Examples of

this process can be found in PPS25, Development and Flood Risk: Practice Guide, Chapter 6.

Flood depth and hazard maps should be used to provide better detail of site specific flood risk and hazard within the Flood Zones. This information should be used to sequentially locate developments of varying vulnerability within a development plot. Six breach locations have been assessed as part of the 1 SFRA. Where these are not in close proximity to proposed development sites, further breach modelling as part of a site specific FRA may be required.

Refer to Figure 3, Appendix A – Flood Defence across Lambeth

18.4 Access and Egress

As part of any FRA, the LPA in consultation with the emergency planning team and emergency services must decide whether safe access and egress is provided.

Safe access and egress is required to enable the evacuation of people from the development, provide the emergency services with access to the development during times of flood and enable flood defence authorities to carry out any necessary duties during flood events.

Safe access and egress is required to enable the evacuation of people from the development, provide the emergency services with access to the development during times of flood and enable flood defence authorities to carry out any necessary duties during periods of flood.

'Safe' access/egress routes are considered by the Environment Agency to be a route that is safe for use by occupiers without the intervention of the emergency services or others. A route can only be completely safe in flood risk terms if it is dry at all times.

For residential developments within the floodplain of the River Graveney the Environment Agency consider 'safe' access/ egress to be dry.

For developments located in areas at tidal risk (i.e. areas to the North of the Borough, Waterloo and Vauxhall) the Environment Agency consider 'safe' access/egress to be in accordance with 'FRA Guidance for new Developments FD 2320[23]' (Joint DEFRA and Environment Agency document) 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 of flooding) is low and should not cause risk to people. (Flood breach results should be used to determine this);
- If a dry route for vehicles is not possible, a route for vehicles where the flood hazard (in terms of depth and velocity of flooding) is low to permit access for emergency vehicles.

[23] FD2320 is a document to assist the 'undertaking of appropriate assessments of flood risk for new developments and enable improved decision-making'.

The Environment Agency would only insist on 'safe' in accordance with FD2320 for residential developments. However, the Environment Agency requires internal access to higher floors for school developments and recommends it for non-residential developments (assuming floor levels have not been raised).

Details of how this will be achieved should be clearly described in site specific Flood Risk Assessments using depth and hazard mapping provided as part of this report.

It is necessary to ensure that proposed roads levels are such that emergency access and evacuation routes are maintained where possible at the 1 in 1000 year flood level. This can significantly reduce the risk of the proposed development becoming inundated by flooding.

Waterloo Opportunity Area

The Flood Depth maps (Figure 12), show flood depths that could be experienced in Waterloo should a breach in defences occur.

For developments located to the north of the main overland railway line running into Waterloo (South Bank Centre, Doon Street, Hothouse, London Nautical School, Gabriel's Wharf and Princes Wharf), access and egress via Stamford Street, the A3200, should be investigated. This road may experience partial flooding to a depth of 0.15m and is at lower risk than the surrounding area. For these areas access via Waterloo Station should also be investigated. Further modelling may be required to establish ground levels experienced in Waterloo Train station and the resulting flood hazard.

Developments located to the east of Waterloo train station and south of the overland railway line (Waterloo Road, Cornwall Road and the Young Vic theatre) should investigate access and egress to Waterloo Road to the south, or Union Street to the east. These roads will experience partial flooding to a depth of approximately 0.15m.

Those developments located in the central section of Waterloo (Shell Centre, Former County Hall and Queen Elizabeth House) should investigate access and egress via Waterloo Station or the A302, Westminster Bridge. In the event of an extreme flood event the railway tracks from Waterloo Station could provide an evacuation route from the concourse and immediate area to the station but this would need to be agreed with the Station operators and form part of the Boroughs overall evacuation plan.

York and Beckett House and Westminster Bridge Road should investigate access and egress via Lambeth Palace Road, either south towards Lambeth Bridge. Lambeth Palace Road may experience flood depths of up to 0.15m to the south.

St Thomas's hospital due to its nature of being a 'more vulnerable' development should have a detailed emergency plan in place. Access during times of flood may be provided either to the north via Westminster Bridge, or to the south towards Lambeth Bridge, via Lambeth Palace Road.

Vauxhall Opportunity Area

Breach modelling shown in Figure 13 for Vauxhall has shown that flood water remains in a contained area in close proximity to Spring Gardens with low and medium hazards identified. Developments in the north of Vauxhall including the Texaco Garage, Albert Embankment, Camelford House and Tintagel House should investigate access and egress to the south via Goding Street.

A review of modelling should be carried out as part of a site specific FRA referring to local ground levels to establish safe access and egress routes.

18.5 Finished Floor Levels

For the limited development that may take place along the River Graveney the Environment Agency suggest that under fluvial/undefended flood risk conditions, a 300mm freeboard on the 1 in 100 year, plus 20% climate change flood level is used when setting finished floor levels (600mm freeboard is required for less precisely computed levels). Where this can not be achieved for practicality reasons flood proofing measures should be utilised up to the 1 in 100 year, plus 20% climate change flood level.

For development that is proposed in the north of the Study Area in Flood Zone 3a: The Environment Agency suggests that under tidal/defended flood risk conditions finished floor levels are as follows:

Where development in flood risk areas is unavoidable as part of the overall regeneration and growth plans, as is the case with both Waterloo and Vauxhall, the most acceptable method of mitigating flood risk is to ensure habitable floor levels are raised above the maximum flood water level. This can substantially reduce the damage to property and significantly reduce the risk of injury and fatalities as well as providing a place of refuge during flood events.

In areas of minimal floodwater depth, raising finished floor levels can usually be accommodated in building design. In areas where a substantial depth of floodwater is expected properties can incorporate a garage, utility area or public space on the ground floor with habitable areas above.

The Environment Agency has confirmed that the requirements for finished floor levels in Waterloo and Vauxhall are as follows:

For ***residential developments***:

- **Where no breach analysis is undertaken by the applicant:**

  Where possible, finished floor levels should be set at or above the Environment Agency's 1 in 1000 year flood level. If this is unfeasible, floor levels should be set at or above the Environment Agency 1 in 200 year flood level.

- **If breach analysis has been undertaken by the applicant:**

  Levels derived from the breach modelling should be used to determine finished floor levels at or above the 1 in 1000 year level. If this is unfeasible floor levels should be set at the 1 in 200 year flood level;

- The Environment Agency also suggests that most planning applications for residential development will be able to use the results of breach modelling included as part of this SFRA to set finished floor levels;

- No freeboard is required for defended areas at residual risk of flooding as raising finished floor levels of defended properties is considered sufficient mitigation.

*For **Less Vulnerable** developments:*

- Finished floor levels do not need to be raised. However, it is strongly recommended where possible (it is appreciated that the nature of development in Waterloo and Vauxhall means that commercial properties may be located underneath privately owned residential property) that internal access is provided to upper floors to provide safe refuge during a flood event.

*For **More vulnerable** developments (e.g. schools):*

- Finished floor levels do not need to be raised, however, internal access to higher floors must be provided to give safe refuge during times of flood.

18.6 Flood Warning and Evacuation Plans

Flood Warning and Emergency Procedures tend to form part of a higher level emergency management plans for the wider area and include information such as repair procedures, evacuation routes, refuge areas, flood warning dissemination and responsibilities.

It is understood that the London Borough of Lambeth has emergency plans in place to respond to any incident that occurs within their administrative area. These documents should be updated to include the information generated by this SFRA. This will ensure that emergency plans are appropriate to the conditions expected during a flood event and that the London Borough of Lambeth and emergency services are fully aware of the likely conditions and how this may affect their ability to safeguard the local population.

When applying the Sequential Test to determine the type of development that may be appropriate in Waterloo and Vauxhall, the type of flood warning procedure that exists and the time between the flood warning and the flood peak should be analysed.

When submitting flood risk assessments for developments within flood risk areas, developers should make reference to local Flood Warning and Emergency Procedures, and any site-specific measure necessary, to demonstrate their development will not impact on the ability of the LPA and emergency services to safeguard the current population.

Flood Hazard in a particular area must be viewed in the context of the potential evacuation and rescue routes to and from that area and discussed as part of a site specific flood risk assessment.

If the likelihood of inundation of evacuation routes is high, the LPA may wish to take a more conservative approach to the allocation of development types to certain areas than may be suggested by the Hazard Zone. This may also be the case where the route to safe high ground is particularly long or the distance from the nearest emergency service to the flood zone is extensive.

Conversely, if the evacuation route in times of flood is extremely secure, there are multiple routes and the length of each route is fairly short, the LPA may wish to be more lenient with the types of development allowable in that area.

18.7 Groundwater Flood Risk Areas

Environment Agency Groundwater data shows that there have been instances of groundwater flooding across the Borough. Local knowledge provided by the London Borough of Lambeth has indicated that the Brockwell Park area has suffered from groundwater flooding in the past and this should be investigated in more detail as part of any site specific FRA in this area.

In areas at risk of ground water flooding a site specific flood risk assessment should assess the level of risk to the site. Local groundwater monitoring should be identified and where possible analysed to assess ground water levels.

Refer to Figure 9, Appendix A – Groundwater Flooding Incidents

18.8 Sewer Flooding

Data provided by Thames Water (5 figure post code) shows instances of flooding from surface water to the east of Lambeth in the Brockwell Park area, post code SE24 0.

In areas at risk of surface water flooding (such as the Brockwell Park area and post code SE24 0), development should seek to reduce surface water runoff rates as a result of development. Furthermore, the appropriate application of sustainable drainage systems (such as pervious paving, green roofs etc) to reduce the overall level of flood risk in the area through the outlay and form of the development would be required.

Refer to Figure 8, Appendix A Thames Water Sewer Flooding Data.

18.9 Surface Water Flood Risk and Storm Water Management

> *'The effective disposal of surface water from development is a material planning consideration in determining proposals for the development and use of land' PPS25 Annex F*

The Lambeth Surface Water Management Plan contains a significant body of information relating to surface water flooding history, hydraulic modelling and policy recommendations. It is recommended that the SWMP document should be referred to for further detail.

In areas at risk of surface water flooding development should seek to reduce surface water runoff rates as a result of development.

The Environment Agency strongly recommends that suitable surface water mitigation measures are incorporated into any development plans in order to reduce and manage surface water flood risk to, and from the proposed development. This should ideally be achieved by incorporating Sustainable Drainage systems (SuDS) which should be described as part of any FRA.

SuDS measures that may be suitable for use in Waterloo and Vauxhall are discussed in more detail in Section 10 of this report

18.10 Main River

Under Section 109 of the Water Resources Act 1991 and/or Byelaws, any works whatsoever in, over, or under within 8 metres of top of the channel of any main river watercourse on its banks within would require Environment Agency prior consent. This distance increases to 16m when considering tidal defences due to the potential presence of ground anchors. Furthermore the Environment Agency would seek an 8 to 16 metre wide undeveloped buffer strip alongside main fluvial/tidal rivers respectively, and would also ask developers to explore opportunities for river restoration as part of the development.

The River Graveney is the only watercourse in the Study Area with a functional floodplain. Advice from the Environment Agency's National Development Control Policy team on brownfield functional floodplain is that, for redevelopment of functional floodplain, the Environment Agency will consider existing building footprints to be part of the functional floodplain, unless it can be proven that they exclude flood waters. If these buildings do exclude flood waters, then solely the area around these buildings will be deemed functional. When undertaking an FRA this matter should be clarified and ideally pre-agreed with the Environment Agency.

Refer to Figure 2, Appendix A – Environment Agency Main Rivers and Flood Zones.

19. DISCUSSION AND CONCLUSIONS

19.1 Overview

The process of the Sequential Test outlined in the NPPF aims to steer vulnerable development to areas of lowest flood risk. The SFRA aims to facilitate this process by identifying the variation in flood risk across the London Borough of Lambeth allowing an area-wide comparison of future development sites with respect to flood risk considerations.

The SFRA presents Flood Zone Maps that delineate the flood zones outlined in the NPPF as Flood Zone 1 - Low Probability, Flood Zone 2 - Medium Probability and Flood Zone 3a - High Probability. In addition, Flood Zone 3b - Functional Floodplain, has also been mapped. Table 1 of the Technical Guidance to the NPPF provides information on which developments might be considered to be appropriate in each flood zone, subject to the application of the Sequential Test and either the Exception Test or a site-specific Flood Risk Assessment demonstrating safety.

The Level 1 SFRA identified the tidal and fluvial floodplains associated with the River Thames and River Graveney. The Level 1 Report also identified that the entire Waterloo Opportunity Area and a large proportion of the Vauxhall Opportunity Area is located in Flood Zone 3a, being an area benefiting from tidal flood defences.

The Level 2 SFRA provides further information on the probability of flooding to the Opportunity Areas of Waterloo and Vauxhall as defined by the London Borough of Lambeth. Further information provided through the hazard and depth maps provided for the tidal River Thames will provide additional information with respect to hazard and flood depths, to provide a better understanding of the spatial variations of flood risk within the Flood Zone 3. This information can then be used to inform the Sequential Test and inform future developers

The full SFRA report should be used to provide a more detailed overview of the flood risks to the London Borough of Lambeth, to assist in the development of policies, strategic planning and flood risk management.

This SFRA recommends various policies pertaining to the London Borough of Lambeth and associated flood risks. Through completion of these recommendations the Borough will be able to transparently manage flood risk and ensure risk to their development sites and communities, now and in the future are mitigated

19.2 How to maintain and update the SFRA

For an SFRA to serve as a practical planning tool now and in the future, it is imperative that the SFRA is adopted as a 'living draft' and is reviewed periodically in light of emerging policy directives and an improving understanding of flood risk within the Borough.

This section 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 predications.

Flood Zones and GIS Layers

As described in Section 3.4, the GIS layers used in the SFRA have been created from a number of different sources, using the best and most suitable information available at the time of publishing. Prior to any amendments taking place, the GIS Layers supplied with this SFRA should be securely backed up.

Should new Flood Zone information become available, the data should be digitised and geo-referenced within a GIS system.

For other GIS layers such as the Historical Flood Outlines or the Sewer Flooding Information, it is likely that data will be added rather than be replaced. For example, where a new sewer flooding incident is reported in the catchment, a point should be added to the sewer flooding GIS layer rather than creating a new layer.

All GIS layers used in the SFRA have meta-data attached to them. When updating the GIS information, it is important that the meta-data is updated in the process. Meta-data is additional information that lies behind the GIS polygons, lines and points. For example, the information behind the SFRA Flood Zone Maps describes where the information came from, what the intended use was together with a level of confidence.

For any new data or updated data, the data tables presented in Appendix B should be checked to ensure they are up-to-date.

Climate Change Prediction

The climate change scenarios based in this report are based on the best practise and predictions available at the time of publishing. However, climate change predictions are constantly being updated and refined. New predictions can have a significant effect on flood zones and therefore the SFRA. When a review of the SFRA is undertaken, it is recommended that, in liaison with the Environment Agency, the climate change scenarios are reviewed to ensure that the SFRA is still relevant to best practise and the latest available knowledge.

OS Background Mapping

The SFRA has made use of the OS 1:25,000 and 1:50,000 digital raster maps. Periodically these maps are updated. Under the London Borough of Lambeth OS Licence, it is likely that these maps will be updated throughout the whole of the London Borough of Lambeth GIS system. Updated maps are unlikely to alter the findings of the SFRA but should be reviewed as part of the SFRA maintenance.

Data Licensing Issues

Prior to any data being updated within the SFRA, it is important that the licensing information is also updated to ensure that the data used is not in breach of copyright. The principal licensing bodies relevant to the SFRA at the time of publishing were the Environment Agency (Thames Region), Ordnance Survey and Thames Water. Updated or new data may be based on datasets from other licensing authorities and may require additional licenses.

Flooding Policy Updates

This SFRA was created using guidance that was current in March 2013, principally the NPPF and the accompanying Technical Guidance.

Should new flooding policy be adopted nationally, regionally or locally, the SFRA should be checked to ensure it is still relevant and updates made if necessary.

Stakeholder Consultation and Notification

The key stakeholders consulted in the SFRA were the London Borough of Lambeth, Thames Water and the Environment Agency. It is recommended that a periodic consultation exercise is carried out with the key stakeholders to check for updates to their datasets and any relevant additional or updated information they may hold. If the SFRA is updated, it is

recommended that the Environment Agency and the Council's Emergency Planning Department are notified of the changes and instructed to refer to the new version of the SFRA for future reference.

Frequency of Updates and Maintenance

It is recommended that the SFRA is reviewed on an annual basis, in liaison with the Environment Agency, to assess any maintenance or update work. Should The London Borough of Lambeth decide any significant changes are necessary; the SFRA should be updated and re-issued. Any subsequent reviews and updates should be recorded in a register.

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APPENDICES

APPENDIX A – FIGURES

APPENDIX B – DATA REGISTER

LONDON BOROUGH OF LAMBETH REQUESTS		
Data Set	**Data Provided**	**Confidence**
Site boundaries	August 2012	Very Good
Development Opportunity Areas	August 2012	Very Good
Historic flooding records	July 2010	Fair
Mapping Tiles	October 2012	Very Good
SWMP outputs	2011	Good
ENVIRONMENT AGENCY REQUESTS		
Data Set	**Data Provided**	**Confidence**
Flood Maps	October 2012	Good
Flood Warning Areas	2007	Good
NFCDD defence layers	August 2012	Good
LiDAR Data	July 2010	Good
River Wandle outputs	August 2012	Good
River Thames Flood Levels	July 2010	Good
Main Rivers	August 2012	Good
Historic flood map	July 2010	Good
Groundwater flooding	July 2010	Fair
AStGWF	October 2012	Fair
Breach modelling outputs	August 2012	Good
THAMES WATER REQUESTS		
Data Set	**Data Provided**	**Comments**
DG5 flooding incidents	October 2012	Good
Sewer Plans	October 2012	Good

APPENDIX C – RIVERSIDE ANALYSIS

The Riverside Analysis was completed for the original SFRA in 2008 and has not been updated for the current 2013 revision. However the original assessment below still provides an indication of residual risk, as it is unlikely that any significant changes in ground level have occurred since 2008.

Introduction

Four breach scenarios were previously modelled at what were deemed to be the four most high risk locations along the River Thames in the London Borough of Lambeth, as agreed with the Environment Agency. However, it was agreed that this study did not adequately assess the risk of flooding as a result of breaches in other areas along the river.

Therefore, an assessment of the topographical levels along the river (and the areas immediately inland) was conducted in order to categorise each area of riverfront in terms of potential flooding from breaches in the flood defences. This information can be used in conjunction with the breach modelling information to determine the appropriate level of assessment required for locations along the River Thames in the London Borough of Lambeth.

Overview

Many areas of the borough can be eliminated immediately from concern because they are located well above the 1 in 1000 year tidal level. The outline of this area is shown in Figure C1. Areas at risk from inundation are generally known as the 'flood cell'.

The Digital Terrain Map (DTM) for the borough, with a cell size of 0.5 metres by 0.5 metres, was derived during the previous breach modelling and is shown in Figure C2. This figure gives a very clear overview of the areas and categories of risk from a purely topographical point of view.

There are two notable low areas within the flood cell (the area at risk of inundation):

- Land to the east of Waterloo Station, extending to the edge of the borough to the east and towards the Imperial War Museum to the south; &
- Land to the east of the train lines between Vauxhall Bridge and Lambeth Bridge, to the north of Kennington Lane.

In order for breaches in the riverfront defences to cause widespread flooding, there needs to be pathways for the floodwaters. That is, low lying areas of land that provide the floodwaters with the storage volumes and potential to travel further and cause more damage and inundation. A breach at some locations may only cause a minimum amount of inundation if the areas of land adjacent to the river are relatively high (or none at all if the land is higher than the tide itself).

The aim of the this study, therefore, was to assess the levels along (and adjacent to) the riverfront, as well as the potential pathways and storage areas associated with each possible breach location, in order to associate an overall risk category to each area along the River Thames within the London Borough of Lambeth.

Topographic Matrix

In order to assess the levels behind the flood defences along the riverfront (where a breach would occur), and the levels directly adjacent to a breach, a simple matrix was constructed along the River Thames.

The outline of the river's edge was initially traced. Then, a series of parallel lines were buffered inwards at distances of 10, 25, 50, 100, 200, 300 and 400 metres. The line started at the western riverside edge of the borough, at the eastern end of Nine Elms Lane in Vauxhall. The line extended downstream to the far edge of the borough, 300 metres upstream of Blackfriars Bridge.

Figure C 1 shows a section of the river's edge between Lambeth Bridge and Westminster Bridge. The thick black line is the river's edge itself and the parallel lines are shown in red.

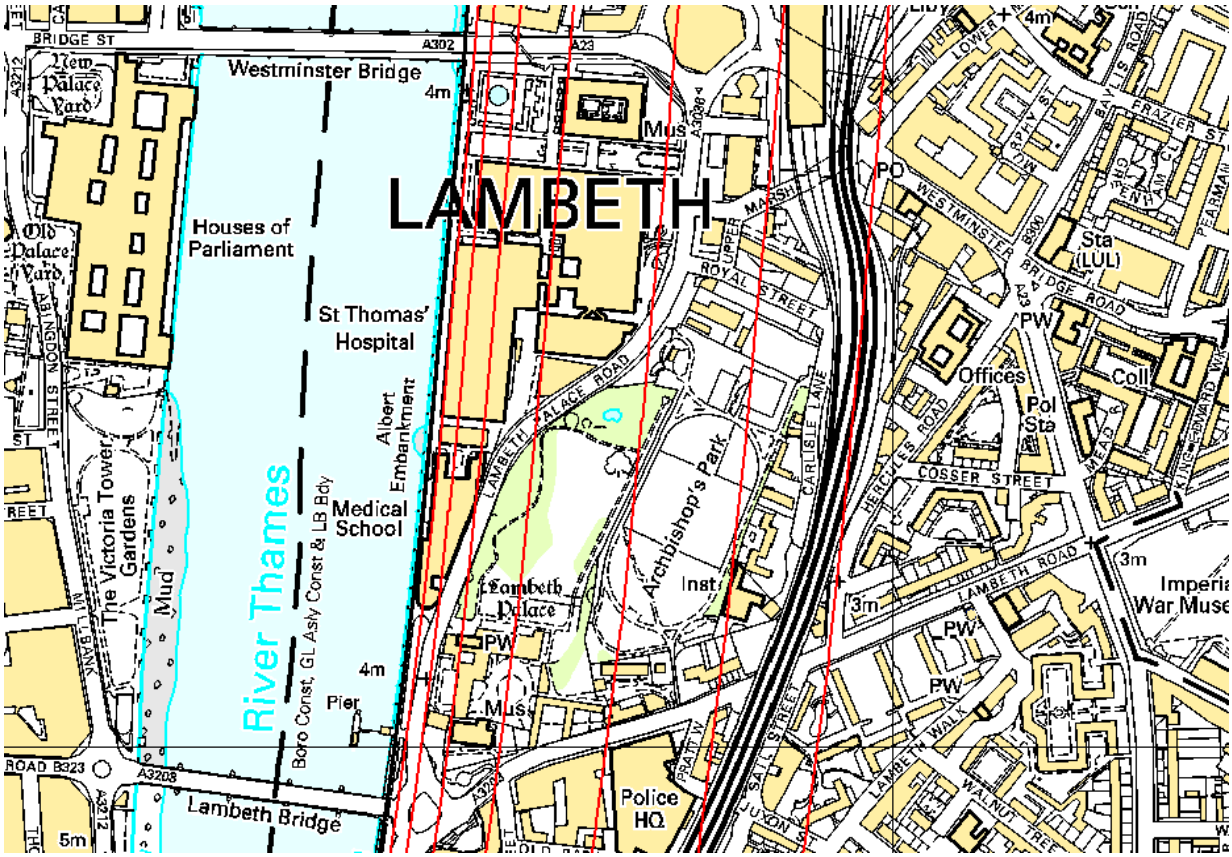

FIGURE C 1: EXAMPLE OF BUFFERED PARALLEL LINES ALONG RIVER'S EDGE

Each of the parallel lines was then divided up into 20 metre segments. Fortunately, as the line's wind to the left and right, the lengths of the lines are approximately of equal length (plus or minus around 5-10 metres). So there are an equal amount of points along the length of each line.

In total, seven sets of 161 points were defined along the 3220 metres of river frontage within the boundaries of the borough. The elevation (in metres above Ordnance Datum) at each of these points was then extracted from the Digital Elevation Model (DTM) data to create a basic matrix or grid for the strip of land running along the River Thames. The data is presented in this Appendix. Note that only the data for the 10, 25, 50 and 100 metre buffers is shown as the data from further inland was not used in the final process.

Data Analysis

The extracted data was initially inspected, point by point, in conjunction with the DTM data (see Figure A2) to correct any obvious errors or inconsistencies. This can occur when land excavations were in progress when the DTM data was recorded or if the DTM data is otherwise poor or incomplete.

Once all of the data was believed to be acceptable and consistent, all data where levels were above the peak 1 in 1000 year tide levels were identified. Note that the peak 1 in 1000 year tide levels vary slightly along the length of the study area (see the breach modelling methodology in Appendix F). For this stretch of the river, the levels for the 1 in 1000 year event range from approximately 5.26 metres AOD near Vauxhall

Bridge in the southwest to approximately 5.22 metres AOD downstream of Waterloo Bridge in the northeast. Although slight, this variation was taken into account.

All points that were higher than these peak levels were deemed to remain dry during a 1 in 1000 year tide event. All sections of the riverfront where the land is 'dry' at least 25-50 metres back from the river's edge were then categorised as Riverside Category 1 (RC-1).

The extent of each of these RC1 areas were also confirmed by a more detailed investigation of the DTM data using a colour palette that only displayed data above the local 1 in 1000 year peak level. An example is shown in Figure C 2, where the blue cells are those that are higher than 5.26 metres AOD.

For all other sections of the riverfront (that is, those that are at risk from flooding) a point by point inspection was done to determine a suitable breach height, should one occur, at that location. This was done using the same method used in breach modelling analyses, whereby a worst case scenario is assumed. The force of the breach is assumed to scour out the land behind the defences to the lowest level behind the breach, within a distance of 25-50 metres inland.

The tables at the back of this Appendix also list the assumed breach levels derived above. Notice that a very conservative approach has been used to assess these levels in terms of the amount of scouring that could potentially occur.

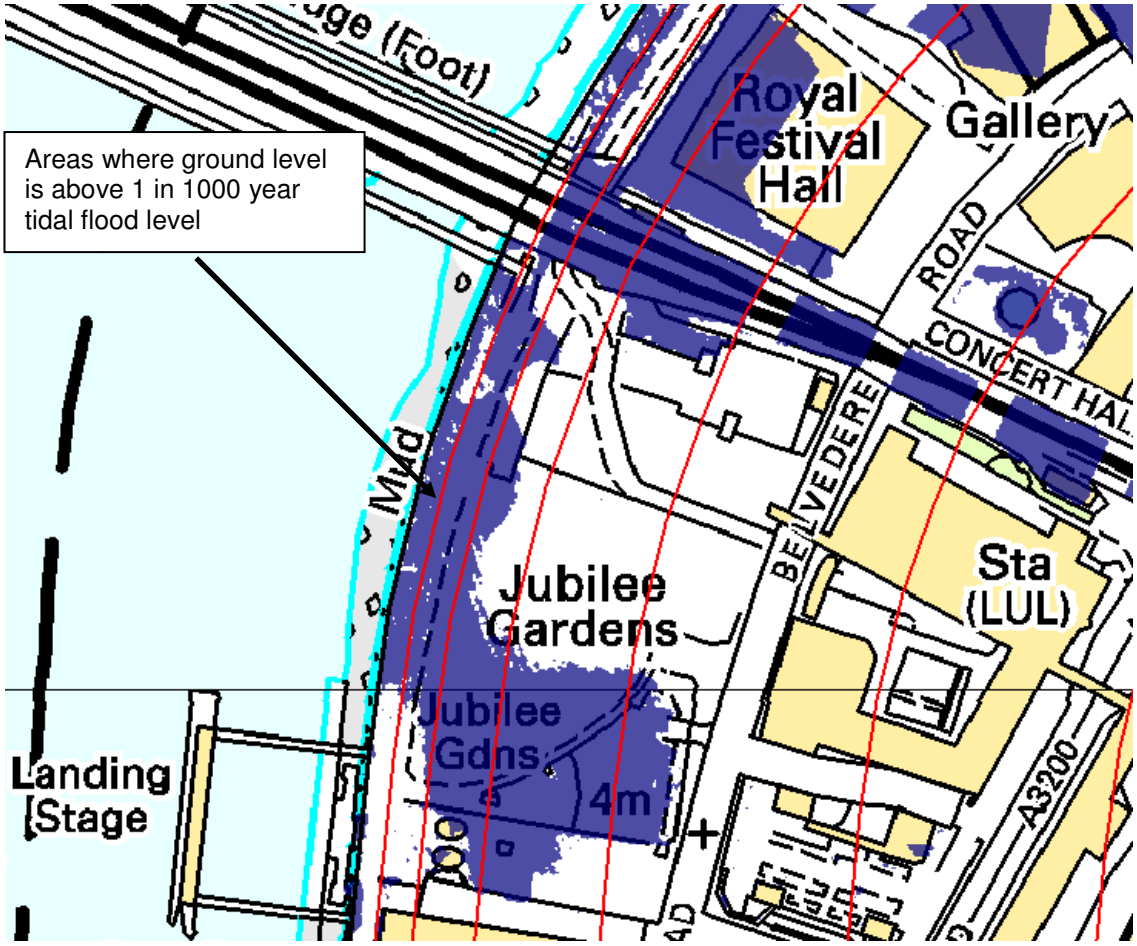

FIGURE H 2: EXAMPLE OF RAISED GROUND ALONG RIVER'S EDGE (HIGHLIGHTED IN BLUE)

Volume Calculations

To gain a general indication of the volumes of water that could travel through breaches of the various levels determined above a relationship was determined using the 1 in 1000 year extreme tidal curve (see Figure C 3), the Broad Crested Weir Equation and an assumed breach width of 20 metres for a range of breach levels.

The Broad Crested Weir Equation used is listed below:

$$\text{Flow } [m^3/s] = 1.55 \times \text{breach width [20m]} \times \text{depth [m]}^{1.5}$$

The depth in this equation is calculated by subtracting the breach level from the tide level at each time interval in the tide curve shown in Figure H 3. The volumes for each time interval while the tide curve is over the breach level are summed to give a total breach volume.

Such volumetric calculations were indicative only and do not match what would happen in a real life breach scenario, nor do they match what was observed during the previous breach modelling exercises for this area. This is because in real life there are obstructions and deviations and frictions that would significantly reduce the volumes that would flow through the 'weir' created by a breach scenario.

However, it once again provides an absolute worst case scenario 'ceiling' for breaches in the flood defences and can be used as a guide in determining the maximum volumes to expect from such breaches.

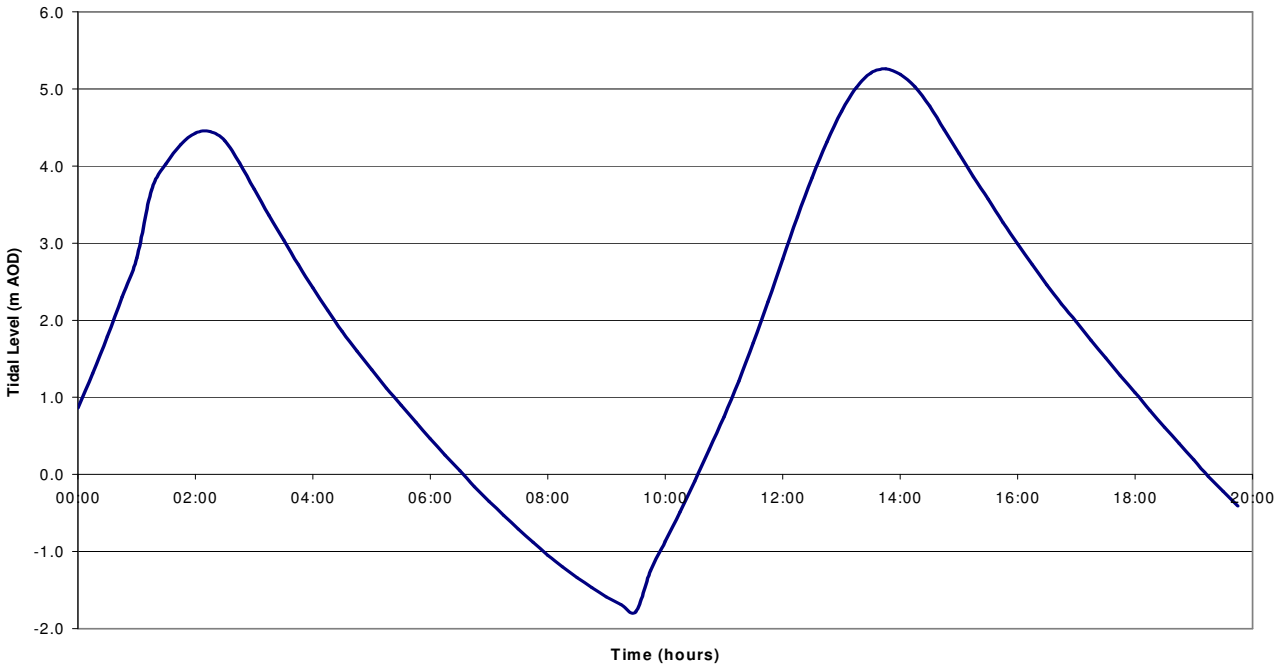

FIGURE C 3: 1 IN 1000 YEAR EXTREME TIDAL CURVE

Figure C 4 shows the relationship derived for breach level against total *maximum* volume that could pass through a breach of that level.

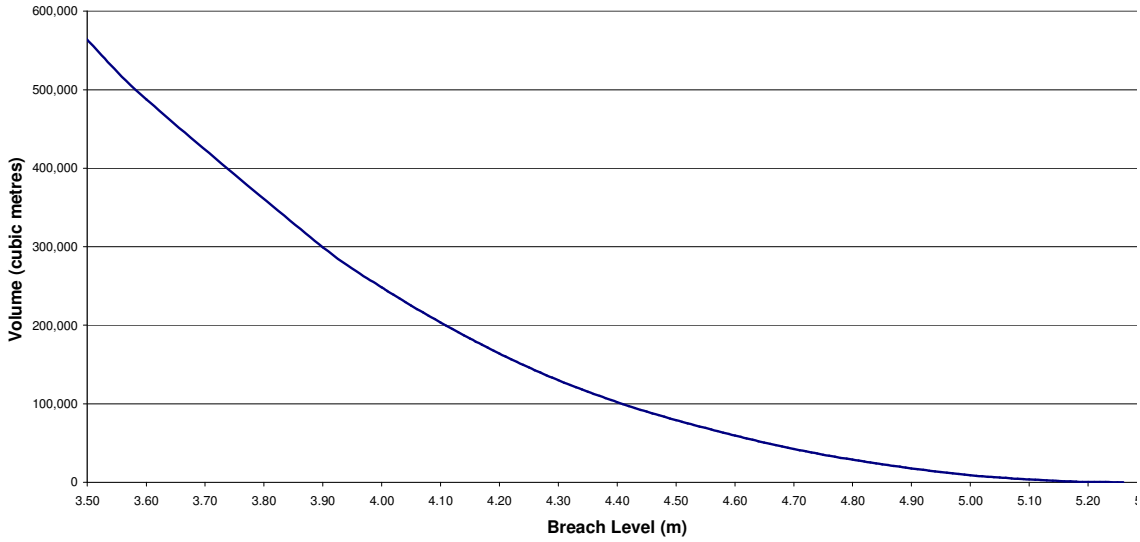

FIGURE C 4: MAXIMUM BREACH VOLUME FOR EACH ASSUMED BREACH LEVEL

Detailed Analysis

Once the assumed breach levels had been assigned for each 20 metre 'slice' of the river frontage, the sections could be further defined by risk categories.

These risk categories were defined principally according to their assumed breach level, according to the relationship in Table C 1 below. However, once again, a visual inspection of the DTM was also involved on a point by point basis. This required that possible flow paths and general topographical characteristics of the land behind the defences were also taken into account.

TABLE C 1: DEFINITION OF RISK CATEGORIES

Riverside Category	Assumed Breach Level [m AOD]	Potential Peak Depth of Flow through breach (1 in 1000 year event) [m]
RC-1	> 5.25	0
RC-2	4.8 – 5.25	0.5 – 0
RC-3	4.3 – 4.8	1.0 – 0.5
RC-4	< 4.3	>1.0

NOTE: Although 5.3 metres AOD has been used to define the 'No Risk' cutoff above, the actual local 1 in 1000 year levels (5.22 to 5.26 metres AOD) were used when greater detail was required

The river was then divided into eight distinct sections. These were generally defined by similar characteristics in the levels behind their defences and similar probable flood flow paths or significant infrastructure or other defining features.

The locations of these sections are shown in Figure H3.

The DTM topography data and the final assessed risk category for each of the eight separate river sections is shown in Figures H3 to H19 in this Appendix. Comparing the two figures for each section demonstrates the derivation of the categories. However, as previously mentioned, at times 'corrections' were made based on errors or inconsistencies in the DTM or by further investigation into the characteristics of the area via site photos, local knowledge or online aerial photos.

Conclusion

An assessment of the risks associated with breaching of the flood defences was made for each point along the Thames River frontage within the London Borough of Lambeth.

Each part of the river frontage was defined a riverside category according to the assumed level of any potential breach and the characteristics of the land behind the breach. The categories are not in any way based upon the probability of defence failure.

This information should be used, with case by case judgement, in conjunction with the previously completed detailed breach modelling study, in order to assess the risk to individual properties.

Riverside Figures List

Figure H1: Maximum Possible Inundation Area

Figure H2: Digital Terrain Model

Figure H3: River Reaches Key Plan

Figure H4: River Reach 1 Digital Terrain Model

Figure H5: River Reach 1 Riverside Category

Figure H6: River Reach 2 Digital Terrain Model

Figure H7: River Reach 2 Riverside Category

Figure H8: River Reach 3 Digital Terrain Model

Figure H9: River Reach 3 Riverside Category

Figure H10: River Reach 4 Digital Terrain Model

Figure H11: River Reach 4 Riverside Category

Figure H12: River Reach 5 Digital Terrain Model

Figure H13: River Reach 5 Riverside Category

Figure H14: River Reach 6 Digital Terrain Model

Figure H15: River Reach 6 Riverside Category

Figure H16: River Reach 7 Digital Terrain Model

Figure H17: River Reach 7 Riverside Category

Figure H18: River Reach 8 Digital Terrain Model

Figure H19: River Reach 8 Riverside Category

APPENDIX D – METHODS OF MANAGING RESIDUAL FLOOD RISK

The following sub-sections outline various methods available for the management of residual flood risk. The methods outlined will not be appropriate for all development types or all geographical areas. Therefore, they should be considered on a site-by-site basis. In addition, it is important that the use of such techniques do not exacerbate flooding elsewhere.

Recreation, Amenity and Ecology

The inclusion of parks and open spaces or river restoration schemes have ecological, biodiversity and sustainability benefits as well as providing flood risk mitigation through the creation of increased flood storage areas and conveyance of rainwater.

Due to the nature of the study area, the opportunity of river restoration is limited to the Effra sewer. However, open spaces and the inclusion of ditches or small pools could be investigated as part of new developments. These all can have the added benefit of improving the ecological and amenity value of an area by providing attractive areas available for recreation as well as providing storm water attenuation The Environment Agency has carried out studies in Sutcliffe Park in Lewisham and Chinbrook Meadows that have shown proven health benefits from providing open spaces to the local community.

Secondary Defences

Secondary defences are those that exist on the dry side of primary defences. Typically, their main function is to reduce the risk of residual flooding following a failure or overtopping of the primary defences.

Secondary defences can relocate floodwaters away from certain areas or reduce the rate of flood inundation following a residual event. Examples of secondary defences include embankments or raised areas behind flood defence walls, raised infrastructure e.g. railways or roads and, on a strategic level, canals, river and drainage networks. The latter are a form of secondary defence as they are able to convey or re-direct water away from flood prone areas even if this is not their primary function. The consequences of increasing water levels at other properties would need to be taken into account whether such a solution were implemented in the active or defended flood plains.

Land Raising

Land raising can have mixed results when used as a secondary flood alleviation measure. It can be an effective method of reducing flood inundation on certain areas or developments by raising the finished levels above the predicted flood level. However, it can also result in the reduction in flood storage volumes which may increase local floodwater levels and exacerbated flooding elsewhere.

The tidal Thames and the River Graveney are both defended and the Environment Agency do not normally be required level for level compensatory flood storage for small scale developments within defended floodplains, assuming that defences will be maintained for the lifetime of the development.

However, the impact of residual risk on other properties should be considered, and where the potential increase of flood levels or potential disruption of flow routes as a result of development is significant, compensatory flood storage should be provided.

Due to the heavily urbanised nature of the study area, land raising and compensatory storage is unlikely to be required.

N.B. Building up land ‘adjacent’ to existing or primary flood defences must respect the byelaw margin: a strip of land kept free of obstructions, to enable maintenance and emergency repair of the primary flood defence.

Finished Floor Levels

Where developing in flood risk areas is unavoidable, the most common method of mitigating flood risk to people is to ensure habitable floor levels are raised above the maximum flood water level.

For the limited development that may take place along the River Graveney: The Environment Agency suggest that under **fluvial/undefended** flood risk conditions, a 300mm freeboard on the 1 in 100 year, plus 20% climate change flood level is used when setting finished floor levels (600mm freeboard is required for less precisely computed levels). Where this can not be achieved for practicality reasons flood proofing measures should be utilised up to the 1 in 100 year, plus 20% climate change flood level.

For development that is proposed in the north of the Study Area in Flood Zone 3a: The Environment Agency suggests that under **tidal/defended flood risk** conditions finished floor levels are as follows:

For *'residential uses'* if no breach analysis has been undertaken by the applicant, then finished floor levels should be set at or above the 1 in 1000 year flood level preferably, if this is not possible then at or above the 1 in 200 year flood level. If breach analysis has been undertaken by the applicant then the 1 in 1000/200 year flood levels from this model would apply in the same way. Most of the London Borough or Lambeth is covered by the breach scenarios included in the Level 1 SFRA and most planning applications for residential development would be able to use the results of this to set their finished floor levels.

For *'Less vulnerable'* uses, finished floor levels do not need to be raised. However, it is strongly recommended that internal access is provided to upper floors to provide safe refuge in a flood event. (It is appreciated that this may not always be possible due to the heavily urbanised nature of the study area with many commercial properties being located underneath privately owned residential accommodation).

Schools – even though these are classed as 'more vulnerable', finished floor levels do not need to be raised as it is not always viable, however, internal access to higher floors MUST be provided to give safe refuge during times of flood.

For both 'less vulnerable' developments and schools where internal access to higher floors is provided, the associated plans showing this should be included within any site specific FRA.

It is also necessary to ensure that proposed roads levels are such that emergency access and evacuation routes are maintained where possible at the 1 in 1000 year flood level. This can significantly reduce the risk of the proposed development becoming inundated by flooding. As with the land raising option, it is imperative that any assessment takes into consideration the volume of floodwater potentially displaced and potential disruption to flow routes posed by such raising.

Flood Resilience

Flood resilient buildings are designed to reduce the consequences of flooding and facilitate recovery from the effects of flooding sooner than conventional buildings.

The Association of British Insurers in cooperation with the National Flood Forum has produced published guidance on how homeowners can improve the food resilience of their properties (ABI, 2004). Such measures should be encouraged for use on existing development subject to flooding, and not purely to justify new development.

The guidance identifies the key flood resistant measures as being:

- Replace timber floors with concrete and cover with tiles,
- Replace chipboard/MDF kitchen and bathroom units with plastic equivalents,
- Replace gypsum plaster with more water-resistant material, such as lime plaster or cement render,

- Move service meters, boilers, and electrical points well above likely flood levels, and,
- Put one-way valves into drainage pipes to prevent sewage backing up into the house.

In considering appropriate resilience measures, it will be necessary to plan for specific circumstances and have a clear understanding of the mechanisms that lead to flooding and the nature of flood risk by undertaking a FRA.

Guidance on resilient construction is being prepares and will be placed on the Communities and Local Government and Planning Portal websites[24]

Advice on flood mitigation for homes and businesses is also given in the ODPM's 2003 report, 'Preparing for Floods' (ODPM) and CLG's 2007 report 'Improving The Flood Performance of New Buildings'.

[24] See www.communities.gov.uk or planningprotal.gov.uk