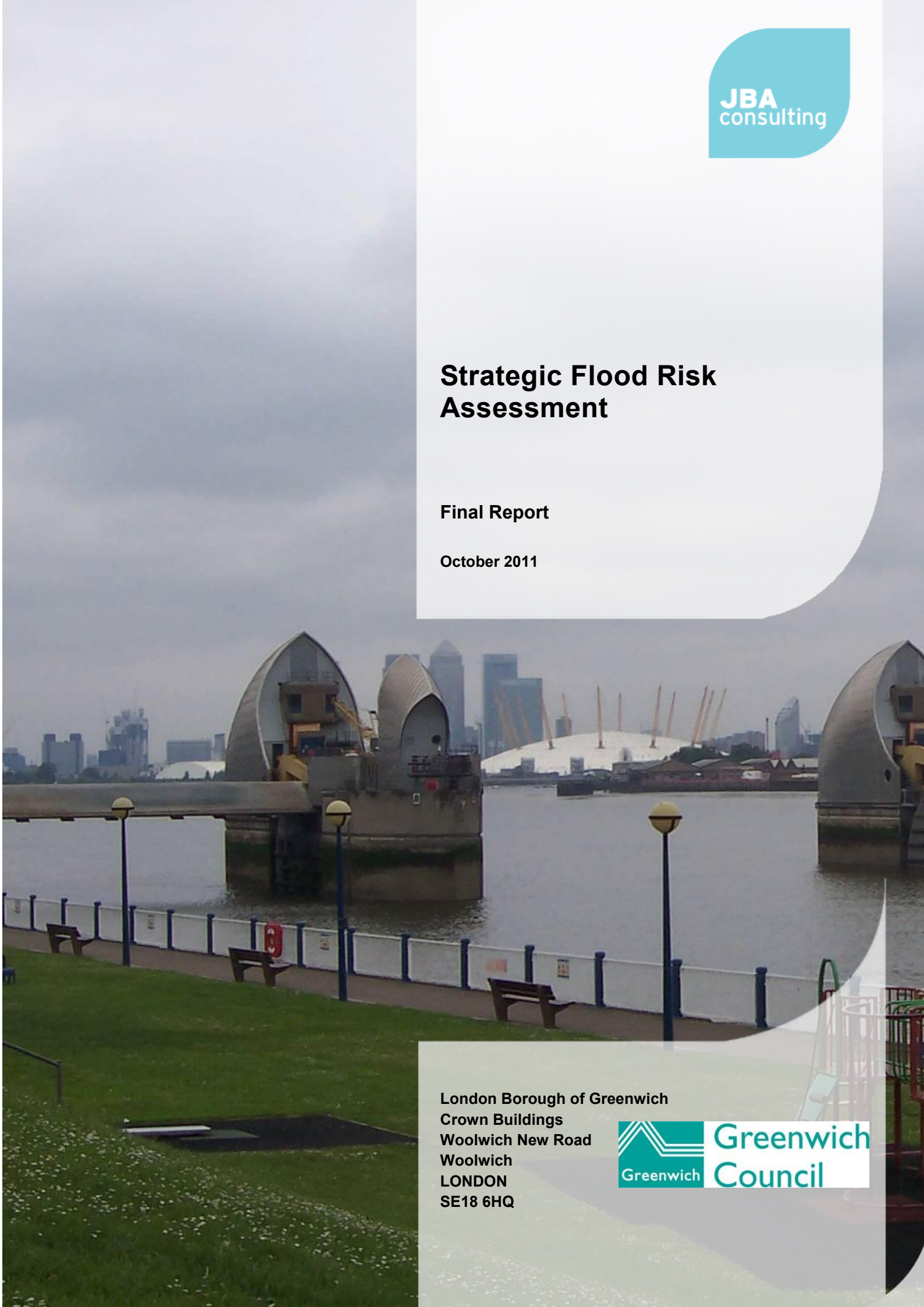

Strategic Flood Risk Assessment

Final Report

October 2011

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Draft Report version 1.0 (May 2008)		Greenwich Council - Steve Tyler & Catherine Warburton (electronic copies). Environment Agency – Sarah Smith and Will Mackay
Draft Report version 2.0 (September 2008)	Changes following comments from Greenwich Council and Environment Agency.	As above
Draft Final Report version 3.0 (May 2009)	As above	As above
Draft Final Report version 4.0 (July 2009)	As above	As above
Draft Final Report version 5.0 (October 2011)	Modifications regarding development in areas of high residual risk (chapters 8 and 9).	As above
FINAL REPORT	None	As above

Contract

This report describes work commissioned by the London Borough of Greenwich under the letter of instruction of 07/05/2008. The London Borough of Greenwich's representatives for the contract were Steve Tyler and Catherine Warburton. Paul Eccleston, Francesca Hurt and David Kearney of JBA Consulting and Nick Jarritt and John Rampley for Entec, carried out the work.

Purpose

This document has been prepared as a final report for London Borough of Greenwich. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

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Acknowledgements

JBA would like to thank all those from The London Borough of Greenwich, the Environment Agency and Thames Water who provided information and data for this report.

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Executive Summary

This report is the Strategic Flood Risk Assessment (SFRA) for the London Borough of Greenwich.

This SFRA has been prepared in accordance with current best practice, Planning Policy Statement 25 Development and Flood Risk (PPS25).

The SFRA is a planning tool that will assist the Council to make the spatial planning decisions required to inform the Local Development Framework (LDF).

High level planning, policy and guidance documents have been identified which have to be taken into account in preparing this SFRA. The documents which have been reviewed include national, regional (including the London Plan) and local planning legislation, together with Environment Agency policy guidance.

A thorough review of existing information, and additional modelling work, has identified the level of flood risk at present within the Borough from fluvial, tidal and other sources. A detailed investigation has been carried out into the effect of defences on flood risk, and the risk that remains behind these defences, as a consequence of defence failure.

The SFRA has identified that there are significant areas at flood risk within London Borough of Greenwich. Fluvial flood risk, while limited to defined river corridors, affects areas of the Borough alongside the River Quaggy, Ravensbourne, Shuttle, Deptford Creek and Butts Canal. Some channel modifications and flood alleviation works have taken place in the Borough, most notably the flood alleviation scheme on the River Quaggy at Sutcliffe Park.

Tidal flood risk is extensive, but at present Greenwich is fully defended against the 0.1% annual probability extreme tide level with climate change to 2107. A breach in the defences, although a low probability of occurrence, would have a high consequence, causing significant flooding of the Thamesmead, New Charlton and Greenwich Peninsula areas of the Borough. A detailed additional study, "Guidance for housing development in areas of high residual flood risk" was prepared in order to address the specific issued of development within these areas, and is presented in Appendix F.

Surface water flooding does not appear to be problematic in the majority of Greenwich but areas such as Abbey Wood have experienced problems in the past, including during the recent heavy rainfall events of July 2007. Surface water modelling did however highlight areas of the Borough which are potentially at risk from surface water flooding. These included areas of Eltham, Kidbrooke, Greenwich Peninsula, New Charlton, Royal Arsenal East, Plumstead and Abbey Wood.

Sewer flooding does not appear to be problematic in the majority of Greenwich but areas such as Eltham have experienced problems in the past.

The Borough is underlain by a large area of minor aquifer, which coincides with the sand silt and gravel bedrock, and a small area of major chalk aquifer. This area of major aquifer has been classified by Defra as a groundwater emergence zone and could be at risk from significant ground water flooding when the water table is high. This emergence zone coincides with the reported incident of groundwater flooding in Abbey Wood.

Maps and GIS layers have been provided with the report showing the revised extents of Flood Zones 2, 3a and 3b, flooding from other sources, the effect of climate change, residual risk, and other supporting information.

Guidance for the LPA on the future management of development with respect to flood risk has been given, including recommendations for LDF policies. Advice has also been given regarding strategic flood risk management and emergency planning.

In addition an outline has been given of requirements for developers for Flood Risk Assessments (FRAs), with supporting guidance on reducing flood risk and making development safe, including Sustainable Urban Drainage Systems (SUDS) and mitigation measures. Advice is also given on other issues to consider as part of a development proposal.

This report was commenced in 2008 and, with the exception of the sections dealing with development in areas of high residual flood risk (principally chapter 10) was approved and finalised in 2009.

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Glossary and Abbreviations

Actual Risk		The risk posed to development situated within a defended area (i.e. behind defences), expressed in terms of the probability that the defence will be overtopped, and/or the probability that the defence will suffer a structural failure, and the consequence should a failure occur
Area Action Plan	AAP	Planning document to guide development in a specific area. Forms part of the Local Development Framework.
Area Benefiting from Defence	ABD	Those areas which benefit from formal flood defences in the event of flooding from rivers with a 1% chance in any given year or from the sea with a 0.5% chance in any given year. If the defences were not there, these areas would be flooded.
AEP		Annual Exceedance Probability
Brownfield		Brownfield (sites or land) is a term in common usage that may be defined as 'development sites or land that has previously been developed'. Prior to PPS25 the term 'Brownfield' was used in Governmental Guidance and Statements, but in PPS25 has been replaced with 'Previously-developed land' See 'Greenfield'.
Core Strategy	CS	This is the strategic vision of the area and is a central pillar of the Local Development Framework, comprising: A vision; Strategic objectives; A spatial land use strategy; Core policies and; A monitoring and implementation framework. The Core Strategy is a Development Plan Document which will determine overall patterns of future development, identifying broad locations where future growth or conservation will take place. All other Development Plan Documents should be in broad conformity with the Core Strategy Document. The Core Strategy is a mandatory document, and a timetable for production is set out within the Local Development Scheme.
Defended Area		An area offered a degree of protection against flooding through the presence of a flood defence structure
DG5 register	DG5	Register held by water companies on the location of properties at risk of sewage related flooding problems
Development Plan Documents	DPDs	These documents have Development Plan Status and consequently form part of the statutory development plan for the area. A DPD will be subject to a independent examination. Typical documents that will have DPD status include the Core Strategy, Site-specific Allocations of Land, Proposals Map, and Area Actions Plans (where needed).
Digital Elevation Model	DEM	A representation of the topography of an area that gives the elevation of the upper surface whether it is the ground, vegetation or a building.

Embayment		Distinct area in the shape of a bay liable to flooding from the estuary.
Extreme Flood Outline	EFO	Flood 'zone' maps released by the Environment Agency in June 2004 depict anticipated 0.1% (1 in 1000 year) flood extents in a consistent manner throughout the UK
Flood Alleviation Scheme	FAS	Works designed to provide protection from flooding.
Flood Risk Management		The introduction of mitigation measures (or options) to reduce the risk posed to property and life as a result of flooding. It is not just the application of physical flood defence measures
Flood Estimation Handbook	FEH	Provides current methodologies for estimation of flood flows for the UK
Floodplain		Any area of land over which water flows or is stored during a flood event or would flow but for the presence of defences
Flood Risk Assessment	FRA	A detailed site-based investigation that is undertaken by the developer at planning application stage
Flood Storage Area	FSA	Area designed to store water in a flood and release it later when flood waters have subsided.
Flood Zone		Areas of land at risk from tidal or fluvial flooding as delineated by the Environment Agency. Zone 1: Low probability of flooding Zone 2: Medium probability of flooding Zone 3: High probability of flooding
Fluvial Flooding		Flooding caused by high flows in rivers or streams exceeding the capacity of the normal river channel.
Formal Defence		A flood defence asset that is maintained by the Environment Agency
Freeboard		A 'safety margin' to account for residual uncertainties in water level prediction and/or structural performance, expressed in mm
Functional Floodplain		An area of land where water has to flow or be stored in times of flood.
Greenfield		Greenfield (sites or land) is a term in common usage that may be defined as 'development sites or land that has not previously been developed'. Prior to PPS25 the term 'Greenfield' was used in Governmental Guidance and Statements, but in PPS25 has been replaced with 'Undeveloped land' See 'Brownfield'.
Greenfield discharge rates		Greenfield discharge rates refer to the amount of discharge that would occur from a site if it was still natural greenfield land.
Hyetograph		A chart showing the distribution of rainfall over a particular period of time or a particular area
Informal Defence		A structure that provides a flood defence function, however is not owned nor maintained by the Environment Agency

JFLOW		2-Dimensional hydraulic modelling package developed by JBA
Local Development Framework	LDF	The Local Development Framework is made up of a series of documents that together will form part of the Development Plan. Broadly Local Development Framework documents fall into two categories: Development Plan Documents Supplementary Planning Documents
Measure		A deliverable solution that will assist in the effective management (reduction) of risk to property and life as a result of flooding, e.g. flood storage, raised defence, effective development control and preparedness, and flood warning
Mitigation		The management (reduction) of flood risk
Ordnance Survey	OS	`
Probability	1%	A measure of the chance that an event will occur. The probability of an event is typically defined as the relative frequency of occurrence of that event, out of all possible events. Probability can be expressed as a fraction, % or a decimal. For example, the probability of obtaining a six with a shake of a fair dice is 1/6, 16% or 0.166. Probability is often expressed with reference to a time period, for example, annual exceedance probability
Rapid Inundation Zone		An area immediately behind defences which, should they fail, will generate a combination of high velocities and flood depths that would cause a risk to life.
Residual Risk		The risk that inherently remains after implementation of a mitigation measure (option)
Return Period		The expected (mean) time (usually in years) between the exceedance of a particular extreme threshold. Return period is traditionally used to express the frequency of occurrence of an event, although it is often misunderstood as being a probability of occurrence.
Risk		The threat to property and life as a result of flooding, expressed as a function of probability (that an event will occur) and consequence (as a result of the event occurring)
Standard of Protection	SoP	The return period to which properties are protected against flooding
Strategic Flood Risk Assessment	SFRA	The assessment of flood risk on a catchment-wide basis for proposed development in a Borough
Strategic Flood Risk Management	SFRM	Considers the management of flood risk on a catchment-wide basis, the primary objective being to ensure that the recommended flood risk management 'measures' are sustainable and cost effective
Supplementary Planning Documents	SPD	Supplementary Planning Documents or SPD support DPDs in that they may cover a range of issues, both thematic and site specific. Examples of SPD may be design guidance or development briefs. SPD may expand policy or provide further detail to policies in a DPD. They will not be subject to independent examination.
Sustainability Appraisal	SA	A Sustainability Appraisal is a systematic process to predict and assess the economic, environmental and social effects likely to arise from DPDs and SPDs, enabling each document to be tested and refined, ensuring that it contributes towards sustainable development.

Sustainable Drainage Systems	SUDS	Current 'best practice' for new urban development that seeks to minimise the impact upon the localised drainage regime, e.g. through the use of pervious areas within a development to reduce the quantity of runoff from the site
Tidal Flooding		Flooding caused by extreme tide levels
Uncertainty		A reflection of the (lack of) accuracy or confidence that is considered attributable to a predicted water level or flood extent

1 Introduction

1.1 Introduction

In April 2008 JBA Consulting and Entec were commissioned by the London Borough of Greenwich to undertake a Strategic Flood Risk Assessment (SFRA).

This SFRA has been prepared in accordance with current best practice, Planning Policy Statement 25 Development and Flood Risk (PPS25). PPS25 reinforced the responsibility of LPAs to ensure that flood risk is managed effectively and sustainably as an integral part of the planning process, balancing socio-economic needs, existing framework of landscape and infrastructure, and flood risk.

1.2 Objectives

The SFRA is a planning tool that enables the Council to identify sites for development away from vulnerable flood risk areas. The assessment focuses on the existing site allocations within the Borough but also sets out the procedure to be followed when identifying future sites for development. The SFRA will assist the Council to make the spatial planning decisions required to inform the Local Development Framework (LDF).

In addition to informing site allocations the SFRA will inform decision making on planning applications on non-allocated sites, strategic flood alleviation measures and other measures to reduce flood risk to existing development, planning requirements for new development and emergency planning.

To this end, the key objectives of the SFRA are:

- To investigate and identify the extent and severity of flood risk from all sources to the area at present and in the future, under the terms of PPS25.
- To inform the Core Strategy, Site Specific Allocations Development Plan Document (DPD), Development Control Policies DPD and any subsequent Supplementary Planning Documents and Area Action Plans.
- To enable the Council to apply the Sequential Test and the Exception Test
- To identify the level of detail required for site-specific FRAs.
- To inform the emergency planning process.

1.3 Background to the study

In June 2005 a SFRA was published for East London, covering 11 London Boroughs. It was commissioned by the Thames Gateway London Partnership. The Environment Agency considers this adequate to inform the Core Strategy for London Borough of Greenwich.

However the Environment Agency do not consider that it is adequate to inform the Local Development Framework's Development Control Policy and Site Specific Allocation DPDs. Therefore, further work is necessary to make the East London SFRA more locally specific to Greenwich. The East London SFRA has its limitations partly due to its publication date (pre PPS25) and partly due to lack of local detail necessitated by the large study area.

The Environment Agency therefore recommend that the East London SRFA should be used as a starting point for a more detailed SFRA for Greenwich which covers all sources of flooding within the Borough.

2 The planning framework

2.1 Introduction

The purpose of this section of the report is to identify and outline those high level documents which must be taken into account in preparing this SFRA, from a national to local level. The documents which have been reviewed include national planning legislation and the London Plan, together with Environment Agency policy guidance.

2.2 National planning policy

2.2.1 Planning and Compulsory Purchase Act

The SFRA has been prepared in a period during which planning authorities have been implementing the provisions of the Planning and Compulsory Purchase Act 2004 and accompanying planning guidance, including PPS 1 Delivering Sustainable Development and PPS 12 Local Spatial Planning. This affected all tiers of the planning system and has necessitated major changes at both the regional and local level which will impact on the way in which planned development is approached in the regional strategy and delivered locally.

2.2.2 PPS25 Development and Flood Risk

In December 2006 the Government published PPS25: Development and Flood Risk.

The aim of PPS25 is to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding and to direct development away from areas at highest risk. The key planning objectives are that "Regional Planning Bodies (RPBs) and Local Planning Authorities (LPAs) should prepare and implement planning strategies that help to deliver sustainable development by:

- Identifying land at risk and the degree of risk of flooding from river, sea and other sources in their areas;
- Preparing Regional or Strategic Flood Risk Assessments (RFRAs/SFRAs) as appropriate, either as part of the Sustainability Appraisal of their plans or as a freestanding assessment that contributes to that Appraisal;
- Framing policies for the location of development which avoid flood risk to people and property where possible and manage any residual risk, taking account of the impacts of climate change;
- Only permitting development in areas of flood risk when there are no suitable alternative sites in areas of lower flood risk and the benefits of the development outweigh the risks from flooding (as proved by passing the Exception Test);
- Safeguarding land from development that is required for current and future flood management e.g. conveyance and storage of flood water and flood defences;
- Reducing risk to and from new development through location, a sequential approach to layout and design, incorporating sustainable drainage systems (SUDS);
- Using opportunities offered by new development to reduce the causes and impacts of flooding e.g. surface water management plans; making the most of the benefits of green infrastructure for flood storage, conveyance and SUDS; recreating functional floodplain and setting back defences;
- Working effectively with the Environment Agency and other stakeholders to ensure that best use is made of their expertise and information so that decisions on planning applications can be delivered expeditiously; and
- Ensuring spatial planning supports flood risk management policies and plans; River Basin Management and emergency planning."

In addition to setting out the roles and responsibilities for LPAs and RPBs, PPS25 identifies that landowners also have a primary responsibility for safeguarding their land and other

property against natural hazards such as flooding. Those promoting sites for development are also responsible for:

- Demonstrating that is consistent with PPS25 and Local Development Documents (LDDs);
- Providing a Flood Risk Assessment (FRA) demonstrating whether the proposed development: is likely to be affected by current or future flooding; satisfies the LPA that the development is safe; and identifies management and mitigation measures.

PPS25 also introduces an amendment to Article 10 of The Town and Country Planning (General Development Order) 1995 which makes the Environment Agency a Statutory Consultee on all applications for development in flood risk areas, and those within 20m of a Main River.

The introduction of PPS25 enables local authorities to make a direction under Article 4 of the Town and County Planning (General Permitted Development) Order 1995. This will enable Local Authorities to remove permitted development rights where those rights threaten to have a direct, significant and adverse effect on a flood risk area, or its flood defences and their access, or the permeability and management of surface water, or flood risk to occupants.

2.2.3 A Practice Guide Companion to PPS25 Living Draft

In June 2008 the Government released the companion guide to PPS25. The practice guide provides guidance on the implementation of the policy set out in PPS25. The guide provides further guidance on the preparation of SFRA's and FRA's, the Sequential and Exception Test, outlines potential mitigation measures e.g. SUDS and risk management techniques.

2.2.4 Other Planning Policy Statements

PPS1 Delivering Sustainable Development published in February 2005 sets out the overarching planning policies for the delivery of sustainable development across the planning system and sets the tone for other PPSs that will follow. PPS1 explicitly states that development plan policies should take account of environmental issues, including flood risk. It proposes that new development in areas at risk of flooding should be avoided. Planning authorities are also advised to ensure that developments are "sustainable, durable and adaptable" including taking into account natural hazards such as flooding.

Whilst not directly relevant to the development of a SFRA, it is important to recognise that the exercise takes place within the context of other planning policy statements, some of which also require Sequential Testing of site allocations and development proposals. PPS3 Housing, PPG4 Industrial and Commercial Development and Small Firms and PPS6 Planning for Town Centres are intrinsic within the planning process, and therefore an understanding of the constraints faced as a result of this additional policy guidance is imperative.

2.3 Regional policy drivers

The creation of the Greater London Authority and the provisions of Greater London Authority (GLA) Act 1999 require the Mayor to produce a spatial plan which deals with matters which are of strategic importance to Greater London.

2.3.1 The London Plan 2008 (consolidated with alterations since 2004)

The Mayor published the first London Plan in February 2004. In December 2006 the mayor published Early Alterations to the London Plan to address pressing housing provision, waste and minerals issues. In addition Draft Further Alterations, to the London Plan, were published for public consultation in September 2006. In February 2008 the Mayor incorporated both the Early and Further Alterations in the "London Plan (consolidated with alterations since 2004)".

The London Plan sets out the strategic principles for the continued growth and development of Greater London. The London Plan contains a series of objectives identified by the Mayor. The overarching objective of the plan is to promote sustainable development. The policies relevant to flooding and flood risk management are listed below:

- Policy 4A.3 Sustainable design and construction - manage flood risk, through sustainable drainage systems (SUDS) and flood resilient design for infrastructure and property.
- Policy 4A.12 Flooding - In reviewing their DPDs, Boroughs should carry out strategic flood risk assessments to identify locations suitable for development and those required for flood risk management. Within areas at risk from flooding (Flood Zones) the assessment of flood risk for development proposals should be carried out in line with PPS25.
- Policy 4A.13 Flood risk management - Where development in areas at risk from flooding is permitted, (taking into account the provisions of PPS25), the Mayor will, and Boroughs and other agencies should, manage the existing risk of flooding, and the future increased risk and consequences of flooding as a result of climate change, by:
    - protecting the integrity of existing flood defences
    - setting permanent built development back from existing flood defences to allow for the management, maintenance and upgrading of those defences to be undertaken in a sustainable and cost effective way
    - incorporating flood resilient design
    - establishing flood warning and emergency procedures.

  Opportunities should also be taken to identify and utilise areas for flood risk management, including the creation of new floodplain or the restoration of all or part of the natural floodplain to its original function, as well as using open space in the flood plain for the attenuation of flood water.

  The Mayor will, and Boroughs and other agencies should, take fully into account the emerging findings of the Thames Estuary 2100 Study, the Regional Flood Risk Appraisal and the Thames Catchment Flood Management Plan.
- Policy 4A.14 Sustainable drainage - Boroughs should, seek to ensure that surface water run-off is managed as close to its source as possible in line with the drainage hierarchy. The use of sustainable urban drainage systems should be promoted for development unless there are practical reasons for not doing so. Developers should aim to achieve greenfield run off from their site through incorporating rainwater harvesting and sustainable drainage. Boroughs should encourage the retention of soft landscaping in front gardens and other means of reducing, or at least not increasing, the amount of hard standing associated with existing homes.
- Policy 4C.5 Impounding of rivers - The Mayor will and Boroughs should resist proposals for the impounding or partial impounding of any rivers unless they are clearly in the wider interest of London. Proposals that include the removal of such impounding structures should generally be welcomed.
- Policy 4C.6 Sustainable growth priorities for the Blue Ribbon Network - The uses of the Blue Ribbon Network and land alongside it should be prioritised in favour of those uses that specifically require a waterside location. These uses include water transport, leisure, recreation, wharves and flood defences. For sites that are not suitable or not needed for these priority uses, developments should capitalise on the water as an asset and enhance the Blue Ribbon Network in order to improve the quality of life for Londoners as a whole, as well as for the users of the development.
- Policy 5D.1 The strategic priorities for South East London - In relevant areas ensure that the effects of climate change and, in particular, potential tidal flood risk are assessed authoritatively and that effective measures are incorporated in the location, design and construction of development to address it.

The London Plan also introduces policies for the Blue Ribbon Network, which recognises the interaction of all London's waterways and water bodies (e.g. canals, streams, rivers, docks, reservoirs, lakes), not just the River Thames. It aims to protect and enhance waterside areas, improve their accessibility, exploit potential for their use for transport, leisure and tourism, and improve biodiversity.

The London Plan assessed the need for additional housing in London. The strategy is to provide 305,000 additional homes in London between 2007/8 and 2016/17. At a Borough

level, Greenwich now has a requirement to secure 20,100 additional new homes between 2007/08 and 2016/17.

2.3.2 Sustainable Design and Construction: The London Plan Supplementary Planning Guidance (Mayor of London, 2006)

The Supplementary Planning Guidance (SPG) seeks to provide additional information to support the implementation of the London Plan. The guide seeks to identify a series of standards and measures to promote sustainable development around the themes of conserving energy, water and other resources, reducing noise, pollution, flooding, conserving and enhancing the natural environment and biodiversity and promoting sustainable waste behaviour.

With regard to water pollution and flooding the SPG identifies the following essential standards:

- Use of Sustainable Urban Drainage Systems (SUDS) measures, wherever practical;
- Achieve 50% attenuation of the undeveloped site's surface water run off at peak times.

However, the SPG identifies that it is the Mayor's preferred standard to achieve 100% attenuation of the undeveloped site's surface water run off at peak times. The guidance identifies that SUDS provide an alternative method to dealing with the management of runoff. The content of the SPG has been used to inform the planning policy recommendations contained within this SFRA.

2.3.3 Water Matters: The Mayor's Draft Water Strategy (Mayor of London, 2007)

The London Mayor's draft water strategy has been derived to promote improved water management. The strategy considers all aspects of water management and how they interact, with focus on integrating land and water management. The strategy outlines 5 Hierarchies, one for each aspect of water management in London. Hierarchy 3 and 5 are most relevant to this study.

Hierarchy 5: Managing Floods in London:

1. Avoid types of development that are vulnerable to flooding in flood risk areas
2. Where this is not avoidable, reduce the vulnerability through design and construction techniques by providing space for rivers and tidal processes to occur. Also, by increasing the resilience of buildings to floods through design and construction techniques such as raising electrical services
3. Alleviate the risk of flooding through flood defences.

Hierarchy 3: Rainwater Drainage:

1. Store rainwater for use later
2. Use infiltration techniques, such as porous surfaces in non-clay areas
3. Attenuate rainwater in ponds or open water features for gradual release to a watercourse
4. Attenuate rainwater in tanks or sealed water features for gradual release to a watercourse
5. Discharge rainwater direct to a watercourse
6. Discharge rainwater to a surface water drain
7. Discharge rainwater to the combined sewer, as a last resort.

In addition proposal 13 promotes flood risk assessment stating that;

Developers should determine, in consultation with the Environment Agency, the sewerage undertaker, Transport for London and the relevant London Borough, whether their proposed development site is at risk from flooding. Developers seeking to develop a site at risk from flooding should undertake an appropriate flood risk assessment. All flood risk management proposals should avoid increasing flood risk to neighbouring areas. In Opportunity Areas, an Integrated Water Management Plan supported by a flood risk assessment should be incorporated into development frameworks.

2.3.4 The London Regional Flood Risk Appraisal (Mayor of London, 2007)

The draft RFRA has gone through consultation in 2007, but the final version is not yet issued. It is a helpful overview of flood risk in the Greater London Area and contains a series of strategic recommendations, many of which are based on the findings of the Thames Catchment Flood Management Plan (see Section 2.5.1) and the Thames Estuary 2100 project (see Section 2.5.2).

Recommendations reinforce those outlined in the London Plan, for example concerning the setting back of development from the river edge, the implementation of the Drainage Hierarchy, and the application of PPS25 to new development, particularly with reference to residual risk. Those with a particular relevance to Greenwich include:

"Recommendation 2 - All Thames-side planning authorities should put in place policies to promote the setting back of development from the river edge to enable sustainable and cost effective upgrade of river walls/embankments, in line with London Plan Policy 4C.6."

"Recommendation 5 – Boroughs at confluences of tributary rivers with the River Thames should pay particular attention to the interaction of fluvial and tidal flood risks. These are Havering, Barking and Dagenham, Newham, Tower Hamlets, Greenwich, Lewisham, Wandsworth, Hounslow, Richmond and Kingston."

The RFRA also examines flood risk for major London development areas, with the following recommendations for developments within Greenwich:

Table 2-1 Recommendations for Major Development Areas from the Regional FRA

Opportunity Areas	Current flood risk characteristics	Future flood risk considerations
Deptford / Greenwich Riverside	Intensively developed protected from daily tidal flooding and River Ravensbourne flooding by river walls and from tidal surges by Thames Barrier.	Raising river walls beyond 2030, setting development back from rivers edge.
Greenwich Peninsula & Charlton Riverside West	Intensively developed, protected from daily flooding by river walls and from tidal surges by Thames Barrier. Contains many shipping related industries requiring operational access to river.	Raising river walls beyond 2030, setting development back from rivers edge.
Woolwich, Thamesmead & Charlton Riverside East	Straddling the Thames Barrier, protected from storm surges by raised river walls but with land lying significantly below high tide levels.	Raising river walls and embankments beyond 2030 for normal tides and tidal surges. Open spaces to be retained for potential flood storage.
Kidbrooke AFI	Substantial area within the River Quaggy flood plain. A recently completed river restoration scheme has increased flood storage.	Need to consider the role of multi purpose open spaces within a wider development zone.

2.3.5 Local planning policy

Following the introduction of the Planning and Compulsory Purchase Act 2004, the way in which development plans are prepared is changing. With the aim of speeding up and simplifying plan preparation and improving community involvement, development plans in their current form are to be abolished and replaced with a new development plan system, the LDF.

2.3.6 London Borough of Greenwich Unitary Development Plan

In July 2006 the London Borough of Greenwich adopted their Unitary Development Plan and covers the period 2001 to 2011, and in the case of the high level strategy in part 1, to 2016.

- E17 “All development will be controlled so as not to give rise to flooding or surface, groundwater or aquifer pollution. Surface water should be disposed of as close to source as possible, or attenuated before discharge to a watercourse or surface water sewer. Surface water should not be allowed to enter the foul system.”
- E18 “Areas within Zones 2 and 3 at risk from fluvial flooding are identified on the Proposals Map. Areas at risk from tidal flooding, but protected by existing flood defences, are shown on Map 7. Planning applications for development on sites of more than 1 hectare within these areas must be accompanied by a flood risk assessment appropriate to the scale of and nature of the development, the level of flood risk, and the protection afforded by the existing defences. Development in undeveloped areas at risk from fluvial flooding will only be permitted in exceptional circumstances. In developed areas at risk from fluvial flooding, development will only be permitted where appropriate flood defence measures are taken, and it can be demonstrated that there is no increased risk of flooding to other sites.”

These policies were developed prior to publication of PPS25, and therefore, as part of this SFRA, will require review and update following PPS25 and the Practice Guide Companion to PPS25.

The UDP will be replaced by the Local Development Framework, including the Core Strategy, which will cover the period 2010 to 2025.

2.4 Environment Agency policy

2.4.1 Thames Catchment Flood Management Plan (Environment Agency, 2007)

The Thames CFMP is a high level policy document covering the whole of the River Thames catchment (fluvial only). It aims to set policies for sustainable flood risk management covering the next 50 to 100 years.

The fluvial rivers in Greenwich (the River Ravensbourne, Quaggy and Kid Brook) form part of the Ravensbourne policy unit, for which the policy is to “take further action to sustain the current level of flood risk into the future (responding to the potential increases in risk from urban development, land use change and climate change). Environment Agency policy to managing flood risk in the long term is to therefore take action to ensure the flood risk does not increase from the current level.

The Ravensbourne policy unit is characterised by highly developed floodplains with little open space and modified river channels. The key messages for this type of catchment are outlined below:

- We need long-term adaptation of the urban environment. There are massive opportunities to reduce flood risk through redevelopment. In most areas we need to change the character of the urban area in the floodplain through re-development. It must be resilient and resistant to flooding and result in a layout that re-creates river corridors
- We are seeking to re-create river corridors through redevelopment so that there is space for the river to flow more naturally and space in the floodplain where water can be attenuated
- We will be seeking to build flood defences as redevelopment occurs and as part of an overall catchment plan. This is because more attenuation and more space in the river corridors are needed for defences to be sustainable. This is more complex but represents better value for society in the long-run even if it is more costly for the Environment Agency today
- These areas are very susceptible to rapid flooding from thunderstorms. Emergency response and flood awareness are particularly important

  Using these messages and the actions contained in the Ravensbourne action plan, the future flood risk management recommendations for Greenwich are as follows:
- Flood risk reduction should be sought through the application of PPS25. The Sequential Test should be used to locate new development in less risky areas. If the Exception Test is passed, development should be appropriate to the level of flood risk,

and design should aim to reduce risk (and residual risk), build in resilience and ensure the development is 'safe'.

- As sea levels rise due to climate change, the risk of tide-locking (when the fluvial Ravensbourne cannot drain into the tidal Thames) will increase. This has the potential to increase fluvial flood risk in the downstream areas of the Ravensbourne. In conjunction with the TE2100 project, investigate what to do when the current assets come to the end of their residual life or the tide-locking situation leads to unacceptable levels of protection.
- Riverside developments should be set back from rivers (8m in fluvial areas, 16m from the back of defences in tidal areas). They should look at opportunities for river restoration and reducing hard engineering structures. There should be a presumption against further culverting.
- SUDS are required on all new development. All sites greater than 1 ha in size require SUDS, greenfield discharge rates and on-site attenuation of a 1% annual probability event plus climate change. Space on land allocations should be set aside for SUDS.
- The functional floodplain should be defined, and greenfield functional floodplain protected from development.
- Areas that may be required for flood risk management in the future, including tidal flood storage areas, should be safeguarded.
- Sites where developer contributions could be used to fund future flood risk management schemes should be identified. Opportunities to make space for water to accommodate climate change should be looked at.
- SFRA should be used to inform the emergency planning process and educate local people to improve flood awareness.

2.4.2 The Thames Estuary 2100 Project (Environment Agency, ongoing)

The Thames Estuary 2100 (TE2100) Project is an Environment Agency initiative to develop a Flood Risk Management Plan for London and the Thames Estuary for the next 100 years, particularly looking at the effects of climate change scenarios beyond the original design life of the current tidal defences (2030). The TE2100 Project has split the Thames Estuary into 23 separate Policy Management Units (PMU) based upon the character of the local area and where the floodwaters would flow during a flood event. Each PMU offers different opportunities for managing flood risk, both at a local level and on an estuary-wide scale and has therefore been subject to a number of detailed studies and appraisals to assist TE2100 in identifying a flood risk management policy specific to the area.

Greenwich lies within the Bermondsey, Greenwich and Thamesmead PMUs. At present TE2100 are reviewing their initial set of flood risk management policies and so cannot commit to any specific policy, however it is likely that for Bermondsey and Greenwich PMUs the current level of flood risk management will be improved upon in order to ensure that the effects of climate change are mitigated against. For the Thamesmead PMU it is likely that action will be taken to ensure that the flood risk posed to people, property and essential infrastructure does not significantly increase with climate change. With this in mind, managing the consequences of flooding will become increasingly important and emphasis should be placed upon emergency planning and applying the sequential approach to new development when making land-use planning decisions.

2.4.3 Interim Position on Defining Safety Against Flood Risk

During the development of this SFRA, the Environment Agency issued an interim policy position with respect to development in areas of high residual flood risk. This accepts habitable rooms except sleeping accommodation being located below the 1 in 200 year breach, and places higher emphasis on non-structural measures, in particular emergency planning, to manage the residual risk. The Environment Agency has also informed the London Borough of Greenwich that it now takes a more advisory role with respect to the management of residual flood risk, and that the decision on what are appropriate responses to the residual flood risk in the Borough should now lie with the Borough itself. Consequently the requirements of the Interim Guidance should be seen as a starting point for the development of a policy for managing residual flood risk in the Borough.

This guidance document is reproduced in full in Appendix F (the design guidance for housing development in areas of high residual flood risk).

2.4.4 July 2007 Flood Review

The Environment Agency have produced a review of the summer 2007 floods, which includes some recommendations with potentially significant implications for flood risk management and drainage in England. The report has six recommendations, which are largely echoed by the final report of the Pitt Review (see section 2.5.1):

- Environment Agency should be given a strategic overview of inland flooding from all sources.
- Key utilities and public services must take responsibility for climate change proofing critical infrastructure, facilities and services.
- Flood risk management investment needs to increase to enable adaptation to climate change.
- Environment Agency to work with Met Office and other partners to develop flood warning techniques appropriate to severe weather events, for example leading to rapid flooding from surface water or minor watercourses.
- Environment Agency needs to ensure that its flood warnings trigger appropriate actions by businesses and the public.
- Multi-agency incident response plans need to consider the possible impact on critical infrastructure more effectively.

2.5 Additional documents of relevance

The Council and the SFRA should be informed by the wealth of strategies, plans and research studies covering flood risk in London and on the tidal River Thames.

2.5.1 The Pitt Review

The final report of the Pitt Review, set up in the wake of the flooding of summer 2007, was published in June 2008. Many of the review's recommendations have implications for local authorities, including planning, emergency planning, building control and drainage functions. The report contains 92 recommendations. Those with specific implications for local authorities are reproduced below. Whilst they are only recommendations, they do indicate a strong probability of significantly greater flood risk management responsibilities for Local Authorities. The recommended timetable for implementation of recommendations foresees all in place by the end of 2010, and many during 2008 and 2009.

- RECOMMENDATION 7: There should be a presumption against building in high flood risk areas, in accordance with PPS25, including giving consideration to all sources of flood risk, and ensuring that developers make a full contribution to the costs both of building and maintaining any necessary defences.
- RECOMMENDATION 8: The operation and effectiveness of PPS25 and the Environment Agency's powers to challenge development should be kept under review and strengthened if and when necessary.
- RECOMMENDATION 9: Householders should no longer be able to lay impermeable surfaces as of right on front gardens and the Government should consult on extending this to back gardens and business premises." (Note, this issue was covered in a Defra consultation on surface water drainage, due for publication in July 2008)
- RECOMMENDATION 10: The automatic right to connect surface water drainage of new developments to the sewerage system should be removed.
- RECOMMENDATION 11: Building Regulations should be revised to ensure that all new or refurbished buildings in high flood-risk areas are flood resistant or resilient.
- RECOMMENDATION 12: All local authorities should extend eligibility for home improvement grants and loans to include flood resistance and resilience products for properties in high flood-risk areas.

- RECOMMENDATION 13: Local authorities, in discharging their responsibilities under the Civil Contingencies Act 2004 to promote business continuity, should encourage the take-up of property flood resistance and resilience by businesses.
- RECOMMENDATION 14: Local authorities should lead on the management of local flood risk.
- RECOMMENDATION 15: Local authorities should positively tackle local problems of flooding by working with all relevant parties, establishing ownership and legal responsibility.
- RECOMMENDATION 16: Local authorities should collate and map the main flood risk management and drainage assets (over and underground), including a record of their ownership and condition.
- RECOMMENDATION 17: All relevant organisations should have a duty to share information and cooperate with local authorities and the Environment Agency.
- RECOMMENDATION 18: Local Surface Water Management Plans, as set out under PPS25 and coordinated by local authorities, should provide the basis for managing all local flood risk.
- RECOMMENDATION 19: Local authorities should assess and, if appropriate, enhance their technical capabilities to deliver a wide range of responsibilities in relation to local flood risk management.
- RECOMMENDATION 20: The Government should resolve the issue of which organisations should be responsible for the ownership and maintenance of sustainable drainage systems.
- RECOMMENDATION 26: The Government should develop a single set of guidance for local authorities and the public on the use and usefulness of sandbags and other alternatives, rather than leaving the matter wholly to local discretion.
- RECOMMENDATION 38: Local authorities should establish mutual aid agreements.
- RECOMMENDATION 41: Upper tier local authorities should be the lead responders in relation to multi-agency planning for severe weather emergencies.
- RECOMMENDATION 66: Local authority contact centres should take the lead in dealing with general enquiries from the public during and after major flooding,
- RECOMMENDATION 68: Council leaders and chief executives should play a prominent role in public reassurance and advice through the local media.
- RECOMMENDATION 76: Local authorities should coordinate a systematic programme of community engagement in their area during the recovery phase.
- RECOMMENDATION 83: Local authorities should continue to make arrangements to bear the cost of recovery for all but the most exceptional emergencies, and should revisit their reserves and insurance arrangements in light of last summer's floods.

2.5.2 Flooding in London (London Assembly Scrutiny Report, 2002)

The scrutiny report clearly identifies that London is vulnerable to flooding, whether it be tidal from the Thames, from rivers during periods of heavy rainfall or from the drainage system. These risks will also increase with the effects of climate change. The report also identifies that it is not feasible to simply construct further defences, but rather there is a requirement to manage floods better.

The scrutiny report identifies a total of 47 recommendations covering the provision of information to the public on flood risk, the requirement for funding for improvements to the Thames Barrier, the need to improve flood defences on London's rivers, the need to ensure that buildings are flood proofed and the need to improve our understanding of the scale of sewer flooding.

2.5.3 London under threat? Flooding risk in the Thames Gateway (London Assembly Scrutiny Report, 2005)

This report updates the previous London Assembly Scrutiny report in the light of planned development in the Thames Gateway and events such as Hurricane Katrina. In particular it identifies the value of Strategic Flood Risk Assessments for areas at flood risk in London.

2.5.4 London Flood Response Plan (London Resilience, 2007)

This is a special plan that complements the Strategic Emergency Plan for London, produced and maintained by the London Resilience Team. Its objective is to ensure a coordinated response to flooding, protecting life and well-being, with the mitigation of property and environmental damage as a strong supporting objective.

2.5.5 Floodscape (2006)

Floodscape is a four year (2002-2006) transnational project to develop innovative solutions to flood risk management, part funded by the INTERREG IIIB North West Europe Programme. It used pilot studies to demonstrate that flood risk management can be combined with other land uses in ways which are acceptable to the public and compatible with present and future spatial planning needs. It particularly examines the decision making process, communication with the public and integration of other European Directives with flood risk management.

2.5.6 Coastal Flood Risk: Thinking for Tomorrow, Acting Today (Association of British Insurers, 2006)

This report was compiled from the perspective of the insurance industry, an important player in terms of people's resilience to and recovery from floods.

With a background of the catastrophic 1953 east coast flooding, it assesses tidal flood risk on the east coast today and into the future with current climate change predictions. It makes recommendations for improving spending on coastal defences and for improvement in planning policy to enable insurers to continue to insure householders against flooding in the UK.

2.6 Summary

In accommodating future development in the London Borough of Greenwich, there is a range of planning policies to consider and balance on a national, regional and local level. Future development needs have been broadly specified in regional plans and are being refined on a local level in the emerging LDF.

The new PPS25 provides the overarching national guidance with respect to development and flood risk, emphasising the need to effectively manage flood risk within the planning system, rather than relying on reactive solutions to flooding. This includes a responsibility for LPAs to reduce flood risk to people and property as a result of new development. It also identifies the preparation of SFRAs as a key process in the understanding and management of flood risk for planning purposes.

It is widely recognised that flood risk is one of a whole raft of policy constraints placed upon the local planning system. Development must facilitate the socio-economic needs of a community, and spatially must sit within an existing framework of landscape and infrastructure. For this reason, a balance must be sought between development need and the risk it may pose upon existing and future dwellers of the area as a result of flooding.

The aim of this SFRA is to provide a better understanding of flood risk in the London Borough of Greenwich that can feed into the emerging LDF and enable informed and balanced planning decisions to be made.

3 Approach to Strategic Flood Risk Assessment

3.1 Overview

The SFRA is a planning tool that can be used to inform the spatial planning process. The SFRA should be used to refine the information relating to the areas within the Borough which may flood, taking into account all sources of flooding and climate change. This information should form the basis of the Borough's future flood risk management policies. In addition the SFRA will inform the LDF, and provide the information to enable the Sequential and Exception tests to be applied during the site allocation and development control process. Land can be separated into four distinct Flood Zones which are at risk from different probability river (fluvial) and/or tidal flooding events.

Flood Zone 1 indicates areas with a 'low' probability of inundation from tidal or fluvial sources, defined as an annual probability of flooding of less then 0.1%. This may also be referred to as a return period of greater than 1000 years. Flood Zone 1 essentially covers everywhere outside of Flood Zones 2 and 3.

It is important to remember that the 'low' probability classification only refers to tidal and fluvial flood risk. Flood risk from other sources, such as groundwater, surface water and sewer flooding may also be present (see Section 6).

Flood Zone 2 indicates areas with a 'medium' probability of flooding from tidal or fluvial sources, defined as an annual probability of flooding of between 0.1% and 1% in fluvial areas (a return period of between 100 and 1000 years) and 0.1% to 0.5% in tidal areas (a return period of between 200 and 1000 years)

Flood Zone 3a indicates areas with a 'high' probability of flooding from tidal or fluvial sources, defined as:

- An annual probability of fluvial flooding of 1% or greater. This may also be referred to as a return period of 100 years or less.
- An annual probability of tidal flooding of 0.5% or greater. This may also be referred to as a return period of 200 years or less.

Where these two overlap, the one with the greatest extent defines the Flood Zone. Flood Zone 3a is entirely within the boundaries of Flood Zone 2.

Flood Zone 3b indicates the 'functional floodplain', defined as an area of land where water has to flow or be stored in times of flood. This is usually taken to be either the envelope defined by the 5% annual probability of flooding, also referred to as a return period of 20 years or less or an area that is designed to flood in a more extreme event.

It should be noted that Flood Zones do not take account of the presence of flood defences.

The Environment Agency publicly publishes maps of Flood Zone 2 and Flood Zone 3 on their website (www.environment-agency.gov.uk).

In line with PPS25 guidelines, the Environment Agency recommend that site allocations should be made outside of the flood risk areas (i.e. in Flood Zone 1) wherever possible. If there are no reasonably appropriate Flood Zone 1 sites, site allocations should be made in Flood Zone 2 first, considering flood risk vulnerability of land uses. Only where there are no reasonably available sites in Zones 1 or 2 should Flood Zone 3 site allocations be made. In order to demonstrate that there are no lower risk sites available the Sequential Test needs to be carried out.

3.1.1 Sequential Test

PPS25 provides the basis for the sequential approach, it recommends that LPAs use a risk based approach to development planning and specifies the need for undertaking RFRAs and SFRAs in Annex E.

When allocating or approving land for development in flood risk areas, those responsible for making development decisions are expected to demonstrate that there are no suitable alternative development sites located in lower flood risk areas.

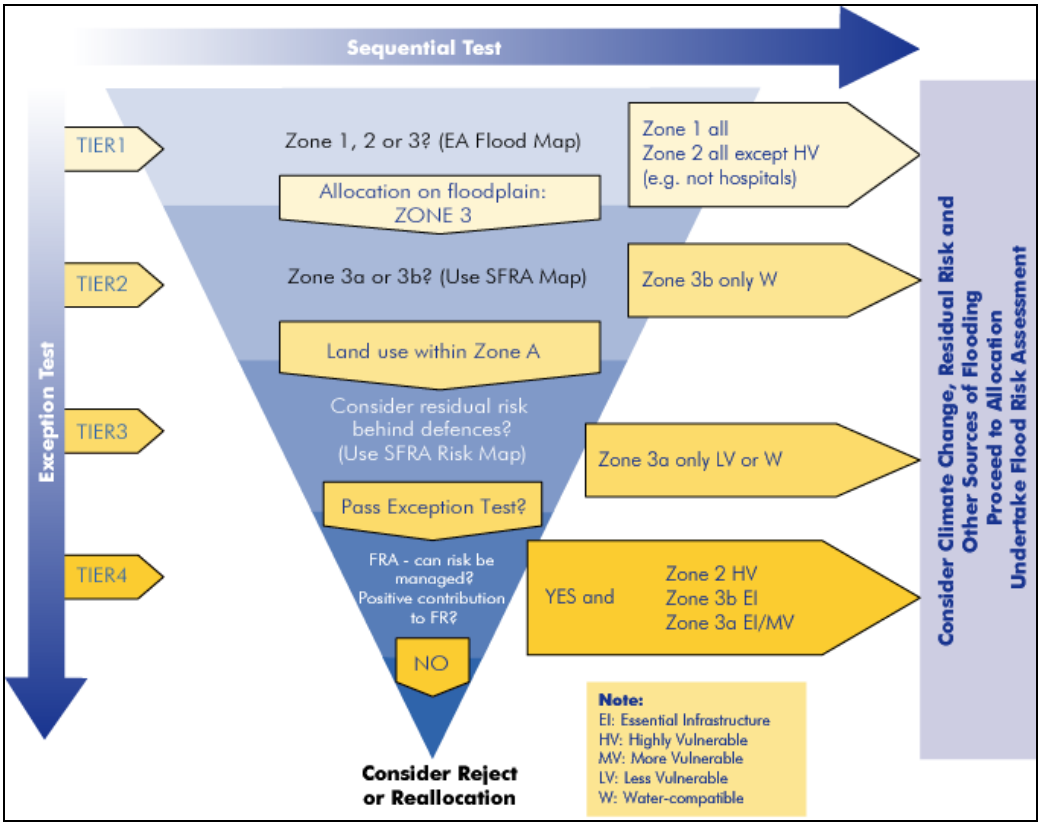
The methodology introduces a Sequential Test that is core to the SFRA process (Figure 3-1). The Sequential Test is the key driver for the SFRA. The Environment Agency Flood Zone Map will provide the basis of the test, which will be undertaken a number of times, considering a greater resolution and understanding of flood risk at each stage taking into account flooding from other sources. At each step, sites of lower flood risk are identified and prioritised in order of vulnerability to flood risk (Table 3-1) and their safety in terms of allocation for development.

A further level of analysis may be required where development is planned behind or adjacent to existing defences in order to test the sustainability and robustness of the mitigation measures.

This SFRA provides the Council with Flood Zone classifications for all present locations identified for development as well as the information required to classify future allocations. The information provided by the SFRA will assist the Council in developing their LDFs and prioritise allocations.

The Council will be required to prioritise the allocation of land for development in ascending order from Flood Risk Zone 1 to 3, including the subdivisions of Flood Risk Zone 3, if necessary. The Environment Agency has statutory responsibility and must be consulted on all development applications allocated with medium and high risk zones, including those in areas with critical drainage problems and for any development on land exceeding 1 hectare outside flood risk areas. In these circumstances, the Environment Agency will require the Council to demonstrate that there are no reasonable alternatives, in lower flood risk categories, available for development. Where appropriate, the Exception Test is to be applied.

Figure 3-1 The Sequential Test: its practical application



3.1.2 The Exception Test

Where departures from the Sequential Test are justified by the need to locate development in higher risk zones than is appropriate, in order to meet the wider aims of sustainable development, it is necessary to apply the Exception Test. PPS25 acknowledges that flood risk is one of many issues (including transport, housing, economic growth, natural resources, regeneration and the management of other hazards) which need to be considered in spatial planning.

The Exception Test is “only appropriate for use when there are large areas in Flood Zones 2 and 3, where the Sequential Test alone cannot deliver acceptable sites, but where some continuing development is necessary for wider sustainable development reasons, taking into account the need to avoid social or economic blight and the need for essential infrastructure to remain operational during floods.” It may also be appropriate to use it where restrictive national designations such as landscape, heritage and nature conservation designations, e.g. Green Belt areas, Areas of Outstanding Natural Beauty (AONBs), Sites of Special Scientific Interest (SSSIs) and World Heritage Sites (WHS), prevent the availability of unconstrained sites in lower risk areas.

PPS25 explains where and for what type of development the Exception Test needs to be applied. In some situations, for certain types of development, it is not appropriate to use the Exception Test to justify development, for example, development which is highly vulnerable to flooding cannot be justified within the high risk zone through the use of the Exception Test. The situations where it is necessary and appropriate to apply the Exception Test are outlined below.

Where the Exception Test is required, it should be applied as soon as possible to all Local Development Document (LDD) allocations for development and all planning applications other

than for minor development[1]. All three elements of the Exception Test have to be passed before development is allocated or permitted. For the Exception Test to be passed:

a. *It must be demonstrated that the development provides wider sustainability benefits to the local community that outweigh flood risk, informed by an SFRA, where one has been prepared. If the Development Plan Document (DPD) has reached the 'submission' stage – see Figure 4 of PPS12: Local Development Frameworks – the benefits of the development should contribute to the Core Strategy's Sustainability appraisal.*
b. *The development should be on developable previously developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable, previously developed land; and*
c. *A Flood Risk Assessment must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.*

PPS25 (paragraphs D11 and D12) states that the Exception Test "should be applied to LDD site allocations for development and used to draft criteria-based policies against which to consider planning applications…Where the Exception Test has been applied in LDD allocations or in criteria-based policies, the local planning authority should include policies in its LDDs to ensure that the developer's FRA satisfies criterion C".

Compliance "with each part of the Exception Test should be demonstrated in an open and transparent way".

Table 3-2 summarises the applicability of the Exception Test for different development sites; housing allocations are classified as 'more vulnerable' and employment allocations are 'less vulnerable'.

3.1.3 Flood Risk Vulnerability Classification

In PPS25 different types of development are divided into five flood risk vulnerability classifications:

- Essential infrastructure
- Highly vulnerable
- More vulnerable
- Less vulnerable
- Water compatible development.

Subject to the application of the Sequential Test, PPS25 specifies which of these types of development are suitable within each zone:

Zone 1: All the uses of land listed above are appropriate in this zone.

Zone 2: The water-compatible, less vulnerable and more vulnerable uses of land and essential infrastructure are appropriate in this Zone. The highly vulnerable uses are only appropriate in this zone if the Exception Test is passed.

Zone 3a: The water-compatible and less vulnerable uses of land are appropriate in this zone. The highly vulnerable uses should not be permitted in this zone. The more vulnerable and essential infrastructure uses should only be permitted in this zone if the Exception Test is passed.

Zone 3b: Only the water-compatible uses and the essential infrastructure that has to be there should be permitted in this zone. Essential infrastructure in this zone should pass the Exception Test and be designed and constructed to meet a number of flood risk related

[1] Definition of minor development:

-Minor non-residential extensions: Industrial/Commercial/Leisure etc. extensions with a footprint less than 250m2

-Alterations: development that does not increase the size of buildings e.g. alterations to external appearance.

-'Householder' development: e.g. sheds, garages, games rooms etc. within the curtilage of the existing dwelling in addition to physical extensions to the existing dwelling itself. This definition EXCLUDES any proposed development that would create a separate dwelling within the cartilage of the existing dwelling e.g. subdivision of houses into flats.

targets. The less vulnerable, more vulnerable and highly vulnerable uses should not be permitted in this zone.

Table 3-1 Flood Risk Vulnerability Classification

Vulnerability	Type of use
Essential Infrastructure	• Essential transport infrastructure and strategic utility infrastructure, including electricity generating power stations and grid and primary substations.
Highly Vulnerable	• Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations and 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 dwellings, student halls of residence, drinking establishments, nightclubs, hotels and sites used for holiday or short-let caravans and camping. • Non–residential uses for health services, nurseries and education. • Landfill and waste management facilities for hazardous waste.
Less Vulnerable	• Buildings used for shops, financial, professional and other services, restaurants and cafes, offices, industry, storage and distribution, 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). • Water treatment plants and 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. • Essential sleeping or residential accommodation for staff required by uses in this category, subject to a warning and evacuation plan.

Notes:

This classification is based partly on DEFRA/Environment Agency research on Flood Risks to People (FD2321/TR2) and also on the need of some uses to keep functioning during flooding.

Buildings that combine a mixture of uses should be placed into the higher of the relevant classes of flood risk. Developments that allow uses to be distributed over the site may fall within several classes of flood risk sensitivity.

The impact of a flood on the particular uses identified within this flood risk vulnerability classification will vary within each vulnerability class. Therefore, the flood risk management infrastructure and other risk mitigation measures needed to ensure the development is safe may differ between uses within a particular vulnerability classification.

(Source: PPS25 Table D2)

Table 3-2 Flood risk vulnerability and Flood Zone compatibility

Vulnerability classification		Essential Infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less Vulnerable
Flood Zone	Zone 1	✔	✔	✔	✔	✔
	Zone 2	✔	✔	Exception Test	✔	✔
	Zone 3a	Exception Test	✔	x	Exception Test	✔
	Zone 3b	Exception Test	✔	x	x	x

Key: ✔ Development is appropriate x Development should not be permitted

(Source: PPS25 Table D3)

The SFRA was carried out as one study, divided into two stages: Level 1 and Level 2. The following sections outline the approach taken and the scope of each stage.

3.2 Level 1 – Scoping Study SFRA

A Level 1 SFRA should be sufficiently detailed to allow the application of the Sequential Test and to identify whether the Exception Test is likely to be necessary[2]. Existing data was used to make an assessment of flood risk from all sources now and in the future.

3.2.1 Data collection and review

A critical phase in the project delivery was the collection and review of existing data. The data sought related predominantly to known or perceived flood risk issues within the area, development pressures and constraints, and current policy governing development within flood risk affected areas.

3.2.2 Assessment of current fluvial and tidal flood risk

Flood risk within Greenwich was assessed, categorised and mapped to a level concurrent with the nature and availability of existing data. In general, however, the following key considerations were addressed:

- Identification of known and/or perceived flood risk areas, providing the initial 'filter' for key flood risk issue areas within the Borough.
- Review of current Flood Zone Map and existing 1D hydraulic models, providing the broad (first pass) definition of High Risk Zone 3.
- Identification of critical floodplain areas and significant structures.
- Location and definition of the standard of existing defences and identification of areas that may be at risk from defence failure, requiring further investigation in Level 2.
- Identification of developing areas contributing to ordinary watercourses and/or known flooding issue areas to ensure impact upon upstream and downstream properties is adequately considered (irrespective of flood risk posed to proposed development).
- Definition of areas subject to development pressure and/or regeneration.
- Definition of the functional floodplain

3.2.3 Review climate change and land use management impact

Climate change and associated sea level rise has the potential to significantly increase the consequences of flooding, and consideration was given to the sustainability of new development under climate change and more extreme events. The future flood extents allowing for climate change were delineated using standard Defra guidelines.

Consideration was given to the implications of wider land management practices on flood risk in the area. This was based on existing information such as the Thames CFMP.

[2] Communities and Local Government, (June 2008). PPS25 Development and Flood Risk: A Practice Guide. p47.

3.2.4 Assess flood risk from 'other sources' and potential for Sustainable Urban Drainage Systems (SUDS)

This stage provided an indication of overland flow routes and areas prone to surface water flooding and sewer flooding. The assessment focused on storm events that exceed the available capacity of surface water systems and is particularly useful when assessing potential sources of flood risk associated with windfall sites.

3.3 Level 2 – Increased Scope SFRA

According to the Practice Guide[3], the principle purpose of the Level 2 SFRA is to facilitate the application of the Exception Test. It considers the detailed nature of flood hazard taking account of the presence of flood risk management measures such as flood defences. This also allows a sequential approach to site allocation within the Flood Zones.

3.3.1 Assessment of 'residual' risk

Further investigation was undertaken in areas protected by flood defences to allow a risk based approach to strategic planning. Tidal flooding from the River Thames is contained by the Thames Barrier and flood defences.

Modelling was carried out to provide an assessment of what is at risk with the defences in place, termed 'residual risk', which is more useful for planning and regeneration purposes. The SFRA examined the probability, depth, velocity and rate of onset of flooding if defences are breached or overtopped. The risk to people will be assessed according to Defra R&D document FD2320[4].

3.3.2 Establishment of Guidance for LPA and Developers at Planning Application Stage

Concise and pragmatic guidance has been developed to assist the council and developers to ensure that the outcomes and recommendations of the SFRA are followed through to the planning application and implementation stage.

It is imperative to ensure that the requirements placed upon developers at planning application are robust and fit for purpose. Similarly, the ownership, roles and responsibilities of the LPA and Environment Agency as appraisal bodies must also be clearly understood to ensure that the intent of the SFRA and planning process are not lost.

[3] Communities and Local Government, June 2008, PPS25: Development and Flood Risk Practice Guide.

[4] Defra/Environment Agency, 2005, Flood Risk Assessment Guidance for New Development. R&D Technical Report FD2320/TR2.

4 Data sources

4.1 Flood Zones

The Environment Agency Flood Zone maps show the areas at risk from extreme events from river (fluvial) and tidal flooding.

The Flood Zone maps were prepared using a methodology based on the national digital terrain model (NextMap), derived river flows (Flood Estimation Handbook (FEH)) and two dimensional flood routing.

The theoretically derived Flood Zone extents have been adjusted in some locations where the results are inconsistent with historical flooding extents, more detailed flood mapping studies are available or where there are known errors in the digital terrain model. In Greenwich, the fluvial Flood Zones have already been updated with the results of detailed flood mapping studies (for example the Ravensbourne modelling, 2010). The Thames tidal Flood Zones have also been remodelled using the Thames ISIS model and TUFLOW flood routing.

The Environment Agency Flood Zone maps are precautionary in that they do not take account of the Thames Barrier or flood defences and, therefore, represent a worst-case extent of flooding. The actual extent of flooding is mitigated by flood defences. Map 1 shows the extent of Flood Zone 2 and 3, for an undefended situation, across the Borough.

4.2 Flood defences

As discussed above the Environment Agency Flood Zone maps **do not take account of the presence of flood defences**. PPS25[5] states that defended areas (i.e. those areas that are protected to some degree against flooding by the presence of a formalised flood defence) are still at risk of flooding, and therefore sites within these areas must be assessed with respect to the adequacy of the defences.

The Environment Agency's National Flooding and Coastal Defence Database (NFCDD) has been supplied and provides information about existing defences in the area, as well as categorising them by type and providing information on who owns and maintains them. Areas Benefiting from Defences (ABDs) have also been provided. ABDs are those areas which benefit from formal flood defences in the event of flooding from rivers with a 1% chance in any given year or from the sea with a 0.5% chance in any given year. If the defences were not there, these areas would be flooded. These two datasets are shown on Map 2.

4.3 Hydraulic modelling studies

4.3.1 Thames ISIS model

An Environment Agency ISIS model covers the Tidal Thames within the study area, from which the Environment Agency provided water levels from Deptford to King George V Docks downstream of the Thames Barrier for 2005, 2055 and 2107. Present day modelled water levels are shown in Table 4-1. The predicted modelled levels are based on a joint probability analysis of fluvial flows, storm surges in the North Sea and barrier closure events. These predicted model levels were published in May 2008 and take account of current Defra guidance for climate change allowances. The ISIS model used had an expected accuracy of ± 0.2m.

For this SFRA therefore, the present day and 2107 modelled levels from the report will be used.

[5] Communities and Local Government. 2006 Planning Policy Statement 25: Development and Flood Risk. Annex G para G2.

Table 4-1 Modelled water levels (mAOD) for the tidal Thames as supplied by the Environment Agency (updated May 2008)

Node label	Name	Return period (years) 2005 condition						
		10 (10%)	20 (5%)	50 (2%)	100 (1%)	200 (0.5%)	500 (0.2%)	1000 (0.1%)
2.42u	Deptford	4.708	4.748	4.786	4.81	4.828	4.848	4.863
2.43	Cutty Sark	4.688	4.725	4.764	4.786	4.806	4.824	4.837
2.44	Isle of Dogs	4.676	4.715	4.754	4.774	4.794	4.814	4.825
2.47	Bugsby Reach	4.633	4.671	4.708	4.73	4.747	4.767	4.779
a2.49	u/s Barrier	4.607	4.644	4.679	4.703	4.72	4.741	4.751
a3.1	d/s Barrier	5.349	5.55	5.822	6.04	6.258	6.528	6.734
3.4	King George V Dock	5.315	5.508	5.762	5.966	6.174	6.432	6.63
a3.5u	u/s Roding	5.313	5.503	5.75	5.949	6.153	6.41	6.606

Source: "Modelled water levels.xls" supplied by Environment Agency, May 2008.

4.3.2 River Ravensbourne Flood Mapping Study, 2006

The River Ravensbourne is covered by a 2006 modelling study managed by the Environment Agency. The Ravensbourne Flood Mapping Study was undertaken by Halcrow. It covers the River Ravensbourne and its tributaries the Kid Brook and Quaggy, which partly lie within the SFRA study area. Some details of the study have been supplied by the Environment Agency, including the modelling report and GIS layers of flood outlines and water depths and velocities on the floodplain. The flood outline data provided for these watercourses includes the 25, 100 year and 100 year plus 20% (climate change) for a defended scenario. The modelling was undertaken using ISIS and TUFLOW models. The modelling from this study differs from the results of the 2000 modelling study as the 2006 extents take account of the defences in place along the Ravensbourne. The area covered by the 2006 modelling is shown in Figure 4-1.

River Ravensbourne Modelling Review, 2009

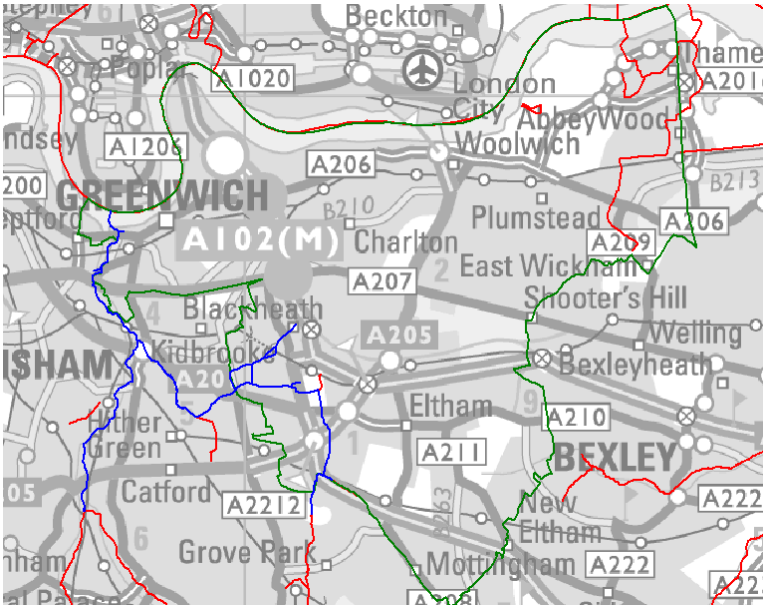
The River Ravensbourne Flood Mapping Study was reviewed in 2009 to take account of the new data available, and advancements in modelling techniques since the original study.

Notable amendments included:

- Conversion of the existing October 2006 model from mainly ISIS with some reaches of TUFLOW combined with ISIS and/or ESTRY to a full ISIS/TUFLOW/ESTRY model.
- Extension of the model to include a number of ex-Critical Ordinary Watercourses (now Main River) that were omitted from the previous study.
- Updating the existing model to incorporate the findings of recent surveys.
- Incorporating the recommendations of the April 2009 Edenvale Independent Review.
- Revising the hydrology through verification with PDM hydrology.

The outputs from this 2009 review have been used for this SFRA.

Figure 4-1 Extent of River Ravensbourne and tributaries hydraulic models



Background Map © Bartholomews

Borough Boundary Main River Modelled Reach

4.4 Topographic data

4.4.1 Digital elevation models

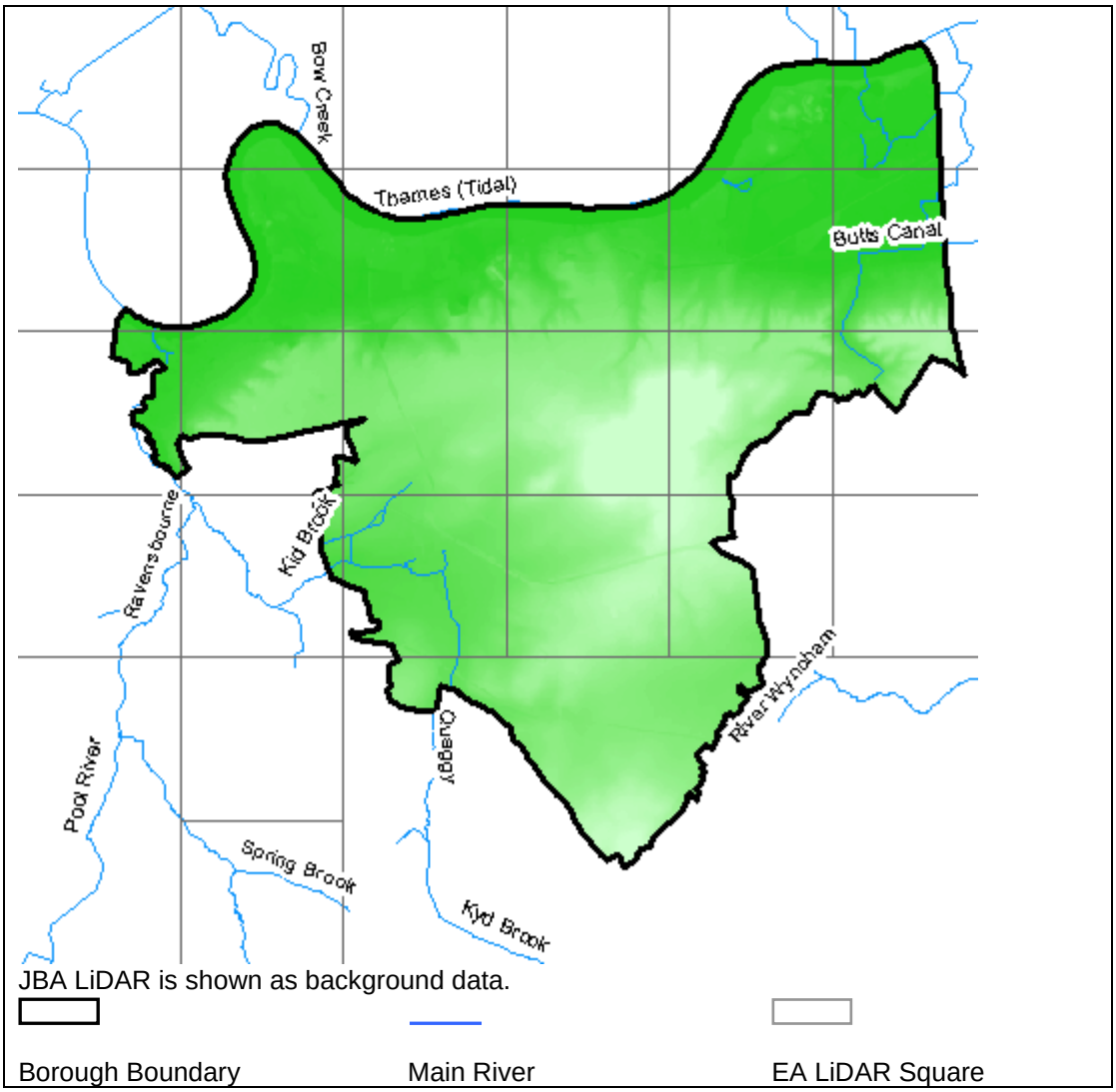
An essential dataset required for flood modelling and mapping is a Digital Elevation Model (DEM). A DEM is a representation of the topography of an area that gives the elevation of the upper surface whether it is the ground, vegetation or a building. There are three main sources of DEM data for Greenwich, as shown in Table 4-2.

Table 4-2 DEM availability

Data type	Owner	Resolution	Filtering	Coverage of Greenwich
NextMap SAR	Environment Agency	5m	Filtered	100%
LiDAR	Environment Agency	1-2m	Filtered and unfiltered	78%
LiDAR	JBA	5m	Filtered	100% (within M25)

LiDAR will be used in preference to NextMap SAR data as it has a higher vertical accuracy. The coverage of the LiDAR datasets available is shown in Figure 4-2. It will be necessary to use both the Environment Agency and JBA LiDAR to obtain full coverage of the catchment. Map 3 shows the topography of the Borough.

Figure 4-2 LiDAR coverage in Greenwich



4.5 History of flooding

A summary of the flood events about which information has been found is given in Table 4-3. This should not be considered a comprehensive list and there may well have been more events, particularly pre 20th century. Historic flooding information, where the flood extent has been mapped, is shown on Map 4. There are a variety of sources of flood history that can be consulted to build up a history of flooding in an area; sources of information for the Greenwich SFRA include:

- The British Hydrological Society's website, Chronology of British Hydrological Events[6]
- Internet searches;
- Reports, photographs, flood level records and maps compiled for more recent events by the Environment Agency and its predecessors.
- Previous studies, such as the River Ravensbourne Flood Mapping Study carried out by Halcrow.

[6] BHS Chronology of British Hydrological Events, http://www.dundee.ac.uk/geography/cbhe/

Table 4-3 Flood history for London Borough of Greenwich

Date	Type of flooding	Location	Source of information
1236	Tidal	Woolwich	CBHE
1809	Fluvial	Along the River Ravensbourne, particularly Lewisham and Deptford.	River Ravensbourne FRM study
November 1875	Tidal	River Thames overflowed from Gravesend to its tidal limit.	CBHE
1866	Fluvial	Along the River Ravensbourne, particularly Lewisham.	River Ravensbourne FRM study
April 1878	Fluvial	Along the Quaggy River.	CBHE
October 1882	Tidal	Flooding of areas adjacent to the River Thames.	CBHE
1928	Tidal	Flooding of areas adjacent to the River Thames.	Environment Agency
March 1947	Fluvial	Widespread flooding in River Thames catchment	Environment Agency Washlands FSA Improvement Works Report
1953	Tidal	Thamesmead	http://en.wikipedia.org/wiki/Thamesmead
September 1958	Fluvial	Along the Quaggy River	Environment Agency Washlands FSA Improvement Works Report; http://www.environment-agency.gov.uk/commondata/acrobat/ea0226_open_sod.pdf
1965	Fluvial	Sutcliffe Park	Environment Agency
September 1968	Fluvial	Quaggy catchment	http://www.environment-agency.gov.uk/commondata/acrobat/ea0226_open_sod.pdf
1977	Fluvial	Along the Quaggy River	River Ravensbourne FRM study
1992	Fluvial	Along the Quaggy River	http://www.defra.gov.uk/news/2007/070605a.htm
1993	Fluvial	Along the Quaggy River	http://www.defra.gov.uk/news/2007/070605a.htm
Summer 1996	Fluvial	Kid Brook at Thomas Tallis School	Thomas Tallis School FRA, August 2007
June 2000	Groundwater	Shooters Hill	Environment Agency
August 2000	Groundwater	Abbey Wood	Environment Agency
November 2000	Groundwater	Eltham	Environment Agency
January 2001	Groundwater	Eltham	Environment Agency
February 2001	Groundwater	Plumstead	Environment Agency
April 2001	Groundwater	Eltham	Environment Agency
June 2001	Groundwater	Woolwich	Environment Agency
March 2002	Groundwater	Shooters Hill	Environment Agency
January	Groundwater	Eltham	Environment Agency

Date	Type of flooding	Location	Source of information
2004			
September 2005	Surface Water	Abbey Wood	London Borough of Greenwich
June 2006	Fluvial	Kid Brook at Thomas Tallis School	Thomas Tallis School FRA, August 2007
July 2007	Surface Water	Abbey Wood	http://www.newsshopper.co.uk/news/topstories/display.var.1561215.0.flash_floods_hit_news_shopper_area.php

4.6 Previous flood risk studies covering Greenwich

4.6.1 Flood Risk Assessments

There will have been numerous flood risk assessments carried out for development proposals in the past within the London Borough of Greenwich:

- **Redevelopment of Thomas Tallis School FRA** – Produced in August 2007 for the London Borough of Greenwich, this covers the proposed development area to the west of the Borough, adjacent to the Kid Brook and partly in Flood Zone 2.
- **Greenwich Millennium Village Phases 3, 4 & 5 FRA** – Produced in January 2005 for the site on the Greenwich Peninsula. The site is shown to be in Flood Zone 3a but is protected by defences.
- **Lovells, Granite, Pipers Badcock Wharf FRA** – Produced in June 2006. The site is within Flood Zone 3a of the River Thames but is protected by defences.
- **The Warren, Royal Arsenal, Woolwich FRA** – Produced in September 2005 for the site to the east of Woolwich ferry crossing. This covers the development by Berkeley Homes which is within both Flood Zone 3a but is protected by the Thames tidal defences and Flood Zone 3b.
- **Tripcock Point FRA** – Produced in July 2005 for a site in the Thamesmead area, adjacent to the River Thames. The site is in Flood Zone 3a but is protected by the Thames tidal defences.
- **Creekside Village East FRA** - Produced in for a site alongside Deptford Creek. The site is in Flood Zone 3a but is protected by the Thames tidal defences.
- **Greenwich Peninsula FRA** - Produced in for a site on the south bank of the River Thames on the Greenwich Peninsula. The site is protected by the Thames tidal defences.

4.6.2 Tilfen Land (2003) Thamesmead Lakes and Canals - Storm water drainage capacity review

Tilfen Ltd (previously Thamesmead Town) is the landowner / development facilitator of the majority of the area included in the study. In the study this area is referred to as 'Thamesmead'; however in practice the area covered by the study is only part of the geographic area known as Thamesmead (Figure 4-3).

The study which began in the 1970's, and had its most recent review in 2003, was visionary in its approach and contains the essence of SUDS. The study devised a network of lakes and canals which would be built in line with development to manage the additional drainage from new development.

This approach has provided Tilfen, developers of the individual areas and the EA with an agreed, simple way to deal with surface water runoff over many years. The principles are still currently accepted within FRAs for developments in the area.

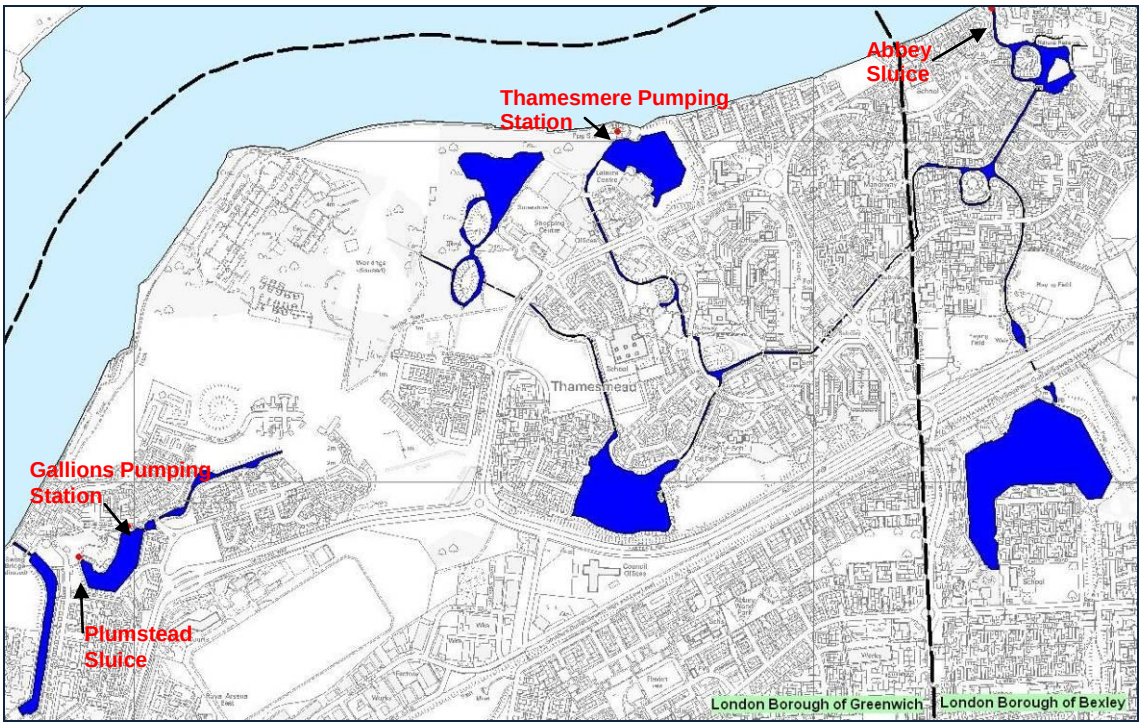
As development has progressed in the area so has the construction of a series of canals and lakes which act together and provide a large amount of surface water attenuation storage.

The features of the scheme provide additional environmental, ecological and aesthetic benefits, plus to benefits to groundwater as a result of minimising tanked attenuation solution.

In 2003 the current drainage capacity of the Thamesmead lakes and canals was reviewed to ensure it could accommodate additional runoff from future development. It assessed the capacity based on a short intense summer storm occurring at high tide (no discharge from sluices) over the 492ha of developable land. The study used a 1 in 200 year storm and modelled two different durations, 3.5 hours and 4.5 hours. The study concluded that the existing system had adequate capacity to accommodate runoff from existing development areas. Nevertheless, there is scope for future development of the lake and canal storage system, as presently the final system proposed by Tilfen does include making use of a link canal and Gallions Lake to the west. It is important that additions to the lakes and canals system are progressed in accordance with future development of the Thamesmead area to ensure a continued high level of flood protection.

This study is nearing the end of its life; a review is required to enable the continued use of this study. In the future it is highly recommended that this study be revised on the basis that it currently does not consider climate change, and only considers 3.5 and 4.5 hour duration storms (longer duration storms would need to be assessed). Additionally, the study relies on three out of four pumps working and no blockage. Therefore there is still a risk from blockage, under capacity structures or pumping station failure.

Figure 4-3 Lakes and canals network, Thamesmead



4.7 Other evidence of flood risk from all sources

Historical flooding events and issues of flood risk from other sources have been identified and assessed utilising a number of information sources as identified below.

4.7.1 Groundwater Flooding

There have been several reported incidents of groundwater flooding to the Environment Agency since 2000 and these are summarised in Map 5. The incidents range from springs appearing in gardens to periodic flooding of properties. Seven of the flooding incidents occurred in areas with bedrock of the London Clay formation. Three incidents occurred in areas of Lambeth and Harwich formations associated with sand and silt and sand and gravel respectively. The remaining incident occurred in an area of chalk formation.

4.7.2 Sewer Flooding

Thames Water was able to provide information regarding sewer flooding events over the past ten years on a broad scale. The information was provided on postal area basis, no specifics were provided as this went against the data protection of Thames Water's customers. In the London Borough of Greenwich there has been one sewer flooding event in the postal area of "SE9 5".

The Thames Water catchment planner covering the Crossness Sewage Treatment Works catchment, which contains Greenwich, was contacted for information regarding the Southern Outfall Sewer (SOS)[7] . Running from Plumstead to Crossness (London Borough of Bexley) within an embankment containing the two Southern Outfall sewers numbers 1 and 2, and Southern High Level Number 2, each 11'6" diameter brick sewers. Thames Water have not undertaken any specific flood risk assessments of the consequences of a major structural failure of the embankment.

4.7.3 Surface Water Flooding

The London Borough of Greenwich provided information on an incident of storm drain surcharge flooding, reported to them on 10 September 2005 in the Abbey Wood area of Thamesmead. Seven residential properties were affected by flooding including sludge and debris. The damage included electrical failure and furniture damage and resulted in the need for two persons to be rehoused. The Abbey Wood (including Boxgrove Road) and Belvedere (including Mitchell Close) areas of the Borough were also affected by flooding in July 2007.

Surface water runoff in part of the Thamesmead area of Greenwich is managed by a series of lakes and canals which provide flood retention and storage and ensure runoff is discharged to the River Thames by means of sluices and pumping stations. However, there is still a risk from blockage, under capacity structures or pumping station failure.

4.7.4 Artificial Sources of Flooding

There are two pumping stations located within the London Borough of Greenwich (Map11), Gallions and Tripcock. These pumping stations pump water out of the numerous drains and canals that run through Thamesmead. Failure of these pumping stations combined with an extreme rainfall event could result in flooding across the low lying area of Greenwich.

4.7.5 Reservoir Flooding

There are five covered reservoirs within the London Borough of Greenwich. Two are located at Woolwich Common; the other three are located in Greenwich Park, Castlewood and Oxleas Wood. Map 11 shows the location of the reservoirs. Table 4-4 provides all the information we have been able to acquire on the reservoirs in the Borough.

Large raised reservoirs with more than 25,000m3 are subject to stringent safety measures under the Reservoirs Act 1975. The Water Act 2003 introduced a new requirement for reservoir undertakers (owners, operators or users) to produce flood plans for their reservoirs. It is currently proposed that all reservoirs covered by the Reservoirs Act 1975, where the dam failing could put people's lives at risk or lead to major damage will need to have a reservoir flood plan. It is proposed that the plan will include the following:

- Full inundation analysis. This will provide a plan of the area inundated and information on velocities and depths of flow.
- On-site emergency plan. This will set out what the undertaker would do in an emergency to try to prevent the dam failing.
- Plan for liaising with external organisations. This will set out and test communication channels between the undertaker and the local authority emergency planning officer, the emergency services and the Environment Agency.

However, it is not thought that any of the reservoirs located within the Borough are large enough to fall under the Reservoir Act. Therefore those who administer the reservoir have a duty of care for the reservoir safety.

[7] Telephone conversation, Keith Barron, Thames Water, 09/05/2008.

Table 4-4 Details of Reservoirs

Reservoir	Details	Administrator	Covered by Reservoir Act
Woolwich Common (Academy Road)	Planning permission granted November 2006 for infill of existing reservoir and temporary use of site as a construction compound.[8]	Unknown	No
Woolwich Common b	Unknown	Unknown	Unknown
Greenwich Park	Constructed 1841-44, covered over in 1871. Currently not operational.	Thames Water	No
Castlewood	Two 7 mega litre compartments. Footprint 81m x 35.5m, Floor level 97.9m AOD, Max depth 5.5m. 450 and 600m diameter Inlet and outlet pipelines underground from reservoir to existing pipework.	Unknown	No Compartments can hold 7,000 m3 each
Oxleas wood	Approximately 18 million gallon capacity[9] (81,829 m3)	Unknown	Yes

[8] Information provided by LBG - Ref 06/2390.

[9] Information provided by LBG from 1987 Council Document

5 Fluvial flood risk

5.1 Introduction

This section assesses risk in Greenwich from fluvial flooding, now and in the future, this does not relate to the River Thames, which is 'tidal flooding' and is addressed in Chapter 7. It makes use of all the data and information described in Section 4. It defines the fluvial Flood Zones 1, 2, 3a and 3b, providing enough information for the Council to perform the Sequential Test for these areas.

Flood Zones 1, 2, and 3 delineate areas of risk from both tidal and fluvial flooding.

- Flood Zone 1: Low Probability. This zone comprises of land assessed as having a less than 1 in 1000 annual probability of flooding in any year (<0.1%).
- Flood Zone 2: Medium Probability. This zone comprises of land assessed as having between a 1 in 100 and 1 in 1000 annual probability of flooding (1% - 0.1%) in any year.
- Flood Zone 3a: High Probability. This zone comprises of land assessed as having between a 1 in 20 and 1 in 100 annual probability of flooding (5% -1%) in any year.
- Flood Zone 3b: The Functional Floodplain. This zone comprises of land assessed as having a 1 in 20 or greater annual probability of flooding (>5%) in any year.

The existing Flood Maps, produced by the Environment Agency, have been used to delineate Flood Zones 1, 2 and 3a. The Environment Agency do not have a Flood Map showing Flood Zone 3b. Therefore the defended 1 in 20 outline from 2009 Ravensbourne modelling study was used to delineate fluvial Flood Zone 3b. Although the other delineations using the EA Flood Maps do not account for defences the functional floodplain would as no land behind defences is functional during a flood. The effect of fluvial defences in Greenwich is described further in Section 5.4.

5.2 Fluvial flood risk

Fluvial flooding is flooding caused by high flows in rivers or streams exceeding the capacity of the river channel and spilling onto the floodplain, usually after a period of heavy rainfall.

The following sections briefly describe fluvial flood risk areas by watercourse.

5.2.1 River Ravensbourne, Quaggy and Kid Brook

The River Quaggy rises as the Kyd Brook at Clay Wood in Bromley and flows north towards Petts Wood before turning and flowing in a north-westerly direction towards Greenwich Borough. Where the watercourse enters Greenwich Borough at Sidcup Road some properties on Mottingham Road and the open ground opposite are shown to be in Flood Zone 3a and b. As the Quaggy travels through Eltham properties between Eltham sports ground and Eltham Green Bridge are shown in Flood Zone 3a. After Eltham Green Bridge the Quaggy enters Sutcliffe Park. In 2004 the River Quaggy was deculverted in part and allowed to re-establish as a meandering, more 'natural' watercourse flowing through Sutcliffe Park. Sutcliffe Park now acts as a flood alleviation scheme and as such is designated as functional floodplain (3b). From Sutcliffe Park the Quaggy runs parallel to Lyme Farm Road and exits the Borough at the A20. Along this stretch properties around Lyme Farm Road and Meadowcourt Road are located in Flood Zone 3a. The Blackheath Sports grounds are also inundated and parts of them act as a functional floodplain (Flood Zone 3b).

Where the Quaggy leaves the Borough is also the confluence with the Kid Brook. The Kid Brook rises in Kidbrooke and flows through the grounds of the Thomas Tallis School. From there the Kid Brook enters a culvert and rises in Brooklands Park. From there it flows through the residential area north of Blackheath Park along Brookway. Much of the floodplain from its source to Brookway is Flood Zone 3a. The Kid Brook then flows under Foxes Dale and Parkgate, before rising as it reaches the boundary of Greenwich and its confluence with the Quaggy.

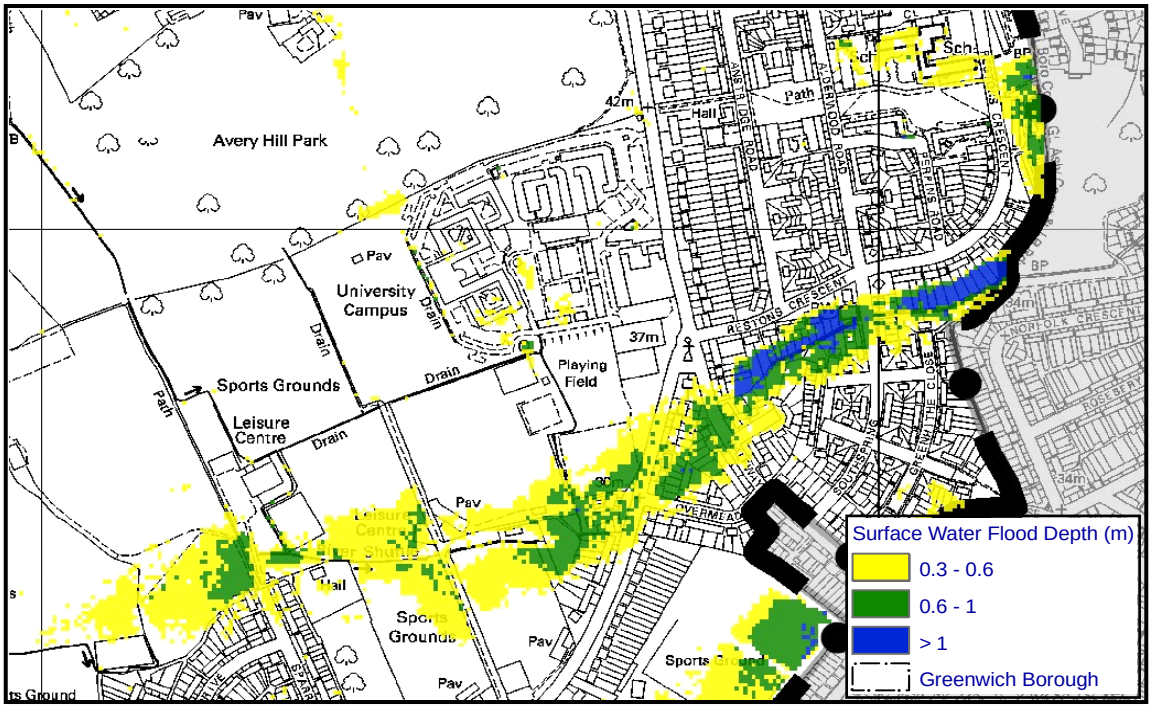
The Quaggy re-enters Greenwich as the River Ravensbourne around Coldbath Street. Some properties downstream of Deptford Bridge along Greenwich High Road are shown to experience flooding. As the Ravensbourne becomes the Deptford Creek as it nears its confluence with the Thames very little is at risk from fluvial flooding.

Map 6 shows the delineation of the fluvial floodplain through Greenwich.

5.2.2 River Shuttle

The River Shuttle rises in Avery Hill Park in the London Borough of Greenwich. From here it flows eastwards under the Avery Hill Road, until it rises again at the back of Restons Crescent, from which it follows the course of Restons Crescent out of the Borough. There is no Flood Zone available for this part of the River Shuttle however the surface water flooding map (see Section 6.2) provides an indication of the extent of flooding likely to be experienced from the River Shuttle (see Figure 5-1).

Figure 5-1 Indicative flood extent for River Shuttle from surface water mapping



5.2.3 Butts Canal, Thamesmead

The Butts Canal rises near Woolwich Cemetery in East Wickham and is culverted along much of its length from the playing fields adjacent to Woodbrook Road to its outfall into South Mere (outside of the Borough boundary) in the Thamesmead area. This upper portion of the Butts canal is informally known as the Wickham Valley Watercourse. This culverted part of the Butts Canal poses an increased flood risk as a result of blockage and siltation. The two silt traps along this section of the Butts Canal (Wickham Valley Watercourse) have to be cleared twice annually. Riparian owners are responsible for clearing silt traps and reed growth, the EA do have permissive powers which allow them to enter land and carry out these works, but they do not have a duty/responsibility. Two areas have been highlighted as at risk of blockage, the Bracondale Road silt trap and the Woodbrook Road trash screens.

The surface water flooding experienced in Abbey Wood in 2005 and 2007 were a direct consequence of water no being able to discharge to the culvert fast enough.

Figure 5-3 shows the indicative drainage path and flood extent of the Butts Canal from Woolwich Cemetery up to Abbey Wood, where the Butts Canal leaves the Borough. Because the surface water map takes no account for the capacity of the culvert, the flood extents should be considered as indicative of flooding in the event of a total blockage of the culvert.

The other section of the Butts Canal in the Borough is up at Thamesmead (Figure 5-2), here the watercourse flows through a series of open drainage channels until it joins the River Thames.

There is no fluvial Flood Zone covering the Butts Canal, the area is only covered by a tidal Flood Zone. However, the surface water flooding map (Figure 5-2 and Figure 5-3) provides an indication of the extent of flooding likely to be experienced from the Butts Canal. In the future the Butts Canal is likely to be formally mapped by the Environment Agency as part of the Thamesmead Rivers Mapping project; however this is not expected to be completed until 2012.

The Butts canal is part of the wider Marsh Dykes surface water drainage scheme. The Marsh Dykes are an area of commercial and residential development, reclaimed from marshland in the 1960s. The Marsh Dykes are divided into 5 sub catchments, these are; Crayford Marsh, Erith, Green Level, Great Breach and Thamesmead. The area of Marsh Dykes which falls within the London Borough of Greenwich is Thamesmead.

Figure 5-2 Indicative flood extent for Butts Canal (Thamesmead) from surface water mapping

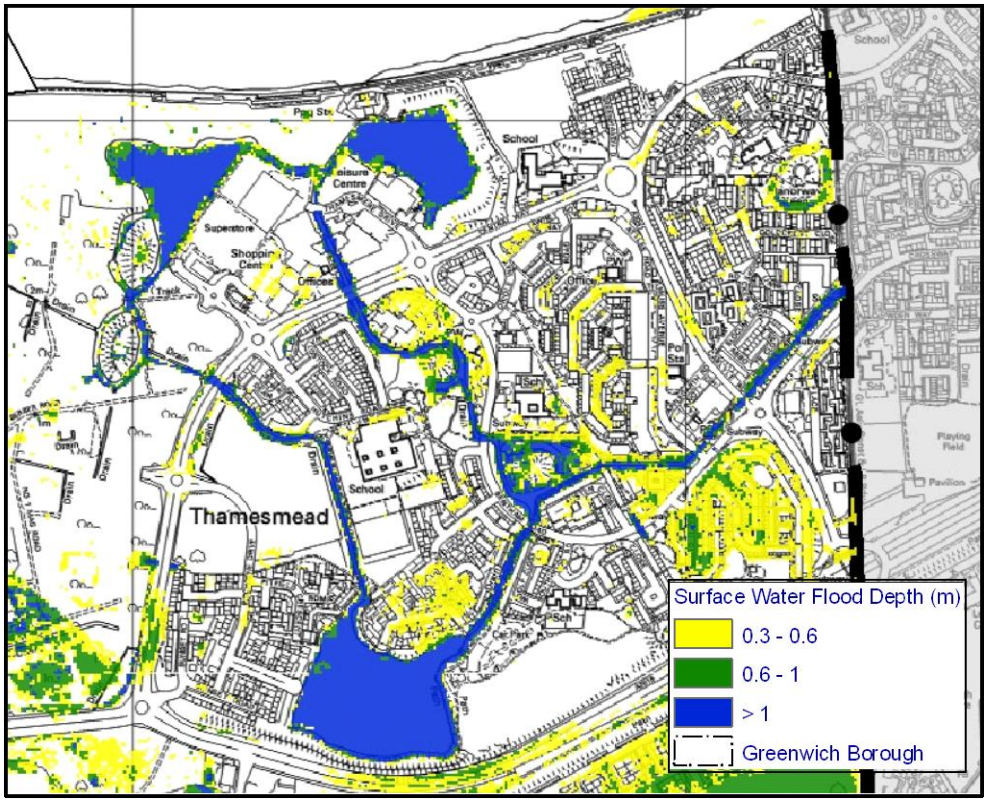
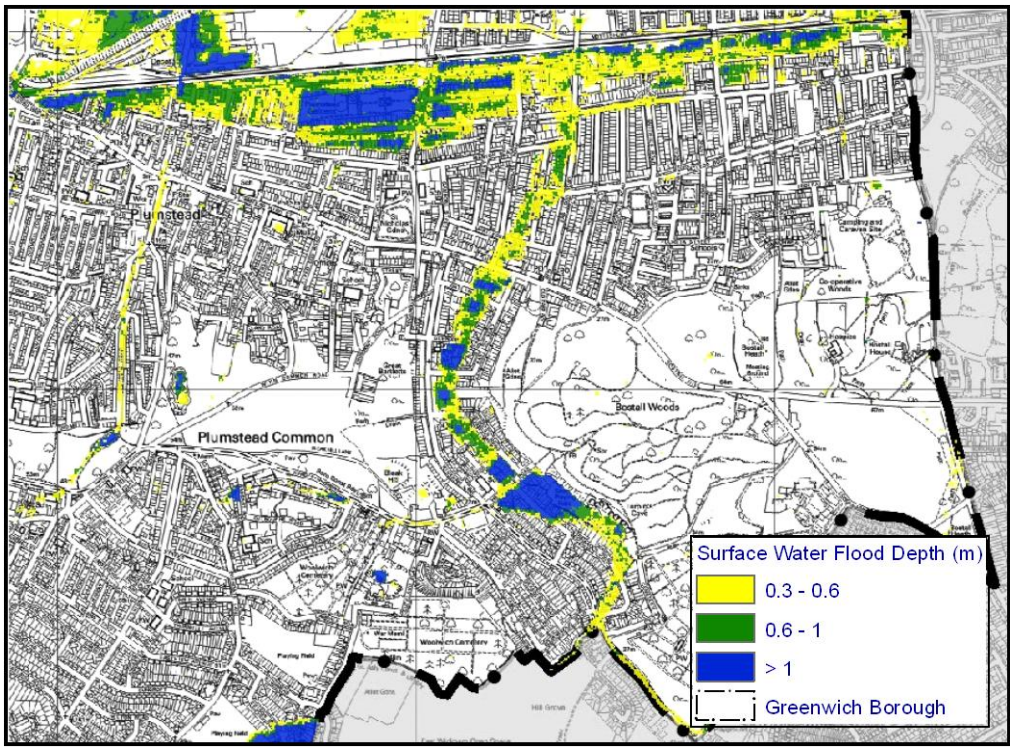


Figure 5-3 Indicative flood extent for Butts Canal (Wickham Valley Watercourse) from surface water mapping



The original Thamesmead surface water drainage scheme involved surface run-off from the surrounding hills discharging onto the site by culverts under passing existing development and then flowing under gravity to three sluices via ditches and dykes. The sluices are named Plumstead Sluice, Abbey Sluice and Great Breach Sluice. This surface water drainage system was replaced by five lakes and a canal network (including the Butts Canal). This new drainage system has a 250 hectare water surface area. The canals drain into the Thames under gravity but in times of tide lock flow can be pumped at Great Breach, Tripcock and Gallions pumping stations. The new system was designed to have a capacity exceeding everyday requirement, thus allowing for storm water. The total storage volume is 189 069 m3. A study conducted by the Environment Agency states 184,870 m^3 of storage volume is required to absorb a 100 year flood event. Therefore, this network can technically accommodate this. However, reed growth has, in practice, reduced this capacity.

5.3 Flood warning systems

The Environment Agency operates a flood warning service covering fluvial and tidal flooding for Greenwich using its Floodline Warnings Direct system. There are two flood warning area which cover fluvial flood risk in the Borough of Greenwich:

- 063FWF438: River Quaggy from Bromley to Lewisham
- 063FWFB433: River Ravensbourne from Catford Hill to Deptford.

The Butts Canal area in Thamesmead is partly covered by the flood warning for the tidal River Thames (063FWT23Thamesmd).

These areas are currently under revision by the Environment Agency to bring them up to date with guidance released in the last few years by making them more community orientated.

5.4 Flood defences

Flood defences can reduce flood risk in the areas they protect. The location and type of defences in Greenwich are shown in Map 2. The River Ravensbourne has raised defences present along its tidal reaches and up to the confluence with the Quaggy. The River Quaggy has raised defences along its length up to the confluence with the Kid Brook. Upstream of the

confluence with the Kid Brook, is the Quaggy Flood Alleviation Scheme which consist of two flood storage areas; Sutcliffe Park and Weigall Road. The Kid Brook has defences present around the entrance to a railway tunnel.

The standard of protection offered by these defences varies; overall most defences along the River Quaggy offer a 1 in 70 standard of protection.

5.5 Fluvial residual risk

The defences along the Rivers Ravensbourne, Quaggy and Kid Brook offer protection to areas in Greenwich. Map 7 shows the extent of a 1% AEP flood event (a flood event with a 1% chance of occurring in any given year) taking into account defences, compared to the undefended situation (Flood Zone 3a). From Map 7 the areas around Meadowcourt Road, to the west of Kidbrooke Park Road and areas of Sutcliffe Park are shown to benefit from flood defences. However, there is always a residual risk that these defences may fail. We have not modelled failure of fluvial defences as the extent of flooding will be similar to that of the undefended Flood zone 3.

5.6 Effect of blockage of culverts on fluvial flood risk

Map 2 shows the location of culverted sections of channel within Greenwich, taken from the Environment Agency's NFCDD database. These include short sections under bridges.

There is a potential for blockage of such structures by debris, both from natural (e.g. logs and trees) and human sources (e.g. fly tipping of furniture, shopping trolleys and other rubbish), particularly in urban areas where rivers are prime targets for fly tippers. Even rubbish dumped on the banks may then be washed downstream by rising water levels during a flood.

Small culverts are most at risk from blockage, and those with trash screens (if they are not cleared during the event), but even larger culverts can get blocked quite rapidly as debris accumulates. Poor maintenance and damage to the structures by the owners can exacerbate blockage problems.

Any blockage that does occur as a result of debris accumulation will cause water levels to be raised upstream of the structure and consequently increase flood risk in these locations.

5.7 Effects of climate change on fluvial flood risk

Defra guidance[10] states that peak fluvial flows are likely to increase by around 20% over the next 50 to 100 years. This translates into higher water levels.

In Greenwich, the Flood Zones were not rerun for climate change; however the results of the Ravensbourne study provide an indication of how the defended extent of flooding increases in the future. From Map 8 it is clear that the future defended 1% AEP flood event does increase along most of the watercourses, but generally this increase mirrors that of the unefended flood zone 3a which indicates the defences along the Quaggy have a reduced standard of protection in the future. The hazard to people associated with higher depths and velocities will also increase.

The only area which suffers a significant increase in extent as a result of climate change is the area south of Deptford Bridge along Greenwich High Road. This will place more people at risk from fluvial flooding in the future, and should therefore be highlighted for the consideration of future emergency plans within the Borough.

Increases in sea level should not have an impact on fluvial flooding. In the future the increased operation of the Thames Barrier should prevent incidences of tide locking as a consequence of sea level rise.

[10] DEFRA, (2006) FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts.

5.8 Effects of future land management on fluvial flood risk

The London Borough of Greenwich is mostly an urbanised area. One third of the Borough is greenfield land; this mainly consists of areas of parkland and open space, which mean that there is limited scope for any large scale changes in land management within the Borough that could significantly impact on flood risk. However small scale changes in land management practices could result in either a negative or positive localised impact on flood risk.

Land management techniques may reduce runoff and flood risk. However, future urban drainage practices will have greater impact in this highly urbanised Borough. Development and redevelopment of sites presents an opportunity to manage runoff locally using SuDs techniques. The degree to which SuDs can be and will be retro-fitted to existing properties will impact upon the extent and severity of urban flooding in the future.

Additionally, the protection of the existing parks and open spaces from development, and the incorporation of new open spaces as part of developments, is important in attenuating runoff and reducing flood risk. The Borough already has a good example of this, Sutcliffe Park, which has been kept as an open space for the Borough but one which also acts as a flood storage area.

Finally, increases to impermeable areas impact upon the volume and rate of runoff. The trend towards paving of front gardens for parking and low maintenance leads to increased volume and rate of runoff. The London Assembly[11] have documented this and other environmental impacts of the paving of front gardens. The Pitt Review[12] recommended the removal of permitted development rights for the paving of front gardens.

On 1st October 2008 the Government released the Town and Country Planning (General Permitted Development) (Amendment) (No.2) (England) Order 2008. This amendment makes hard surfacing of more than 5 square metres of domestic front gardens permitted development only where the surface in question is rendered permeable. Use of traditional materials, such as impermeable concrete, where there was no facility in place to ensure permeability, requires an application for planning permission.

[11] London Assembly (2005) Crazy Paving. The environmental importance of London's front gardens.

[12] Pitt, M (2008) Learning lessons from the 2007 floods. An independent review by Sir Michael Pitt.

6 Other sources of flood risk

6.1 Introduction

In addition to fluvial flood risk, alternative sources of flooding including flooding from surface water, sewers, groundwater, and flooding from reservoirs within the London Borough of Greenwich, as described in Annex C of PPS25. Table 6-1 summarises the data collected and the effect of each source in Greenwich. The following sections describe each source in more detail.

Table 6-1 Summary of flooding from other sources in Greenwich

Type of flooding	Data collected	Effect in Greenwich
Surface water flooding	Surface water modelling with JFLOW	Non-main river drainage paths and areas where water may pond in heavy rain have been identified.
Flooding from groundwater	Groundwater flooding incidents since 2001 (Environment Agency) GIS layer of aquifers and bedrock geology	Some incidences across the Borough but not a major source of flood risk in Greenwich.
Flooding from sewers	DG5 sewer flooding data (Thames Water) Incidents of storm drain surcharge (Council)	Some incidences across the Borough but not a major source of flood risk in Greenwich.
Flooding from reservoirs, canals and other artificial sources	Location of reservoirs, canals from OS 10k map.	No known problems in the past in Greenwich.

6.2 Surface water flooding

Flooding of land from surface water runoff is usually caused by intense rainfall that may only last a few hours, and usually occurs in lower lying areas often where the drainage system is unable to cope with the volume of water. Of course surface water flooding problems are inextricably linked to issues of poor drainage or drainage blockage by debris, and sewer flooding.

2D modelling was undertaken to provide an indication of surface water flow routes and locations where surface water may accumulate and cause flooding as a result of a 6 hour intense rain storm. JFLOW (a 2D model) has a function to model rainfall falling across every cell of a DEM and route the flow across the ground surface. The design rainfall prediction for a 1% annual probability event for a 'representative' catchment in the area was obtained from the Flood Estimation Handbook (FEH) Depth-Duration Frequency model. A 6 hour 1% annual probability storm equated to 70mm of rain. A summer storm profile (representing rapid urban runoff) was applied to give a hyetograph. JFLOW has a function to model rainfall falling across every cell of a DEM. The storm profile was entered into JFLOW as a rainfall inflow.

No allowance has been made for water entering the storm drains, it has been assumed that the drainage system had reached capacity and the results therefore represent a worst case scenario.

The results of this modelling are shown in Map 9. The map provides an indication of drainage paths for the whole Borough. The yellow and red areas can be interpreted as indicative of areas where surface water flooding is likely to be a risk, for example susceptibility to problems such as impassable roads or risk of flooding to ground floors and basements. Some of the main areas shown to be at risk are listed below:

- Eltham – Eltham Road and Sidcup Road

- Kidbrooke – A2 and Eastbrook Road
- Greenwich Peninsula – Mauritius Road, Blackwall Lane, Azof Street, Bellot Street and Commerell Street.
- New Charlton – Eastmoor Street and Westmoor Street
- Royal Arsenal East – Griffin Manor Way, Hadden Road, Boughton Road and Nathan Way.
- Plumstead - area around Plumstead Gardens including Birkdale Road, Marmadon Road, Church Manor Way, Brookdene Road and Bracondale Road.
- Abbey Wood – Eynsham Drive, Edington Road, Boxgrove Road, Chalcombe Road, Luffield Road, Ampleforth Road, Grovebury Road, Godstow Road, Peterstone Road, Cookhill Road, Finchale Road, Manister Road, Penmon Road, Panfield Road, Stanbrook Road, Bracondale Road and Abbey Grove.
- Railway Lines - running through New Eltham, and in the north of the Borough.

In addition to the 1% annual probability storm, another modelling run was undertaken to model the 1% plus climate change annual probability storm, this was represented by applying a 20% increase to 70mm to generate 6hr 84mm event.. The results of the 6 hour 84mm storm are shown in Map 10. The extent of surface water flooding doesn't change significantly with climate change in Greenwich; the only difference is that most areas experience deeper flooding than present day.

6.3 Flooding from groundwater

Groundwater flooding can occur after prolonged periods of rainfall cause the water table to rise and intersect with the ground surface. It is most common where aquifers occur close to the ground surface under normal conditions. The risk of flooding from groundwater is subject to uncertainty as it is dependent upon the water table conditions at any location for any given time. Consequently, there is a lack of understanding with regards the risk of groundwater flooding, and no national mapping of groundwater flood risk exists.

The bedrock geology of Greenwich consists of bands of Chalk in the north of the Borough, Sand, Silt, and Gravel in the north and south of the Borough, and Clay in the centre and very south of the Borough. The Borough is underlain by a large area of minor aquifer, which coincides with the sand silt and gravel bedrock, and a small area of major chalk aquifer (shown on Map 5). This area of major aquifer has been classified by Defra as a groundwater emergence zone[13] and could be at risk from significant ground water flooding when the water table is high. This emergence zone coincides with the reported incident of groundwater flooding in Abbey Wood.

The Environment Agency has supplied records of recent flooding events it has recorded since 2000 which have been reported as groundwater flooding, and these are shown in displayed as points on Map 5 and listed in more detail in Table 6-2.

After further thought it seems unlikely that groundwater was the sole cause of all of these incidents. Certainly the cluster of incidents reported in the area where there are seasonally wet loamy soils and no underlying aquifer are probably a result of drainage issues rather than true groundwater flooding.

[13] Defra, March 2004, Strategy for Flood and Coastal Erosion Risk Management: Groundwater Flooding Scoping Study (LDS 23) Final Report Volume 2

Table 6-2 Recorded groundwater flooding incidents since 2000 (source Environment Agency)

Date Reported	NGR	Details	Comment
06/06/2000	TQ435770	Spring in garden/patio, Shooters Hill	-
09/06/2000	TQ4359376920	Water seeping in cellar, Shooters Hill	-
08/08/2000	TQ470789	Periodic flooding of street/property, Abbey Wood.	Coincides with location of major aquifer.
10/11/2000	TQ435733	Water under floor, Eltham	-
03/01/2001	TQ408740	Spring in garden, Eltham	-
28/02/2001	TQ450783	Water under floor slab, Plumstead	Geology - London Clay
10/04/2001	TQ4469374575	Spring at bottom of garden, Eltham	Blackheath Beds - possible spring?
04/06/2001	TQ4340877200	Spring from neighbours garden entering her garden, Woolwich	Geology - London Clay /Gravels Seasonal Spring flowing overground into her garden.
04/03/2002	TQ4404977410	Boggy garden, Shooters Hill	Geology - London Clay Possible bad drainage - sorted.
13/01/2004	TQ4383274628	Water in basement garage, Eltham	Geology - Harwich Fm over Lambeth Group
11/02/2004	TQ4181475577	Water in club basement, nearby buried river?	Geology - London Clay

6.4 Flooding from sewers

6.4.1 Surcharge of sewer

From the DG5 data provided by Thames Water there has only been one incident of sewer flooding in the past ten years within the London Borough of Greenwich. This incident was located in the postal district of 'SE9 5', Eltham, and was the result of a combined sewer overflow.

The East London SFRA also notes that "low-lying areas behind the River Thames tidal defences (Greenwich, Barking and Dagenham and Thamesmead) do not appear to suffer from sewer flooding to a significant extent. This could be due to the fact that surface water drainage infrastructure is designed to cope with a significant tidal event where runoff needs to be stored/pumped for a period of time during high tide before being released to the River Thames. Proposed new development for the low-lying areas along the River Thames could potentially worsen this status quo situation."

In addition the Council provided information on an incident of storm drain surcharge flooding, reported to them on 10 September 2005 in the Abbey Wood area of Thamesmead. Seven residential properties were affected by flooding including sludge and debris. The damage included electrical failure and furniture damage and resulted in the need for two persons to be rehoused.

6.4.2 Collapse of elevated sewer

The Southern Outfall Sewer (SOS) (shown on Map11) runs from Plumstead, Greenwich to Crossness (London Borough of Bexley) within an embankment. The embankment contains the two Southern Outfall sewers numbers 1 and 2, and Southern High Level Number 2, each 11'6" diameter brick sewers. Thames Water has not undertaken any specific flood risk assessments of the consequences of a major structural failure of the embankment.

A simple assessment was carried out using JFLOW. Inflows were calculated from statistics available on the Thames Water web site and in their Draft Water Resources Plan. Three

"collapse" locations were tested on each side of the sewer, each for multiples of 1, 3 and 6 times Dry Weather Flow, to test the flooding impact under a range of flow rates. Full details of the method and assumption applied are included in Appendix E.

Map 28 shows the possible extents of flooding due to a severe collapse of the outfall sewer, based on a series of conservative assumptions. No data was available on the probability of a collapse occurring. It is not known whether a collapse has occurred in the sewer's 150 year history. However, given the possibly severe consequences, any ground works in the vicinity of the Southern Outfall Sewer should be undertaken with particular care. The consequences of failure should also be included within emergency plans.

6.5 Flooding from reservoirs and artificial sources

6.5.1 Reservoirs

There are five covered reservoirs within the London Borough of Greenwich. Two are located at Woolwich Common; the other three are located in Greenwich Park, Castle Wood and Oxleas Wood. Map 11 shows the location of the reservoirs.

Table 4-4 provides all the information we have been able to acquire on the reservoirs in the Borough.

Defra is funding a project to produce a 'Guide to Emergency Planning for UK Reservoirs'. The guide went out to informal consultation in Autumn 2006 and is now being reviewed and taken forward by Defra's new contractors, Atkins. This project will work closely with the Local Resilience Forums, who will ultimately use the flood plans for emergency planning and response. It will go out to formal consultation, and will be subject to a regulatory impact assessment in Summer 2008. Reservoir flood plans are expected to become a legal requirement from Spring 2009 when the Secretary of State in England and the National Assembly in Wales will direct undertakers to produce flood plans for reservoirs where a dam failing could have a major impact.

There is little information available to fully assess residual risk from reservoirs in the borough, and given these ongoing developments with relation to the management of flood risk from reservoirs, it was decided that no analysis of the "residual risk" would be undertaken at this time. Further information regarding reservoir safety should be obtained by the council through the local resilience forum.

6.5.2 Pumping station failure

Within the Marsh Dykes there are four pumping stations, two of these fall within the boundary of the London Borough of Greenwich: Tripcock and Gallions (Map11).

The Marsh Dykes are an area of commercial and residential development, reclaimed from marshland in the 1960s. The Marsh Dykes are divided into 5 sub catchments, these are; Crayford Marsh, Erith, Green Level, Great Breach and Thamesmead. The area of Marsh Dykes which falls within the London Borough of Greenwich is Thamesmead.

The original Thamesmead surface water drainage scheme involved surface run-off from the surrounding hills discharging onto the site by culverts under passing existing development and then flowing under gravity to three sluices via ditches and dykes. The sluices are named Plumstead Sluice, Abbey Sluice and Great Breach Sluice. This surface water drainage system was replaced by five lakes and a canal network (including the Butts Canal). This new drainage system has a 250 hectare water surface area. The canals drain into the Thames under gravity but in times of tide lock flow can be pumped at Great Breach, Tripcock and Gallions pumping stations. The new system was designed to have a capacity exceeding everyday requirement, thus allowing for storm water. The total storage volume is 189 069 m3. A study conducted by the Environment Agency states 184 870 m3 of storage volume is required to absorb a 100 year flood event. Therefore, this network can technically accommodate this. However, reed growth has, in practice, reduced this capacity.

Tripcock pumping station is the principle pumping station. It came into operation in 1977. The pumping station was designed to pump the volume of water a 100 year storm event would produce. It was calculated that two pumps had the capacity to deal with a 100 year event.

The pumping station consists of two unmanned electric pumps with a back up two diesel pumps in case of power failure. Both sets of pumps are automated to start and stop according to water level. The pumping station at Lake 4 has a capacity of 5772 litres/second.

Gallions pumping station is a subsidiary site. The pump system is identical to Lake 4 with two electric and two backup diesel pumps with automatic start/ stop according to water levels. The pumping station at Lake 5 has a capacity of 1136 litres/second.

The effect of pumping station failure during storm conditions would be expected to be similar to that depicted by the surface water flood map (Map 9 & 10), as the surface water flood map is based on drainage infrastructure failure.

7 Tidal flood risk

7.1 Introduction

This section assesses risk in Greenwich of tidal flooding from the River Thames, now and in the future. It makes use of all the data and information described in Section 4. It defines the tidal Flood Zones 1, 2, 3a and 3b, providing enough information for the Council to perform the Sequential Test for these areas.

Much of the area at risk from tidal flooding is protected by flood defences. However there remains a residual risk that the defences could fail during a flood event. The spatial variation in the level of risk across the floodplain must be identified to enable a more detailed Sequential Test within tidal Flood Zone 3.

7.2 Tidal flood risk

Tidal flooding is flooding caused by extreme tide levels exceeding ground levels. In the case of Greenwich this means extreme tide levels in the River Thames estuary, caused by storm surges in the North Sea such as that experienced in 1953.

Flood Zones 1, 2 and 3 delineate areas at low risk, medium risk and high risk respectively from both tidal and fluvial flooding. The delineation of the tidal Flood Zones is shown on Map 12. Flood Zones do not take into account the effects of flood defences, and as such provide a worst case assessment of flood risk.

Most of the area to the north of the London to Dartford rail line would be at risk from tidal flooding was it not for the defences in place along the Thames estuary and for this reason is included in both Flood Zone 2 and 3.

Extreme tide levels for Greenwich are given in Table 4-1.

However in reality this area is defended to a high standard by the tidal Thames defences. An assessment of this 'residual' risk is essential for planning purposes. A detailed assessment of residual risk is made in the following sections.

7.3 Flood warning systems

The Environment Agency operates a flood warning service covering fluvial and tidal flooding for Greenwich using its Flood Warnings Direct system. These areas are currently under revision by the Environment Agency to bring them up to date with guidance released in the last few years by making them more community orientated.

There are currently three flood warning areas covering tidal flood risk in Greenwich:

- Tidal Thames from Deptford Creek to the River Wandle (063FWT23Bermndsy)
- Tidal Thames from Woolwich Arsenal to Deptford Creek (063FWT23Greenwch)
- Tidal Thames from Erith High Street East to Woolwich Arsenal (063FWT23Thamesmd)

7.4 Tidal defences

Most of the London Borough of Greenwich is protected from events in the tidal Thames to a standard of over and above the 0.1% annual probability flood (1000 year return period), by the Thames Barrier and raised defences such as walls and concrete capped embankments. The location and type of defences are shown in Map 2. There are only a few areas of land which do not receive the protection of the Thames Tidal Defences as the defences are set back from the water's edge.

Tidal flood defence levels are maintained at a minimum level which varies along the defence line. Immediately downstream of the Thames Barrier the defences are maintained to a

minimum level of 7.2m AODN, this reduces to 7.1m AODN at Tripcock Ness. Immediately upstream of the Thames Barrier the defences are maintained to a minimum level of 5.18m AODN, increasing the 5.23m AODN at Blackwall Point. A short section of the Deptford Creek Tidal defences are maintained to a minimum level of 5.28m AODN. These levels must be maintained by their owners. Moveable flood gates are incorporated into the defences for access to the riverside where necessary.

7.5 Effects of climate change on tidal flood risk

Table B.1 of PPS25 gives recommended contingencies for net sea level rise up to 2115. For the south east coast, sea level is predicted to rise by 0.67m within 100 years (to 2107). When the effect of the estuary is taken into account by modelling, levels downstream of the Thames Barrier are likely to rise by 0.8m at Greenwich over the next 100 years (see Table 7-1). Upstream of the barrier the rise in water level as a result of sea level rise is minimal, less than 0.01m. This is a consequence of the future barrier operation. In the future it is assumed that the Thames Barrier will continue to function as intended, with the number of closures increasing as a result of climate change, although this is not guaranteed. Consequently, this results in the peak water level upstream of the barrier not increasing with climate change.

Table 7-1 Effect of sea level rise on water levels in the Thames Estuary (mAOD)

Node Label	Name	200 year (0.5% AEP) Level – 2005 Condition	200 year (0.5% AEP) Level – 2107 Condition
2.42u	Deptford	4.828	4.828
2.43	Cutty Sark	4.806	4.809
2.44	Isle of Dogs	4.794	4.798
2.47	Bugsby Reach	4.747	4.754
a2.49	u/s Barrier	4.72	4.729
a3.1	d/s Barrier	6.258	7.112
3.4	King George V Dock	6.174	6.989
a3.5u	u/s Roding	6.153	6.978

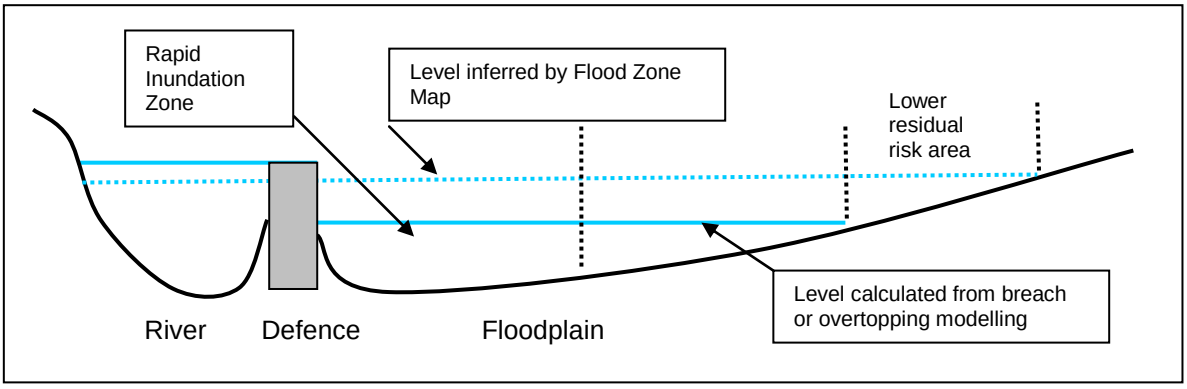
Source: “Modelled water levels.xls” supplied by Environment Agency, May 2008.

Current statutory tidal defence levels in the London Borough of Greenwich range from 7.2m AODN downstream of the Thames Barrier to 5.28m AODN upstream of the barrier (see section 7.4 for more detail). The statutory levels, upstream of the barrier and in most parts downstream of the barrier, would provide sufficient defence against a 0.5% event even accounting for climate change to 2107.

7.6 Tidal residual risk

‘Residual risk’ is defined as the flood risk remaining with flood mitigation measures in place. There is a residual risk associated with all the flood defences described in Section 7.4. The land behind the defences is only at risk of flooding through failure or overtopping of the defences (see Figure 7-1).

Figure 7-1 Illustration of residual risk behind defences



7.6.1 Risk of overtopping and failure of defences

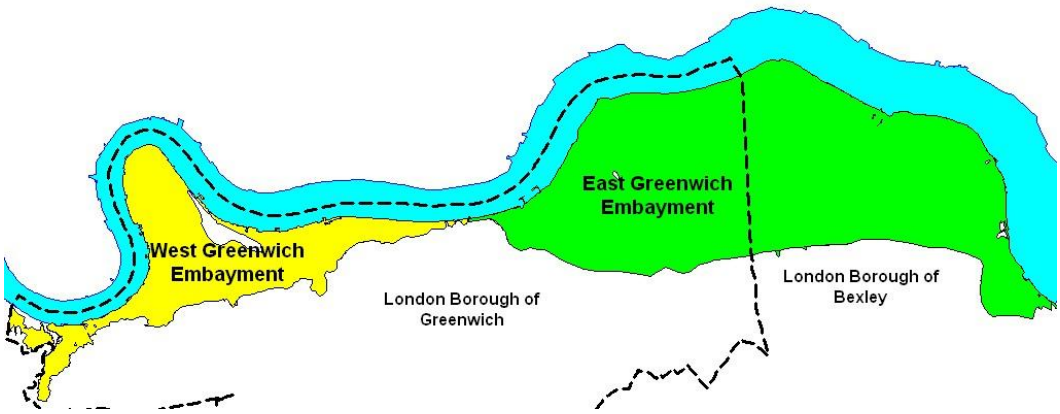
Due to the high level of the defences, they are not likely to overtop within the range of extreme water levels usually considered in an SFRA (up to a 0.5% annual probability), even accounting for climate change (see Section 7.5).

The Thames tidal defences are in good condition, strengthened with concrete and sheet piling, and are maintained and inspected regularly. This means that the risk of failure of the Thames tidal defences is also very low. However it must be investigated for the purposes of the SFRA, and an assessment of the level of residual risk made. To this end, 2D modelling has been carried out to simulate the effect of breaches in the tidal defences and outfalls.

7.6.2 Overview of Greenwich's embayments

The River Thames forms the 14km northern boundary of the Greenwich Local Authority area. The low lying tidal floodplain of the Thames has been disconnected from the river by the construction of flood defences, which provide a 1 in 1000 year standard of protection. The result of this has been the creation of embayments adjacent to the river – former areas of the floodplain reclaimed by development. Two embayments are present within the London Borough of Greenwich, as depicted in Figure 7-2, described as the West Greenwich and East Greenwich embayments. Thamesmead falls within the East Greenwich Embayment (referred to in the East London Strategic Flood Risk Assessment as the Thamesmead Embayment). From Map 3 it is clear that the East Embayment has significantly more areas of low lying land than the West Embayment, with areas falling below 0m AOD.

Figure 7-2 Greenwich East and West embayments as defined by the 7.5mAOD contour



West Greenwich embayment

The West Embayment is characterised by three distinct areas, each separated by high land which run north to south under the sites of the Meridian Trading Estate and Stone Lake Roundabout. These two elevated areas, the A102 and the embanked railway running parallel to Ferndale Road, form potential barriers to flow in the event of a breach. Both barriers are punctuated with underpasses which would control the flow between the three low-lying areas. The area to the west of aforementioned railway is characterised by low topographic elevations, typically in the region of about 1.5mAOD.

For the purposes of this SFRA the two small embayments either side of the Deptford Creek have been included as part of the West Embayment.

East Greenwich embayment

The East Embayment is significantly larger than the West Embayment, and contains a greater number of barriers to flow. The main division in the East Embayment is created by the embanked Southern Outfall Sewer. The presence of this sewer causes a significant barrier to flow, and only two flow connections between the southern and northern parts of the embayment were identified. The first was the culvert passing beneath the sewer near South Mere; the second is the underpass at Plumstead Station. The Plumstead underpass will only become critical to the flow of water when flood water levels reach over 3m AOD, whereas the South Mere culvert will control the flow of water at much lower water levels. Other less

significant barriers are present in the embayment; these are however typically due to variations in ground. The presence of water courses in the East Embayment (particularly in the north), will present preferential flow pathways and allow water to distribute rapidly across the embayment.

7.6.3 Assessment of residual flood risk - breach modelling

The flood defence breach analysis was modelled using tidal hydrographs of the Thames River provided by the Environment Agency and a 2D TuFLOW hydraulic model.

Two scenarios were simulated for those breaches downstream of the Thames Barrier based on the current (2005) tidal estimates and the future (2107) climate change levels. The breaches identified upstream of the Thames Barrier were run for the current (2005) tidal estimate, as this estimate does not increase with climate change (see section 7.5). All scenarios were assessed using the 1 in 200 year tidal storm surge event.

Each simulation produced results for water depth, water level and flood hazard. The rate of onset was also estimated through the interrogation of 2-hourly model timesteps. It is important to note that model results can only give a general impression of the rate of onset as the actual failure of defences was not simulated.

TuFLOW software does not allow for 'dam failure'[14] to be modelled. Therefore, to assess the breaching of flood defences, some assumptions were made in accordance with Environment Agency guidelines.

Formal flood defences can be classified as either hard or soft. Examples of hard defences are steel sheet piled walls, concrete walls, or masonry walls. Examples of soft defences are clay cored earth embankments. The composition of soft defences means that during a breach they are likely to erode to a greater width than hard defences. The Environment Agency considers it will take more time to make safe a breach in a soft defence due to the rapid tidal erosion it will experience. Therefore, soft defences were modelled by inserting a 50m 'hole' in the defence and simulated for three tidal peaks (36 hours), whereas hard defence breaches were represented with a 20m 'hole' in the defence and modelled for 18 hours (two tidal peaks).

The Environment Agency identified ten breach locations in Greenwich which have been numbered one to ten, in sequence from east to west (see Map 13). Five of these were in the East Greenwich embayment; five were in the West Greenwich embayment. Only breach locations 1 and 5 were identified as being soft defences, the other eight breach locations were considered to be hard defences.

The breach invert levels were determined by interrogating the LiDAR data at the toe of the defence structure. The invert levels for each breach are shown in Table 7-2.

Table 7-2 Breach dimensions

Breach Location Reference	Invert Level (mAOD)	Breach Width (m)
1	0.8	50
2	-0.5	20
3	-0.3	20
4	0	20
5	4.4	50
6	4.0	20
7	4.0	20
8	1.7	20
9	3.4	20
10	4.0	20

Table 7-3 outlines the ground roughness values (Manning's N) that were applied in the modelling process.

[14] Dam Failure = when a wall of water many metres high burst through a structure.

Table 7-3 Modelled Manning's N values

Land use	Manning's N Value
Buildings	0.5
Open Water	0.01
Rest of the model	0.035

Within the East Greenwich embayment the culvert identified at South Mere, which runs under the Eastern Way A Road and the embanked Southern Outfall Sewer was identified as one of the key control structures for the distribution of flow. A detailed survey of the culvert dimensions was not available and so the dimensions were required to be estimated. In consultation with the Environment Agency[15] it was agreed that all three of the culvert openings were the same and that each was approximately a 2m by 2 m box culvert.

7.6.4 Results of the breach modelling

The maximum depths experienced from each of the ten breaches were combined to get an overall map of maximum depth from breaching across Greenwich (Map 14). Map 15 and 16 show the maximum depths experienced in each of the embayments. The maximum depths experienced from each of the ten breaches for a future climate were combined in the same way and Maps 17 and 18 detail the future maximum depths in each embayment.

In accordance with DEFRAs Flood Risk to People[16] report, flood hazard is calculated as a function of depth and velocity, which can then be related to a corresponding level of risk based on the four categories presented in Table 7-4.

[15] Anthony Hammond – Flood Risk Mapping and Data Management 13/05/08

[16] Flood Risk to People – Phase 2 FD2321/TR2 Guidance Document, Defra / Environment Agency Flood and Coastal Defence R&D programme, (March 2006)

Table 7-4 Flood hazard classifications

Hazard Classification d x(v +0.5)	Degree of Flood Hazard	Description
<0.75	Low	Caution "Flood zone with shallow flowing water or deep standing water"
0.75 – 1.25	Moderate	Dangerous for some "Danger: Flood zone with deep or fast flowing water"
1.25 – 2.5	Significant	Dangerous for most people "Danger: Flood zone with deep and fast flowing water"
>2.5	Extreme	Dangerous for all "Extreme danger: Flood zone with deep fast flowing water"
Taken from the Flood Risk to People Report – Phase 2 (March 2006)		

The flood hazard classifications from each of the ten breaches were combined to get an overall map of maximum flood hazard from breaching across Greenwich (Map 19). Map 20 and 21 show the flood hazard classifications experienced in each of the embayments. The flood hazard classifications experienced from each of the ten breaches for a future climate were combined in the same way and Maps 22 and 23 detail the future flood hazard classifications in each embayment.

East Greenwich Embayment (Thamesmead)

Residual flood risk in the eastern embayment is significant due to the low ground elevations and low invert levels of the breaches. The absence of any natural topographic barriers to flow immediately beyond the breach locations, the large embayment area, and the presence of canals, results in extensive flooding which propagates rapidly.

Modelled flood depths (current scenario) in the embayment are also significant, being recorded at over 3m for many areas and the climate change scenarios show a significant increase in flood risk.

Flooding in the eastern embayment is characterised by a distinct division between the north and south, due to the presence of the embanked Southern Outfall Sewer This results in flood waters only being able to pass from one side to the other through either the South Mere culvert or the Plumstead Station underpass. As discussed in Section 7.6.3, due to the lack of survey information, assumptions for the culvert dimensions were made. The inclusion of more detailed information for these two structures is likely to impact on the passage of flood waters between the two halves of the embayment.

The breach locations modelled (1 to 5) do not benefit from the protection offered by the Thames Barrier. The climate change scenarios show a significant increase in flood risk.

Appendix A contains more details about each breach downstream of the Barrier.

West Greenwich Embayment (Greenwich)

The propagation of the flooding from breach location 5 (immediately downstream of the Thames Barrier) is controlled by a series of north-south running topographic barriers, for example, the gentle ridge of higher ground which runs through the New Charlton Industrial Estate. These features result in water ponding behind them, causing the flooding extent to expand until the threshold spill levels are reached and water can flow into adjacent parts of the embayment.

The 36 hour simulation results in extensive flooding of the Greenwich West Embayment and the Greenwich Peninsula. The eastern side of the peninsular is not flooded as the ground elevations here are above the predicted design flood levels. Flood waters which reach the western limit of the embayment do not drain freely back into the Thames through the breach due to the high ground running through the New Charlton Industrial Estate, which separates the western part of the Embayment from the breach location.

Breach 6 flows in the same direction as 5, yet as the breach is upstream of the Thames Barrier the amount of water flowing through the breach is reduced and therefore the extent and depth of flooding is not as great. Breaches 7 and 8 flood the Greenwich Peninsula. The Millennium Village area does not experience flooding due to the raised level of the land in this part of the peninsula. Breach 8 causes the largest depth of flooding to the area around Mauritius Road, Azof Street and Blackwall Lane. From the depth and extent of flooding it is clear that the Blackwall tunnel is at risk of inundation if a breach occurs along the peninsula.

Breaches 9 and 10 flood the land adjacent to the Deptford Creek. Breach 10 is a breach in the Deptford Creek tidal defences. For both breaches the extent of flood from the breach is small compared to the other breaches in Greenwich as a result of the higher land levels and lower water levels in the Thames.

Appendix A contains more details about each breach upstream of the Barrier.

7.6.5 Onset of flooding

The onset of flooding for each breach location is provided in Appendix B. These figures present the extent of flooding after 1 hour and then at 3 hour intervals until the end of the simulation.

7.6.6 Volume remaining in the embayments

The volume of water remaining in the East Greenwich and West Greenwich (Thamesmead) embayments at the end of each simulation, under current day conditions, has been calculated. These estimates have been provided to allow the Council to assess the time it might take to pump the flood water out of the embayment, once the modelled defence breach has been sealed. For these calculations it has been assumed that the breach will be sealed on the second low tide after the breach. Table 7-5 provides an estimate of the residual volume of flood water resulting from each of the 4 modelled breaches for the Thamesmead area.

The volumes presented in Table 7-5 have been derived from the final water depths in the embayment at the end of the model run and should be viewed as indicative values only as it is not possible to predict at what point in the tidal cycle the breach would effectively be sealed. For each of the breach locations the model simulations ran the low point of the final tide cycle. Consequently, the final water depths do not account for any further reduction in water level that would occur before water started to spill back into the embayment on the rising limb of the next tidal cycle. Neither is there any allowance for discharge via the existing surface water drainage systems.

Table 7-5 Remaining volume of water in the embayment at the end of the model run (current day)

Breach Location	Embayment	Volume (m3)*
1	East	11,900,000
2	East	6,600,000
3	East	6,100,000
4	East	3,100,000
5	East	1,115,000
6	West	50,000
7	West	200,000
8	West	700,000
9	West	30,000
10	West	20,000

* Most of the volumes in the table have been rounded down to the nearest 100,000 m3, where they are smaller that this they have been rounded to the nearest 10,000 m3.

7.6.7 Mapping residual risk

There is a residual risk associated with all flood defences. The breach modelling undertaken for this SFRA investigates the residual risk at 10 points along the defence line. However, in theory a breach could occur anywhere along the defence line, therefore we have undertaken some analysis of those areas which do not suffer inundation from our modelling to assess whether they are possibly at residual risk.

The method used to determine the additional areas at residual risk in Greenwich is detailed in Appendix C. In summary there were five stages involved in the mapping:

- Sub-divide river stretch into distinct water level zones according to water level at nodes from an ISIS model.
- Create a buffer zone of 500 metres and project extreme Thames water levels (as provided by the Environment Agency) over the area. The resulting surface water area was then projected over a DTM.
- This projection produces a larger flood extent than the breach simulation as the rate of inundation is not limited by size of the defence failure.
- Identify the Hazard Inundation Extent by eliminating any area of flood extent not directly connected to the Thames.

The method was adapted for Royal Arsenal West area of Woolwich due to a high flood risk. The extent of Flood Zone 3 was incorporated into the Hazard Inundation map.

This information from the breach modelling and residual risk mapping has been assimilated to produce a map of residual risk within tidal Flood Zone 3 with the aim of allowing the application of the Sequential Test within tidal Flood Zone 3 (see Maps 24 to 26).

A similar approach to defining residual risk has been used to the East London SFRA. The classification used, and the relationship between residual risk and UK flood hazard, is shown in Table 7-6.

Table 7-6 Residual risk classification

Classification	Criteria
High	Areas from breach inundation modelling with an Extreme, Significant or Moderate UK flood hazard rating. Areas identified as being at risk from a breach which were not modelled.
Medium	Areas with a Low UK flood hazard rating
Low	Areas which have not been classified as at risk from a breach but are still within the Environment Agency's Flood Zone 3.

8 Recommendations for the Council

8.1 Introduction

The overall aim of PPS25 is to direct development to lower flood risk sites wherever possible. “The aims of planning policy on development and flood risk are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at higher risk”.

The Local Planning Authority is well placed to play an important role in strategic flood risk management. The guidance given in this Section of the SFRA, and in Sections 9 and 10 should help the LPA to achieve the aims of PPS25, the Thames CFMP, the TE2100 project, and Making Space for Water, now and into the future.

One of the key objectives of the SFRA is to provide an evidence base which will inform the preparation of the Local Development Framework for the London Borough of Greenwich with respect to local flood risk issues and the location of future development.

The transition from the existing UDP to the LDF following the enactment of the Planning and Compulsory Purchase Act 2004 provides an ideal opportunity for the London Borough of Greenwich to review and update their policies on flood risk and to ensure consistency with national guidance and regional planning policy. The development of policies on flood risk need to embrace the concept of ‘balanced management’, facilitating development which serves the social and economic needs of the community whilst controlling flood risk and ensuring it is properly managed and mitigated.

Breach modelling carried out for this SFRA has highlighted the high residual risk which exists in the Thamesmead embayment, parts of New Charlton and the western half of the Greenwich Peninsula in the event of a breach in the Thames tidal defences. Large areas of Thamesmead and Abbey Wood, and smaller areas of New Charlton and the Greenwich Peninsula are predicted to experience flood depths of 3m or greater in the unlikely event of such a breach occurring.

At the same time, the London Borough of Greenwich (LBG) has challenging housing targets, and pressing needs for housing regeneration. Within the Thamesmead embayment, much of the existing housing is 1960's/70's, built on stilts with ground-floor parking to avoid the perceived surface water flood risk. This has created an environment of walkways and stairwells which provide poor access and are perceived to encourage crime. LBG want the redevelopment of the area to provide better housing, in particular ground floor access, no stairwells, walkways etc.

During development of the SFRA, it emerged that meeting the requirements of PPS25, at the same time as providing new housing which delivers the council's objectives for place-making and Lifetime Homes standards posed a serious design challenge. The combination of development pressure and widespread high residual risk present in a large, already urbanised area in Thamesmead are thought to be unique in London, and requires some difficult choices to be made.

A supplementary study to support the SFRA, the "Guidance of Housing Design in Areas of High Residual Flood Risk" was undertaken to consider possible measures to address this challenge. This guidance is reproduced as Appendix F of this SFRA. As this supplementary guidance is of key importance to significant areas of the Borough, the additional guidance it contains is clearly signposted as follows: **For further guidance see Appendix F: Chapter 1**.

8.2 Recommendations for LDF policy on flood risk

In order to assist with the preparation of future LDF policies this section of the SFRA seeks to identify policy recommendations to be considered by the council (additional details are also provided in section 8.3).

Policy recommendations will not necessarily reflect the approach which will be adopted by the Borough in considering planning applications or potential allocations within their LDF. The Council will have regard to PPS25 Development and Flood Risk and to the most recent Strategic Flood Risk Assessment in assessing the suitability of land for development at all levels of the planning process. It will apply the Sequential Test and Exception Test set out in Annex D of PPS25 in master planning, allocating sites for development and assessing individual planning applications by ensuring that there are no other suitable sites in areas with a lower risk of flooding.

It is recommended that the Council resist development in areas of flood risk unless the type of development is commensurate with the type of flood risk in each Flood Zone as outlined in Table D.1 and D.2 of PPS25.

The Council should seek flood risk reduction in every new development and redevelopment through design, changes in land use and drainage requirements.

All development, including changes of use, should require at least an initial assessment of flood risk.

A detailed site specific Flood Risk Assessment must be submitted with planning applications for:

- Major developments located in Flood Zone 1 (>1ha);
- All development in Flood Zones 2 and 3 (see Map 3 and 4);
- All development, or change of use, where flood risk from other sources is identified by the SFRA:
    - Where surface water flooding shown as 0.3m or deeper (Map 9)
    - Within 100m of a sewer flooding incident
    - Within 250m of groundwater flooding incident (Map 5)

The following sections outline recommended policy objectives that the Council should aim to achieve.

8.2.1 Flood risk reduction

PPS 25 requires that new development does not exacerbate flood risks elsewhere. The Council should seek flood risk reduction, both onsite and downstream, and evidence that all new development can manage flood risk and be safe.

All proposed development sites should be required to demonstrate:

- That the probability and consequences of flooding will be reduced.
- How actual and residual flood risk to the development and flood risk to others from all sources will be managed over the lifetime of the development, taking into account climate change.
- That development will be safe through the layout, form and floor levels of the development and mitigation measures.
- That development will be safe in terms of dry access, egress and refuge, and that emergency planning is considered.
- That the development will not constrain the natural function of the floodplain, either by impeding flood flows, reducing storage capacity or otherwise increasing flood risk elsewhere.
- That the development will not undermine, breach or destabilise flood defences

8.2.2 Drainage

Surface water runoff from development should be controlled as close to the source as possible.

Developments should maintain or improve on existing runoff from the site by achieving greenfield runoff rates.

The use of Sustainable Drainage Systems (SUDS) should be required on all new developments, if SUDS are not used, the developer must provide a valid reason why they are not suitable.

All sites greater than 1 ha in size should require the following:

- SUDS,
- Greenfield discharge rates[17]
- 1 in 100 year on-site attenuation taking into account climate change.

The council should maintain an accurate record of SUDS installed, those adopted and maintenance required.

8.2.3 Riverside developments

The Council should ensure that all riverside developments:

- Are set back from the river's edge or ordinary watercourses providing a buffer strip:
  - 5m from ordinary watercourses/canals
  - 8m from fluvial main rivers
  - 6m from the landward toe of flood defences in tidal areas.
- Seek to de-culvert rivers for flood risk management and conservation benefit. There should be a 4m buffer strip alongside culverted rivers.
- Enhance the river form and habitat.

Where development is on riparian land, this policy 'makes space for water' and allows additional flow capacity to accommodate climate change. It also allows access for the upgrading and ongoing maintenance of river walls, embankments and flood defences. Such space should be considered in the light of sustainable methods of working over the lifetime of the development and river structures.

Appendix F has identified that strategic reinforcement of the tidal defences would provide a comprehensive reduction in risk to all homes, community facilities and businesses within the areas of high residual risk, both existing and new, with the potential to reduce residual flood risk to such a low level that habitable rooms including sleeping accommodation could be placed on the ground floor of housing developments. There would be issues of land-take along the line of the defences, but inside the defences there would be no land-take required for secondary flood risk management measures.

A strategic approach to the upgrading of defences would need to be co-ordinated between the Environment Agency and the London Boroughs of Greenwich and Bexley. It is highly unlikely that this option would be funded by EA/Defra alone.

For further guidance see Appendix F: Chapter 4.

8.2.4 Functional floodplain

The areas of greenfield, including greenfield floodplain, within the Borough should be protected against future development maintaining it as a flood risk management asset.

Therefore development should not be permitted if it would result in the net loss of functional floodplain as defined in PPS25. The Council should protect currently greenfield land acting as Functional Floodplain from development and should seek risk reduction on brownfield sites acting as Functional Floodplain. Map 6 and 12 show the extent of functional floodplain, Flood Zone 3b, within the Borough.

[17] Greenfield discharge rates refer to the amount of discharge that would occur in the site was natural greenfield land. The Greenfield discharge rates are varied in the London Borough of Greenwich. It is 8 l/s when discharging to the Ravensbourne, 4 l/s when discharging to the Quaggy, and if discharging to the Thames attenuation is required and the developer would have to demonstrate no scour of the foreshore.

8.2.5 Structural approaches to housing development in areas of high residual risk

A study entitled "Housing Design Guidance in Areas of High Residual Flood Risk" (reproduced in Appendix F) was undertaken to support the SFRA, to consider possible measures to address the challenge of achieving safe, sustainable development. Four options were identified for detailed consideration:

Option 1: Strategic reinforcement of defences along the River Thames.
Option 2: Defences around new developments.
Option 3: Land-raising at new developments.
Option 4: Building design – investigate how building design could be used to achieve no habitable rooms below water level plus Council's objectives.

During the development of this guidance, the Environment Agency issued an interim policy position. This accepts habitable rooms except sleeping accommodation being located below the 1 in 200 year breach, and places higher emphasis on non-structural measures, in particular emergency planning, to manage the residual risk. The Environment Agency has also informed the London Borough of Greenwich that it now takes a more advisory role with respect to the management of residual flood risk, and that the decision on what are appropriate responses to the residual flood risk in the Borough should now lie with the Borough itself. Consequently the requirements of the Interim Guidance should be seen as a starting point for the development of a policy for managing residual flood risk in the Borough.

Taking into consideration the Environment Agency policy (as set out in TE2100) and other communications with the Environment Agency regarding the condition and maintenance of defences, the Borough needs to consider whether the level of residual risk of tidal breach flooding is sufficiently low to permit development with ground-floor sleeping accommodation, as long as it is demonstrated in the site-specific FRA that appropriate risk reduction measures will be implemented with the primary aim of reducing risk to life.

Although the guidance in Appendix F is specifically aimed at addressing residual flood risk to housing, many of the principles and design options discussed have relevance for other forms of development.

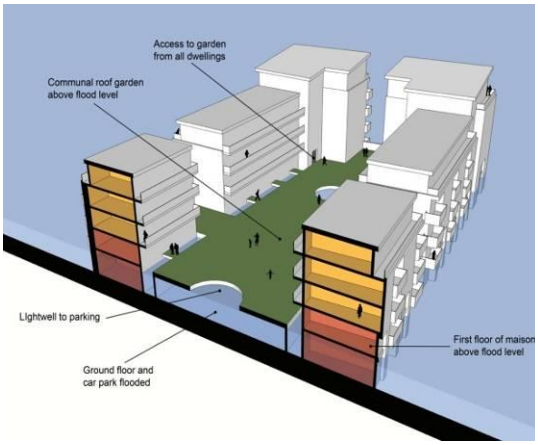
Figure 8-1: Visualisation of structural options for managing residual flood risk

Option 1: Strategic reinforcement of defences

Option 2: Defences around new developments

Option 3: Land-raising at new developments

Option 4: Housing design



Recommended approach

- Option 1, reinforcement of strategic defences would provide a comprehensive reduction in risk to all homes, community facilities and businesses within the areas of high residual risk, both existing and new.
- The Environment Agency has expressed its support in principle to the Borough for Option 1, whilst recognising that there are significant difficulties with delivery. Prior to embarking on Option 1 as a systematic programme of improvements to the tidal defences, it would be necessary to develop the evidence base to enable an informed decision on the risk of flooding due to a breach event, using probabilistic modelling to take into consideration both the probability of failure at a range of water levels, and the consequences of flooding. This would enable the Borough to decide what is an appropriate level of residual risk below which other risk reduction measures would not be required
- Options 2 (defences around new developments) and 3 (raising of new developments) seek to reduce the residual risk at new developments by providing local defences or land-raising. The study has identified significant issues with these two options, specifically increased risk to neighbouring communities, compromised place making and high land-take where gentle slopes are employed.
- Whilst land-raising or local defences around developments may be feasible at some sites, in general they would require significant compromises in either the quantity or quality of housing delivery and as such neither Option 2 nor Option 3 recommend themselves as a strategic option for managing residual risk in Greenwich.

- Option 4, housing design, seeks to reduce the residual risk of flooding through design, whilst also aiming to achieve wider objectives for sustainable living and place-making. The case study for The Moorings illustrates how multiple objectives can be achieved on a larger development site. One exception to this is the requirement for building all dwellings to Lifetime Homes standards. The ground floor within maisonettes should not be considered suitable for use as sleeping accommodation, and therefore it will not be possible to meet all of the requirements of the Lifetime Homes standard.
- Within the context of the Environment Agency's interim position statement, Option 4, housing design, represents the best available option for most housing developments within the areas of high residual risk in Greenwich. This position may change as Environment Agency takes a more advisory role and the London Borough of Greenwich develops its own policy on the appropriate responses to the residual risk. **For further guidance see Appendix F.**

8.2.6 Safe access and egress

The Council should ensure that safe access and egress to a development is provided during a flood.

'Safe' access should remain dry for 'more' and 'highly vulnerable' uses, and should preferably be dry for 'less vulnerable' land use classifications. Dry escape for residential dwellings should be up to the 1% annual probability event taking into account climate change for fluvial flood risk or defence breach during a 0.5% annual probability event plus climate change in tidal areas.

Where flood risk is from failure of defences, all developments will have to demonstrate that:

- 'Safe' access includes the ability to escape to higher levels without having to pass through flood waters.
- The LPA's emergency planners are consulted on the proposals.
- The emergency services are consulted on the proposals.
- A robust flood warning plan should be developed and communicated.
- The development would be structurally safe against the effects of breach flood waters.

For major highly vulnerable development and essential infrastructure safety will also need to be ensured through demonstration that a robust evacuation plan to dry land is developed.

Within the areas of high residual risk, and particularly within the Thamesmead embayment, containment of the affected residents is recommended as the most pragmatic means of maintaining safety. This should be followed by a rescue operation due to the lengthy period of flood water inundation.

- It is recommended that housing design must facilitate rescue of residents by air or water.
- It is recommended that vulnerable residents are identified who may need to be rescued as a matter of priority.
- It is recommended that a developer flood plan is prepared as part of the planning process. The Council and/or the Environment Agency can provide additional guidance as to the issues to be addressed. The plan should be prepared by a qualified emergency planner.
- It is recommended that post-development, a community flood plan is produced by the residents and a copy held by the Council and that the Council play an active role in ensuring that the plan is maintained by the plan owners. This should be carried out in accordance with the Cabinet Office's Strategic National Framework on Community Resilience.
- Consideration should be given to including a simple, discreet sign in each new property to inform them of the risks, impacts and what to do.
- The Multi-Agency Flood Plan (MAFP) should be updated to reflect the risk to the new development and make reference to the community flood plan.

8.2.7 Existing development proposals with outline planning permission.

It is noted that the London Borough of Greenwich currently has a large number of sites which already have outline planning permission. It is also noted that many of these have already had an initial flood risk assessment as part of the planning process. Nevertheless, it is highly recommended that these development proposals with outline planning permission be reviewed to ensure they fulfil all the same requirements and recommendations mentioned in this chapter. The recommended policies should not solely be applicable to new development proposals. It is very important for those developments which have outline permission to be constructed be designed and constructed with the findings of this SFRA in mind.

The Environment Agency's policy regarding appropriate responses to residual flood risk has evolved during 2010 and 2011. It may therefore be especially appropriate to revisit sites with outline planning permission within these areas.

8.3 Recommendations for Emergency Planning

Emergency planning is put in place by the council to manage and mitigate the risk to life of residents in existing and future developments throughout the Borough.

Under the Civil Contingencies Act (2004), the Local Authority is classified as a category 1 responder. During an emergency such as a flood event, coordination with the other category 1 responders (including the emergency services and the Environment Agency) is essential to guarantee the safety of residents. Under the Civil Contingencies Act, the Local Authority holds a statutory duty to provide civil protection to their communities to ensure human welfare, environmental stability and UK security are not affected. It should follow the principles and responses outlined in the London Flood Response Strategic Plan.

8.3.1 Recommendations for the LPA with respect to Emergency Planning

In areas where the LPA plans to add new population to Flood Zone 2 or 3, consultation with the Council's Emergency Planning team is essential, and must be undertaken at an early stage.

The advice of Emergency Planners is a material consideration when considering planning applications. The LPA and Emergency Planners should work together to ensure that the site layout and building design will reduce risk to people and allow safe access for evacuation. This is essential for major developments.

8.3.2 Recommendations for Emergency Planning Team

This SFRA contains useful data to allow emergency planning processes to be tailored to the needs of the area and be specific to the risks faced.

When reviewing their Emergency Plan, and any other plans specific to flooding, the Emergency Planning Team should:

- Consider and understand the possibility, likelihood and spatial distribution of all sources of flooding, including fluvial, tidal, surface water, sewer and groundwater flooding, as shown in the Maps of this report, and put in place specific responses to each.
- Take into account the likely extents of flooding caused by a breach in the Thames defences and the extreme depths and hazard of flooding that would ensue with very little warning.
- Encourage and advise that specific evacuation plans be put in place for existing vulnerable institutions in the floodplain and other areas at high flood risk.
- When consulted by the LPA on new development, make sure it is possible to provide adequate flood warning and evacuation plans in the event of a flood including safe havens within the floodplain, and safe routes to rest centres, prior to approval. This is particularly important in the riverside area, where breach of the tidal defences could cause flooding of depths and velocities that would be a danger to life. It should also ensure that these plans are put in place if the development goes ahead, and maintained and updated as appropriate.

- Clearly acknowledge the role of the Environment Agency in a flood event in the Major Emergency Plan, and liaise with the Environment Agency on flood warning and response to flooding.

Emergency Planners should also use the SFRA to educate local people to improve flood awareness. This should include measures that people can take to make their homes more resilient to flooding from all sources, and encouraging all those at fluvial and tidal flood risk to sign up to the Environment Agency's Floodline Warnings Direct service.

8.3.3 Essential infrastructure and vulnerable institutions

For emergency planning purposes it is necessary to identify all essential council infrastructure and vulnerable institutions that are at flood risk and their requirements for evacuation if a flood occurs.

Map 27 shows council infrastructure, the location of vulnerable institutions (e.g. hospitals, schools, and care homes); compiled using the available GIS layers.

Table 8-1 summarises which infrastructure is within the medium to high residual risk areas, and what Defra hazard rating they experience.

In addition to those affected by tidal residual risk, the following infrastructure is at risk of flooding in the 1% AEP flood event:

- Thomas Tallis School
- Bissextile House 1/4
- Coldbath Meeting Room

Table 8-1 Infrastructure at residual risk

	Defra Hazard Rating			
	Low	Moderate	Significant	Extreme
Rail line (North Kent East Jn – Dartford Jn via Greenwich)				
A206 through Charlton				
Thistlebrook Caravan Site				
St. Alfege with St Peters CE School				
St. Thomas A Becket RC School				
St Linton Mead School				
Millennium School				
Discovery School				
Bishop John Robinson CE School				
Christ Church CE School				
Boxgrove Primary School				
Hawksmoor School				
Windrush School				
St. Joseph's RC School				
Abbey Wood Secondary School				
De Lucy School				
Heronsgate School				
Arnott Pre School				
St. Paul's Thamesmead Pre School				
St. Michael's Pre-School				
Grace Neighbourhood Nursery				
Robert Owen Nursery School				
Woolwich Dock Yard Day Nursery				
Triangle Day Nursery				
Rachel McMillan Nursery School and Children's Centre				
Robert Owen Early Years Centre				
Heronsgate Playgroup				
Courtyard Playgroup				
Woolwich Polytechnic				
C2K Youth Centre				
Archway Project, Youth Club				
Blackwall Lane Youth Centre				
West Thamesmead Youth Club				
Hawksmoor Youth Club				
Meridian Adventure Playground				
Abbey Wood Clinic				
Gallions Reach Health Centre				
Godstow Road surgery				
Intermediate treatment centre				
Geepharm Chemists				
Sainsbury's Pharmacy				
Whinchat Pharmacy				
Metex Pharmacy				
Boots the Chemists Ltd, Earlswood Street				
Mental Health Respite Unit, Peterstone Road				
Brook House Care Centre				
Gallions View Nursing Home				

Malborough Court Care Centre				
Cedar Court Nursing Home				
Residential Home De Lucy Street				
Residential Care- Learning Disabilities				
Sheltered Housing, Defiance Walk				
Sheltered Housing, Armitage Road				
Substance Misuse Care Management Team				
East Greenwich Neighbourhood Office				
Abbey Wood Neighbourhood Office				
Flamsteed Estate Meeting Room				
Caletock Meeting Rooms				
Gavin House Meeting Room				
Valley Mediation Centre				
Asian Community Centre Site				
Waterways Community Children Centre				
Jamokie Family Centre (Abbey Grove)				
East Greenwich Library				
Abbey Wood Library				
Former Charlton Skill Centre/Ferranti Close				
Waterfront Leisure Centre				
Thamesmere Leisure Centre Library; Thamesmere Leisure Centre/Pool				
The Pegasus Public House				
Thamesmead Boating Club				
Petrol Station - Central Way				
Abbey Wood Park & Car park				
GAS works				
Belmarsh Prison				
Creek Road Industrial Estate				
Anchorage Point Ind. Estate;				
New Lydenburg Industrial Estate				
Thistlebrook Industrial Estate Unit				
White Hart Road Depot				
Birchmere Depot				
Felixstowe Road Depot,				
Mottisfont Road Depot				
Boord Street Lorry Park				
Westmoor Street Lorry Park				
Nathan Way Amenity Site				
Greenwich Mini Town Hall				
Rothbury Hall				
Valley House				
Boyle House				
Grovebury Hall				

9 Guidance for developers

9.1 Introduction

This section provides a series of recommendations to be considered when undertaking future developments within the London Borough of Greenwich. It is for the information of both Developers and the Council's planning department. This guidance can be applied to new developments and redevelopments, including the many sites within the London Borough of Greenwich which have already been given outline planning permission.

A supplementary study to support the SFRA, the "Guidance of Housing Design in Areas of High Residual Flood Risk" was undertaken to consider possible measures to address the challenge of achieving safe development alongside other objectives for place-making and sustainable development in these areas . This guidance is reproduced as Appendix F of this SFRA. As this supplementary guidance is of key importance to significant areas of the Borough, the additional guidance it contains is clearly signposted as follows: **For further guidance see Appendix F: Chapter 1.**

9.2 Requirements for future developments

The minimum requirements for future development are summarised in the following sections.

9.2.1 Flood Zone 1 (Low Probability)

All development (essential infrastructure, highly vulnerable, more vulnerable, less vulnerable and water-compatible development) is allowed in Flood Zone 1. Opportunities should be sought to reduce the overall levels of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of sustainable drainage techniques.

Developments >1ha

- A detailed site-specific FRA, including drainage impact assessment, should be undertaken in accordance with PPS25 and the Council's policies assessing risk from other sources of flooding which are not considered by the Flood Zone maps (Section 9.3.1).
- The effects of any flood risk identified should be mitigated by suitable methods up to the 1% annual probability pluvial event plus climate change without increasing flood risk elsewhere. (Sections 9.4 and 9.5).
- The development should meet the following drainage requirements to reduce flood risk elsewhere on both greenfield and brownfield sites:
    - Greenfield discharge rates[17]
    - Attenuation up to the 1% annual probability event plus climate change
    - Use of SUDS (Section 9.4)

Developments <1ha

The developer should identify whether the site is at risk from 'other sources' of flooding, has a known drainage problem, or has experienced flooding from other sources. If so, then the same requirements should be met as described above for a site >1ha. For those proposed developments where there is not a known drainage issue then a detailed FRA is not required. Nevertheless, the proposed development should include the appropriate application of SUDS techniques (Section 9.4) so as to maintain, or preferably reduce the existing runoff and flood risk in the area.

'Dry islands'

Greenwich includes isolated areas of Flood Zone 1 surrounded by Flood Zone 2 and 3 (Map 12) where land rises above the extreme tide level. These areas require special consideration as they can present hazards in terms of access and egress in a flood event. Any development

planned in these areas should have a detailed FRA with emphasis on safe access and egress (Section 9.6).

9.2.2 Flood Zone 2 (Medium Probability)

Flood Zone 2 is considered suitable for water-compatible, less vulnerable, more vulnerable and essential infrastructure. Highly vulnerable development is only allowed where the Exception Test is passed.

Opportunities should be sought to reduce the overall levels of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of sustainable drainage techniques, through the consideration of the following:

- A detailed site-specific FRA must be undertaken in accordance with PPS25 and the Council's Local Development Framework policies, assessing risk from fluvial and tidal flooding, risk from all 'other sources' of flooding, and the effect of climate change on flood risk over the lifetime of the development (Section 9.3.2).
- The effects of the flood risk identified should be mitigated by suitable methods up to the highest water level caused by a 1% annual probability fluvial/pluvial event plus climate change, without increasing flood risk elsewhere (Sections 9.4 and 9.5).
- Safe access should be provided to an appropriate level for the type of development (Section 9.6).
- The development should meet the following drainage requirements to reduce flood risk elsewhere:
    - Greenfield discharge rates[17]
    - Attenuation up to the 1% annual probability event plus climate change
    - Use of SUDS (Section 9.4)
- Formal consultation with Emergency Planners

In addition, any proposed development be required to provide evidence that the Sequential Test, and if required the Exception Test, have been passed.

9.2.3 Flood Zone 3a (High Probability)

Water-compatible uses and less vulnerable development are allowed in this Flood Zone, following testing within the sequential process. According to PPS25 Annex D, Table D.1 highly vulnerable development is not permitted and essential infrastructure and more vulnerable development need to pass the Exception Test. Essential infrastructure should be designed and constructed to remain operational and safe for users in times of flood.

Developers should aim to reduce the overall level of flood risk in the area through the layout and 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 floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage. The following should be considered:

- A detailed site-specific FRA should be undertaken in accordance with PPS25 and the Council's Local Development Framework policies, assessing risk of fluvial flooding (including tide locking and culvert blockage), residual risk behind tidal defences, risk from all 'other sources' of flooding, and the effect of climate change on flood risk over the lifetime of the development (Section 9.3.3).
- The effects of the flood risk identified should be mitigated by suitable methods up to the highest water level caused by a 1% annual probability fluvial/pluvial event plus climate change or a breach in the tidal defences during a 0.5% annual probability tidal event plus climate change, without increasing flood risk elsewhere (Sections 9.4 and 9.5).
- Safe access should be provided to an appropriate level for the type of development (Section 9.6).

- Flood flow routes are preserved, and floodplain storage capacity is not reduced, but where necessary is compensated for on a level for level basis outside of the floodplain (Section 9.7).
- Riverside development is set back an appropriate distance from the watercourse and development enhances the river form and habitat. If culverted the development, will not build over the culvert, will be set back an appropriate distance from the culvert and should seek to de-culvert the watercourse as part of the development.
- The development should meet the following drainage requirements to reduce flood risk elsewhere:
    - Greenfield discharge rates
    - Attenuation up to the 1% annual probability event plus climate change
    - Use of SUDS
- Consultation with emergency planners and emergency services with regards emergency/evacuation plans.

In addition, any proposed development be required to provide evidence that the Sequential Test, and if required the Exception Test, have been passed.

9.2.4 Flood Zone 3b (Functional Floodplain)

Currently undeveloped functional floodplain should be protected from development. Therefore development should not be permitted if it would result in the net loss of functional floodplain as defined in PPS25. Maps 6 and 12 show the areas of functional floodplain, Flood Zone 3b, within the Borough.

Water compatible development, essential infrastructure and redevelopment may be allowed in Flood Zone 3b.

On brownfield sites, buildings, unless permeable to floodwaters, are not considered to be part of the functional floodplain. Land/infrastructure around these buildings is considered to be functional.

If proposed, brownfield floodplain redevelopment must not exceed the existing footprint of the site as the land around these sites is considered to be functional. In addition, where brownfield redevelopment is proposed the Council should request a detailed site-specific FRA, seek opportunities to apply the policy aims of PPS25, and consider the following:

- Removal of buildings and restoration of the natural floodplain.
- Changing the land use to a less vulnerable classification.
- Changing the layout and form of the development (e.g. reducing the building footprint).
- Preserving and improving flow routes.
- Improving conveyance/storage, e.g. replacing solid building with building on stilts.
- Sequential approach to design of site

Brownfield redevelopments within the functional floodplain should also be fully flood resilient to minimise damage and enable quick recovery from flooding.

It should be noted that this only applies to regeneration in functional floodplain areas. In Zone 3a, whilst the same policy aims are included in PPS25, there is a greater presumption that redevelopment can occur, applying the Exception Test where necessary, except where the residual risks are significant.

Essential development which should locate in a functional floodplain will be designed to remain operational at times of flood or incorporate means of mitigation.

9.2.5 Sites within more than one Flood Zone

Where sites cross more than one Flood Zone the sequential approach is applied within development sites to design the site layout to reduce flood risk as much as possible, in accordance with PPS25. Most large developments involve a range of land uses, providing the opportunity to locate more vulnerable land uses in areas of lower risk. High risk areas closer

to the river in Flood Zone 3b should be used for recreation and amenity. Further advice is given in the Practice Guide to PPS25.

It should be noted that the sequential approach is not limited to sites with areas within more than one Flood Zone and should be applied throughout the process.

9.2.6 Riverside developments

All riverside developments should be:

- Set back from the river's edge or ordinary watercourses providing a buffer strip:
  - 5m from ordinary watercourses/canals
  - 8m from fluvial main rivers
  - 16m from the landward toe of flood defences in tidal areas.
- Seek to de-culvert rivers for flood risk management and conservation benefit. There should be a 4m buffer strip alongside culverted rivers.
- Enhance the river form and habitat.
- Assess the condition of existing assets and renew them so that its lifetime is commensurate with the lifetime of the development. Enhancement opportunities should be sought when renewing assets (Section 9.9).

9.3 Flood Risk Assessments

The aim of a Flood Risk Assessment (FRA) is to demonstrate that proposed development will not be at risk to flooding during the design event. This includes assessment of mitigation measures required to safely manage flood risk. The FRA also needs to demonstrate that the proposed development will not increase flood risk either upstream or downstream of the site. All sources of flood risk, including tidal, fluvial, surface water runoff and drainage need to be considered. FRAs for proposed development in Greenwich should follow the approach recommended by:

- The Environment Agency (see Flood Risk Standing Advice for England – PPS25 Version 2.0 Available from http://www.envrionment-agency.gov.uk/research/planning/82582.aspx)
- DEFRA/Environment Agency, 2005. Flood Risk Assessment Guidance for New Development Phase 2: Framework and guidance for Assessing and Managing Flood Risk for New Development – Full Documentation and Tools. R&D Technical Report FD2320/TR2;
- PPS25 and its Practice Guide Companion.
- CIRIA report 624, Development and flood risk: Guidance for the construction industry.
- National SUDs Working Group, 2004, Interim Code of Practice for Sustainable Drainage Systems.

This section will present the guidance for the developers on the appropriate level of FRA required for development in Flood Zones 1, 2, 3a and 3b, and gives advice on other issues that should be considered in development proposals. It should be read with reference to the maps contained in this report, showing the location of different types of flood risk.

If a detailed FRA is required, it should be undertaken by a suitably qualified professional. Assessments should be on a site by site basis making use of local knowledge, but an initial assessment of potential sources of flooding can be made by consulting the maps in this SFRA.

9.3.1 Flood risk assessments for Flood Zone 1

If the site is greater than 1ha in size, it will require a detailed site-specific FRA and meet the following criteria:

- The developer should check whether the site has been identified as at flood risk from other sources by the SFRA (see section 9.2.7). If so, a more detailed assessment of this risk and how it will be managed up to a 1% annual probability surface water,

groundwater or sewer flooding event plus climate change over the lifetime of the development should be made.

- A drainage impact assessment should be carried out by a suitable professional to identify the impact of the proposed development on surface water drainage, including the potential impact upon areas and receiving watercourses downstream, and recommend the approach to controlling runoff to the required discharge rates.
- Show that flood risk will be reduced overall.

If the site is less than 1ha in size, the developer is required to check whether it has been noted as at risk from flooding from other sources by the SFRA (see section 9.2.7). If so, a detailed flood risk assessment is required as above. If not, an FRA is not required but the development should still strive to use SUDS techniques and reduce runoff.

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

9.3.2 Flood risk assessments for Flood Zone 2

A detailed site specific FRA should be undertaken. It is strongly recommended that the Sequential Test, and, depending on the vulnerability of the development (see Table D.2 of PPS25), the first two parts of the Exception Test, be satisfied before the FRA is commenced.

The FRA should meet the following criteria:

- If the development is within fluvial or tidal/fluvial Flood Zone 2, assess the flood risk from fluvial flooding, including an assessment of the effects of climate change over the lifetime of the development.
- If the development is within tidal Flood Zone 2, demonstrate through use of the information contained in the SFRA that the site is not at risk from tidal flooding or residual risk behind tidal defences.
- Check whether the site has been identified as at flood risk from other sources by the SFRA. If so, a more detailed assessment of this risk and how it will be managed up to a 1% annual probability surface water, groundwater or sewer flooding event plus climate change over the lifetime of the development should be made.
- Show that flood risk will be reduced, and that suitable methods of mitigation will protect the development against the following (whichever are applicable):
    - 1% annual probability fluvial event plus climate change over the lifetime of the development.
    - A 1% annual probability (plus climate change over the lifetime of the development) surface water, groundwater or sewer flooding event.
- Show that safe access can be provided to an appropriate level for the type of development.
- Show that drainage requirements can be met.

9.3.3 Flood risk assessments for Flood Zone 3a

A detailed site specific FRA should be undertaken. It is strongly recommended that the Sequential Test, and, depending on the vulnerability of the development (see Table D.2 of PPS25), the first two parts of the Exception Test, be satisfied before the FRA is commenced.

The FRA should meet the following criteria:

- If the development is within fluvial or tidal/fluvial Flood Zone 3a, assess the flood risk from fluvial flooding, including an assessment of the effects of climate change over the lifetime of the development.
- If the development is within tidal Flood Zone 3a, assess the flood risk from a breach in the Thames tidal defences.
- Check whether the site has been identified as at flood risk from other sources by the SFRA. If so, a more detailed assessment of this risk and how it will be managed up to a 1% annual probability surface water, groundwater or sewer flooding event plus climate change over the lifetime of the development should be made.

- Show that flood risk will be reduced, and that suitable methods of mitigation will protect the development against the following (whichever are applicable):
    - 1% annual probability fluvial event plus climate change over the lifetime of the development
    - A breach in the Thames tidal defences during a 0.5% annual probability tidal event plus climate change over the lifetime of the development
    - A 1% annual probability (plus climate change over the lifetime of the development) surface water, groundwater or sewer flooding event.
- Show that safe access can be provided to an appropriate level for the type of development.
- Show that drainage requirements can be met.
- Show that flood flow routes are preserved and floodplain storage capacity is not reduced.
- If the development is adjacent to a river, it should be set back an appropriate distance from the watercourse and development should enhance the river form and habitat. If culverted, the development should not build over the culvert, should be set back an appropriate distance from the culvert and should seek to de-culvert the watercourse as part of the development.

9.3.4 Flood risk assessments for Flood Zone 3b

Only planning applications for essential infrastructure, water compatible development or redevelopment will be considered in Flood Zone 3b. It is strongly recommended that the Sequential Test, and (if the development is essential infrastructure), the first two parts of the Exception Test, be satisfied before the FRA is commenced.

A detailed FRA should be produced covering all the requirements for Flood Zone 3a. In addition development should at a minimum:

- Not increase the building footprint on the site, and if possible reduce it.
- Preserve and where possible improve flow routes.
- Improving conveyance/storage, e.g. replacing solid building with building on stilts.
- Be fully flood resilient
- Undertake a sequential approach to design of site

A detailed FRA should also show that the following have been considered and if not suitable provide justification as to why:

- Removal of buildings and restoration of the natural floodplain.
- Changing the land use to a less vulnerable classification.
- Changing the layout and form of the development (e.g. reducing the building footprint).

Essential infrastructure built within the functional floodplain should:

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

9.3.5 How to assess risk from fluvial flooding

Fluvial flood risk in Greenwich is described in Section 5 of the SFRA. If the site is within fluvial Flood Zone 2 or 3, water levels for extreme fluvial events across the site from adjacent watercourse or watercourses should be determined by a hydraulic model, at a level of detail deemed fit for purpose for the location by the Environment Agency.

The existing approved hydraulic models of the Ravensbourne Studies can be purchased from the Environment Agency for use in an FRA. Their coverage is shown in Figure 4-1. If the watercourse is not covered by these models, then a modelling study should be undertaken by

a qualified flood risk management professional. The Ravensbourne Modelling study is currently being redone and revised outputs (including undefended and defended flood extents, ABD extents and hazard mapping) should be available for use from early 2009. An FRA will be required to use these revised outputs to assess fluvial flood risk when they become available.

The 1%, 1% plus climate change and 0.1% annual probability fluvial events should be modelled as part of the FRA. The site layout should then be designed sequentially based on flood risk. Mitigation and safe access should be provided up to the 1% annual probability plus climate change water level.

The required precautionary climate change allowances for peak river flows are given in Table B.2 of PPS25, and should be modelled for an FRA. These are: 10% added to peak river flow up to 2025, and 20% thereafter to 2115. The appropriate period for climate change assessment is the designed lifetime of the development.

If the site is within the tidal/fluvial Flood Zone 2 or, then an additional model run should be carried out to assess the impact of tide locking during a fluvial event. The 1% annual probability plus climate change event with a spring tide in the Thames should be modelled as a minimum, and preferably sensitivity of water levels to the combination of tide and flow should be tested.

If the site within 100m of the upstream end of a culvert, then the effect on water level of a 75% blockage of this culvert should also be modelled as part of the FRA.

If any river restoration or de-culverting is planned as part of the development, then it should be modelled. The FRA should demonstrate that such changes will not increase (and preferably will reduce) water levels across the site.

9.3.6 How to assess risk from tidal flooding and residual risk behind defences

Tidal flood risk in Greenwich is described in Section 7 of the SFRA. If the site is in tidal Flood Zone 2 or 3 only then an assessment of risk from tidal flooding is required to an appropriate level.

Extreme tide levels at Greenwich from the Tidal Thames model should be obtained from the Environment Agency (although it should be remembered that these levels are based on the assumption that the Thames Barrier will continue to function as intended). The SFRA has shown using these water levels that Greenwich is protected by well-maintained defences that will not overtop even up to the 0.5% annual probability event plus climate change to 2107. The SFRA has identified areas at high, medium and low residual risk on Map 24:

- If the site is in tidal Flood Zone 2 only, then the SFRA should be considered an acceptable assessment of tidal risk. The site is defended from all tidal risk, including residual risk, and no further detail should be required in the FRA.
- If the site is in tidal Flood Zone 3, but at low residual risk on Map 24 then the SFRA should be considered an acceptable assessment of residual risk. The site is defended from all tidal risk, and is at low residual risk.
- If the site is in tidal Flood Zone 3, and been identified as being within high and medium residual risk zones on Map 24, residual risks will need to be considered in detail by the FRA as described below.

Consultation with the Environment Agency will be required to agree what breach location would cause the greatest water levels at the site. If one of the breaches modelled for the SFRA is likely to be the worst case location for the site, then it should be sufficient to use the SFRA breach results.

However further breach analysis will be required by a qualified flood risk management professional if this is not the case. A detailed site-specific analysis of breach scenarios should involve:

- Locating appropriate breach locations and determining the relative dimensions to be modelled. The Environment Agency will be able to offer guidance on location of a breach, defence heights and proposed breach widths.

- 2D modelling of a breach in a defence for the tidal flood event with a 0.5% annual probability, including the impact of climate change. The breach should occur for a duration of at least two tide cycles dependent on the defence type.
- Extraction of detailed site specific data including depths, UK flood hazard index and speed of onset.

The depths, UK flood hazard index and speed of onset can then be used to assess the risk to life using the FD2320 methodology and test the robustness of mitigation schemes.

9.3.7 How to assess flood risk from 'other sources'

Flood risk from 'other sources' in Greenwich is described in Section 6 of the SFRA. All developers should refer to Maps 5, 9, 10 and 11 prior to submitting a planning application and use this information to assess whether the site may be susceptible to flooding from surface water, sewer flooding or groundwater flooding.

Guidelines to use should be:

- Where surface water flooding shown as 0.3m or deeper (Map 9).
- Within 100m of a sewer flooding incident
- Within 250m of groundwater flooding incident as shown on Map 5 or constructing a new basement on an aquifer (Map 5).

If the SFRA indicates that the site may be at risk then the level of risk will need to be quantified in greater detail at the site by a qualified flood risk management professional using appropriate local data:

- The capacity of the existing drainage system and any planned improvements.
- The nature and behaviour of local aquifers.

After initial scoping, the need for drainage or groundwater modelling using appropriate software should be sensibly assessed depending on the severity of the problem.

Any existing surface water flow routes (including routes that groundwater flooding takes overland) should be preserved by the development. Mitigation against the likely depths of flooding should be provided up to the 1% annual probability plus climate change event.

The required precautionary climate change allowances for peak rainfall intensity are given in Table B.2 of PPS25, and should be modelled for an FRA. These are: 5% added to peak rainfall intensity up to 2025, 10% to 2055, 20% to 2085 and 30% to 2115. The appropriate period for climate change assessment is the designed lifetime of the development.

9.4 Managing flood risk downstream through SUDS

Sustainable Drainage Systems (SUDS) are management practices which enable surface water to be drained in a more sustainable manner.

As a consequence of the Draft Flood and Water Management Bill (2009) the Council will have to give approval for all proposals' to construct SuDs in the Borough. In addition they will have the power to inspect construction and monitor the operation of the system to ensure it is in line with the proposal. The Council will also be responsible for maintaining the SUDS in compliance with national standards.

The effectiveness of a flow management scheme within a single site is heavily limited by site constraints including (but not limited to) topography, geology (soil permeability), and available area. The design, construction and ongoing maintenance regime of such a scheme should be carefully defined, and a clear and comprehensive understanding of the catchment hydrological processes (i.e. nature and capacity of the existing drainage system) is essential. Additionally, for infiltration SUDS it is imperative that the water table is low enough and a site specific infiltration test is undertaken. Where sites lie within or close to source protection zones further restrictions may be applicable, and guidance should be sought from the Environment Agency.

There are many different SUDS techniques which can be implemented. The Environment Agency Thames Region has issued a practical guide on SUDS, in which they suggest a sustainability based hierarchy of appropriate techniques (Table 9-1). Further information can also be found in the Flood Risk Standing Advice for England – PPS25 Version 2.0 Available

from the Environment Agency (http://www.envrionment-agency.gov.uk/research/planning/82582.aspx). In addition the London Mayor's Draft Water Strategy (2007) proposes a similar hierarchy with regards on site rainwater drainage options (Chapter 6, Hierarchy 3).

The suitability of the following list of techniques, which is by no means comprehensive, will be dictated in part by the development proposal and site conditions. Advice on best practice is available from the Environment Agency and the Construction Industry Research and Information Association (CIRIA).

Table 9-1 The SUDS hierarchy

	SUDS technique	Flood Reduction	Pollution Reduction	Landscape and Wildlife Benefit
Most Sustainable ↓	Living roofs	✔	✔	✔
	Basins and ponds Constructed wetlands Balancing ponds Detention basins Retention ponds	✔	✔	✔
	Filter strips and swales	✔	✔	✔
	Infiltration devices Soakaways Infiltration trenches and basins	✔	✔	✔
	Permeable surfaces and filter drains Gravelled areas Solid paving blocks Porous pavements	✔	✔	
Least Sustainable	Tanked systems Over-sized pipes/tanks Storm cells	✔		

9.4.1 Living (green) roofs and walls

Living Roofs and walls can vary in type from Roof Gardens, Roof Terraces, Green Roofs and Green Walls. This approach utilises plants and their substrate provide temporary storage of rainfall. The water retained by the substrate and lost through evaporation and evapotranspiration minimises runoff from the roof.

Figure 9-1 Example of a green roof in Fulham

7 Beaufort Court, Lillie Road, Fulham © Peabody Trust

An award winning example of a green roof is Beaufort Court, Lillie Road, Fulham (Figure 9-1). This is a social housing development created in 2003 with sedum roofs to reduce surface water run-off and provide a visual amenity. Other examples of successful green roof projects can be found in the Mayor of London's 'Living Roofs: Case Studies' document.

Sedum is not the only green roof substrate recommended. Other possibilities include wildflower turfs which exert a similar weight loading and moisture retention but offers additional biodiversity benefits.

9.4.2 Basins and ponds

Basins and ponds enhance flood storage capacity by providing temporary storage for storm water through the creation of landscape features within a site (which can often provide opportunities for the creation of wildlife habitats). Basins, ponds and wetlands can be fed by swales, filter drains or piped systems. In some instances, storm water runoff from a development can feed a pond which overflows into a vegetated wetland area to act as a natural soakaway.

9.4.3 Filter strips

Filter strips are vegetated areas that are intended to treat sheet flow from adjacent impervious areas. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. This approach to SUDS also provides scope for the creation of wildlife habitats and biodiversity gain.

9.4.4 Infiltration devices

Infiltration devices drain water directly into the ground. They may be used at source or the runoff can be conveyed in a pipe or swale to the infiltration area. They include soakaways, infiltration trenches and infiltration basins as well as swales, filter drains and ponds. Infiltration devices can be integrated into and form part of the landscaped areas.

9.4.5 Permeable surfaces and filter drains

Pervious pavements such as permeable concrete blocks, crushed stone and asphalt will allow water to infiltrate directly into the subsoil before soaking into the ground. According to the London Plan SPG regarding Sustainable Design and Construction this technique may be particularly appropriate on London Clay where infiltration is slow, where, if necessary, an overflow can keep the pavement free of water in all conditions

Filter drains are gravel filled trenches which trap sediments from run-off and provide attenuation. Flow is directed to a perforated pipe which conveys run-off back into the sewerage network or into a water body. Filter drains are used mainly to drain road and car park surfaces.

9.4.6 Rainwater harvesting

Rainwater harvesting techniques, such as the installation of water butts, can aid in increasing the attenuation of rainfall and contribute to the on-site recycling of water.

9.5 Reducing flood risk

The minimum acceptable standard of protection against flooding for new property within flood risk areas is 1% annual probability for fluvial flooding and a breach during a 0.5% annual probability tidal event, with allowance for climate change over the lifetime of the development.

The measures chosen will depend on the nature of the flood risk, and obviously development vulnerable to sewer flooding will require a different approach to one at risk from breaching of the tidal Thames defences. Some of the more common measures are outlined here, and more detail is given in Chapter 5 of the Practice Guide to PPS25.

9.5.1 Reducing flood risk through site layout and design

Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development. Most large development proposals include a variety of land uses of varying vulnerability to flooding.

The Practice Guide to PPS25 states that a sequential, risk-based approach should be applied to try to locate more vulnerable land use to higher ground, while more flood-compatible development (e.g. parking, recreational space) can be located in more high risk areas.

Low-lying waterside areas, or areas along known surface water flow routes, can be used for recreation, amenity and environmental purposes, allowing the preservation of flow routes and flood storage, and at the same time providing valuable social and environmental benefits contributing to other sustainability objectives.

Landscaping should ensure safe access to higher ground from these areas, and avoid the creation of isolated islands as water levels rise.

9.5.2 Modification of ground levels

Modifying ground levels to raise the land above the required flood level is a very effective way of reducing flood risk to the site in question, particularly where the risk is entirely from tidal flooding and the land does not act as conveyance for flood waters. In those areas of the Borough at residual risk from tidal breaching, the possible depths of flooding during such an event could exceed 2m. In such circumstances it is unlikely that land-raising of 2m or more would be compatible with other place-making objectives (**see Appendix F chapter 5 for detailed consideration of this issue**). A hybrid of land-raising and other measures may, however, be appropriate for some sites.

In most areas of fluvial flood risk, conveyance or flood storage would be reduced by raising land above the floodplain, adversely impacting on flood risk downstream. Compensatory flood storage should be provided. Storage should equate to level for level compensatory volume. Where the site is entirely within the floodplain it is not possible to provide compensatory storage at the maximum flood level and this will not be a viable mitigation option. Compensation schemes should be environmentally sound.

9.5.3 Building design

The raising of floor levels within a development avoids damage occurring to the interior, furnishings and electrics in time of flood. Floor levels should be raised by the following amounts:

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

- In areas at risk of a breach in the tidal defences, development of habitable rooms including bedrooms may be considered acceptable subject to the Borough being assured that the development is safe. As a minimum Structural measure, this will require an internal safe-haven within each unit to be built with a floor level at least-300mm above the maximum water level caused by a defence breach during a 0.5% annual probability event plus climate change event

This additional height that the floor level is raised is referred to as the 'freeboard'.

Making the ground floor use of a building water compatible is an effective way of raising living space above flood levels. However, consideration must also be given as to the implications of such measures, for example the long-term sustainability of commercial premises on the ground floor, or the place-making implications of creating a "sterile" street scene. **See Appendix F chapter 6 for a detailed consideration of these issues.**

Putting a building on stilts is not considered an acceptable means of flood mitigation for new development. However it may be allowed in special circumstances if it replaces an existing solid building, as it can improve flood flow routes. In these cases attention should always be paid to safe access and egress, and legal protection should be given to ensure the ground floor use is not changed.

Single storey developments are not acceptable in flood risk areas.

Overall the development should be made structurally safe against the effects of flood waters.

9.5.4 Resistance and resilience

There may be special instances where flood risk remains to a development. For example where the use is water compatible, where an existing building is being changed, where residual risk remains behind defences, or where floor levels have been raised but there is still a risk. In these cases (and for existing development in the floodplain), additional measures can be put in place to reduce damage in a flood and increase the speed of recovery. These measures should not be relied on as the only mitigation method.

The 2003 'Preparing for Floods' document published by the Office of the Deputy Prime Minister provides further details on possible resilience measures.

Temporary barriers

Temporary barriers consist of moveable flood defences which can be fitted into doorways and/or windows. The permanent fixings required to install these temporary defences should be discrete and keep architectural impact to a minimum. On a smaller scale temporary snap on covers for airbricks and air vents can also be fitted to prevent the entrance of flood water. The Environment Agency provides a list of manufacturers, with the Kitemark, of temporary defences on their website (www.environment-agency.gov.uk).

Temporary or demountable defences are not acceptable flood protection for a new development; however they are useful for protecting existing against flood risk.

Temporary defences or demountable defences should only be installed where there is a flood warning with an adequate lead time to provide enough time for the defences to be put in place.

Permanent barriers

Permanent barriers can include built up doorsteps, rendered brick walls and toughened glass barriers (Figure 9-2).

Figure 9-2 Permanent flood barriers

Wet-proofing

Interior design to reduce damage caused by flooding, for example:

- Electrical circuitry installed higher level with power cables being carried down from the ceiling not up from the floor level.
- Water-resistant materials for floors, walls and fixtures.

If redeveloping existing basements new electrical circuitry installed higher level with power cables being carried down from the ceiling not up from the floor level to minimise damage if the basement floods.

Resilience measures will be specific to the nature of flood risk, and as such will be informed and determined by the FRA.

The 2003 ‘Preparing for Floods’ document published by the Office of the Deputy Prime Minister and the 2007 Communities and Local Government document ‘Improving the Flood performance of New Buildings – Flood Resilient Construction’ provides further details on resilience measures.

9.5.5 Raised defences

Construction of raised floodwalls or embankments to protect new development is not a preferred option, as a residual risk of flooding will remain. Compensatory storage should be provided where raised defences remove storage from the floodplain.

9.5.6 Developer contributions to flood defences

In some cases, it may be necessary for the developer to make a contribution to the improvement of flood defence provision needed by the development in question, which may also benefit the wider local community.

9.6 Making development safe

9.6.1 Safe access and egress

Safe access and egress to and from a development during a flood should be ensured. 'Safe' access should remain dry for 'more' and 'highly vulnerable' uses, and should preferably be dry for 'less vulnerable' land use classifications. Dry escape (or internal safe-havens where the

emergency plan is to remain in place in the event of a flood) for residential dwellings should be up to the 1% annual probability event taking into account climate change for fluvial flood risk or defence breach during a 0.5% annual probability event plus climate change in tidal areas.

The developer will be required to ensure that safe access and egress is provided to an appropriate level for the type of development.

As part of the FRA, the developer should review the acceptability of the proposed access using the 'Flood Risk to People' FD 2320 calculator. In this instance it needs to be demonstrated that depths and velocities of flood water will be acceptable to the 'risks to some' category of this calculator.

9.6.2 Flood warning and evacuation

Emergency/evacuation plans should be in place for all properties, large and small, at residual risk of flooding; those developments which house vulnerable people (i.e. care homes and schools) will require more detailed plans. Advice should be sought from the Council's Emergency Planning Team when producing an emergency/evacuation plan for developments as part of an FRA. Detailed emergency/evacuation plans for developments should undertake consultation not only with the Council's Emergency Planning team but also the Emergency Services so they know what is expected of them in the event of an emergency.

All homes and businesses within Flood Zone 2 and 3 are eligible for the Environment Agency's Floodline Warnings Direct service, and should be encouraged to sign up to it. It is recommended that the developers make new owners of the property aware of this so they can sign up to FWD. This applies even if the development is defended to a high standard. It should be noted however that at present this service does not contain any provision of warnings in the event of a breach of the defences.

9.7 Making space for water

9.7.1 Opportunities for river restoration and enhancement

All new development close to rivers should consider the opportunity presented to improve and enhance the river environment. Developments should look at opportunities for river restoration and enhancement as part of the development. Restoration can take place on various scales, from small enhancement measures to full river restoration. Options include backwater creation, de-silting, in-channel habitat enhancement, removal of structures e.g. weirs, toe boarding[18], restoration of banks.

When designed properly, such measures can have benefits such as reducing the costs of maintaining hard engineering structures, reducing flood risk, improving water quality and increasing biodiversity. Social benefits are also gained by increasing green space and access to the river.

9.7.2 Buffer strips

As a minimum, developers should aim to set back development 5m from ordinary watercourses/canals, 8m from fluvial main rivers and 16m in tidal areas, providing a buffer strip to 'make space for water' and allow additional capacity to accommodate climate change.

9.7.3 Culverted rivers

There should be a presumption against further culverting and building over culverts. All new developments with culverts running through their site should seek to de-culvert rivers for flood risk management and conservation benefit. Where culverts are to remain unchanged allowance should be made for future improvements to the watercourse, including replacement of the culvert. Widths of such a buffer strip will depend on site circumstances but will be at least 4 - 6m.

[18] Toe boarding is a low wall built in the river channel to prevent erosion of the riverbank.

9.7.4 Drainage capacity

The capacity of internal drainage infrastructure is often limited and is at or near capacity under existing conditions. Development that leads to increased peak runoff within the drainage catchments may lead to infrastructure capacity being exceeded, with the potential for increased flood risk. Development locations should be assessed to ensure capacity exists within both the on and off site network. Thames Water state that:

"To ensure all future development is sustainable detailed computer modelling of development sites will be carried out to identify infrastructure requirements once the exact location and scale of development is known. Development will not be allowed to precede the delivery of essential infrastructure, identified as part of this modelling work and the LPA will work closely with the water company to reject unsustainable sites or attach Grampian planning conditions on sites where essential infrastructure is required."

9.8 Managing flood risk from other sources

9.8.1 Surface water and sewer flooding

If a new development is approved in an area where the drainage or sewage network is inadequate, responsibility lies with Thames Water to improve the network. The developer can also contribute to such improvements and speed up this process. The development should improve the drainage infrastructure to reduce flood risk on site. It is important however that a drainage impact assessment shows that this will not increase flood risk elsewhere, and the drainage requirements regarding runoff rates and SUDS for new development are met.

If residual surface water flood risk remains, the likely flow routes and depths across the site should be modelled. The site should be designed so that these flow routes are maintained, and building design should provide resilience against the risk of surface water or sewer flooding.

When redeveloping existing buildings the installation of some permanent or temporary flood proofing and resilience measures could prevent both surface water and sewer flooding. Non-return valves prevent water entering the property from drains and sewers. Non-return valves can be installed within gravity sewers or drains, within the property's private sewer upstream of the public sewerage system. These need to be carefully installed and should be regularly maintained. The CIRIA publication, 'Low cost options for prevention of flooding from sewers', provides further information. Additionally, manhole covers within the property's grounds could be sealed to prevent surcharging.

9.8.2 Groundwater

Groundwater flooding has a very different flood mechanism to any other, as it rises up from below ground level, and for this reason many conventional flood defence and mitigation methods are not suitable. The only way to fully reduce flood risk would be through building design, ensuring that floor levels are raised above the water levels caused by a 1% annual probability plus climate change event. Site design would also need to preserve any flow routes followed by the groundwater overland and make sure flood risk is not increased downstream. The design of any new basements should ensure that flood risk is not increases for existing adjacent basements by changes to groundwater flow.

When redeveloping existing buildings it may be acceptable to install pumps in basements as a resilience measure. However for new development this is unlikely to be considered an acceptable solution.

9.9 Existing defences and assets

Proposed developments which are adjacent to the River Thames should show that access to existing defences for their maintenance, and where appropriate improvement has been considered. In accordance with the London Plan, and London's RFRA development adjacent to the Thames will need to be set back 16m (as recommended by the Environment Agency) from the landward toe of the flood defence structure to enable sustainable and cost effective upgrades of river walls/embankments.

Developers should also assess existing assets (e.g. bridges, culverts, river walls, embankments) and renew them to last the lifetime of the development. Enhancement opportunities should be sought when renewing assets, e.g. bioengineered river walls, raising bridge soffits to account for climate change.

10 Assessment of site specific allocations

10.1 Introduction

The Council provided a series of site allocations they wish to be assessed as part of this SFRA. These are predominantly sites allocated in the 2006 Adopted UDP, some of which already have planning permission. An initial review of flood risk for the proposed sites has been undertaken, allowing the council to apply the Sequential Test.

The overarching aim of PPS25 is to guide development away from high flood risk through the use of the Sequential Test. An SFRA cannot carry out the Sequential Test on behalf of the Council, because the Council is much better placed to consider wider issues that may affect availability of development sites, but is designed to provide a basis for the Test. Where a large percentage of the site is within Flood Zone 2 or 3, the Council should be able to demonstrate that:

- No suitable development sites are available in lower risk areas. For land to be allocated within the high risk zone, the full range of planning issues has been evaluated.
- It has been determined through the SEA (Strategic Environmental Assessment) and SA (Sustainability Appraisal) that the land is the most suitable for development

If the Sequential Test is passed, the Council should consult Table 3-2 on what types of development are appropriate.

This SFRA does not assume that the Sequential Test has been passed for any site, but rather gives advice on what further work needs to be done in the event that a site does pass the Sequential Test. This guidance focuses on the technicalities of flood risk management rather than the other planning issues an LPA must consider in selecting allocations.

10.2 Initial assessment of site allocations

Table to Table list all the sites and provides an initial overview of flood risk. The sites have are categorised according to their flood risk with reference to PPS25, and their residual risk rating, to enable the councils to carry out the Sequential Test.

The sites have been assessed based on their area, Flood Zone, residual risk, other sources of flooding and whether an FRA will be required under PPS25.

25 of the sites are in the low probability Flood Zone 1, but the remainder all have at least part of their area within Flood Zones 2 and 3. Many of the sites are large and cross several Flood Zones. Those sites with a high flood risk which would require further flood risk assessment have been carried forward into a series of site specific assessment.

Note: 'Other Sources' of flood risk considered in the following tables are Groundwater (GW), Surface Water (SW) and the Southern Outfall Sewer (SOS).

Table 10-1 Development sites identified in UDP

Development Site[i]	UDP Ref	Area (ha)	Flood Risk					FRA Required ?	FRA carried out?
			Flood Zone	Residual Risk	Other Sources GW	SW	SOS		
Horseferry Place / Thames Street	cb1	0.10	3a	Yes	No	No	No	Yes	No
Thomas Tallis Secondary School (Kidbrooke)	cb2	2.78	1	No	No	No	No	Yes*	Yes
Thamesmere Drive	cb3	0.61	3a	Yes	Yes	No	No	Yes	No
Tripcock Point School Site	cb4	1.62	3a & 2	Yes	Yes	No	No	Yes	Yes
Lombard Wall / Anchor and Hope Lane	j2	1.99	3a & b	Yes	Yes	No	No	Yes	No
Angerstein Triangle	j3	4.60	1	No	Yes	Yes	No	Yes**	No
Bowater Road / Faraday Road	j4	1.74	3a & 2	Yes	Yes	No	No	Yes	No
Thames Barrier Approach	j5	2.30	3a & 2	Yes	Yes	Yes	No	Yes	No
Lower Norman Road	j7	0.93	3a & 2	Yes	Yes	No	No	Yes	No
Norman Road and railway arches	j8	0.39	3a & 2	Yes	Yes	No	No	Yes	No
A102(M) / Bugsby's Way	j9	4.89	3a & 2	Yes	No	Yes	No	Yes	Part
Horn Link Way / Pear Tree Way	j10	1.16	3a & 2	No	Yes	No	No	Yes	Yes
Warspite Road / Rushton Road	j11	0.40	3a & 2	No	Yes	No	No	Yes	No
Hervey's site, Ramac Way	j12	0.83	3a & 2	No	Yes	No	No	Yes	No
Nathan Way	j14	1.05	3a & 2	No	Yes	No	No	Yes	No
Nathan Way	j15	0.52	3a & 2	No	Yes	No	No	Yes	No
East of Plumstead Bus Garage	j16	0.86	3a & 2	No	Yes	No	No	Yes	Yes
Harrow Manor Way	h1	1.11	3a & 2	Yes	Yes	No	No	Yes	Yes
McMillan Street	h2	0.27	1	No	No	No	No	No	N/A
Eltham Pools	h3	0.29	1	No	No	No	No	No	N/A
National Maritime Museum Storage Site (Kidbrooke)	h4	1.84	1	No	No	No	No	Yes*	No
Thomas Tallis School (Kidbrooke)	h5	2.50	1	No	No	No	No	Yes*	Yes
West Ferrier precinct (Kidbrooke)	h6	14.15	2	No	No	Yes	No	Yes**	Yes
East Ferrier Estate (Kidbrooke)	h7	16.7	1 & 2	No	No	Yes	No	Yes**	Yes
Land adj Broadwater Dock	h8	0.76	3a	Yes	Yes	No	No	Yes	No
Hervey Road Playing Fields	o2	4.78	1	No	No	No	No	Yes*	No
Mansion Site	o4	7.46	1	No	No	Yes	No	Yes**	No
Southwood Site	o5	7.07	1	No	No	Yes	No	Yes**	No
									No
Crossrail	m5	25.9	All	Yes	Yes	Yes	Yes	Yes	No
Thamesmead Pier	m8	0.12	3b	No	No	No	No	Yes***	No
Former Plumstead Coal Yard	m11	3.20	3a & 2	Yes	Yes	Yes	Yes	Yes	Yes

Development Site[i]	UDP Ref	Area (ha)	Flood Risk					FRA Required ?	FRA carried out?
			Flood Zone	Residual Risk	Other Sources GW	SW	SOS		
Coronet Cinema	mu1	0.43	1	No	No	No	No	No	N/A
Stockwell Street	mu3	0.81	1	No	No	Yes	No	Yes**	Yes
Deals gateway	mu4	0.50	1	No	Yes	Yes	No	Yes**	Yes
Blackwall Lane / Pelton Street	mu7	0.28	2	No	Yes	No	No	Yes	No
Callis Yard	mu8	0.27	1	No	Yes	No	No	Yes**	Yes
Macbean Centre	mu9	1.06	1	No	Yes	No	No	Yes**	No
Hare Street / Powis Street	mu10	1.26	1	No	Yes	Yes	No	Yes**	Yes
Goldie Leigh Hospital	mu11	7.30	1	No	Yes	No	No	Yes**	No
Land north of Eltham High Street	mu12	1.85	1	No	No	No	No	Yes*	No
Warren Lane 'Teardrop' Site	mu13	1.53	1	No	Yes	No	No	Yes**	Yes
Woolwich Arsenal station	mu14	3.19	1	No	Yes	Yes	No	Yes**	Part
Grove Market Place	mu15	0.51	1	No	No	Yes	No	Yes**	No
Hilton's, Lion and Saxon Wharves	mu16	0.90	3a & 2	Yes	No	No	No	Yes	No
Creek Road / Bardsley Lane	mu17	0.63	3a & 2	Yes	No	Yes	No	Yes	Maybe in EIA
O2 and tip of peninsula	mu19	16.47	3a & 2	Yes	No	Yes	No	Yes	Yes
Delta / Blackwall Wharf	mu21	9.70	3a & 2	Yes	No	Yes	No	Yes	Yes
A102(M) / West Parkside	mu22	9.39	3a & 2	Yes	No	No	No	Yes	Yes
East Parkside / Bugsby's Reach	mu23	8.41	3a & 2	Yes	No	No	No	Yes	Yes
Woolwich Royal Arsenal	mu24	7.15	3a & 2	Yes	Yes	No	No	Yes	Yes
Royal Hill Court	mu25	0.32	1	No	Yes	No	No	Yes**	No
Woolwich Campus 'Island' Site	mu27	1.12	1	No	Yes	Yes	No	Yes**	No
Former public baths building	mu28	0.20	1	No	No	No	No	No	No
Maritime Industrial Estate	mu29	2.32	3a & 2	Yes	Yes	No	No	Yes	Yes
Deptford Bridge North Side	mu31	0.26	3a & 2	No	Yes	Yes	No	Yes	Yes
131-161 Greenwich High Road	mu33	1.57	3a & 2	Yes	Yes	Yes	No	Yes	No
161-171 Greenwich High Road	mu34	0.51	3a & 2	Yes	Yes	No	No	Yes	No
121-151 Powis Street	mu36	0.87	1	No	Yes	No	No	Yes**	Part
Waterfront Leisure Centre Car Park	mu37	0.74	3a & 2	Yes	Yes	Yes	No	Yes	No
Kidbrooke Station Area	mu39	4.84	1	No	No	No	No	Yes*	Yes
Tripcock Point / Tamesis Point	mu40	29.90	3a & 2	Yes	Yes	No	No	Yes	Yes

Development Site[i]	UDP Ref	Area (ha)	Flood Risk					FRA Required ?	FRA carried out?
			Flood Zone	Residual Risk	Other Sources GW	SW	SOS		
Note: * indicates sites where a FRA is required as the site area is > 1ha. An individual summary sheet has not been produced for these sites. Note: ** indicates sites where a FRA would be required due to site being at risk of 'other sources' of flooding. An individual summary sheet has not been produced for these sites. Note: *** indicates sites where a FRA is required as the site area is in Flood Zone 3b, however as there are no other sources of flooding or residual risk and the use proposed is Water Compatible a separate summary sheet has not been produced.									

Table 10-2 Defined Industrial Areas identified in UDP

Defined Industrial Areas	Ref	Area (ha)	Flood Risk					FRA Required ?
			Flood Zone	Residual Risk	Other Sources GW	SW	SOS	
Western Greenwich Penninsula	DIA1	28.04	3a & 2	Yes	Part	Yes	No	Yes
Charlton Riverside	DIA2	36.26	3a & 2	Yes	Yes	Yes	No	Yes
West Thamesmead/Plumstead	DIA3	18.94	3a & 2	Yes	Yes	Yes	Yes	Yes

Table 10-3 Opportunity Areas identified in the draft Thamesmead and Abbey Wood SPD

Opportunity Area[ii]	Ref	Area (ha)	Flood Risk					FRA Required ?
			Flood Zone	Residual Risk	Other Sources GW	SW	SOS	
Thamesmead Town Centre	OA1	42	3a & 2	Yes	Yes	Yes	No	Yes
Abbey Wood	OA2	24	3a & 2	Yes	Yes	Yes	Part	Yes
The Ridgeway	OA3	56	3a & 2	Yes	Yes	Yes	Yes	Yes
The Moorings	OA4	84	3a & 2	Yes	Yes	Yes	Part	Yes
The Arches	OA5	18	3a & 2	Yes	Yes	Yes	Yes	Yes
Pettman Crescent	OA7	63	3a & 2	Yes	Yes	Yes	Part	Yes

Table 10-4 Additional Areas identified by the council

Additional Areas	Ref	Area (ha)	Flood Risk					FRA Required ?
			Flood Zone	Residual Risk	Other Sources GW	SW	SOS	
Woolwich Council Estate Regeneration	AA1	?	1	No	Yes	No	No	Yes*
Creekside Area	AA2	6.5	All	No	Yes	Yes	No	Yes
Woolwich Town Centre	AA3	2.69	1	No	Yes	Yes	No	Yes**
Note: * indicates sites that a FRA is required as the site area is > 1ha. An individual summary sheet has not been produced for these sites. Note: ** indicates sites that a FRA would be required due to site being at risk of 'other sources' of flooding. An individual summary sheet has not been produced for these sites.								

10.3 Assessment of specific site allocations

A detailed examination of flood risk at each SSA site, including the effect of defences and residual flood risk, has been carried out as part of the Level 2 SFRA. Appendix A contains a summary for each site of:

- Flood risk vulnerability classification of proposed development and whether the Exception Test would be required once the Sequential Test has been passed.
- Flood Zone map
- Sources of flooding with detailed maps where appropriate
- Flood defences

- Residual risk
- Effect of climate change
- Requirements for a Flood Risk Assessment – specific to issues at the site, the requirements given in section 10 also apply
- Requirements for passing Part 'c' of the Exception Test

The sites are at widely varying levels of flood risk. Many have flood risk that can be managed easily, for example where the part of the site within Flood Zone 2 and 3 is relatively small, it may be possible to use 'sequential design' within the allocation to relocate highly vulnerable and more vulnerable development away from the higher risk areas as appropriate.

Others are at relatively high flood risk but the development proposed is 'Water Compatible' and should be permitted under PPS25, for example the proposal for Riverside Wharves on Lombard Wall / Anchor and Hope Lane, and the proposal for the construction of a pier at Thamesmead.

Many of the sites have development planned which is classed as 'more vulnerable', either residential or educational. For these sites to pass the Exception Test they will require mitigation against the sources of flood risk, and consideration of safe access and egress, flood warning and evacuation.