Oxford City Council

Strategic Flood Risk Assessment for Oxford City

Final Report

June 2008

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1.0 INTRODUCTION

1.1 Need for a Flood Risk Assessment

Flooding is the most widespread and frequently occurring of natural hazards and, therefore, flood risk is one of many factors that should influence the spatial planning process. All forms of flooding and their impact on the natural and built environment are material planning considerations.

Planning Policy Statements set out the Government's national policies on different aspects of land use planning in England. Planning Policy Statement 1: Delivering Sustainable Development (PPS1) sets out the Government's objectives for the planning system and describes how planning should facilitate and promote sustainable patterns of development, avoiding flood risk and accommodating the impacts of climate change.

Planning Policy Statement 25: Development and Flood Risk (PPS25) complements other national planning policies and should be read in conjunction with Government policies for flood risk and water management, including Making Space for Water and the forthcoming Water Framework Directive. The aims of PPS25 are to ensure that flood risk is taken into account at all stages of the planning process to avoid inappropriate development in areas at risk of flooding and to direct development away from areas at highest risk (the Sequential Test). If, exceptionally, new development is necessary in such areas the policy aims to make the development safe without increasing flood risk elsewhere and, where possible, reducing flood risk overall (the Exception Test).

PPS25 requires an assessment of flood risk to be carried out to an appropriate degree at all levels of the planning process viz:-

- a Regional Flood Risk Appraisal (RFRA) to inform the Regional Spatial Strategy (RSS);
- a Strategic Flood Risk Assessment (SFRA) to inform the Local Development Documents (LDDs);
- a site-specific Flood Risk Assessment (FRA) to be submitted with planning applications for development in areas of flood risk, under the circumstances identified in the PPS;

The Planning and Compulsory Purchase Act 2004 requires that a Sustainability Appraisal is undertaken for Regional Spatial Strategies, Development Plan Documents and Supplementary Planning Documents. Regional planning bodies (RPBs) and Local Planning Authorities (LPAs) are required under PPS25 to prepare and to implement planning strategies that help deliver sustainable development. In developing their policies and strategies, RPBs and LPAs should work with the Environment Agency and other relevant operating authorities and stakeholders in appraising, managing and reducing flood risk. As part of this process, RPBs should prepare Regional Flood Risk Appraisals (RFAs) and LPAs should prepare Strategic Flood Risk Assessments (SFRAs) as freestanding assessments to contribute to the Sustainability Appraisal of their plans.

1.2 Objectives

The requirements for a Strategic Flood Risk Assessment are set out in PPS25 and a completed SFRA should:

- Provide sufficient data and information to enable the LPA to apply the Sequential Test to land use allocations and, where necessary, the Exception Test.
- Enable the LPA to prepare appropriate policies for the management of flood risk within the Local Development Documents (LDDs)
- Inform the Sustainability Appraisal so that flood risk is taken into account when considering options and preparing strategic land use policies
- Identify the level of detail required for site-specific FRAs in particular locations, and
- Enable LPAs to determine the acceptability of flood risk in relation to emergency planning capability.

1.3 Scope of this Document

The Oxford SFRA has been prepared in accordance with PPS25 to inform the Oxford City Council's planning process. This document includes and builds on the findings of the Oxford West End SFRA by considering the City of Oxford as a whole for the Sequential Test.

The Environment Agency regularly review and update, if necessary, their Flood Zone Maps as more detailed hydraulic modelling of rivers and mapping of flood risk is undertaken along with more recent historical events. This work will improve the quality of data available and the understanding of flood risk within the City. It may also result in changes to the predictions for flood levels and flood extents that may have to be taken into account in future decisions at development control level.

All SFRAs should be considered to be living documents, subject to regular review in response to changing policy requirements and improved understanding of flood risk in the areas to which they apply.

1.4 Flood Risk in Oxford

The City of Oxford lies wholly within the catchment of the River Thames. The city has generally developed eastwards from the Thames (or Isis), which flows southwards through the western/south western side of the city. The main tributary in the area, the River Cherwell, also flows through the city, as do a number of minor watercourses, both natural and artificial.

The 2001 census reported that the City of Oxford had a population of approximately 135,000 at the time of the census. Of these, the inhabitants of approximately 5000 properties are at risk of flooding with the most recent events of December 2000, January 2003 and July 2007 resulting in significant flooding across the city.

1.5 Local Planning Policy Relating to Flood Risk

1.5.1 Introduction

The Local Plan sets out the policies and proposals for future development and land use within Oxford City for the period 2001 – 2016 and forms part of the Oxford Local Development Framework.
Within the Local Plan there are 8 policies which are relevant to flood risk through Oxford, these policies address the management of development in relation to the Water Environment.

1.5.2 Policy NE.6 – Oxford's Watercourses

Planning permission will only be granted for waterside development proposals that complement and enhance the waterside setting, and protect or, where appropriate, create wildlife habitats and public access along the watercourse.

1.5.3 Policy NE.7 – Development in the Undeveloped Flood plain

Planning permission will only be granted for development within the undeveloped floodplain where:

a. the proposed use is appropriate in the floodplain, or a particular location is essential and an alternative lower-risk location is not available;
b. it is provided with the appropriate standard of flood defence;
c. it does not impede flood flows ; and
d. it does not result in a net loss of flood storage.

The area and boundaries of the Undeveloped Flood Plain are defined on the Proposals Map.

1.5.4 Policy NE.8 – Development on Low-Lying Land

Planning permission will only be granted for development within low-lying areas where:

a. The appropriate standard of flood defence is provided; and
b. The development will not lead to an increased risk of flooding elsewhere and incorporates where necessary, appropriate mitigation and compensation measures.

The area and boundaries of low-lying land are defined on the Proposals Map.

1.5.5 Policy NE.9 – Flood Risk Assessment

A Flood Risk Assessment must be submitted alongside planning applications for any development within undeveloped flood plain or low-lying land, and developments elsewhere which could significantly increase run-off or are at risk from flash floods. The Flood Risk Assessment must assess the risk of flooding to the proposed development over its expected lifetime, its possible impact on flooding elsewhere, and propose mitigation measures where appropriate.

1.5.6 Policy NE.10 – Sustainable Drainage

Planning permission will only be granted for developments that would not significantly increase surface water run-off. Wherever practicable, this will be through the use of sustainable drainage systems. The City Council will require developers to demonstrate that they have made appropriate provision for surface water drainage and that this would effectively mitigate any potential adverse impact from surface water run-off.

1.5.7 Policy NE.11 – Land Drainage and River Engineering Works

Planning permission will only be granted for river management, flood protection works and land drainage schemes that are designed to protect the flora and fauna of Oxford's flood meadow and other wetland habitats.

Planning permission will not be granted for proposals to culvert watercourses or ditches. As part of new development proposals the City Council will, in suitable locations, seek opportunities to remove existing culverts and restore the watercourse to a more natural state.

1.5.8 Policy NE.12 – Groundwater Flow

The policy states that planning permission will not be granted for developments that will have an adverse impact on groundwater flow. Where necessary, effective preventative measures will be enquired to ensure that groundwater flow will not be obstructed. The City Council hopes this policy will be taken forward in the future.

1.5.9 Policy NE.13 - Water Quality

Planning permission will only be granted for development that will not cause a deterioration in surface or ground water quality. Appropriate measures to prevent pollution will be required. The applicant may be required to submit details of investigation of the site and any precautionary measures which are proposed. Precautionary measures will be secured through planning conditions or a planning obligation.

1.5.10 Policy NE.14 – Water and Sewerage Infrastructure

Planning permission will only be granted for developments that would increase the demand for on and off-site service infrastructure where:

a. Sufficient capacity already exists; or
b. Extra capacity can be provided in time to serve the development that will ensure that the environment and the amenities of local residents are not adversely affected.

1.5.11 Summary

Policies NE.7, NE.8, NE.9, NE.10, NE.12 and NE.14 provide planning policy guidance on the management of planning applications for proposed developments that are located on land deemed to be at risk of flooding or, on sites which may adversely affect flood risk elsewhere.

Policy NE.6 provides recognition to the importance of the river corridor through Oxford ensuring that proposed developments at waterside locations are sensitive to this valuable environmental and social asset.

Policy NE.11 recognises the value of flora and fauna associated with wetland habitat in Oxford and identifies that works associated with the river corridor must demonstrate proposed measures to protect these environmental assets.

Policy NE.14 ensures that proposed developments will not overload existing sewer infrastructure, either sufficient capacity must be available or additional capacity provided to serve the new development.

The local plan and its policies referenced here will be replaced by the Core Strategy currently being developed. There should be recommendations to include policy in the future to ensure a reduction of flood risk, in accordance with PPS25.

2.0 PHASE 1 – DESK RESEARCH

2.1 Summary

The purpose of the desk research phase of the SFRA is to identify and obtain information regarding flood risk. It is during this phase that existing knowledge has been collated with regards the source and extent of flood risk, existing flood management measures and the land use and development opportunities within Oxford. It should be noted, however, that the flood risk in Oxford is dependent on factors upstream and downstream of Oxford within the Thames and Cherwell river catchments. Policies that other local authorities have in managing flood risk will influence flood risk in Oxford. Vale and Cherwell are also beginning to undertake SFRAs and therefore any update of the Oxford SFRA should include reference to their recommendations and interpret the implications of these recommendations for Oxford.

Consultations were undertaken with Oxford City Council, the Environment Agency, British Waterways, Thames Water and adjoining LPAs.

The information gathered during this phase is used to assess the potential extent and frequency of flood risk.

2.2 Flooding Sources

2.2.1 Fluvial

The primary source of flood risk in Oxford is fluvial flooding based on the number of properties at risk. Located at the confluence of the Rivers Cherwell and Thames, the city is vulnerable from both watercourses independently and, in wider flood events, concurrently.

The River Thames flows into the city from the North-West, passing through Wolvercote before entering the western side of the city centre. The River Cherwell flows into the city from the North-East, passing through Marston before entering the eastern side of the city centre. The flood plains of both of these watercourses consist of farm land and recreational area with few properties at risk.

The River Cherwell joins the River Thames south of the city centre, which then flows south through New Hinksey and out of the city boundary. In this area, the flood plain contains a number of housing estates which are known to have flooded in 2003.

Boundary Brook also joins the River Thames, south of New Hinksey, and the Environment Agency's Flood Zone Mapping suggests that there is flooding along its length. Historically flood events have shown a greater area of flooding than the flood zones due to the affect of structures on water levels within the watercourse. The Environment Agency have recently been undertaking modelling work to establish risk more accurately in this area.

The River Thames, and the River Cherwell flow through wide, flat floodplain corridors upstream, through, and downstream of Oxford City. During times of high water, out-of-bank flow causes flooding across these low lying floodplains covering vast areas. This out of bank flow potentially impacts the urban areas of New Botley, Osney, New Hinksey, South Hinksey, Grandpont, Wolvercote, Summertown and New Marston.

Further flood risk is associated with Castle Mill Stream through the West End of Oxford, Boundary Brook through Florence Park and Temple Cowley, and Northfield Brook/Littlemore Brook through Blackbird Leys.

2.2.2 Surface Water Drainage

Surface water flooding as a result of sewer blockages, failure or insufficient capacity has the potential to contribute significant flood risk in urban areas. This is due to the rapid run off rates associated with urban land use and the volume of water that flows into the sewer systems in relatively short periods of time.

The sewerage undertaker for Oxford, Thames Water, holds records of flooding issues relating to surface and foul water sewers on a postcode basis. Thames Water has been consulted during this SFRA and has not identified any known flood risk issues within the Oxford City.

The Environment Agency have identified surface water flood risk issues in the areas of Littlemore and Northfield.

2.2.3 Canal Infrastructure

The Oxford Canal runs north south from Coventry to Oxford for approximately 77km before joining the River Thames between Jericho and New Osney. During the final 800m through Jericho the canal and Castle Mill Stream run parallel and in some places are within 5 metres of each other. There are no other canals within the city limits.

The Oxford Canal, Castle Mill Stream and River Thames are linked through a series of locks and spills which enable the management of canal water levels and boat passage between the canal and the river system.

Although British Waterways have not identified any historic occurrences of flood risk associated with the canal within Oxford City, the common assets between canal and river system and the proximity of the canal to the watercourses comprise a potential source of flooding.

The first is associated with the close proximity of the Canal and Castle Mill Stream directly upstream of Hythe Bridge Street which passes over the stream at the northern boundary of the West End area of Oxford. At this location, the two water bodies run parallel within 5m of each other with the water level of the canal approximately 1m above that in the stream. Should failure of the canal bank occur in this location subsequent water spill into Castle Mill Stream could potentially drain the canal as far as Wolvercote Lock (Lock 45) located a further 3.5km upstream.

Further potential for raised water levels in the Castle Mill Stream are associated with failure of the water level control assets located by the cricket ground in Jericho and directly upstream of Hythe Bridge Street. These controls are in the form of spills from the canal into the Castle Mill Stream. Failure of either of these control structures has the potential to raise water levels in Castle Mill Stream and subsequent flood risk through Oxford City centre.

The Oxford canal discontinues at Hythe Bridge Street. There is some interest however, in the possibility of extending the Oxford Canal into the Worcester Street car park.

2.2.4 Groundwater

Groundwater flooding issues do exist within the Thames Valley through Oxfordshire. The floodplain is situated above buried gravels which act as underground reservoirs which spill onto the floodplain when full. The majority of the sites where groundwater flood risk exists are in the low lying areas subject to fluvial flood risk.

Groundwater flooding issues have been identified by the Environment Agency and have been recorded within their groundwater flooding register. These are located in the Grandpont and New Hinksey areas, and in the Oxford District area to the East of the city centre. The incident within the Environment Agency's groundwater records for Headlington has been confirmed to be a mains water leak rather than groundwater.

2.3 Recent Studies on Flood Risk

Several studies have recently been, and are being, undertaken within the Thames catchment which have a relevance to the Oxford City SFRA. There are four main studies that are worth consideration.

The Thames Region Catchment Flood Management Plan (CFMP) is a high level strategic flood risk management tool. It is used to develop flood risk management strategies at a catchment level over the next 50 to 100 years. The aims of the CFMP are to provide flood risk management policies which; reduce flood risk to people and the built environment; maximise opportunities to work with the natural environment; contribute towards sustainable development and sustainable flood management practice; support implementation of EU directive and Government policies and targets; and to support planning policies statutory land use plans and implementation of the Water Framework Directive. The Draft Thames Region CFMP document was published for consultation during January 2007.

Oxford falls into the category of *"Large urban areas with no major built flood defences"* and the messages are:

- The most sustainable way of reducing the flood risk will be through floodplain management. It is essential that partners have a shared vision for future land use that meets a wide range of objectives if this is the happen.
- Through re-development, there can be a net reduction in flood risk whilst meeting wider community needs.
- Where they can, the Environment Agency will progress options to reduce flood risk that are most effective and sustainable in the long-term. Options to manage the consequences of flooding may be more sustainable than defences in many cases.

The specific objectives for the Oxford Policy Unit are:

- *"That Local Authorities and the Environment Agency have a common understanding and shared vision of future land use within the floodplain. That this vision is sufficiently well developed so that there can be a net reduction in flood risk from redevelopment, whilst at the same time recognising the wider pressures on land use within the city. The Strategic Flood Risk Assessments (or future revisions) can be one mechanism for coming to this understanding.*
- *Based on this shared vision, that there is a net reduction in flood risk from development at a scale agreed between the Local Authority and Environment Agency. Layout (for example, set back) and design (for example, flood resistant buildings) will be key components.*
- *Reduce the consequences of flooding through continued action to raise public awareness of flooding, tailoring the advice and approach (e.g. community based) to ensure those "at risk" take appropriate action to respond to flooding.*
- *Continue to reduce the impact of low order flooding (up to a 10% to 20% AEP flood - 1 in 10 to 1 in 5 year return period) by maintaining conveyance where it is both effective and sustainable to do so (for example on the Thames tributaries). Continue to maintain the capacity and function of the undeveloped natural floodplain within the city (for example on Port Meadow) and upstream to retain water so that it can continue to reduce the impact of low order flood events to people and property and maintain floodplain habitats.*
- *Safeguard the existing undeveloped natural floodplain through the appropriate application of the sequential test within PPS25.*

- *Where it is most effective, progress options to reduce flood risk in the long-term. This could be to manage the probability of flooding (for example through defences), or to manage the consequences (for example through resilience). Option selection should be based on what is the most effective and sustainable and not short-term factors (for example, the ease of capital funding streams) and will be addressed within the Oxford Strategy."*

The Oxford Flood Risk Management Study Stage 1 was undertaken on behalf of the Environment Agency and commissioned in 2001. This study included review of existing detailed hydraulic models to incorporate more information and calibrate it against the flood events in 2000 and 2003. The study provided a detailed assessment of the causes of flood risk in the Oxford area and made recommendations for viable flood management measures to reduce the level of flood risk in Oxford City. The study concluded that the most viable approach to managing flood risk within the Oxford area is to increase the volume of water that can be carried through the western side of the River Thames floodplain thus bypassing Oxford City.

Following the success of the Oxford Flood Risk Management Study Stage 1 the Environment Agency commissioned Stage 2 of the Oxford Flood Risk Management Study. The purpose of Stage 2 is to assess each of the options identified within the management study with regard to their impact upon the natural and human environment, and their potential benefits to Oxford. The study will assess the interdependencies between groundwater and surface water flooding and will recommend mitigation options. The Oxford Flood Risk Management Study Stage 2 is now ongoing and is planned to conclude in 2009.

The Environment Agency has undertaken a Flood Forecasting Model for the Thames including the Cherwell confluence completed November 2006. Following the flooding in July 2007 a review of the ratings within the flood forecasting model has been undertaken.

2.4 Historic Flood Events

Oxford is located at the confluence of the Rivers Thames and Cherwell and as such is at risk of flooding by both watercourses.

Records of historic flood risk events are documented by the Environment Agency in the form of reports, photographs and maps. Flood extent data is available for nine separate flood events dating back to the Spring of 1947 with the most recent events being recorded in the Winter of 2003 and Summer 2007. Table 1 lists the events for which flood extent data is available.

Table 1: Historic Flood Events in Oxford

Date of Flood Event
Spring 1947
Summer 1977
Winter 1979
Autumn 1992
Autumn 1993
Easter 1998
Winter 2000
New Year 2003
Summer 2007

A complete flood outline of the Summer 2007 event has been completed, and flood incident reports are complete and these show that the main areas that experienced flood risk during this event were Botley Road between New Osney and Botley which caused flooding to New Botley and Osney, and Abingdon Road and its immediate

surrounding area through New Hinksey. Botley and Abingdon Road are both closed off during most flood events.

Appendix A shows the flood extents mapped for the 1947, 1979, 2000 and 2003 events which are recognised as the largest recorded events. Significant flooding occurred on the Thames and Cherwell floodplain and in the areas surrounding the Cherwell/Thames confluence.

The Thames has flooded a number of areas, one of which is Wolvercote, in the North-West of the catchment, which is shown to have flooded in the 1947 floods only. It is unknown whether the housing estate was built at that time, but the area has not been inundated since, even when the surrounding area is flooded. It is thought that Wolvercote may have suffered from surface water flooding.

The area between Wolvercote and the city centre shows regular inundation through all of the events. This area is largely Farmland and recreational land, so there is a smaller cost implication associated with its inundation.

Around the A420 (Botley Road), a number of houses, roads and gardens have been inundated during some of the recorded events. Properties not directly affected by flood waters have been impacted by access difficulties caused by high flood waters to roads.

Historically, the area surrounding the confluence between the Cherwell and the Thames and the area directly downstream, has experienced the greatest flooding to property. The largest flood extents were observed during the Spring 1947 and New Year 2003 events.

Along the Cherwell, very few properties have been flooded by the listed events. The 1947 event has inundated the greatest area, however the properties that are located within this flood extent are predominantly sporting facilities. It is suspected that these properties were not built in 1947 and the finished floor levels have been set above the 1947 flood level. This would explain why they have largely not been affected by subsequent flooding, including the similarly sized 2003 event. In addition, in 1998 road around Oxford were flooded from the River Cherwell.

Table 2 provides a narrative of a number of historic events within the River Thames from Eynsham Lock to Sandford Lock Flood Warning Area. This information is provided within the Environment Agency document titled ‘Local Flood Warning Plan - The County of Oxfordshire Local Authority Area’.

Table 2 Narration of Historic Events in Oxford

Year	Month/Period	Number of Properties/Area Affected
1947	March	Areas/roads affected: Bullstake Close, Folly Bridge, Abingdon Road, Botley Road, Marlborough Court, Binsey Lane, Duke Street, Bridge Street, South Street, West Street, Osney Mead Industrial Estate, John Towle Close and Lamarsh Road in Oxford and Rosamund Road, Home Close, Elmthorpe Road and Goodstow Road in Wolvercote.
1979	Not Known	Areas/roads affected: Kennington Road in Kennington, Fox Crescent, Canning Crescent, Dale Close, Weirs Lane, Sadler Walk, Sunningwell Road, Trinity Street, John Towle Close, Abingdon Road, Folly Bridge, Abbey Road, Port Meadow, Wytham Street and Riverside Road.
2000	December	Areas/roads affected: Folly Bridge, Jubilee Terrace, Marlborough Road, Weirs Lane, Watermans Reach, Binsey, Binsey Lane, Port Meadow, Botley Road, Stone Meadow, Coxes Ground and Bullstake Close in Oxford and Dunstead Lane in Wytham.
2003	January	Areas/roads affected: Sandford Lane, Kennington, Manor Road, South Hinksey, Rose Island, Littlemoor, Botley Road, Wytham Street, Marlborough Road, Abingdon Road, Sunningwell Road, Weirs Lane, Peel Place, Fox Crescent, Chatham Street, Port Meadow and Bullstak Close

2.5 Existing Flood Defences

2.5.1 Definition of a Flood Defence

Information on flood defences is required to indicate areas where there is protection from fluvial flood risk, the level of protection provided by the defence and the predicted life of the defence.

Flood defences are raised structures which prevent floodwater from flooding surrounding areas by altering the natural flood flow paths from a watercourse or retaining flood water. Flood defences are categorised as 'formal' defences or 'informal' defences. A 'formal' defence is a structure that was built specifically to defend land or property from flooding and is maintained for this purpose by the Environment Agency, Local Authority, or a riparian landowner. An 'informal' defence is a structure that has not been specifically built to retain floodwater and is not maintained for this specific purpose but may afford some protection against flooding. 'Informal' defences include boundary walls, industrial buildings and railway and road embankments.

The extent, condition and standard of protection of the defences owned and maintained by the Environment Agency are recorded within the National Flood and Coastal Defence Database (NFCDD).

To determine the standard of protection provided by the defence, the following information is essential:

- Location of defence
- Defence Crest Level

Where available the following information was also collated;

- Condition of the defence (based on the NFCDD scale and measured between 1 and 5 Good – Poor)
- Residual life
- Type of defence

2.5.2 Formal Flood Defences

Consultation with the Environment Agency has revealed there to be no formal flood defences for which the Agency is responsible for performance and maintenance within Oxford. There is, however, an Agency controlled 0.6m wide sluice gate (penstock) and 8 no. x 300mm diameter overflow pipes set in a stone headwall either side of an earth bank walkway, upstream of Hythe Bridge Street. This water level control is operated by the lock keeper at Osney.

Through consultations with the Oxford City Council it has been confirmed that Oxford has no formal flood defences maintained by the council or riparian landowners.

2.5.3 Informal Flood Defences

The Environment Agency supplied a mapping table that locates a number of informal flood defences within the city limits, however, on review of this information in conjunction with the Environment Agency it was agreed that none of these informal defences provide protection relevant to the SFRA. The reasons for this are that the defences identified either provide a standard of protection less than the 1 in 25 year event or are discontinuous in their defended line, therefore, it is felt that the level of protection is not relevant to this SFRA.

The major problem with private river defences is that they are constructed to protect individual properties and this is often at the expense of others. Often these informal defences simply increase flooding on the opposite bank, or increase the water levels downstream. This can only be avoided by creating a planned scheme for the whole area, for which this report is the first step.

In addition, there are structures and assets that provide some form of flood defence but were never designed to do so. This group of defences includes structures such as buildings, garden walls, railway and road embankments.

Within Oxford City, after consultation with the Environment Agency, it has been identified that there is a railway embankment which runs in a north-south direction through the city, a small section of defence which provides protection to a number of properties at Manor Place on Hollywell Mill Stream and Worcester car park which provides flood alleviation. There are plans to redevelop Worcester car park as a canal basin which may improve flood risk in the area.

2.6 Flood Warning

The Environment Agency issue Flood Warnings for fluvial flooding. The aim is to issue a Flood Watch 2 hours prior to the start of flooding and Flood Warnings 2 hours prior to the start of property flooding. Flood Warnings apply to flooding caused by rivers and streams, not to flooding from other sources, such as sewer and surface water flooding, burst water mains, impounding, etc. For fast responding catchments (particularly in urban areas) it may be necessary to issue Flood Warnings (or even Severe Flood Warnings) directly without issuing a Flood Watch first.

2.6.1 Lead Time Analysis

Application of the Flood Estimation Handbook to the Thames and Cherwell catchments has identified that each catchment is slow to respond to rainfall, there is potentially a lead time of approximately 20 hours from peak rainfall in the upstream parts of the catchment to peak water levels through Oxford City. This is a significant amount of time which contributes to the successful delivery of flood warning services through Oxford.

2.6.2 Existing Flood Warning Areas

Oxford City is currently covered by 2 Flood Warning Areas these include:

- The River Cherwell and its tributaries from Lower Heyford to Oxford
- River Thames from Eynsham Lock, Eynsham to Sandford Lock, Sandford-on-Thames

Flood Warning areas are drawn to the extent of Flood Zone 2 and will cover all properties that fall within this boundary. The River Cherwell Flood Warning Area (FWA) covers the Cherwell Valley and is inclusive of the villages of Enslow, Kirtlington and Kidlington.

The River Thames FWA covers the River Thames channel through Oxford City including the West End. The area of the West End that is included within this FWA is the same as the Environment Agency Flood Zone 3. This is essentially an area of the left bank of the River Thames, inclusive of areas surrounding Friars Wharf, Dale Close, Thames Street and Cromwell Street, and a channel through the West End following the path of Castle Mill Stream.

The Environment Agency recommends everyone sign up to the Environment Agency's flood warning system, Floodline Warnings Direct (FWD). FWD is a multimedia flood warning system that is used to issue flood warnings to specific areas by telephone, mobile, fax or pager. The aim of this service is to increase awareness of the risk of flooding and provide advice on how people can limit the damage that flooding can cause. This is a free service and people are encouraged to register to receive flood warning messages if they are at risk of flooding. Environment Agency monitoring continues through out the year. Please contact the Floodline service to register for a flood warning and for further information on 0845 988 1188.

2.7 Land Allocations

The information on land allocations used within this SFRA study to assess the appropriateness of proposed land uses have originated from Oxford City Council's Planning Department. These sites are split into two separate groups, the first group includes the 4 large potential strategic development sites within Oxford and the second group includes the 24 sites identified within the West End of Oxford. Appendix B contains plans of the potential strategic development sites and those within the West End.

Of these sites, two of the potential strategic development sites, Barton and Summertown, have some part within the Cherwell FWA. Of the 24 separate allocated sites within the West End, 8 are, to varying degrees, identified to have some part within the Thames FWA. Table 3 identifies those sites deemed to be located in full or part within the FWA.

Table 3: Land Allocations Within Flood Warning Areas

Site Ref.	Allocated Site Name
4	Island site (Park End St/Hythe Bridge St)
5	Worcester Street Car Park
9	Ocean and Collins, Hythe Bridge Street
11	Cooper Callas Site, Paradise Street
17	Oxpens
19	Oxford and Cherwell Valley College
20	Westgate Shopping Centre
23	Telephone Exchange, Speedwell Street

2.8 Emergency Plans

Consultations have been undertaken with representatives of the Environment Agency, Oxford City Council and Oxfordshire County Council to determine whether there are any emergency plans in place for Oxford City.

The Environment Agency has a local Flood Warning Plan for Oxfordshire and they are working with Oxfordshire County Council and Oxford City Council on emergency response. Oxford City has a plan to distribute sandbags to various locations to deploy temporary defences in Bulstake Close and to evacuate people to Kassam Stadium.

3.0 PHASE 2 – ANALYSIS

3.1 Flood Risk Sensitivities

The definitions of flood risk in Oxford defined in previous sections of the SFRA makes possible an assessment of the sensitivity of this risk to potential changes caused by climate change, variability associated with development (particularly urban development) and the potential failure of the identified informal flood defences throughout the city.

3.1.1 Flood Sensitivity to Climate Change

The Thames CFMP identifies that the major cause of increased flood risk in the future will be the effects of climate change. The expectations are that winter floods will happen more often and in urban areas flooding from thunderstorms will be more regular and more severe.

Recent guidance from Defra on assessing climate change sensitivity recommends assuming a 10% increase in fluvial flow up to 2025 and then an increase of 20% thereafter. In consultation with the Environment Agency, it was agreed that the recently modelled 200 year event would be appropriate to represent the climate change up to 2050.

The possible affects of climate change on flood prevalence in Oxford can be seen along the River Thames in the Wolvercote, New Osney and Grandpont areas, as well as along Botley Road (A420). On the River Cherwell, the increased outline will encompass a smaller number of properties that are evenly spread along the watercourse. Appendix C identifies the 100 year and 200 year, climate change, flood outlines upon which the additional areas at risk of flooding are based. The use of the 200 year outline as a proxy for the climate change event is a local agreement.

The properties affected on the Thames would include commercial offices, a college, schools, a police station, a telephone exchange and a number of residential properties. The properties affected on the Cherwell are predominantly residential, but also include a number of recreational properties.

3.1.2 Flood Sensitivity to Increased Urban Development

The Central Oxfordshire Sub-region Strategy includes Oxford City centre and forms part of the South East Plan. It is clear from the Sub-Region Strategy and the Thames CFMP that opportunities exist to plan future urban development and regeneration whilst giving consideration to the management of flood risk within Oxford.

Appreciating the risk, and reducing it by protection or relocation, forms part of this strategic managed approach. This will be achieved through planning and development.

Appropriate design, situation and location of future development can all contribute to reducing the risk of flooding, including:

- Steering developments outside of the floodplain;
- Application of property and location specific flood protection measures;
- Improving property resilience to flood damage;

- Identifying river corridors and the natural flood plain to provide potential riverside storage and urban river corridors in built up areas and encourage set-back from watercourses and opening up and reducing the number of structures and blockages along the watercourse;
- Application of sustainable urban drainage techniques for new developments.

The steps set out in the Sub-Region Strategy to deal with pressures associated with growth of new development in Oxfordshire is focused on surrounding towns such as Bicester, Didcot, Wantage and Grove. Oxford is already highly developed in terms of urban footprint and the only remaining land is in the floodplain. This is currently farmland or recreational ground and is likely to be unsuitable for development due to the flood risk.

Development areas identified in the Local Plan are concentrated along the river corridor, located along both the left and right banks. As described above, the adaptation of development behaviour to the consequences of flooding will be crucial in the reduction of flood risk in Oxford. PPS25 forms the framework for this process.

3.1.3 Raised Defence Breach Analysis

As there are no formal flood defences identified within Oxford, undertaking location specific breach analysis is not appropriate

With regards to informal defences, the discontinuous nature of the defences throughout Oxford makes a breach analysis inappropriate. This is because under existing conditions flood waters would not be contained behind these defences.

4.0 PPS 25 AND THE SEQUENTIAL TEST

4.1 Background

The Government expects Local Planning Authorities (LPAs) to apply a risk-based approach to the preparation of development plans and their decisions on development control. Planning and Policy Statement: Development and Flood Risk (PPS 25) encourages LPAs to steer development away from areas affected by flood risk and recommends the application of a 'Sequential Test' that splits a local planning district into zones of high, medium or low flood risk. PPS 25 is the key guidance for planners managing flood risk as it clearly defines the appropriateness of development type for each of the defined flood risk zones.

4.2 Sequential Test

Historically settlements have evolved along river corridors where the river has provided a source of water, food, transport and energy. The result of this is that many of the urban centres of England are at risk of flooding due to their close proximity to rivers.

Planning needs to be at the forefront of managing flood risk in a sustainable manner by steering development away from areas that are susceptible to flooding. PPS25 advocates a sequential approach that will guide the planning decision making process (i.e. the allocation of sites). The aim of the Sequential Test is to:

"steer new development to areas at the lowest probability of flooding (Flood Zone 1). Where there are no reasonably available sites in Flood Zone 1, decision-makers identifying broad locations for development and infrastructure, allocating land in spatial plans or determining applications for development at any particular location should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zone 1 or 2 should decision-makers consider the suitability of sites in Flood Zone 3, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required".

"Within each flood zone, new development should be directed first to sites at the lowest probability of flooding and the flood vulnerability of the intended use matched to the flood risk of the site, e.g. higher vulnerability uses located on parts of the site at lowest probability of flooding".

The Sequential Test should be applied throughout an entire planning authority district to ensure that development sites are considered on a sequential basis in reference to flood risk. The results of the Sequential Test will identify appropriate zones for development and will identify appropriate land uses in accordance with PPS25.

This SFRA provides the basis for carrying out the Sequential Test by firstly identifying the sequential risk flood zones as specified by PPS25 and secondly applying these flood zones to the areas of search for strategic development sites identified by the Council.

The results of the Sequential Test will provide the information required for planners to make informed development decisions with a strategic understanding of flood risk issues throughout Oxford. This applies to both new development proposals and to existing proposals that are potentially affected by flood risk.

It must be borne in mind that, from a flood risk perspective alone, development sites should be sited where possible in areas of least risk. If these sites are unavailable, a

sequential approach should be adopted when considering development sites within flood risk zones.

This SFRA document has reviewed the areas of search for strategic development sites identified by the council and have assessed, using PPS25, appropriate land use vulnerabilities for those sites. Where required, the need for Exception Tests to help justify development proposals has also been documented.

4.3 Flood Zone Definition

4.3.1 Introduction

This section describes the existing Flood Zone Map and the process by which the existing Flood Zone Maps were updated for the purpose of the SFRA utilising newly available information.

4.3.2 Existing Flood Map

In July 2003 to improve awareness of the areas that were at risk of flooding, the Environment Agency launched the Flood Mapping Strategy to improve the quality and coverage of flood risk information. This led to the delivery of the Flood Map. This included Flood Zones which replaced the Indicative Floodplain Map. Flood Zones were sent to all Local Authorities in June 2004 and were published on the Environment Agency website in October 2004. The production of Flood Zones supports the implementation of Planning Policy Guidance Note 25 (PPG25) by indicating whether areas are potentially at risk of flooding. The new Flood Map combines where possible, detailed local data with information from a new nationally consistent computer model of flood risk across England. The Environment Agency Flood Maps are contained within Appendix D.

The published flood zones are based on national modelling of flood extents (using the 'JFlow' methodology) using the Environment Agency's new national Digital Terrain Model (DTM) and known flood event data

Overall the new national generalised modelling is more accurate. Catchments of much smaller watercourses are now included and the Environment Agency has sought to remove all subjective or inconsistent data.

However, the Flood Map and Flood Zones show only the extent of flooding and do not provide information on flood depths or levels, speed or direction of flow. In accordance with the Office of the Deputy Prime Minister's Scoping Report, Flood Zones are indicative of the natural undefended floodplain (i.e without formal defences)

Since the original Flood Map outlines were published, further flood risk management and hydraulic modelling studies have been undertaken which have further developed understanding of flood risk through Oxford.

4.3.3 PPS25 Flood Zones

PPS25 identifies 4 separate Flood Zones which should be used when determining the appropriateness of proposed development uses when considering flood risk after the application of the Sequential Test. These Flood Zones represent flooding without flood defences in place.

Tables D1 and D2 within Annex D of PPS25 provide detail of these Flood Zones and the appropriate land use vulnerabilities for each of these sites. A summary of each Flood Zone and land use is provided below.

Flood Zone 1 is defined as 'Low Probability' of flooding and incorporates areas where the annual probability of flooding is lower than 0.1%. PPS 25 imposes no constraints on the vulnerability type of development here.

Flood Zone 2 is defined as 'Medium Probability' with an annual probability of flooding between 0.1 and 1.0% for fluvial and 0.1 and 0.5% for tidal and coastal flooding. PPS25 recommends that Flood Zone 2 is suitable for most development with the exception of Highly Vulnerable uses, as defined within Table D.2 of PPS25.

Flood Zone 3 is defined as 'High Probability' with an annual probability of flooding of 1.0% or greater for fluvial and 0.5% or greater for tidal or coastal. PPS25 recommends that appropriate development is based upon a further classification of Flood Zone 3 into: 3a High Probability and 3b Functional Floodplain. Greater constraints are placed upon development within Flood Zone 3 compared to any other Flood Zone; refer to Table 4 for details.

For development within Flood Zones 2 and 3, the vulnerable uses are considered appropriate in PPS25 only after the Sequential Test has been applied, that is, where there are no alternative sites at lower flood risk.

This SFRA does not address the Exception Test which will need to be carried out, if required, at the planning application stage as part of a site specific flood risk assessment.

Table 4: Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Risk Vulnerability Classification (see Table D2 of PPS25)		**Essential Infrastructure**	**Water Compatible**	**Highly Vulnerable**	**More Vulnerable**	**Less Vulnerable**
Flood Zone (see Table D1 of PPS25)	Zone1 Low Probability	✓	✓	✓	✓	✓
	Zone2 Medium Probability	✓	✓	Exception Test required	✓	✓
	Zone 3a High Probability	Exception Test required	✓	*x*	Exception Test required	✓
	Zone 3b 'Functional Floodplain'	Exception Test required	✓	*x*	*x*	*x*

✓ Development is appropriate
X Development should not be permitted

4.4 Updating the Flood Zone Map for this SFRA

Recent flood management studies have further developed the understanding of flood risk within Oxford and, as part of this SFRA, the previously published Flood Map has been refined to reflect this understanding. The key data sets that have been used to update this Flood Map are newly available hydraulic models and the water levels generated from these.

This refinement exercise has been undertaken for the purpose of the SFRA but these revisions have not yet been released on the Environment Agency website.

4.4.1 New Model Level Data

The Environment Agency has undertaken hydraulic modelling studies within the Thames catchment, specifically through Oxford, which provides additional water level information to that used to generate the original Flood maps. The Wolvercote hydraulic model (OX_05.dat) has been developed by the Environment Agency and provided for the purpose of generating flood outlines for the 25, 100 and 200 year events through Oxford for the purpose of this SFRA.

Through consultation with the Environment Agency, three separate flood events were used to represent the PPS25 Flood Zones. Flood Zones are derived from a combination of modelled and historical, or observed, data. Table 5 identifies the modelled flood events that were used to update the existing Flood Maps.

Table 5: Flood event Model Data used to update the Flood Map

Model Return Period	Flood Zone
200 Year	FZ2
100 Year	FZ3a
25 Year	FZ3b

4.4.2 Mapping the New Water Levels

The water level data that has been provided by the Environment Agency originates from the Wolvercote Model referenced OX_05b.dat, dated May 2006. The Environment Agency's ongoing work uses a wide range of design storms, however only the 25, 100 and 200 year return periods have been used in this study. The flood outlines were generated by extending water levels across the floodplain until higher ground was met. This was based on a digital terrain model (DTM) which gives ground levels across the catchment and was supplied by the Environment Agency.

At the time of producing this SFRA document, the Environment Agency had not reviewed and agreed the flood outlines generated, ideally the outlines used within the SFRA would have been verified by the Environment Agency but due to time constraints this was not possible prior to the production of this SFRA. It is felt, however, that the outlines that have been produced for this SFRA are appropriate for conducting the SFRA and the reasons for this are stated below.

Atkins has undertaken the flood risk mapping as part of this SFRA in accordance with the Environment agency's specifications set out as part of their Strategic Flood Risk Mapping Framework.

The flood outlines generated from the Wolvercote model during this SFRA were verified against previous flood risk mapping data for the River Cherwell, historic flood outlines available from the Environment Agency and the published Flood Map.

The Environment Agency supplied Atkins with a copy of the official Environment Agency flood outlines for the River Cherwell. When compared to the outlines generated for the SFRA, it was found that the Cherwell outlines and the SFRA outlines were very similarly aligned and deemed appropriate for a strategic study such as an SFRA. Similarly, the outlines generated during this SFRA align very closely to the published Flood Map 3 for the 100 year event.

Finally, the outlines produced for the SFRA were compared to the historical flood outlines provided by the Environment Agency and detailed within Table 1 of Section 2.4. The historical data has come from different sources and caution should be used as it is sometimes of unknown quality. The comparison of this data to the outlines

created by Atkins showed good correlation for the areas known to flood contained within the SFRA flood outlines.

The catchment shape is broadly U-shaped, with a wide flood plain bounded by relatively steep sides. This shape suggests that flooding will cover a large area of the flood plain, but once the flood plain is covered, changes in water level will have little effect on the area of inundation. The mapping created by Atkins suggests that the floodplain is largely covered during all of the SFRA required flood events; this therefore, provides further confidence that the outlines produced for the SFRA are appropriate and that final, approved Environment Agency flood maps will not differ significantly.

Finally, on site walkover surveys were conducted through the urban areas identified to be at flood risk to confirm whether or not out of bank flow and subsequent flooding could occur at specific locations.

For all of the reasons above, the flood outlines generated as part of this SFRA are considered to form the information to be used as a basis for the sequential test to be applied by the local authority.

It is not recommended that these flood outlines generated as part of this SFRA replace the current Flood Zone mapping due to the ongoing work in this area, however they are considered adequate and essential for the requirements of this study.

Boundary Brook
The Wolvercote model did not provide water level data for Boundary Brook and therefore outlines for the purpose of the SFRA could not be generated using this data. The Environment Agency have recently developed a hydraulic model for Boundary Brook but no flood outlines are currently available.

It is the Environment Agency's opinion that the Flood Map's representation of flooding in this area to be significantly less than the real area at risk which has potential implications should planning decisions be based on this reduced flood risk area. It was decided in consultation with the Environment Agency that a more conservative approach to flood representation in this area was required; therefore, the existing Flood Map 2 outline has been used to represent the PPS25 Flood Zone 3b – Functional Floodplain.

Flood Zone representation on Boundary Brook can be reviewed upon completion of Boundary Brook flood risk mapping. In the meantime any development proposed in this area, must undertake modelling to establish the extent of flooding.

Northfield Brook and Liitlemore Brook
The Blackbird Leys area in the south area of Oxford City is drained by Northfield and Littlemore Brook, no water level data has been available for these watercourses for the purpose of flood risk mapping purposes. The Environment Agency is currently starting a programme to map this area more accurately. Any future reviews of the SFRA should include this work.

For the purpose of the SFRA a conservative approach has been adopted, the existing Flood Map 2 outline has been used to represent the Functional Floodplain through the Blackbird Leys area in the absence of more detailed information.

Flood Zone Definition outside of the City Boundary
Flood Zone definition outside of the city boundary is based upon the existing Flood Map outlines; these outlines have been included for aesthetic purposes on the mapping element of this SFRA. Functional Floodplain has only been defined within the City Boundary, or, in the case of Bayswater Brook, to provide completeness of flooded watercourses.

4.5 Assessing Flood Risk Using the Sequential Test

4.5.1 Methodology

Figure 1 below sets out the methodology adopted to undertake the Sequential Test in the form of a flow diagram. This diagram identifies the steps undertaken to identify the Flood Zones where each of the development allocation sites reside, these steps are outlined below;

1. Obtain the latest editions of the Environment Agency Flood Map and overlay within a Geographic Information System (GIS) for review.

2. Based upon catchment flood knowledge and re-modelling works, subsequent to flood map publication, update Flood Zones 2 and 3 if appropriate. Additional modelling for the River Thames through Oxford has been undertaken by the Environment Agency and model outputs have been made available for this SFRA.

3. Identify Functional Floodplain, using newly available hydraulic model data. Assign this area as Flood Zone 3b.

4. Consult with Oxford City Council to identify all potential allocation sites within Oxford. Review these allocations and agree on allocation sites for the SFRA and digitise within GIS.

5. Incorporate the allocation sites and the Flood Zone maps within a digital mapping environment.

6. Determine in which Flood Zone each of the allocations is located and tabulate the results.

The Sequential Test methodology has been applied to potential development sites identified by Oxford City Council. Proposed development for “windfall sites” will by definition not derive from any potential development by the council. The Sequential Test will need to be carried out and, if necessary, the Exception Test at the planning application stage.

Appendix K provides guidance notes to planners on how to carry out the Sequential Test for windfall sites.

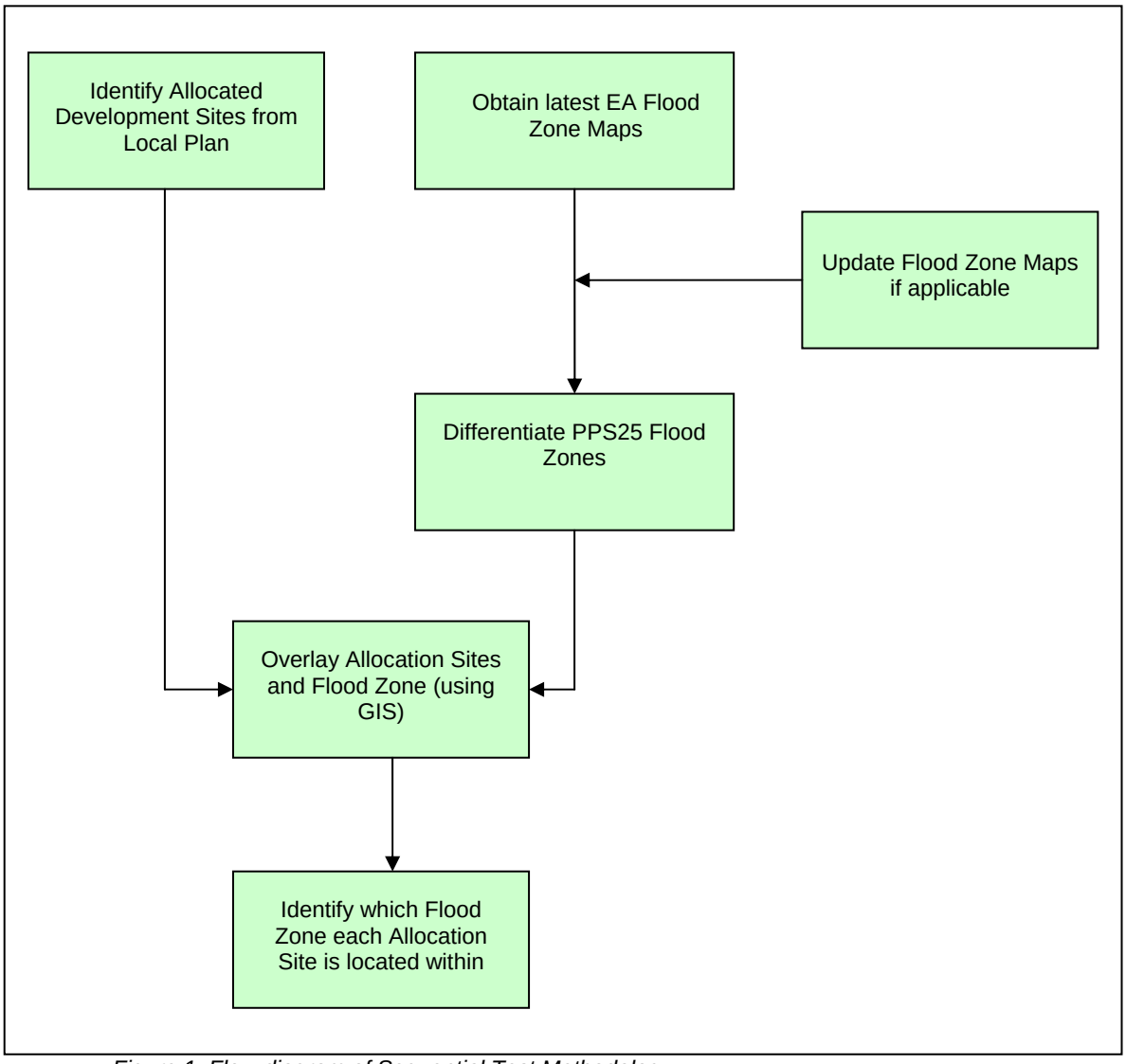

Figure 1: Flow diagram of Sequential Test Methodology

5.0 FLOOD RISK IN OXFORD CITY

5.1 Introduction

Recent studies and the evaluation of historic evidence has identified there to be a significant flood risk to the City of Oxford. This risk is currently being quantified in terms of extent and frequency of occurrence through ongoing hydraulic modelling studies being undertaken by the Environment Agency.

In meeting PPS 25's recommended risk-based approach to development planning the Sequential Test has been applied to a number of sites across the city. A sequential test has already been completed for the West End area, but this report aims to update these findings and cover the rest of Oxford. The Sequential Test has been undertaken for Oxford as a whole reviewing sites across Oxford City and a separate assessment is covered for the sites identified within the West End Area Action plan.

As the flood sources within Oxford are fluvial, ideally the 1000 year and 100 year fluvial flood extents will be used for undertaking this analysis, however as water level data for the 1000 year event is unavailable the 200 year event data, the greatest return period available, has been used to represent PPS Flood Zone 2.

5.2 Summary of Results for Oxford City

The flood risk for sites in Oxford have been identified in preparation for the Sequential Test. Flood Zones have been identified for each of the PPS25 Flood Zones using the data and methods described within Section 4.

Appendix E contains a plan of these Flood Zones, clearly defining the boundaries between Flood Zone 1, 2, 3a and 3b. The information on this map should be used to undertake the sequential approach for all future planning decisions.

5.2.1 Potential Strategic Development Sites

As previously identified there are 4 large greenfield sites that were identified as possible strategic development sites in the Core Strategy preferred options document. The four sites include:

- Summertown
- Pear Tree
- Barton
- Southfields Golf Course

These sites have been compared to the Flood Zones, comparison can be seen in Appendix F, the results of this comparison follow:

Summertown
This site is a 17 hectare site located in the Summertown area adjacent to the River Cherwell. The South East corner of this site is located within Flood Zone 3b, this area equates to approximately 0.8 hectares. Similarly sized areas of this site are located within Flood 3a and Flood Zone 2. Approximately 90% of the site is located within Flood Zone 1.

No groundwater or surface water flooding issues have been identified in close proximity to this site.

As part of this site is identified to be Flood Zone 3b, under PPS25 only 'Water Compatible' uses are considered appropriate for the site and an Exception Test is required should Essential Infrastructure be proposed. However, to be pragmatic, 90% of this site is within Flood Zone 1 and therefore through careful planning of the site it may be possible to avoid development within flood risk areas altogether.

Should it be required that the area of land considered at risk of flooding be developed then a sequential approach should be adopted across the site to firstly utilise low risk areas before areas of higher flood risk. In conjunction with this, land uses of higher vulnerabilities should be steered to the higher ground of the site. Refer to Table 4 for guidance on which land uses are appropriate for specific Flood Zones.

A site specific FRA is required for the Summertown site as parts of the site are in Flood Zones 2 and 3 and because the site it is over 1 hectare in size.

Pear Tree

Pear Tree is a 18 hectare site at the Northern most boundary of Oxford City in the Wolvercote area, the site is intersected by the A44 Woodstock Road and stretches between the A34 Western Bypass Road and the Birmingham – Oxford railway line.

This site is not affected by the PPS25 Flood Zones, is not within the historic flood outlines listed in Section 2.4 and no records of surface or groundwater information have been identified.

It is considered therefore that this site, subject to completion of an FRA due to being over 1 hectare in size, is appropriate for all forms of development under PPS25.

Barton

The Barton site is a 36 hectare site and is located in Headington and is between the Northern Bypass Road, the A40, and the Oxford City Boundary. Directly west of Barton, the site is predominantly a green field site. The northern edge of the site runs adjacent to Bayswater Brook and is within the Brooks floodplain, approximately 10% of the site is located within the Flood Zones 2 and 3.

Functional Floodplain, Flood Zone 3b, has not been defined for this brook as the Wolvercote model does not extend this far, therefore, to demonstrate a conservative approach, the Flood map 2 outline is considered to be Functional Floodplain at this location.

Under PPS25, only 'Water Compatible' land uses are appropriate within this Functional Floodplain and an Exception Test is required should Essential Infrastructure be proposed. As 90% of the site is within Flood Zone 1, careful planning of the site may avoid the need to develop within the floodplain altogether. Furthermore, as the floodplain does not encroach a considerable distance onto the site and is a linear feature it may be possible to incorporate this as a public open space and wildlife pathway feature on the development.

Should it be required that the area of land considered at risk of flooding be developed then a sequential approach should be adopted across the site to firstly utilise low risk areas before areas of higher flood risk. In conjunction with this, land uses of higher vulnerabilities should be steered to the higher ground of the site. Refer to Table 4 for guidance on which land uses are appropriate for specific Flood Zones.

A site specific FRA is required for the Barton site as it is over 1 hectare in size and it has a flood risk greater than 1 in 1000. The FRA should investigate further the Flood Zone classification for Bayswater Brook in order to accurately represent Functional floodplain. The FRA will also need to investigate groundwater flooding issues in the area as there is a record of groundwater flooding in the Headington area.

Southfields Golf Course
The Southfield Golf Course site is located on Southfields Golf Course in the New Headington are of Oxford, the site is split into two parts, the West area is 26 hectares and the East area is 8 hectares.

The golf course drains into Boundary Brook which is known to have flooding problems. Although both parts of the site are located within Flood Zones 1, due to their proximity to Boundary Brook and the need for an FRA on a size basis already, it is recommended that a more detailed FRA is undertaken to asses the actual risk of fluvial flooding to these sites.

Should the site remain in Flood Zone 1, no restrictions on development type are imposed under PP25.

5.3 Summary of Results for the West End Area

5.3.1 Summary of Results

The West End SFRA produced in June 2007 included an initial Sequential Test on proposed sites within the West End. This City wide SFRA supersedes the previous SFRA. The Flood Zone map within Appendix E should be referred to for Flood Zones across the entire city boundary while Appendix G provides a more detailed map of Flood Zones and sites through the West End.

A summary of the Sequential Test results is provided within Table 6 below which shows clearly the number of sites affected, in some part, by the Flood Zones.

Table 6: Summary of the flood risk status of proposed sites

Number of Sites	Flood Zone 1 Low Probability	Flood Zone 2 Medium Probability	Flood Zone 3a High Probability	Flood Zone 3b Functional Floodplain
Proposed Sites	6	8	7	3

In total, there are 24 development sites identified within the West End Boundary. 6 of these sites fall within Flood Zone 1 'Low Probability' and therefore no constraints imposed by PPS25 restrict development. 8 sites are within Flood Zone 2 'Medium Probability' and are therefore subject to the Exception Test should Highly Vulnerable land uses be proposed.

The remaining 10 sites are all within Flood Zone 3, 7 of which are within Flood Zone 3a 'High Probability' and the remaining 3 within Flood Zone 3b 'Functional Floodplain'. It is identified that some of these sites are only partially within Flood Zone 3a and that no sites are wholly within Flood Zone 3b. For these sites, dependent upon the intended use, the proposed land uses may be appropriate, inappropriate or require the Exception Test.

Table 7 below lists all of the sites within the West End Area, identifies the 'Worst Case' Flood Zone that they are located in and provides guidance on appropriate land use vulnerabilities for each site according to PPS25. Furthermore, the table identifies whether the Exception Test is required for specific sites. Further information on the proposed land use of these sites is contained within Appendix H and proportions of each site within each flood zone are contained in Appendix I.

Table 7: Summary of appropriate development type for proposed sites

Proposed Site	Flood Zone	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
1. Oxford Railway Station	FZ1					
2. Fire Station, Rewley Road	FZ1					
3. Beaver House, Hythe Bridge Street	FZ3a					
4. Island site (Park End St/Hythe Bridge St)	FZ3a					
5. Worcester Street Car Park	FZ1					
6. Odeon Cinema, George Street	FZ1					
7. New Theatre, George Street	FZ1					
8. Becket Street Car Park	FZ3a					
9. Ocean and Collins, Hythe Bridge Street	FZ3a					
10. Macclesfield House, New Road	FZ1					
11. Cooper Callas Site, Paradise Street	FZ3b					
12. County Hall, New Road	FZ1					
13. St Aldate's / Queen Street	FZ1					
14. Town Hall, St. Aldates	FZ1					
15. Nursery, Osney Lane	FZ3a					
16. Osney Warehouse, Osney Lane	FZ3a					
17. Oxpens	FZ3b					
18. OCVC remainder	FZ3a					
19. Oxford and Cherwell Valley College	FZ3b					
20. Westgate Shopping Centre	FZ2					
21. Albion Place and Magistrates' Courts	FZ2					
22. Speedwell House, Speedwell Street	FZ2					
23. Telephone Exchange, Speedwell Street	FZ2					
24. Police Station, St. Aldates	FZ2					

Appropriate for Use

Innappropriate for Use

Exception Test required

All sites within Flood Zones 2, 3a and 3b require a site specific FRA to support the development proposal, sites over 1 hectare in size also require an FRA. Table 8 below identifies which sites require FRAs.

Table 8: Sites Requiring FRAs

Proposed Site	Flood Zone	Area (Hectares)	FRA Required
1. Oxford Railway Station	FZ1	1.56	Yes
2. Fire Station, Rewley Road	FZ1	0.47	
3. Beaver House, Hythe Bridge Street	FZ3a	0.27	Yes
4. Island site (Park End St/Hythe Bridge St)	FZ3a	0.63	Yes
5. Worcester Street Car Park	FZ1	0.49	
6. Odeon Cinema, George Street	FZ1	0.11	
7. New Theatre, George Street	FZ1	0.21	
8. Becket Street Car Park	FZ3a	1.06	Yes
9. Ocean and Collins, Hythe Bridge Street	FZ3a	0.07	Yes
10. Macclesfield House, New Road	FZ1	0.23	
11. Cooper Callas Site, Paradise Street	FZ3b	0.1	Yes
12. County Hall, New Road	FZ1	0.39	
13. St Aldate's / Queen Street	FZ1	1	
14. Town Hall, St. Aldates	FZ1	0.65	
15. Nursery, Osney Lane	FZ3a	0.21	Yes
16. Osney Warehouse, Osney Lane	FZ3a	0.21	Yes
17. Oxpens	FZ3b	7.31	Yes
18. OCVC remainder	FZ3a	0.91	Yes
19. Oxford and Cherwell Valley College	FZ3b	1.5	Yes
20. Westgate Shopping Centre	FZ2	3.6	Yes
21. Albion Place and Magistrates' Courts	FZ2	0.3	Yes
22. Speedwell House, Speedwell Street	FZ2	0.34	Yes
23. Telephone Exchange, Speedwell Street	FZ2	0.4	Yes
24. Police Station, St. Aldates	FZ2	0.41	Yes

5.3.2 Undertake Detailed Feasibility for Oxpens Storage Site

The West End SFRA identified the importance of the Oxpens site for the renaissance of Oxford's West End, as identified with Table 8 part of this site is located within Flood Zone 3b and therefore this will have significant implications to development types for the site.

A potential opportunity for the provision of compensatory storage has been identified and initial investigations indicate that such a scheme could provide the required volume of storage that the Oxpens site currently offers.

It is recommended that a more detailed study is undertaken of the compensatory storage options to determine the feasibility of such a scheme and the associated costs of implementation. Any such compensatory storage scheme should endeavour to provide a level for level flood storage relationship maintaining the existing spill and top water levels as well as providing a volume for volume compensation.

5.3.3 Impacts of climate change on the Sequential Test Results

As previously discussed, the impact of climate change upon flood risk is that the frequency and severity of flooding is likely to increase into the future.

The climate change outline has been based upon the known 200 year water levels The Flood Zone 2 definition used for the SFRA is also based upon the 200 year flood outline.

Therefore, it has been assumed, based upon the best available information that, for the purpose of assessing the impact of climate change upon land allocations through the West End, the current Flood Zone 2 would in fact become the climate change Flood Zone 3a.

The impacts of this are that sites previously within Flood Zone 2 would now be located within Flood Zone 3a, this would affect the 8 allocation sites in Table 9. All of these sites are intended for More or Less Vulnerable land uses and as a result of the climate change impact these sites would be identified as requiring an Exception Test under PPS25.

Table 9: Impact of Climate Change on Flood Zone 2 Sites.

Proposed Sites
1. Oxford Railway Station
2. Fire Station Rewley Road
5. Worcester Street Car Park
20. Westgate Shopping Centre
21. Albion Place and Magistrates' Courts
22. Speedwell House, Speedwell Street
23. Telephone Exchange, Speedwell Street
24. Police Station, St. Aldates

Under climate change conditions, it is expected that the boundary of Flood Zone 2 would extend beyond its existing extent. The impact of this change upon the land allocations results is limited as the only constraint imposed under PPS25 for Flood Zone 2 applies to Highly Vulnerable land uses, and, as there are no intended land uses within the West End classified as 'Highly Vulnerable' this impact would be minimal.

6.0 FLOOD MANAGEMENT THROUGH OXFORD CITY

6.1 Overview

Making Space for Water sets out a new Government Strategy for flood and coastal erosion risk management. The vision of the strategy is that the concept of sustainable development will be firmly rooted in all flood risk management and coastal erosion decisions and operations. Flood and coastal erosion risk management will be clearly embedded across a range of Government policies, including planning, urban and rural development, agriculture, transport, and nature conservation and conservation of the historic environment.

Recent flood events have showed the devastating impact that flooding can have on lives, homes and businesses. A considerable number of people live and work in areas susceptible to flooding, and the ideal scenario would be to remove this development into areas not susceptible to flooding. However, it is recognised that this is not a practicable solution so measures should be put in place to minimise the risk to property and life posed by flooding. PPS25 requires that measures should mitigate flooding throughout the lifetime of any development and should therefore include any likely impacts from climate change.

6.2 Strategic Flood Risk Management

Development along river corridors during the industrial age has resulted in large urban areas at risk of flooding. Historically, the management of flood risk was undertaken in a somewhat reactive manner, addressing problems on an 'as needed' basis in response to a flooding event. It was recognised by Government that this approach was generally not a particularly cost effective solution and often failed to consider individual problem areas within the 'bigger picture' of the wider river system. The Environment Agency is now moving towards a more sustainable management of flood risk by steering away from the construction of raised defences and favouring solutions which work with natural processes.

The Environment Agency also endeavours to take a strategic approach to managing flood risk by considering flood risk on a catchment wide basis. Within the context of effective flood risk management, therefore, the importance of influencing both the strategic planning process and development control as an outcome of these strategies is widely recognised as a key Environment Agency objective. For this reason, it is vital that the recommendations of the SFRA are consistent with the long-term strategy(s) for flood risk management within the District (catchment).

A number of flood risk management strategies have been undertaken of the Thames catchment encompassing Oxford City.

Thames Catchment Flood Management Plan

Catchment Flood Management Plans (CFMPs) are a planning tool through which the Environment Agency aims to work in partnership with other key decision-makers within a river catchment to explore and define long term sustainable policies for flood risk management.

The Environment Agency has recently published for consultation (April 2007) a draft CFMP document for the Thames Region of which Oxford forms part. The CFMP's message on sustainable flood defences is clear;

> *It is not sustainable or realistic to build defences to protect all of the people and properties at risk of flooding. We do expect to be able to maintain our existing*

flood defences, and this will benefit many communities. However some defences will become increasingly unsustainable. To manage flood risk in the future for the half a million people at risk, we need to focus increasingly on the consequences rather than the likelihood of flooding.

The most sustainable way of reducing the flood risk will be through flood plain management. In the long term, this includes removing vulnerable development from the flood plain. Where there are exceptional circumstances for building in the flood plain, the ongoing cycle of redevelopment and urban regeneration is a crucial opportunity to reduce the risk. This involves changing the layout and design of development within the flood plain.

The impacts of climate change may mean that flood defences are not the most sustainable way of reducing risk in all of these areas in the long term. We do not anticipate major flood defences being constructed in the immediate future. However, we will seek to implement schemes that are proven to be sustainable. Some land may be needed for future flood management, for example for conveying or storing water. This land will need to be safeguarded from development.

Oxford Flood Risk Management Study

The Oxford Flood Risk Management study identifies that the most appropriate approach to management of flood risk through Oxford is to maximise flood conveyance through the western part of the Thames floodplain in order to bypass the city. The study identified a number of potential solutions of which the main options were:

- Maximise the capacity of existing floodplain
- Construct a new channel to increase capacity
- A combination of approaches

The Oxford Flood Risk Management study is reviewing the full range of measures that are available for managing flood risk.

The preferred strategy will include a portfolio of different measures for managing flood risk and not just one single solution. Stage 1 of the study has already identified that there is economic justification for reducing flood risk in Oxford. The key measures required to significantly reduce flood risk are likely to include increasing flood conveyance through the western part of the Thames floodplain. Stage 2 will consider what other measures will be combined with the increased conveyance measure to produce the optimum solution (following DEFRA's Project Appraisal Guidance).

6.3 River Corridor Management

One of the main contributory factors to flood risk through urban environments is the constrictions of watercourses. These constrictions may take the form of failure in part of bankside walls, culverts or bridges, blockages by vegetation, in channel shoals and berms or bank collapse. The Environment Agency encourages the removal or replacement of culverts with clear span structures with higher soffit levels to reduce their role as a constriction.

During site visits it was identified that the channel in places was constricted by vegetation growth, this vegetation can lead to further debris being collected thus leading to increased water levels during high water events. Two examples of this were identified on Wareham Stream and on Castle Mill Stream through the West End.

Wareham Stream between the Castle Mill Stream off take and Hythe Bridge Street, refer to Figure 2, shows clearly the in channel vegetation which is causing further material to be collected.

Figure 2: In Channel Vegetation and Debris Material in Wareham Stream

Routine and regular maintenance of the watercourses through Oxford helps reduce some low order flood events associated with blockage and it is recommended that maintenance works are continued on a regular basis to clear the channel of debris. Furthermore, it is recommended that works are undertaken to clear the two sites identified above of debris currently in situ.

The Environment Agency has published a document called 'Living on the Edge' which provides information on the roles and responsibilities of the Environment Agency and riparian land owners in relation to undertaking works on watercourses.

There is a need to create buffer strips to maintain the floodplain by setting back buildings from the edge of watercourses in any redevelopment whilst also providing ecological benefits.

6.4 Surface Water Management

The planning system can act as an effective means of ensuring that all new developments manage surface water in a sustainable manner. Conventional surface water drainage systems have traditionally used underground pipe networks to efficiently convey water away from sites. In the past this has led to problems of downstream flooding, reductions in groundwater recharge and waste pollution incidents associated with surface water overwhelming combined sewers. Both '*Making Space for Water*' and the '*Water Framework Directive*' have highlighted the need for an improved understanding and better management of how our urban environments are drained.

PPS25 requires that a site-specific flood risk assessment is undertaken for all sites including those in Flood Zone 1 with an area greater than one hectare to ensure that downstream flooding problems are not made worse by surface water runoff from the development.

Surface water drainage systems for a development should ensure that there is little or no residual risk of flooding for events in excess of the return period for which the sewer system on the site is designed.

For previously undeveloped sites the rate of runoff from the development sites should be no greater than the existing (greenfield) rate of runoff from the site

For developments on previously developed (brownfield) sites the rate of runoff should not exceed the runoff of the site in its previously developed condition. However, developers should be encouraged to reduce runoff from these developments to below previous rates wherever practicable to take account of Climate Change effects.

As the Cherwell and the Thames flow through Oxford City the Council has responsibility to ensure development does not increase flows downstream in neighbouring authorities.

Sustainable Urban Drainage Systems (SUDS) aim to mimic the natural drainage processes whilst also removing pollutants from urban runoff at the source before entering a watercourse. There are a wide range of SUDS techniques, including green roofs, permeable paving, swales, detention basins, ponds and wetlands.

6.5 Flood Management through redevelopment

Where there is an existing developed area, the redevelopment of it can reduce flood risk to the surrounding area, by reducing existing discharge of surface water runoff rates back to greenfield levels, by reducing footprints of buildings to create more flood storage and encouraging resilience to minimise the consequences.

6.6 Emergency Evacuation Routes

Although there are no emergency evacuation plans in place for managing a flood event through Oxford and hence no planned evacuation routes identified, this SFRA

has attempted to identify the key routes into and out of the City and the impact that flooding may have upon them.

Access to the city as a whole, during a flood event, would be easiest from the East, however many areas would be rendered inaccessible, as described below.

To the North of the city, a Q100 design event on the Thames will block the route to the West of Wolvercote along Godstow Road. However, the more favourable route would be East along the same road which does not flood.

Further downstream, Osney is inundated and this includes the main route through the area. The main road is the A420 (Botley Road) and is inundated at a number of points between Botley and New Osney. This makes evacuation from the area susceptible to the affects of rising water as no other direct routes are available.

The River Cherwell only causes flooding on the edges of urban areas and therefore does not affect any evacuation routes.

Just downstream of the confluence of the Rivers Thames and Cherwell, the area of New Hinksey floods during the Q100 design storm. The main road that runs North-South throught the area is the A4144 (Abingdon Road) and this is clear of flooding north of the Eastwyke Ditch crossing. South of here it is flooded almost until it reaches the A423 at the city boundary. There is only one other route out of the area and that is along the B4495 (Weirs Lane) which is clear East of the Weirs Mill Stream crossing.

These potential evacuation routes are defined as at risk of flooding and therefore during peak water levels evacuation by these routes may prove challenging. Vehicular passage may be possible on these routes dependant upon water depth. Appendix J includes maps of indicative flood depth through Oxford for the 100 year event, due to the methods by which these depths have been generated they should only be used as an indication of likely depths.

Further consideration must also be give to the flood warning services provided within Oxford and the potential lead time of 20 hours as identified within Section 2.6. This time period is significant and could be used to evacuate inhabitants prior to the occurrence of flood inundation, this would help reduce the level of risk associated with flood waters on evacuation routes.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

It has been found that the main risk of flooding to Oxford City is fluvial flooding associated with out of bank spills from the River Cherwell and Thames and their tributaries. No incidence of foul water flooding has been identified, isolated occurrences of surface water flooding exist in Littlemore and Northfield and no occurrences of flooding have resulted from canal infrastructure. Groundwater flood risk does exist in localised areas through the city, the majority of these sites in the low lying areas subject to fluvial flood risk.

There are no formal flood defences in Oxford, there are however informal defences providing some form of flood protection for events greater than the 25 year event.

For the purpose of this SFRA, the worst case has been used to assess the implications of flood risk upon proposed development sites. Flood outline generated as part of this study have been produced without defences in place, either formal, informal or 'defacto', when in reality some form of protection may be provided. Secondly, the method of assessment applied, PPS25 Sequential Test, requires that proposed development sites are assessed on the basis of the greatest flood risk that affects any part of the site regardless of the proportion of the site that is affected.

Of the 4 potential strategic development sites, it has been identified that 2 of these sites are not affected by flood risk, Pear Tree and Southfields Golf Course, and that the remaining 2 sites, Summertown and Barton, have some part within Flood Zone 3b.

The assessment of the sites within the West End has resulted in the following conclusions with reference to PPS25:

- 9 of the sites are within Flood Zone 1 and therefore have no development restrictions on the type of development imposed under PPS25.

- 5 sites are identified to be within Flood Zone 2 and should 'Highly Vulnerable' land uses be proposed on these sites an Exception Test would be required to justify the development at this location. Non flood related sustainability issues should be considered.

- 7 sites are within Flood Zone 3a, on these sites 'Highly Vulnerable' land uses are considered inappropriate and should either 'Essential Infrastructure' or 'More Vulnerable' land uses be proposed an Exception Test will be required. Non flood related sustainability issues should be considered.

- The remaining 3 sites are, in part, located in Flood Zone 3b, these sites are subject to the greatest level of restriction under PPS25.'Highly', 'Medium' and 'Low' Vulnerability land uses are not appropriate at these locations and 'Essential Infrastructure' proposals would require an Exception Test. The only land use considered appropriate is 'Water Compatible' land uses.

- 16 of the West End sites require site specific FRAs.

If, as PPS25 allows under wider sustainability grounds, the exception test is passed, then the focus will be to ensure that these development proposals are appropriate (resilient, safe and not increasing flood risk elsewhere) rather than dwelling on the principle of whether they should happen. If, however, the strategic land use questions are not adequately addressed through the SFRA and Sustainability Appraisal then

Proposed development for "windfall sites" will by definition not derive from any potential development sites that have been sequentially tested as part of this SFRA. The Sequential Test will need to be carried out for windfall sites and, if necessary, the Exception Test at the planning application stage.

The conclusions of this SFRA have been drawn together to support Oxford City Council's planning process and is based upon the current level of understanding of flood risk through Oxford which is currently under review by the Environment Agency.

7.2 Recommendations

7.2.1 Boundary Brook Flood Risk Mapping

The Environment Agency has previously commissioned a flood risk mapping study for Boundary Brook in Oxford City, no flood outlines exist at present for this brook. The Environment Agency has identified a need for further hydraulic modelling sensitivity work prior to the completion of these outlines.

As Boundary Brook flows through densely urbanised areas in Oxford, it is recommended that this modelling work and subsequent mapping be undertaken in order to increase understanding of flood risk in the Temple Cowley and Florence Park area of Oxford in order to inform the planning decision makers of flood risk in these areas.

7.2.2 Site Specific Flood Risk Assessments

This SFRA does not replace the need for site specific flood risk assessments. A greater level of detail should be provided by these assessments with respect flood risk and any protection afforded to the site, including from informal flood defences.

Consideration should be given to the proportion of the site located within specific PPS25 Flood Zones and the implications of this upon the development layout of the site. This process will allow planning of sites to place higher vulnerability uses on the higher ground. Where required, the Exception Test should be undertaken as part of the site specific FRA.

Site specific FRAs are required for all sites over 1 hectare in size and for all sites located with Flood Zones 2, 3a and 3b.

Surface water drainage systems for a development should ensure that there is little or no residual risk of flooding for events in excess of the return period for which the sewer system on the site is designed. For previously undeveloped sites the rate of runoff from the development sites should be no greater than the existing (greenfield) rate of runoff from the site. For developments on previously developed (brownfield) sites the rate of runoff should not exceed the runoff of the site in its previously developed condition. However, developers should be encouraged to reduce runoff from these developments to below previous rates wherever practicable.

Further guidance on the need for and the content of FRAs is contained within Appendix K.

7.2.3 River Corridor Maintenance

Vegetation growth within the channels of Castle Mill Stream and Wareham Stream has been identified. This vegetation should be removed in order to avoid the build up of debris and subsequent reduction in channel capacity. Similar exercises should be

undertaken at other locations throughout the City of Oxford where in channel vegetation has the potential for blockage.

Routine maintenance should be undertaken of all watercourses throughout the Oxford City to ensure that the channels stay clear of debris and vegetation growth. Condition assessments of the bridges and engineered channel sections should be undertaken on a regular basis.

7.2.4 Groundwater Flooding

The level of flood risk posed by groundwater both now and in the future is not fully known. It is recommended that further studies are undertaken to assess the risk and consequences of groundwater flooding and to develop warnings for flooding in Oxford.

7.2.5 Safeguarding Land

There is a need to protect land that may be required in the future for flood alleviation. The Environment Agency's Flood Risk Management Strategy. The Strategy has identified improving conveyance to the west of the city as the preferred option. It is recommended that any land, which could be utilised as part of the construction of any such scheme, should be protected from development at this time

7.2.6 Emergency Planning

There should be a revision of the emergency plan for Oxford based on the updated information in the SFRA.

As water levels rise and begin to pose a risk to life and/or livelihood, it is the responsibility of the emergency services to coordinate the evacuation of residents. This evacuation will be supported by the Council. It is essential that a robust plan is in place that clearly sets out as a minimum:

- Roles and responsibilities
- Paths of communication
- Evacuation routes
- Community centres to house evacuated residents
- Contingency plans in case of loss of power and/or communication

There is a need to assess whether there is any critical infrastructure, e.g. hospitals, emergency services, etc within the floodplain for emergency planning purposes and to ensure there is access and egress during a flood event.

7.2.7 Review of the Oxford City SFRA

The SFRA has been produced based on current understanding of flood risk and existing and available flood risk information. In time, as Environment Agency studies are complete and further flood risk understanding is developed the information within this document will become outdated, Therefore, it is important that the SFRA is reviewed and updated at regular intervals to incorporate this information.

8.0 REFERENCES

Central Oxfordshire Sub Regional Strategy

Development and Flood risk: A Practice Guide Companion to PPS25 – 'Living Draft' (2006), Communities and Local Government

Living on the Edge – a guide to the rights and responsibilities of riverside occupation (2007), Environment Agency

Making Space for Water - taking forward a new Government strategy for flood and coastal erosion risk management in England (2005), Defra

Oxford Area Flood Information – Guidance Booklet to the Management of Flooding and Flood Risk (2006), Oxford Area Flood Group

Oxford Flood Risk Management Study – Scoping Consultation Paper (2005), Environment Agency

Oxford Local Plan 2001 – 2016, Oxford City Council (2005)

Planning Policy Statement 25: Development and Flood Risk (2006), Communities and Local Government

Preferred Options Document for Oxford's West End Area Action Plan, Oxford City Council

Thames Region Catchment Flood Management Plan, Summary Document (2007), Environment Agency

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Appendix A – Historic Flood Records

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Appendix B – Identified Sites and Potential Strategic Development Sites

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Appendix C – Climate Change Map

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Appendix D – Published Environment Agency Flood Map

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Appendix E – SFRA Flood Zones

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Appendix F – Strategic Development Sites and Flood Zone Maps

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Appendix G – West End Flood Zones and Development Sites

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Appendix H – Results of the Sequential Test

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Proposed Site Land Use Classifications and the Sequential Test Results

		Essential infrastructure		More Vulnerable							Less Vulnerable							Water Compatible
Proposed Site	Flood Zone	Transport	Community energy	Town houses	Flats	Student accommodation	Hotels	Conference	Education	Amenities for housing	Offices	Public offices	Retail	Food and drink	Museums	Arts/other cultural uses	Leisure	Public space
1. Oxford Railway Station	FZ2	P																S
2. Fire Station, Rewley Road	FZ2		S	S	M				S	S	M							
3. Beaver House, Hythe Bridge Street	FZ3a										P							
4. Island site (Park End St/Hythe Bridge St)	FZ3a				S		S			S	S		M	S	S			
5. Worcester Street Car Park	FZ2				S				S		S			S	S			P
6. Odeon Cinema, George Street	FZ1												M	M		P		
7. New Theatre, George Street	FZ1															P		
8. Becket Street Car Park	FZ3a	P		P	M		S				M							
9. Ocean and Collins, Hythe Bridge Street	FZ3a													S	S			
10. Macclesfield House, New Road	FZ1				S						M		P	S	S			
11. Cooper Callas Site, Paradise Street	FZ3b				S						S			S		S		
12. County Hall, New Road	FZ1				S				S	S	S			S				
13. St Aldate's / Queen Street	FZ1				S	S					S		P	S				
14. Town Hall, St. Aldates	FZ1							P			S			S		S		
15. Nursery, Osney Lane	FZ3a			S	S					S								
16. Osney Warehouse, Osney Lane	FZ3a			P														
17. Oxpens	FZ3b		P	P	M		P	P		S	S	P		M	S		P	P
18. OCVC remainder	FZ3a			P	M					S	M							
19. Oxford and Cherwell Valley College	FZ3b								P									S
20. Westgate Shopping Centre	FZ2				S								P	S				S
21. Albion Place and Magistrates' Courts	FZ2				S				S		S				S			
22. Speedwell House, Speedwell Street	FZ2				S	S												
23. Telephone Exchange, Speedwell Street	FZ2			S	S						S				S			
24. Police Station, St. Aldates	FZ2			S	S						S			M				

P	Priority use	Appropriate for Use	
S	Secondary Use	Innappropriate for Use	
M	Minor Element	Exception Test required	

Note: The Flood Zone represented within column 2 is the 'worst case' Flood Zone on the site.

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Appendix I – Percentage of Sites within Flood Risk Zones

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Percentages of Identified Sites Within Flood Zones

Proposed Site	'Worst Case' Flood Zone	Percentage of site within each Flood Zone			
		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
1. Oxford Railway Station	FZ2	97%	3%	0%	0%
2. Fire Station, Rewley Road	FZ2	98%	2%	0%	0%
3. Beaver House, Hythe Bridge Street	FZ3a	12%	39%	49%	0%
4. Island site (Park End St/Hythe Bridge St)	FZ3a	5%	67%	28%	0%
5. Worcester Street Car Park	FZ2	81%	19%	0%	0%
6. Odeon Cinema, George Street	FZ1	100%	0%	0%	0%
7. New Theatre, George Street	FZ1	100%	0%	0%	0%
8. Becket Street Car Park	FZ3a	89%	6%	5%	0%
9. Ocean and Collins, Hythe Bridge Street	FZ3a	80%	17%	3%	0%
10. Macclesfield House, New Road	FZ1	100%	0%	0%	0%
11. Cooper Callas Site, Paradise Street	FZ3b	0%	0%	83%	17%
12. County Hall, New Road	FZ1	100%	0%	0%	0%
13. St Aldate's / Queen Street	FZ1	100%	0%	0%	0%
14. Town Hall, St. Aldates	FZ1	100%	0%	0%	0%
15. Nursery, Osney Lane	FZ3a	0%	0%	100%	0%
16. Osney Warehouse, Osney Lane	FZ3a	0%	0%	99%	1%
17. Oxpens	FZ3b	68%	9%	7%	16%
18. Oxford and Cherwell Valley Colley Site - Remainder	FZ3a	74%	20%	6%	0%
19. Oxford and Cherwell Valley College	FZ3b	38%	31%	15%	16%
20. Westgate Shopping Centre	FZ2	53%	47%	0%	0%
21. Albion Place and Magistrates' Courts	FZ2	10%	90%	0%	0%
22. Speedwell House, Speedwell Street	FZ2	2%	98%	0%	0%
23. Telephone Exchange, Speedwell Street	FZ2	49%	51%	0%	0%
24. Police Station, St. Aldates	FZ2	23%	77%	0%	0%

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Appendix J – 100 Year Flood Depths

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Appendix K – Guidance Notes for Planners and Developers

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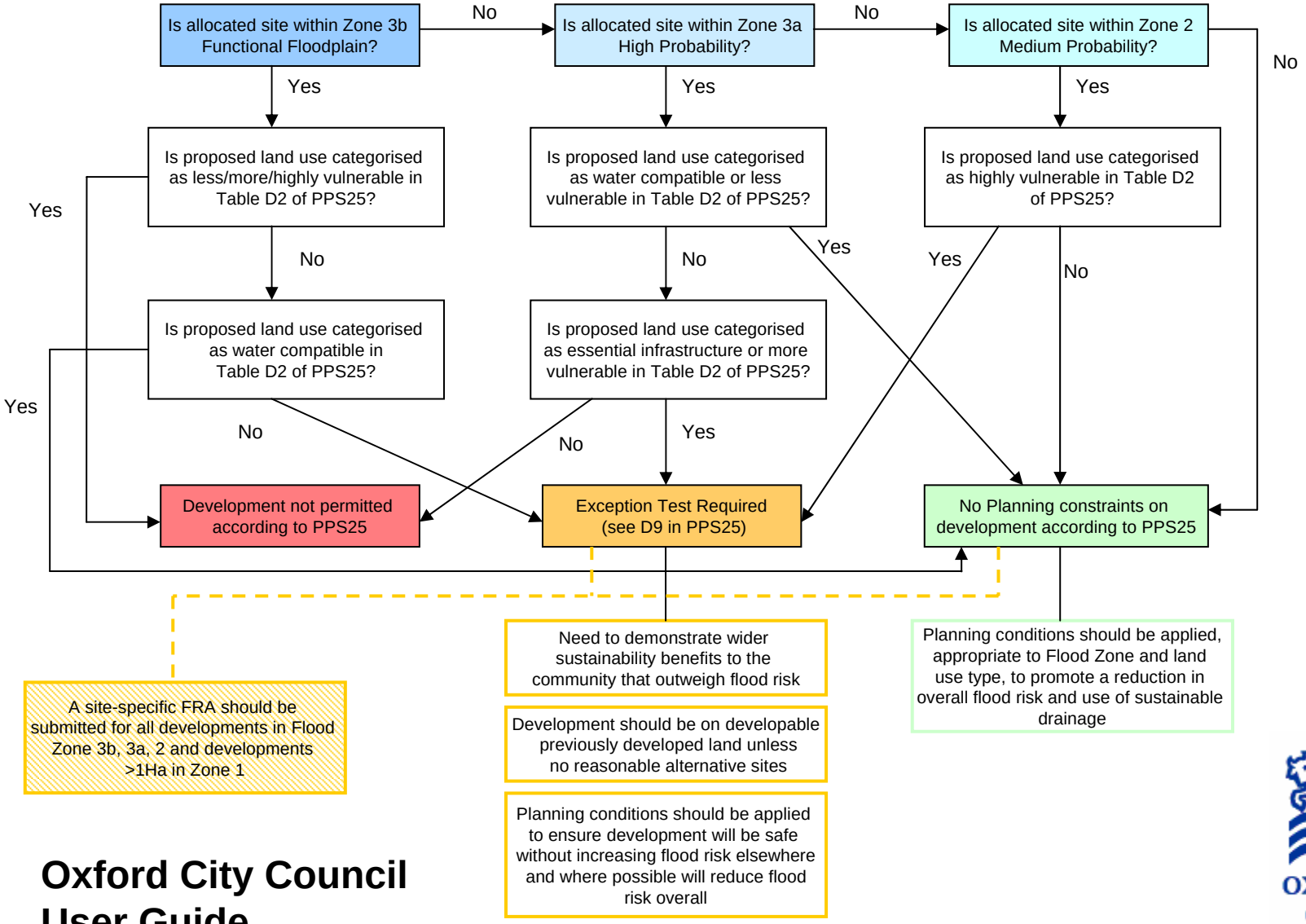
Planners from Oxford City Council should carry out the Sequential Test (refer Section 4.0 of the SFRA) before considering the development of an allocated site



A site-specific FRA should be submitted for all developments in Flood Zone 3b, 3a, 2 and developments >1Ha in Zone 1

Need to demonstrate wider sustainability benefits to the community that outweigh flood risk

Development should be on developable previously developed land unless no reasonable alternative sites

Planning conditions should be applied to ensure development will be safe without increasing flood risk elsewhere and where possible will reduce flood risk overall

Planning conditions should be applied, appropriate to Flood Zone and land use type, to promote a reduction in overall flood risk and use of sustainable drainage

Oxford City Council User Guide

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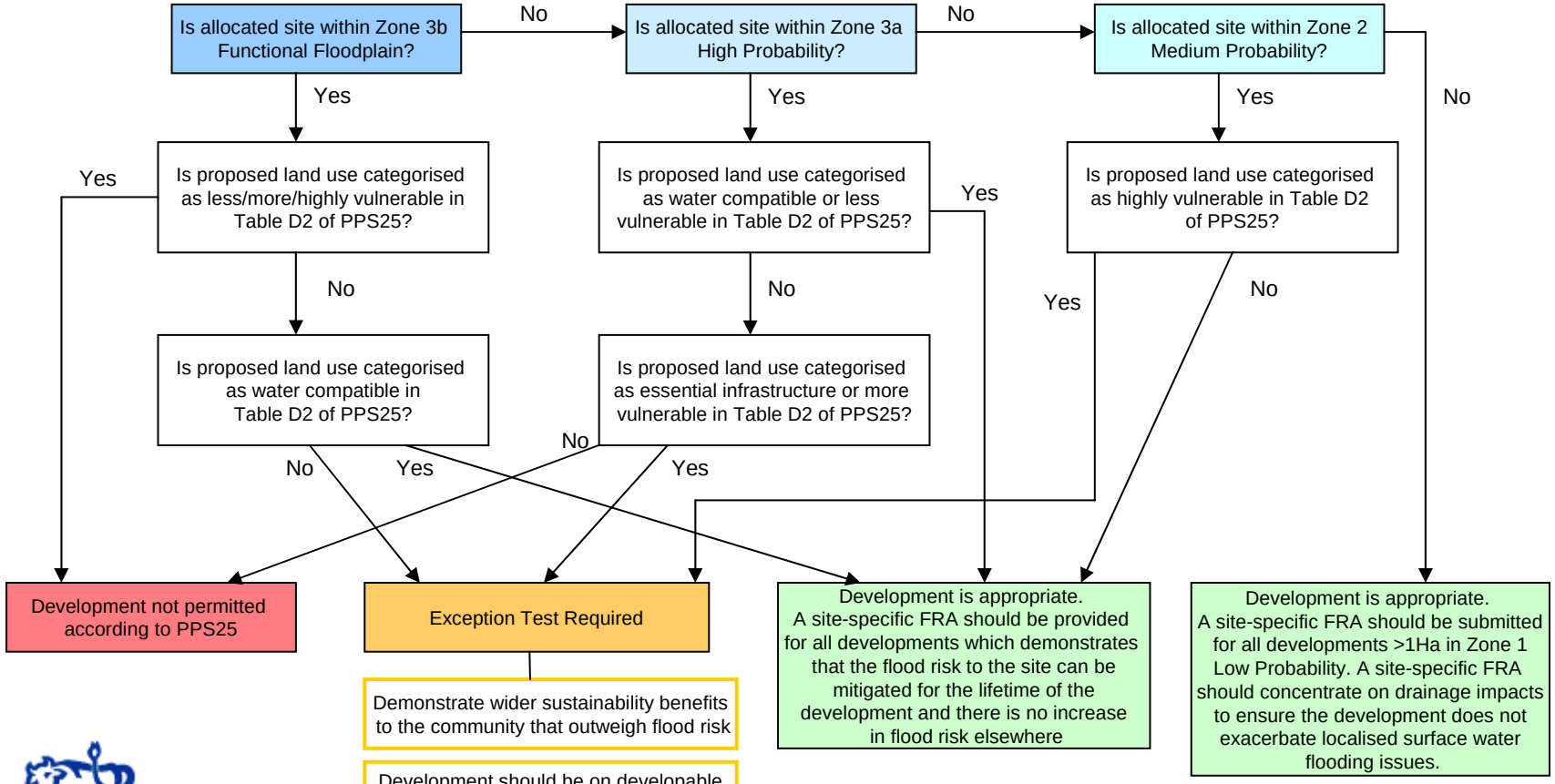
Unless development is proposed on an allocated site that has been included in The SFRA then the Developer should carry out the Sequential Test (refer Section 4.0 of the SFRA) before considering the development of an allocated site



Demonstrate wider sustainability benefits to the community that outweigh flood risk

Development should be on developable previously developed land unless no reasonable alternative sites

A site-specific FRA should be provided which demonstrates that the flood risk to the site can be mitigated for the lifetime of the development and there is no increase in flood risk elsewhere and if possible a reduction in flood risk overall

OXFORD CITY COUNCIL

Developer User Guide

Guidance Notes for Developers

How to Use the Strategic Flood Risk Assessment

The Strategic Flood Risk Assessment is the assessment and categorisation of flood risk on a district wide basis in accordance with PPS25. SFRAs refine information on the probability of flooding, taking other sources of flooding and the impacts of climate change into account. The SFRA provides the basis for applying the Sequential Test and the Exception Test where consideration needs to be given to the impact of the flood risk management infrastructure on the frequency, impact, speed of onset, depth and velocity of flooding within the Flood Zones considering a range of flood risk management maintenance scenarios.

A developer should consider flood risk issues at a site as early as possible. The SFRA can be used to provide an indication of the likely flood risk issues at a site from all sources of flooding. Developers should identify whether the development site has been allocated for that type of land use in the Local Development Documents. For allocated sites the SFRA can provide information on the application of the Sequential Test and where undertaken the Exception Test to see if the land use is appropriate.

When is a Flood Risk Assessment Required?

A Flood Risk Assessment (FRA) will be required to accompany planning applications for:

- any development proposals of I hectare or greater in Flood Zone 1
- any development proposals in Medium Probability Flood Zone 2
- any development proposals in High Probability Flood Zone 3

The FRA should identify and assess the risks of all sources of flooding to and from the development, taking into account climate change and demonstrate how the risk will be managed.

A FRA will also be required where the proposed development or change of use to a more vulnerable class may be subject to other sources of flooding or where the Environment Agency, Internal Drainage Board and/or other bodies have indicated that there may be drainage problems.

Standard Flood Risk Management Guidance for Developers

The broad aim of the Planning Policy Statement 25 is to reduce the number of people and properties within the natural and built environment at risk of flooding. To achieve this aim, planning authorities are required to ensure that flood risk is properly assessed during the initial planning stages of any development.

Responsibility for this assessment lies with developers and they must demonstrate the following:

- Whether the proposed development is likely to be affected by current or future flooding from any source.
- Whether the proposed development will increase flood risk elsewhere.
- Whether the measures proposed to deal with any flood risk are sustainable.

The developer must prove to the Local Planning Authority and the Environment Agency that the existing flood risk or flood risk associated with the proposed development can be satisfactorily managed.

The detail to be provided by a FRA will depend on where the proposed site fits within the development framework, particularly on its justification against the sequential test, described in the SFRA.

Development should follow the standard flood risk assessment approach provided by the Environment Agency and Ciria, as follows:

- National Standing Advice to Local Planning Authorities for Planning Applications - Development and Flood Risk in England' (June 2004)
- CIRIA Report C624 "Development and Flood Risk – Guidance for the Construction Industry" (2004).

The general requirements of a FRA are listed in Appendix E of PPS25 and within the Practice Guide to PPS25. To assist local planning authorities, the Environment Agency has produced standing advice to inform on their requirements regarding the consultation process for planning applications on flood risk matters. Further guidance on the level of detail required for a FRA can be found in the Environment Agency's Flood Risk Assessment guidance notes available at http://www.pipernetworking.com/floodrisk/index.html

Guidance for Development within Each Flood Zone

An FRA should be commensurate with the risk of flooding to the proposed development. For example, where the risk of flooding of the site is negligible (Zone 1 Low Probability) there is little benefit to be gained in assessing the potential risk to life and/or property as a result of flooding. The particular requirements for FRAs within each of the flood zones delineated within PPS25 are outlined below.

Flood Zone 1 Low Probability

There are generally no flood risk related constraints placed upon future development within Zone 1 Low Probability according to PPS25; however it is important to recognise that if development is not carefully managed within this zone it may adversely affect the existing flooding regime.

The risks of alternative sources of flooding (e.g. groundwater, pluvial) need to be considered. The proposed development should also consider surface water runoff to ensure that there are no detrimental effects to existing development and where possible the runoff is reduced through sustainable drainage systems.

Flood Zone 2 Medium Probability

After the Sequential Test has been applied and the lowest risk suitable site has been chosen, PPS25 recommends that development within Flood Zone 2 should be restricted to 'essential infrastructure', 'water compatible', 'more vulnerable' or 'less vulnerable' land uses.

Where no suitable alternative sites at lower flood risk is found during the Sequential Test if highly vulnerable development should be considered further within Flood Zone 2 it will be necessary to carry out the Exception Test.

PPS states that for the Exception Test to be passed:

1. *it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared.*
2. *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*
3. *a FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.*

The risks of alternative sources of flooding (e.g. groundwater, pluvial) need to be considered. The proposed development should consider surface water runoff to ensure that there are no detrimental effects to existing development and where possible the runoff is reduced through sustainable drainage systems.

As part of the FRA, it will be necessary to demonstrate that the residual risk of flooding can be effectively managed and a planned evacuation route or safe haven can be provided.

Flood Zone 3a High Probability

To satisfy the requirements of the Sequential Test, PPS25 recommends that development within Flood Zone 3a should be restricted to 'Less Vulnerable' and 'Water Compatible' land uses.

Where no suitable alternative sites at lower flood risk is found during the Sequential Test if 'more vulnerable' vulnerable development and 'Essential Infrastructure' should be considered further within Flood Zone 3a it will be necessary to carry out the Exception Test (see above for details).

An FRA should include the following:

- The vulnerability of the development to fluvial and/or tidal flooding as well as other sources.
- The impact of climate change over the lifetime of the development on the flooding regime, i.e. maximum water levels, flood extents and flow paths.
- The effect of the new development on surface water runoff ensuring that there are no detrimental effects to existing development and where possible that runoff is reduced through sustainable drainage systems.
- Demonstration that residual risks of flooding, after existing and proposed flood management and mitigation measures are taken into account, are acceptable.
- Demonstration that dry access can be provided to enable the safe evacuation in the case of flooding or where this is not achievable a safe haven can be provided.

Flood Zone 3b Functional Floodplain

To satisfy the requirements of the Sequential Test, PPS25 recommends that development within Flood Zone 3b should be restricted to 'water compatible' land uses.

Where no suitable alternative sites at lower flood risk is found during the Sequential Test if 'Essential Infrastructure' should be considered further within Flood Zone 3b it will be necessary to carry out the Exception Test (see above for details).

An FRA should include the following:

- The vulnerability of the development to fluvial and/or tidal flooding as well as other sources.
- The impact of climate change over the lifetime of the development on the flooding regime, i.e. maximum water levels, flood extents and flow paths.
- The effect of the new development on surface water runoff ensuring that there are no detrimental effects to existing development and where possible that runoff is reduced through sustainable drainage systems.
- Demonstration that residual risks of flooding, after existing and proposed flood management and mitigation measures are taken into account, are acceptable.
- Demonstration that dry access can be provided to enable the safe evacuation in the case of flooding or where this is not achievable a safe haven can be provided.

Additional Guidance

Undefended Floodplain

Areas at risk of fluvial flooding need to be assessed against the 1% annual exceedance probability (AEP) criteria with 0.5% AEP criteria for tidal flooding. The Environment Agency's hydraulic models may be made available for use by developers to determine the site's vulnerability to flooding. . The developer will need to firstly ensure that the models are fit for

purpose and sufficiently detailed to provide an accurate understanding of flood risk to the site. If existing models are not available, then a developer will need to assess the extent and requirements of any modelling work that is required. Detailed hydraulic modelling will involve the following:

- Carrying out a hydrological assessment using Flood Estimation Handbook techniques and using gauging records where available.
- Constructing an in-bank model using up to date survey data including structures, e.g. bridges, weirs, culverts and sluices.
- Extending the in-bank model to include floodplains where necessary using appropriate hydraulic modelling approaches to replicate the extent, storage and conveyance of the floodplains, e.g. through extended cross sections, reservoir units or 2-D modelling.
- Calibrating or verifying the hydraulic model where hydrometric monitoring data or flood records are available.
- Carrying out sensitivity analysis to confirm modelling assumptions and assess climate change impacts.
- Mapping of flooding extents

Defended Floodplain

Development sites within a defended tidal or fluvial floodplain are at particular risk due to the risk of the defences being overtopped or breached, resulting in the rapid onset of fast flowing and deep water flooding with little or no warning.

Residual risk from the breach or overtopping of defences needs to be considered as part of a FRA. Defra's[1] Flood Risk Assessment Guidance for New Development provides guidance on the level of risk related to distance and flood depth for overtopping and breaching scenarios.

The objectives of a breach analysis are as follows:
- to determine the Rapid Inundation Zone where there is a potential risk to life
- to investigate the impact of the proposed development on the flood risk to others
- to test the effectiveness of mitigation measures

Consideration of flood risk behind defences should take into consideration the standard of protection and design freeboard of the flood defence along with its condition and potential mechanisms of failure. The parameters of a breach in terms of potential location, width and invert level as well as the duration of a flood event should be agreed with the Environment Agency prior to any analysis.

Design Floor Levels

It may be feasible to reduce the risk to a development through raising the ground level above the level of flood risk.

Floor levels should be raised above the 1% AEP fluvial flood level plus an allowance for climate change assuming a 20% increase in flow over the next 100 years.

For coastal flood risk, floor levels should be raised above the 0.5% AEP plus climate change. Climate change predictions for rises in sea level vary across the country and should be based on Defra[2] guidance.

[1] 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. Defra/Environment Agency 2005

[2] Flood and Coastal Defence Appraisal Guidance FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts. Defra, October 2006

In addition, the design flood level should include a freeboard above the flood level. For non-residential development, e.g. commercial freeboard, the Environment Agency usually requires a freeboard of 300mm, and for residential development a freeboard of 600mm.

Compensatory Storage

Where development is proposed in undefended areas of floodplain, which lie outside of the functional floodplain, the implications of ground raising operations for flood risk elsewhere needs to be considered. Raising existing ground levels may reduce the capacity of the floodplain to accommodate floodwater and increase the risk of flooding by either increasing the depth of flooding to existing properties at risk or by extending the floodplain to cover properties normally outside of the floodplain. Flood storage capacity can be maintained by lowering ground levels either within the curtilage of the development or elsewhere in the floodplain, in order to maintain at least the same volume of flood storage capacity within the floodplain. Compensatory storage should be provided on a level for level and volume for volume basis.

For development in a defended flood risk area, the impact on residual flood risk to other properties needs to be considered. New development behind flood defences can increase the residual risk of flooding if the flood defences are breached or overtopped by changing the conveyance of the flow paths or by displacing flood water elsewhere. If the potential impact on residual risk is unacceptable then mitigation should be provided.

Surface Water Drainage Assessment

Developers should demonstrate that the disposal of surface water from the site will not exacerbate existing flooding from new development within Flood Zones 3 and 2, development greater than 1Ha in Flood Zone 1 and within areas that are known to suffer from surface water drainage or sewer flooding.

A surface water drainage assessment should be undertaken to demonstrate that surface water runoff from the proposed development can be effectively managed without increasing flood risk elsewhere. A surface water drainage assessment should include the following:

- Assessment of whether the development will increase the overall discharge from the site by calculating the change in area covered by roofs and hard-standing.
- Details of how overland flow from the new development can be intercepted to prevent flooding of adjacent land.
- Details of how additional onsite surface water attenuation can be provided to mitigate against known flooding problems or as a result of incapacity on the drainage systems.
- Demonstration that overland flows will not increase flood risk to both existing development and receiving watercourses.
- Agreement that the rates of discharge from the development are acceptable to the Environment Agency and utilities authorities.

Reference to the following documents and websites are recommended:

- Interim Code of Practice for Sustainable Drainage Systems, National SUDS Working Group, 2004.
- Planning Policy Statement 25, Annex F, Communities and Local Government, 2006
- The SUDS Manual C697, CIRIA, February 2007
- www.ciria.org.uk/SUDS/

The permeability of the soil provides and indicative suitability of the SUDS technique as summarised in the table below.

Permeability	Indicative Suitability of SUDS Techniques

High Permeability	Infiltration and Combined Systems
Moderate Permeability	Infiltration and Combined Systems
Low Permeability	Attenuation Systems

It is important to note that the above assessment of the spatial suitability of SUDS is an indicative estimate and should be confirmed at the site specific level, using ground investigation data.

Infiltration Systems

Infiltration systems allow surface water to discharge directly into the ground. These systems are only appropriate where ground conditions permit; 1) a suitable water acceptance potential and 2) in locations where groundwater recharge will not adversely affect drinking water aquifers as identified by the Environment Agency's source protection zones, available on their website http://www.environment-agency.gov.uk. Such systems may include:

- Permeable surfaces
  - Gravel
  - Permeable Paving
  - Block Paving with voids
  - Grassed areas
- Sub Surface Infiltration
  - Filter Drains
  - Geocellular Systems
  - Soakaways

Attenuation Systems

If ground conditions cannot support infiltration systems, surface water may need to be attenuated using measures to store surface water. Attenuation systems, if designed at ground level, have the potential to take up large areas of development sites. Early consideration of such constraints is therefore essential. Attenuation systems may include:

- Landscaped
  - Detention Basins
  - Balancing Ponds
  - Retention Ponds
  - Wetlands
  - Lagoons
- Engineered
  - Underground Tanks
  - Ornate Water Features
  - Rainwater Harvesting
  - Green Roofs
  - Oversized Pipes

Combined Systems

SUDS designs for most sites can include a combination of infiltration and attenuation systems and they have been categorised above according to the dominant process. Other forms of SUDS which can provide more balanced benefits of infiltration and attenuation include:

- Swales
- Filter Strips

Selection of Appropriate Mitigation Measures

The sequential approach should be applied within development sites to locate the most vulnerable elements of a development in the lowest risk areas. Where vulnerable development cannot be allocated within low risk areas then measures could be put in place to mitigate against the flood risk.

There are several sources of information on potential mitigation measures, as follows:

- Flood Risk Assessment Guidance for New Development, Environment Agency R&D (FD2320)
- Development and Flood Risk – Guidance for the Construction Industry, CIRIA 624

The Environment Agency R&D Guidance on Flood Risk Assessments for new development suggests that mitigation measures can be split into three types:

- Measures that reduce the physical hazard, e.g. through raised defences or flood storage
- Measures that reduce the exposure to the hazard, e.g. raise properties above flood levels
- Measures that reduce the vulnerability to the hazard, e.g. flood warning or emergency planning.

The selection of appropriate mitigation measures depends on the requirements of the development and its sensitivity to flood risk. Any mitigation measure selected should be sustainable in the future by taking into consideration the impact of climate change on flood risk. The residual risk of developing an area vulnerable to flooding with mitigation measures in place should also be considered.

Flood defence walls or embankments

Flood defences, fully funded by the development can be constructed to protect a new development. However, the impact on the risk of flooding elsewhere with defences in place needs to be assessed and managed for example through compensatory storage. Residual risk of flooding with flood defences also needs to be assessed and managed.

Flood Storage

Flood storage either offline or online can be used to manage water levels at or downstream of a development site.

Building Design

Flood management measures only manage the risk of flooding rather than remove it completely. Therefore, buildings should be designed to be flood resistant and flood resilient where they are built behind flood defence systems. Flood resistnace is the prevention of flood water entering a building through, for example, flood barriers or raising floor levels. Flood resilience is ensuring the finish (e.g. type of flooring) and services (e.g. electrics) are such that following a flood the building can be returned quickly to its normal operation. A basic level of flood resistance and resilience can be achieved through good building practice and complying with Building Regulations (ODPM, 2000).

Flood Warning

The Environment Agency provides flood warnings to a number of existing properties at risk of flooding to enable owners to protect life and manage the effect of flooding of their property. Flood warning should only be provided as a measure to manage residual risk and should not be used as the sole measure to offer protection to a development.

Access and Egress

PPS25 requires that safe access and escape is available to and from new developments in flood risk areas. Where possible, safe access routes should be located above design flood levels and an evacuation procedure should be in place for an extreme flood event. If no safe access can be provided then a safe haven should be provided within the development.

For developments within Zone 3a High Probability and Zone 2 Medium Probability which are not offered protection from raised defences, the following is required:

- Dry escape, above the 100 year flood level taking into account climate change, should be provided for all 'more vulnerable' (including residential) and highly vulnerable' development.
- 'Safe' should be dry for all other uses such as educational establishments, hotels and 'less vulnerable' land use classifications.

For developments within Zone 3a High Probability and Zone 2 Medium Probability which are offered protection from raised defences, the following is required:

- 'Safe' access should preferably be dry for 'highly vulnerable' uses
- 'Safe' access should incorporate the ability to escape to levels above the breach water level.

For major 'highly vulnerable' development, safety will also need to be ensured through the development of a robust evacuation plan. This should clearly define routes to dry (i.e. 'un-flooded') land. This may include routes through flood waters, providing the depth and speed of flow across the evacuation route are below the risk defined by the "some" threshold in Flood Risk to People (Defra, FD2320)

For infrastructure development, safety will also need to be ensured through the development of a robust evacuation plan. This should clearly define dry escape routes (above the 100 year plus climate change flood level) to dry (i.e. 'un-flooded') land.

In exceptional circumstances, dry access (above the 100 year plus climate change flood level) for 'more vulnerable' and/or 'highly vulnerable' development may not be achievable. In these exceptional circumstances, liaison must be sought with the Environment Agency and the Council Emergency Planning Team to ensure that the safety of site tenants can be satisfactorily resolved.