Thurrock Strategic Flood Risk Assessment
Level 2 Report

Final Report
February 2010

Prepared for:

THURROCK COUNCIL

Revision Schedule

Thurrock Strategic Flood Risk Assessment: Level 2 Report
February 2010

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Acronyms and Abbreviations

Abbreviation	Description
AONB	Area of Outstanding Natural Beauty
BAR	Broad Areas for Regeneration
BGS	British Geological Society
CFMP	Catchment Flood Management Plan
CLG	Communities and Local Government
Defra	Department for Environment, Food and Rural Affairs
DPD	Development Plan Document
DTM	Digital Terrain Model
FRA	Flood Risk Assessment
GIS	Geographical Information System
IDB	Internal Drainage Board
KCDC	Key Centre for Development and Change
LDDs	Local Development Documents
LDF	Local Development Framework
LDS	Local Development Scheme
LiDAR	Light Detection and Ranging
LPA	Local Planning Authority
ODPM	Office of Deputy Prime Minister
PCPS 2004	Planning and Compulsory Purchase Act 2004
PPS	Planning Policy Statement
RBMP	River Basin Management Plan
RFRA	Regional Flood Risk Appraisal
RPG	Regional Planning Guidance
RSS	Regional Spatial Strategy (East of England Plan)
SA	Sustainability Appraisal
SAC	Special Area for Conservation
SFRA	Strategic Flood Risk Assessment
SPA	Special Protection Area
SPD	Supplementary Planning Document
SPZ	Source Protection Zone
SUDS	Sustainable Drainage Systems
WCS	Water Cycle Study
WFD	Water Framework Directive

Glossary

Term	Definition
Aquifer	A source of groundwater comprising water-bearing rock, sand or gravel capable of yielding significant quantities of water.
Catchment Flood Management Plan	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Culvert	A channel or pipe that carries water below the level of the ground.
Flood Defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floodplain	Area adjacent to river, coast or estuary that is naturally susceptible to flooding.
Flood storage	A temporary area that stores excess runoff or river flow often ponds or reservoirs.
Fluvial flooding	Flooding by a river or a watercourse.
Freeboard	Height of flood defence crest level (or building level) above designed water level
Groundwater	Water that is in the ground, this is usually referring to water in the saturated zone below the water table.
Inundation	Flooding.
Local Development Framework (LDF)	The core of the updated planning system (introduced by the Planning and Compulsory Purchase Act 2004). The LDF comprises the Local Development Documents, including the development plan documents that expand on policies and provide greater detail. The development plan includes a core strategy, site allocations and a proposals map.
Local Planning Authority (LPA)	Body that is responsible for controlling planning and development through the planning system.
Mitigation measure	An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere.
Overland Flow	Flooding caused when intense rainfall exceeds the capacity of the drainage systems or when, during prolonged periods of wet weather, the soil is so saturated such that it cannot accept any more water.
Risk	The probability or likelihood of an event occurring.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Sustainable drainage system	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations meeting their own needs.
1 in 100 year event	Event that on average will occur once every 100 years. Also expressed as an event, which has a 1% probability of occurring in any one year.
1 in 100 year design standard	Flood defence that is designed for an event, which has an annual probability of 1%. In events more severe than this the defence would be expected to fail or to allow flooding.

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1 Introduction

1.1 Overview

Planning Policy Statement 25: Development and Flood Risk (PPS25) published in December 2006 emphasises the active role Local Planning Authorities (LPAs) should have in ensuring flood risk is considered at all stages of strategic land use planning. PPS25 encourages LPAs to undertake a Strategic Flood Risk Assessment (SFRA) as part of the evidence base for development of their Local Development Framework (LDF).

Scott Wilson has been commissioned to undertake a review of the SFRA for Thurrock Borough Council (BC) which was prepared in conjunction with neighbouring local authorities as part of the Thames Gateway South Essex SFRA (2006).

PPS25 outlines a two staged approach to the completion of a SFRA:

- Level 1 SFRA – Enables the application of the Sequential Test
- Level 2 SFRA – Increased scope of SFRA for sites where the Exception Test is required

The Level 1 SFRA (Scott Wilson 2009) provides a strategic overview of the potential sources of flooding throughout Thurrock. The information presented within the Level 1 report forms the evidence base for undertaking the Sequential Test within Thurrock and should be read and understood.

In large parts of Thurrock it is not possible to allocate all proposed development in accordance with the sequential approach, steering development to areas at lowest risk of flooding, and therefore it has become necessary to increase the scope of the Level 1 SFRA to provide information necessary for the application of the Exception Test.

To this end, this Level 2 SFRA provides a more detailed assessment of flood risk in areas where pressure to develop has been recognised. The deliverables from the Level 2 SFRA should provide Thurrock BC with further information for allocation sites that may require the Exception Test, and should be read in conjunction with the Level 1 SFRA.

1.2 Aim of Level 2 SFRA

The aim of this study is to build on the findings of the Level 1 SFRA and provide detailed information regarding flood hazard in order to inform the suitability for development of potential sites with known flooding issues, as identified and outlined in the Level 1 SFRA and the PPS25 Sequential Test.

This report presents the findings of the Level 2 SFRA. Specifically, it details the methodology and results of an extensive flood modelling and mapping exercise, considering the actual and residual flood risk from tidal flooding across Thurrock. Modelling has been completed to assess the tidal flood risks as a result of breach failure of the tidal defences. The aim of the flood modelling is to simulate flood events to determine potential flood extents, depth, a flood hazard categorisation based on flood depth and velocity, and the time taken before inundation by floodwaters. In addition to informing forward planning, this information can also enable a sequential approach to site allocation and/or development within a Flood Zone and where necessary application of the Exception Test.

The Level 1 and 2 reports should be used in conjunction with each other for strategic land use planning and development control decisions. The Level 1 contains an overview of flood sources within Thurrock and should be read and understood before the Level 2 is consulted.

As with the Level 1 SFRA, this report should be regarded as a “living document” to ensure that the SFRA remains up-to-date with new data and guidance as and when it becomes available.

1.3 Study Area

The total study area is defined by the administrative area of Thurrock BC. During the Level 1 SFRA, particular attention was focused on the Broad Areas for Regeneration, and potential Minerals and Waste sites have been assessed within a Supplementary document.

As part of the Level 2 SFRA, the flood risk posed to the Broad Areas for Regeneration will be assessed in further detail.

In addition, a large number of individual development sites have been identified throughout the preparation of the Strategic Housing Availability Assessment (SHLAA) and Thurrock BC’s Preferred Options Site Allocations Development Plan Document (DPD). The flood risks posed to these sites will be considered as part of this Level 2 SFRA.

1.4 Level 2 SFRA Objectives

The aim of the Level 2 SFRA is to provide sufficiently detailed information regarding the nature of flood risk posed to Thurrock to enable the application of the Exception Test. This will be achieved through the following objectives:

- Carry out 2D hydrodynamic modelling of the agreed breach locations along the Thurrock Borough frontage for 1 in 200 and 1 in 1000 year tidal flood events taking account of 100 years of climate change until 2109;
- For each scenario, provide mapping of the following information:
    i. The depth of flooding;
    ii. The flood hazard based on the depth and velocity of flood water;
    iii. The time to inundation;
- Provide mapping of flood depth and flood hazard for the River Mardyke and Stanford Brook based on modelling completed as part of the South Essex Catchment Flood Management Plan;
- Provide guidance on the application of the Exception Test for potential development sites; and,
- Advise on the requirements of site-specific Flood Risk Assessments in the light of findings from the Level 2 SFRA.

2 Sources of Flooding

2.1 Tidal

Due to the large area of defended tidal floodplain in the Borough of Thurrock, a large portion of the Broad Areas for Regeneration and potential allocation sites for minerals and waste sites are located within areas of residual risk. PPS25 defines residual risk as the risk remaining after flood management or mitigation measures have been put in place.

Thurrock is protected by tidal flood defences along the River Thames Estuary as shown in Figure 11 of the Level 1 SFRA (Scott Wilson 2009). The NFCDD records a range of tidal and fluvial flood defences within the Thurrock study area. The tidal flood defences in Thurrock are mainly raised reinforced concrete walls, steel walls, or earth embankments. There is limited information regarding the condition of these defences within the NFCDD dataset. However the Figures 10A and 10B of the Level 1 SFRA (Scott Wilson 2009) show the design standard and authority responsible for maintaining the defences in the Borough. The large majority of these defences are maintained by the Environment Agency which has stated that the defence height varies slightly, depending on exposure, between 6.9m AOD to 7.2m AOD. This corresponds very closely to the range of 1 in 1000 year peak tides for the year 2109. As a result no overtopping has been assumed to occur and has therefore not been assessed in this study.

2.1.1 Likely Future Policy

The Thames Estuary 2100 Project is an Environment Agency initiative, which seeks to plan for future flood protection needed for London and the Thames Estuary over the next 100 years. Under the project a number of preferred management objectives have emerged that are of relevance to Thurrock.

2.1.1.1 Rainham Marshes & Mardyke Policy Management Unit

The recommended flood risk management policy is P4: to take further action to sustain the current level of flood risk into the future, responding to the potential increases in risk from urban development, land use change and climate change.

- Management of fluvial flood risk on the marsh drainage system will require outfall improvements, including pumps, and local fluvial flood storage.
- It is suggested that enhancement of the marshes could be carried out in the Aveley valley to improve the capacity and support freshwater and grazing marsh. This could contribute to compensation for losses of freshwater and grazing marsh features elsewhere.

2.1.1.2 Purfleet, Grays & Tilbury Policy Management Unit

The recommended flood risk management policy is P4: to take further action to sustain the current level of flood risk into the future, responding to the potential increases in risk from urban development, land use change and climate change.

- There is likely to be a limit placed on the number of times the new Tilbury Dock flood gate can be closed because of interference with shipping. A possible mitigation measure would be to raise the quay edges in the dock, though there may be implications for interference with commercial operations.

- As sea levels rise and rainfall increases, upgrading of the drainage systems in Purfleet, West Thurrock and Tilbury will be required. Mitigation measures may include improvements to drainage channels and outfalls, additional pumping capacity, additional flood storage and new or improved local flood defences.

2.1.1.3 East Tilbury & Mucking Marshes Policy Management Unit

The recommended policy for East Tilbury and Mucking Marshes is P3: to continue with existing or alternative actions to manage flood risk at the current level, accepting that flood risk will increase over time from this baseline.

- Due to the low monetary value of assets in the area covered by this policy unit, it may become difficult to justify the replacement of flood defences when they reach the end of their lives. This situation therefore provides perfect opportunity for localised managed realignment in order to improve habitats in combination with local defences to protect important assets, including East Tilbury.
- New and improved flood defences should be designed so that all defences have continuous public access.
- Mitigation measures for fluvial flood risk include outfall improvement, flood storage and local flood defences.

2.1.1.4 Shell Haven & Fobbing Marshes Policy Management Unit

The recommended policy for East Tilbury and Mucking Marshes is P3: to continue with existing or alternative actions to manage flood risk at the current level, accepting that flood risk will increase over time from this baseline.

- Fobbing marshes are designated as part of the proposed South Essex community parklands in the Thames Gateway Parklands vision. As a result, no new development should be permitted in the marsh areas.
- The southern part of the policy unit is likely to remain commercial and industrial for the foreseeable future, and secondary defences are recommended to provide localised protection against rising sea levels to these key sites.
- It is anticipated that the London Gateway port at Shell Haven will include improved flood defences, possibly by raising the new quay level above flood defence level.
- Managed realignment is proposed for Mucking to provide replacement intertidal area and salt marsh in conjunction with the proposed new London Gateway port.
- As sea levels rise and rainfall increases, upgrading of the drainage systems on the Fobbing and Vange marshes are required including improvements to channels and outfalls as the need arises.

With these policies in mind, it will become increasingly important to manage flood risk through the careful positioning of development using the sequential approach and thorough emergency planning.

2.1.2 Breaching

Breaches occur when there is a failure in a raised defence. This may be caused by a collision of shipping traffic, hydrostatic water pressure during high tides, vehicle collision or a floodgate being left open. Breaches are more likely to occur during high water level events including extreme tides or periods of high river flow when loads on the defence will be greater.

The time taken for a breach to be blocked can have a major impact on the extent and depth of flood experienced. The highest flood hazard typically exists in the period immediately following a breach, and usually but not necessarily, in the areas closest to the breach.

Floodwater flowing through a breach in the defences will be of high velocity and volume, dissipating rapidly across large low lying areas. Flooding as a result of a breach in defences from tidal sources such as this can be life threatening with far reaching consequences.

Breaching of the flood defences has the potential to generate considerable flood hazard and damage to homes and infrastructure. The aim of flood modelling is to simulate flood events to determine the areas at highest risk. This information can then assist in the development of future strategies concerning development and flood prevention.

As part of this SFRA, 2D modelling has been carried out to assess the residual risk following 21 breach scenarios along the Thurrock frontage. A detailed methodology for 2D modelling of the tidal breach events is included in Appendix D.

The results from this modelling should be used to develop an understanding of the nature of the residual flood risk behind the defences in order to inform the application of the Exception Test and the sustainability and suitability of possible residual risk management options.

2.2 Fluvial

2.2.1 River Mardyke

The River Mardyke drains a semi-rural catchment of approximately 12km^2 in north west Thurrock, and flows south to meet the River Thames near Purfleet. The upper catchment is predominantly open space and public access land. In the south the land use changes to residential and industrial uses.

The River Mardyke has been modified as part of a flood relief scheme to include channel widening, the raising of river banks and incorporation of wooden floodgates where the River Mardyke joins the Thames at Purfleet. The gates are self-activating and close is response to pressure created from the rising Thames, thereby protecting the River Mardyke and its floodplain from extreme tidal movements.

2.2.2 Stanford Brook

The Stanford Brook flows through Stanford-le-Hope and the Mucking Marshes into the Thames Estuary.

The catchment is small, predominantly urban and surrounded by steeper topography. As a result this system responds rapidly to rainfall, and properties in close proximity to the watercourse are therefore at risk of flooding.

The risk posed by the River Mardyke and Stanford Brook has been considered in further detail in this Level 2 SFRA through the use of hydraulic modelling prepared as part of the South Essex Catchment Flood Management Plan (Environment Agency 2008).

2.2.3 Policy Unit Action Plans, CFMP 2008

The South Essex Catchment Flood Management Plan provides an overview of the broad policies for the sustainable management of present and future flood risk within Thurrock. A summary of the preferred policy options for the fluvial Policy Units within Thurrock is presented below:

2.2.3.1 Policy Unit 9: Stanford-le-Hope

The recommended policy is Policy 5: Take further action to reduce flood risk now and in the future.

This policy unit is subject to high fluvial flood risk from the Horndon Brook / Stanford Brook. The high surrounding topography and urban nature of the unit contribute to rapid responses to rainfall.

The following actions are suggested for this policy unit:

- A new flood defence scheme could be implemented to reduce the number of people and property at risk both now and in the future.
- Increased flood storage and managed runoff in upstream locations such as the upper Mardyke catchment could help to reduce flood risk in Stanford-le-Hope.
- Develop an Urban Drainage Plan for Stanford-le-Hope to investigate the risk from surface water flooding.
- Develop Emergency Response Plans for sites at risk of flooding.
- Investigate the feasibility of creating a flood forecasting and warning system for Stanford-le-Hope.

2.2.3.2 Policy Unit 10: Upper Mardyke / Horndon Catchment

The recommended policy is Policy 6: Take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits, locally or elsewhere in the catchment.

The predominant land use in this policy unit is agricultural and therefore there is limited flood risk to people or property.

- As part of the Plan a Flood Storage Strategy is suggested for the area. Creating flood storage within the policy unit will benefit downstream areas of Tilbury, Purfleet and Stanford-le-Hope. Suitable storage options may include the creation of floodplain wetlands or attenuation sites. Alternatively, the floodplain could be naturally restored which would save on expense and potentially deliver environmental benefits.
- No development should be permitted within the floodplain, as this is deemed to be functional floodplain.
- A Land Management Plan is proposed, to explore changes in land use and to develop sustainable land management practices.

2.2.3.3 Policy Unit 10: Upper Mardyke / Horndon Catchment

The recommended policy is Policy 6: Take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits, locally or elsewhere in the catchment.

The main source of flooding in this unit is from the River Mardyke and agricultural drainage networks. A small number of scattered farms and isolated properties are at risk of flooding. A larger risk is evident downstream and is of primary concern when considering policy options for this unit.

- As a result, the key aim within this unit is to attenuate flows through the provision of floodwater storage. This may be provided through engineered formal flood storage areas which would help to protect people and property from flooding. An alternative, more cost beneficial option would be natural floodplain storage which would involve changes in land use, flood proofing measures and flood awareness campaigns for properties at risk in this policy unit.
- As a result the CFMP suggests the development of a Land Management Plan to explore changes in land use and develop sustainable land management practices, and development of an Environmental Enhancement Project to improve the natural state of the river and its habitat.

2.2.4 Flood Zone Mapping

PPS25 Flood Zones associated with these two watercourses, including Flood Zone 3b Functional Floodplain, have been mapped and are presented in the Figures in Appendix B and C. The methodology is presented in Section 3.3.

2.3 Surface Water Flooding

Surface water flooding is another key source of flooding within Thurrock. During periods of heavy rainfall water runs over the ground surface and ponds in low lying areas. Urban centres such as Purfleet, Tilbury, Grays and Stanford-le-Hope are particularly susceptible to this form of flooding especially where the finite capacity of conventional drainage systems are unable to cope with the volume and timing of runoff.

The Environment Agency has undertaken broad scale, national mapping of areas susceptible to surface water flooding which is presented within the Level 1 SFRA (Scott Wilson 2009). The mapping has been created using a simplified method that excludes urban sewerage and drainage systems, excludes buildings, and uses a single rainfall event. The mapping is intended for use by Local Resilience Forums (LRFs) and to inform emergency planning and for land use planning. However this mapping has the following limitations:

1) The mapping does not show the interface between the surface water network, the sewer systems and the water courses;

2) It does not show the susceptibility of individual properties to surface water flooding;

3) The mapping has significant limitations for use in flat catchments, which is important in Thurrock.

In the light of these limitations, it is recommended that the mapping be used only as an initial review of surface water flooding across the area, and not to inform planning decisions within the Borough of Thurrock.

A better understanding of surface water flood risk needs to be developed for Thurrock, particularly considering the level of anticipated development and regenerative growth, and to this end, it is recommended that a Surface Water Management Plan (SWMP) is undertaken following the Defra guidance (February 2009).

The aim of the SWMP will be to enable better understanding and management of local flood risk as well as influence land use planning and flood risk management investment decisions.

On a smaller scale, surface water flooding should remain a key consideration during the preparation of site specific Flood Risk Assessments. Further information is included in Chapter 6.

3 Methodology

3.1 Overview

This section describes the methodology used in the production of mapping and deliverables for this study. Hydrodynamic modelling of potential breaches in the defences is intended to provide a greater level of detail regarding the variation of the residual flood risk in Thurrock. Hydraulic modelling of the River Mardyke and Stanford Brook enables a better appreciation of the flood risk associated with these watercourses.

These assessments are made at the strategic level and should be used to inform how the Broad Areas for Regeneration and development may be at risk from these sources of flooding. This should therefore form a ‘stepping-stone’ for a site-specific Flood Risk Assessment (FRA), considering the recommendations presented throughout the SFRA.

3.2 Hydrodynamic Breach Modelling

The Level 1 SFRA identified that a large portion of Thurrock lies within the defended tidal floodplain of the River Thames Estuary and is at residual risk of tidal flooding. Part of the requirement of the Level 2 SFRA, in accordance with PPS25, is to make an assessment of residual risk and therefore hydrodynamic breach modelling has been carried out at a 21 locations along the Thurrock frontage. These locations and their corresponding flood cells are shown in Figure A1. A detailed report of the methodology adopted for this modelling is included within Appendix D.

Table 3-1: Breach Locations

Code	Flood cell	Easting / Northing	Breach Width
A001	A	554826 / 178741	Sluice 12m
A002	A	554835 / 178550	50m
B001	B	555944 / 177456	20m
B002	B	556452 / 177157	20m
B003	B	558820 / 176385	20m
B004	B	559687 / 177309	20m
B005	B	560188 / 177511	20m
C001	C	560825 / 177566	20m
C002	C	561116 / 177530	20m
C003	C	561610 / 177275	20m
C004	C	561737 / 177086	20m
C005	C	562570 / 175474	Sluice 20m
C006	C	564832 / 175210	20m
C007	C	566216 / 175373	20m
D001	D	569385 / 178504	20m

E001	E	570214 / 180987	50m[1]
F001	F	570840 / 181560	20m
F002	F	574353 / 181584	20m
F003	F	574611 / 181780	20m
F004	F	574272 / 183902	20m
F005	F	574050 / 184228	20m

[1] - sluice to the west of the breach provides considerable flooding during large events. Therefore, for models, it was assumed to be left as is (i.e. not raised). These models are therefore, essentially a two-breach system.

The following flood events were simulated for each breach location;

- A tidal flood event with a return period of 1 in 200 years (present day 2009);
- A tidal flood event with a return period of 1 in 200 years (with climate change 2109);
- A tidal flood event with a return period of 1 in 1000 years (with climate change 2109).

3.2.1 Modelling Outputs

Breach analysis enables an appreciation of the residual risk of flooding from a failure of local defences. Outputs such as flood depth, flood hazard and time to inundation within the study area provide Thurrock BC with additional information to enable a more detailed consideration of the Sequential Test within Flood Zone 3a. This data will also enable part c) of the Exception Test to be addressed and will help to inform the production of the emergency flood response plan for the area.

Maximum Flood Depth

The maximum flood depth is obtained from the water level achieved at each point in the model, minus the LiDAR topographic level at that point. This has been processed for the climate change scenarios (2109) only.

The flood depths experienced during each breach have been mapped together, using the maximum values at each point in the floodplain. These are included in the Figures within Appendices B and C.

Hazard Rating

Flood hazard is a function of the flood depth and flow velocity at a particular point in the floodplain. Each element within the model is assigned one of four hazard categories ‘Extreme Hazard’, ‘Significant Hazard’, ‘Moderate Hazard’, and ‘Low Hazard’.

The derivation of these categories is based on Flood Risks to People FD2320 (DEFRA & EA, 2005), using the following equation:

*Flood Hazard Rating = ((v+0.5)*D) + DF*   *Where v = velocity (m/s)*

D = depth (m)

DF = debris factor

The depth and velocity outputs from the 2D hydrodynamic modelling are used in this equation, along with a suitable debris factor. For this SFRA, a precautionary approach has been adopted inline with FD2320; a debris factor of 0.5 has been used for depths less than and equal to 0.25m, and a debris factor of 1.0 has been used for depths greater than 0.25m.

Table 3-2 Hazard categories based on Defra Research Paper FD2320 (Flood Risk to People), DEFRA & Environment Agency 2005

Flood Hazard			Description
(green)	HR < 0.75	**Low**	**Caution** – Flood zone with shallow flowing water or deep standing water
(yellow)	0.75 ≥ HR ≤ 1.25	**Moderate**	**Dangerous for some** (i.e. children) – Danger: flood zone with deep or fast flowing water
(orange)	1.25 > HR ≤ 2.0	**Significant**	**Dangerous for most people** – Danger: flood zone with deep fast flowing water
(red)	HR > 2.0	**Extreme**	**Dangerous for all** – Extreme danger: flood zone with deep fast flowing water

Hazard outputs have been processed for the 1 in 200 year and 1 in 1000 year event (2009) and have been included in the Level 1 SFRA Report. Hazard outputs for the 1 in 200 year event with climate change (2109) and the 1 in 1000 year with climate change (2109) have also been processed and are presented within this Level 2 SFRA Report.

The hazard outputs for each of the 21 breach locations have been mapped together, using the maximum hazard rating at each point in the floodplain. These are shown in the Figures included in Appendix B and C.

Time to Inundation

The time taken for floodwaters to spread across the flood cell has been mapped using the following methodology.

Time 0 is set to the time when tidal water enters the breach. This means that the <1 hour band encompasses all areas that are inundated (wet) within the first hour of water travelling through the breach and into the flood cell. Further bands have been produced to show wet cells at: 1-4 hours, 4-8 hours, 8-12 hours, and for each 4 hour interval up to 28-32 hours.

This data has been processed for the climate change scenarios only.

The outputs for time to inundation for each of the 21 breach scenarios have been mapped together, showing the most conservative results for Thurrock as a whole. This mapping is included in Appendix B and C.

3.3 Fluvial Modelling

PPS25 defines Flood Zones according to the probability of fluvial flooding, as shown in Table 3-3.

Table 3-3: Fluvial Flood Zone Definitions (as defined in PPS25, Table D.1)

Flood Zone	Definition	Probability of Flooding
Flood Zone 1	Land at risk from flood event less than the 1 in 1000 year event (less than 0.1% annual probability of flooding each year)	Low Probability
Flood Zone 2	Land at risk from flood event between the 1 in 100 and 1 in 1000 year event (between 1.0% and 0.1% annual probability of flooding each year)	Medium Probability
Flood Zone 3a	Land at risk from flood event less equal to, or greater than, the 1 in 100 year event (greater than 1.0% annual probability of flooding each year)	High Probability
Flood Zone 3b	Land where water has to flow or be stored in times of flood, or land purposely designed to be flooded in an extreme flood event (0.1% annual probability). The 1 in 20 year annual probability floodplain is the starting point for consideration but local circumstances should be considered and an alternative probability can be agreed between the Local Planning Authority and the Environment Agency	Functional Floodplain

The River Mardyke and Stanford Brook have been hydraulically modelled as part of the South Essex Catchment Flood Management Plan (Environment Agency 2008). Broad scale models have been produced in order to provide information regarding the fluvial flood risk in the study area associated with a range of return periods, which are summarised below:

3.3.1 River Mardyke

- 1 in 20 Year - Used to map Flood Zone 3b (2009)
- 1 in 20 Year + Climate Change - Used to map Flood Zone 3b (2109)
- 1 in 100 Year - Used to map Flood Zone 3a (2009)
- 1 in 100 Year + Climate Change - Used to map Flood Zone 3a (2109)
- 1 in 1000 Year - Used to map Flood Zone 2 (2009)
- 1 in 1000 Year + Climate Change - Used to map Flood Zone 2 (2109)

The flood extents from these modelled scenarios have been used to map Flood Zones 3b, 3a and 2 with and without climate change, in accordance with Table 3-3.

3.3.2 Stanford Brook

- 1 in 10 Year
- 1 in 20 Year - Used to map Flood Zone 3b (2009)
- 1 in 50 Year

- 1 in 75 Year
- 1 in 100 Year - Used to map Flood Zone 3a (2009)
- 1 in 100 Year + Climate Change - Used to map Flood Zone 3a (2109)
- 1 in 1000 Year - Used to map Flood Zone 2 (2009)

The model for the Stanford Brook does not include modelled scenarios for the 1 in 20 year plus climate change, and therefore it was agreed with the Environment Agency that the flood outline for the 1 in 50 year event should be used as a surrogate.

In addition, there is no modelled scenario for the 1 in 1000 year event including an allowance for climate change which should be used to map Flood Zone 2 (2109). In order to determine the flood extent during this scenario, the present day and climate change cases of the 1 in 100 year scenario were used as a basis for extrapolating the 1 in 1000 year plus climate change (2109) flood extent. This was subsequently mapped as Flood Zone 2 (2109).

3.3.3 Modelling Outputs

Maximum Flood Depth

Maximum flood depths have been obtained by calculating the difference between the water level achieved at each point in the model and the LiDAR topographic level at that point. This has been processed for the 1 in 100 year plus climate change and 1 in 1000 year plus climate change scenarios (2109) for the River Mardyke and the 1 in 100 year plus climate change for the Stanford Brook. The 1 in 100 fluvial scenario is considered comparable with the 1 in 200 year tidal scenario and therefore the results from these scenarios have been mapped together in the Figures included in Appendix B and C.

The model for the Stanford Brook did not include a scenario for the 1 in 1000 year plus climate change event. In order to provide a suitable substitute for this information the following methodology has been used; the difference between water levels for the present day and climate change cases of the 1 in 100 year scenario were used as a basis for extrapolating the 1 in 1000 year plus climate change (2109) water levels. To do this, the known level changes between the present day and climate change cases were multiplied by the differences in the peak inflows of the present day input hydrographs.

New maximum water levels were then extrapolated for the 1 in 1000 year event, and compared with the LiDAR topographic data in the same manner as the other modelled cases in order to determine the maximum flood depths.

Hazard Rating

Flood hazard has been calculated for the River Mardyke and Stanford Brook flood outlines using the same formula applied for the breach assessments shown in Section 3.2.1. For these fluvial systems, the velocity has been assumed as 0. A debris factor of 0.5 has been used for depths less than and equal to 0.25m, and a debris factor of 1.0 has been used for depths greater than 0.25m.

The hazard rating for the River Mardyke and Stanford Brook has been mapped with the tidal hazard rating resulting from the breach scenarios. Where these overlap, the highest hazard rating at each point in the floodplain has been presented to present the most conservative results.

3.4 Limitations

3.4.1 Hazard Rating

Hazard mapping is developed as a product of the depth and velocity from a particular breach event or combined breach event within a given flood cell. These hazard classifications do not indicate a change in the flood probability.

It should be noted when using hazard zone maps that **they represent the hazard arising from one or more specific breach locations, and that the hazard will almost certainly vary spatially if the breach locations are in different local areas**. This is also the case for the flood depth maps.

Other issues that should also be noted include the following:

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

3.4.2 Time to Inundation

The values presented for time to inundation are indicative only. The modelling methodology used for this study produces results from a breach present in the defences from the onset of flooding. This is analogous to a flood gate being left open at low tide and as the tide rises flood waters flow through the breach. In reality, if a breach were to occur, the breach would take place at the maximum tide level, as a consequence of maximum water pressure acting on the defence. If a breach were to occur at the high point of the tide, time to inundation could shorten significantly.

4 Mapping and Site Assessment

The purpose of the Level 2 SFRA is to present more detailed information with respect to flood risk to enable application of the Exception Test. The increased scope of the SFRA includes the production of mapping showing flood depth, flood hazard and time to inundation.

4.1.1 Broad Areas for Regeneration

Thurrock BC has identified a number of Broad Areas for Regeneration within the district. The figures included within Appendix C show mapping of the Flood Zones and outputs from the hydrodynamic breach modelling in relation to each of these Broad Areas for Regeneration.

A PPS25 Sequential Test Report is being prepared for these Broad Areas for Regeneration in Thurrock, identifying where the Sequential Test has been passed, where further sequential testing will be needed within the Broad Area, and where the Exception Test is required because there are no alternative sites for the proposed development. Table 4-1 summarises the findings of the PPS25 Sequential Test Report.

Table 4-1 Sequential & Exception Test Requirements for Broad Areas for Regeneration in Thurrock

Broad Area for Regeneration	Flood Zone	Results from the Sequential Test
Aveley Urban Area	1	Sequential Test Passed
Chadwell St Mary	1	Sequential Test Passed
East Tilbury	1, 2, 3a	Sequential Approach Needed within the Broad Area
Grays Urban Area	1, 2, 3a	Sequential Approach Needed within the Broad Area
London Gateway*	3a	Exception Test Needed, no alternative sites available
Purfleet Urban Area	1, 2, 3a	Sequential Approach Needed within the Broad Area
South Ockendon	1	Sequential Test Passed
Stanford-le-Hope & Corringham	1, 2, 3a	Sequential Approach Needed within the Broad Area
Stifford Clays / North Grays	1	Sequential Test Passed
Tilbury	3a	Exception Test Needed, no alternative sites available
Villages	1	Sequential Test Passed
West Thurrock	1, 2, 3a	Sequential Approach Needed within the Broad Area

*London Gateway has been accepted as a development area and the site for a new port and logistics complex.

Development can be situated anywhere within the Broad Area for Regeneration due to its location in Flood Zone 1. The Sequential Test is passed.
Development should be steered to lower flood risk areas where possible as Flood Zones 2 and 3 are present. A sequential approach is needed within flood zones using the flood hazard classifications to ensure more vulnerable developments are located in lower flood hazard areas. The Exception Test will need to be applied where the sequential approach is not applicable due to the prevalence of flood zones within a broad area for regeneration and a limited number of alternative sites.
If development cannot be steered to other broad regeneration areas flood hazard classifications should be used to steer more vulnerable developments to lower flood hazard areas in Flood Zone 3. Application of the Exception Test is necessary. Emergency planning measures should be in place to ensure response to a flood emergency is planned, this will support part c) of Exception Test.

Table 4-1 illustrates that proposed redevelopment sites within the large majority of the Broad Areas for Regeneration in Thurrock will require further application of the Sequential and Exception Tests.

4.1.2 Development Site Allocations

Specific development sites have also been identified by Thurrock BC for consideration within the Level 2 SFRA. A large number of sites have been identified throughout the Strategic Housing Land Availability Assessment (SHLAA). As part of the SHLAA, an assessment will be made to determine whether sites are suitable, available and achievable for housing development over the next 15 year period. In order to assist with this process, these sites have been considered in relation to flood risk within this Level 2 SFRA.

Sites which have since been rejected from the Preferred Options but are identified in the SHLAA have been included within this assessment in order to assist with their potential development in the future and/or to enable comparison during application of the Sequential Test.

Employment site allocations that have been identified through the Employment Land Review completed by URS Corporation Ltd in 2007 have been included in the assessment and sites which have been identified throughout the Core Strategy and Site Allocations Proposed Submission stage have also been considered. These include sites allocated for primary and secondary employment uses, as well as mixed use developments, leisure and other uses.

The figures and tables included in Appendix C summarise the flood risk posed to each of these sites in terms of flood depth, hazard rating, and time to inundation by floodwaters. The proposed use and vulnerability classification is also recorded for each site, and whether the site will require the Exception Test, should it pass the Sequential Test.

4.1.3 Minerals and Waste Allocations

Thurrock BC is currently preparing their Minerals and Waste Site Allocations DPD. During the initial search for sites, a number of sites have been identified for mineral extraction and waste disposal. A supplementary document has been prepared which considers the flood risk posed to these sites. This supplement forms part of the evidence base for the preparation of the Minerals and Waste DPD.

5 The Exception Test

5.1 Overview

When considering future regeneration and development in particular areas of Thurrock, it is likely that some sites will need to be considered that can only be deemed compatible with the flood risk posed if it can be demonstrated that there are no reasonably available alternative sites in areas of lesser flood risk and that the development passes all elements of the PPS25 Exception Test.

The purpose of the Exception Test is to ensure that new development is only permitted in medium and high flood risk areas where flood risk is clearly outweighed by other sustainability factors; where the development will be safe during its lifetime, considering climate change; where the development will not increase flood risk elsewhere, and where possible will reduce flood risk overall.

The tables included in Appendix C identify which sites will require the Exception Test. These sites will only require the Exception Test where it can be demonstrated that the Sequential Test has been satisfied, i.e. that there are no other reasonably available alternative sites in areas of lower flood risk where the development could be located.

5.2 Application

The Exception Test comprises three criteria, all three of which must be satisfied before a development may be considered appropriate within an area of medium or high flood risk.

5.2.1 Part A – Wider Sustainability to the Community

It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by the SFRA where one has been prepared. If the DPD has reached the ‘submission’ stage (Figure 4 of PPS12; Local Development Frameworks) the benefits of the development should contribute to the Core Strategy’s Sustainability Appraisal.

- The site should be scored against the sustainability criteria of the Sustainability Appraisal (SA) (Scott Wilson 2007).
- Where a development fails to score positively against the SA, Thurrock BC should consider whether the use of planning conditions or Section 106 Agreements could make it do so.

It is the role of the developer or Thurrock BC to consider the proposal against the objectives of the SA in order to determine whether the site will satisfy this element of the Exception Test.

5.2.2 Part B – Redevelopment of Previously Developed Land

The development must be on developable previously developed land or, if it is not on previously developed land, it must be demonstrated that there are no reasonable alternative sites on developable previously developed land.

Planning Policy Statement 3: Housing states that in order to be considered 'developable', sites should be in a suitable location for housing development, (or the proposed use), and there should be a reasonable prospect that the site is available for, and could be developed at the point envisaged.

Planning Policy Statement 3: Housing defines 'previously developed' land as 'land which is, or was occupied by a permanent structure, including the curtilage of the developed land and any associated fixed surface infrastructure.'

The definition includes defence buildings, but excludes:

- Land that is or has been occupied by agricultural or forestry buildings.
- Land that has been developed for minerals extraction or waste disposal by landfill purposes where provision for restoration has been made through development control procedures.
- Land in built-up areas such as parks, recreation grounds and allotments, which, although it may feature paths, pavilions and other buildings, has not been previously developed.
- Land that was previously-developed but where the remains of the permanent structure or fixed surface structure have blended into the landscape in the process of time (to the extent that it can reasonably be considered as part of the natural surroundings).

There is no presumption that land that is previously-developed is necessarily suitable for housing development nor that the whole of the curtilage should be developed.

The tables included in Appendix C identify which of the proposed redevelopment sites are previously developed, which will assist with part b) of the Exception Test.

5.2.3 Part C – Safe from Flood Risk

A Site-specific Flood Risk Assessment (FRA) must demonstrate that the development will be safe, without increasing flood risk elsewhere, and where possible, will reduce flood risk overall. It must consider the risks throughout the design life of the development, and the PPS25 Practice Guide recommends that for residential development a minimum of 100 years is specified, unless there is specific justification for considering a shorter period. For non-residential developments, the design life is considered to be 75 years.

The PPS25 Practice Guide provides details on the definition of 'safe' in Chapter 6 – Risk Management by Design, and Chapter 7 – Residual Risk.

For sites subject to the Exception Test, PPS25 requires consideration of the following issues in order to demonstrate safety:

- Actual flood risk throughout development lifetime i.e. defence overtopping
- Residual flood risk throughout development lifetime i.e. defence/pumping station failure
- Access and egress routes
- Flood warning and evacuation procedures

The outcome of part c) will be site-specific and the following Chapter outlines the issues that will need to be addressed as part of a site-specific Flood Risk Assessment for submission with the planning application, and where required, satisfy part c) of the Exception Test. The assessment presented within the figures and tables of Appendix C provide an initial indication of whether the development is likely to pass part c) of the Exception Test.

It is emphasised that the definition of safe should be clarified and agreed between Thurrock BC and the Environment Agency and may require additional considerations depending on the precise nature of the proposed development and flood risk.

5.3 Next Steps

The findings of the Level 1 SFRA (Scott Wilson, 2009) and PPS25 Sequential Test (Scott Wilson, 2009) conclude that a large majority of development will need to be located in areas of flood risk in order to maintain and regenerate the main urban areas. This will particularly be the case for Grays Urban Area, Purfleet Urban Area, West Thurrock Urban Area and Tilbury Urban Area.

It is the role of Thurrock BC to apply the Sequential Test to their allocation sites within these areas and preferentially develop land at lowest risk of flooding. Where there are no reasonably available sites for development, the Exception Test may then be required.

With this in mind, a review of all the development sites has been undertaken to identify those that will require the Exception Test, should the Sequential Test be passed. This review is presented in the tables in Appendix C.

5.3.1 Windfall Sites

Windfall Sites are sites which become available for development unexpectedly and are therefore not included as allocated land in a planning authority's development plan.

Should a site become available that is not located within one of the Broad Areas for Regeneration, the Sequential Test should be applied on an individual site basis and the developer will need to provide evidence to the LPA that they have adequately considered other reasonably available sites. This will involve considering windfall sites against other sites allocated as suitable for housing plans.

The following steps should be followed for windfall sites:

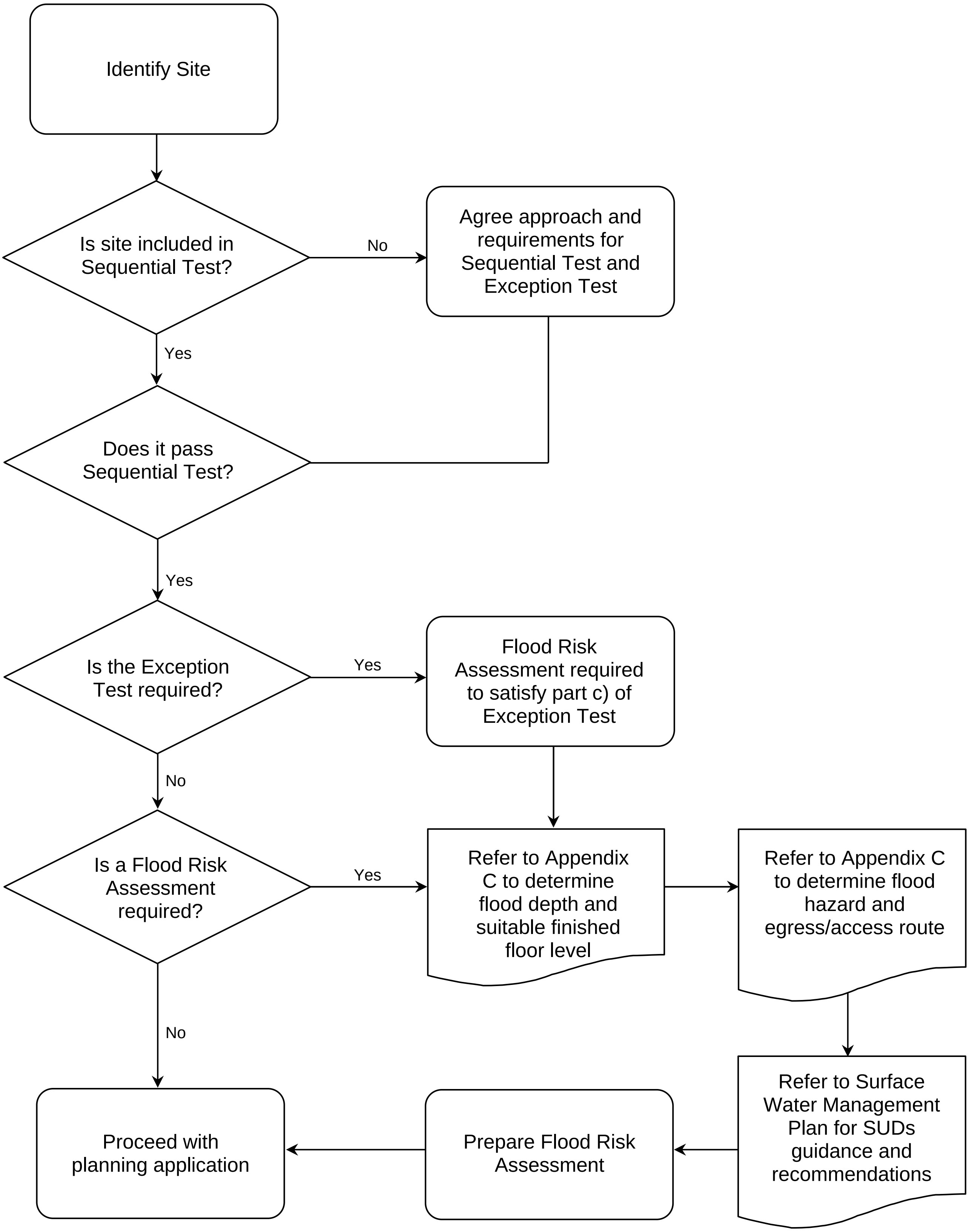
1. Identify if the Sequential Test is required- Paragraph D.15 of PPS25 states that if the application is minor development or for a change of use, the Sequential and Exception Tests are not required. The application will still need to meet the requirements for FRAs and flood risk reduction as set out in Table D.1 of PPS25.

2. If the Sequential Test is required, identify which Flood Zone the site is located within using the Environment Agency flood maps (included in Appendix A).

3. Agree scope and considerations for the site-specific Sequential Test and, where necessary, Exception Test with the LPA and Environment Agency.

Figure 5-1 presents a summary of the procedure that should be followed from identifying a development site through to submission of planning application.

Figure 5-1 Application of the Sequential and Exception Tests



6 Site-Specific Flood Risk Assessment Guidance

6.1 Overview

The Level 1 and 2 SFRAs for Thurrock BC provide a comprehensive assessment of the flood risk posed to the area. The Level 2 report provides more in-depth information about the nature of the potential residual risks and hazards from tidal sources. However, these documents have a strategic scope and therefore it is essential that site-specific Flood Risk Assessments (FRAs) are also developed for individual development proposals and that where necessary and appropriate, suitable mitigation measures are incorporated. FRAs should use findings from the SFRA to inform the assessment.

This section presents recommendations and guidance for site-specific FRAs prepared for submission with planning applications in Thurrock.

6.2 When is a Flood Risk Assessment Required?

The Environment Agency provides flood risk standing advice for applicants and agents on their website http://www.environment-agency.gov.uk/research/planning/82587.aspx. This includes information on when a Flood Risk Assessment is required and advice on the contents of FRAs for various development types in Flood Zones 1, 2 and 3.

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

1. The development site is located in **Flood Zones 2 or 3**;
2. The area of the proposed development site area is 1 hectare or greater in Flood Zone 1. This is to ensure surface water generated by the site is managed in a sustainable manner and does not increase the burden on existing infrastructure and/or flood risk to neighbouring property. Surface water management will also need to be considered as part of the Flood Risk Assessment for sites of 1 hectare or greater in Flood Zone 2 and 3; and
3. The development site is located in an area known to have experienced flooding problems from any flood source.

6.3 FRA Requirements

The Practice Guide to PPS25 sets out a staged approach to site-specific Flood Risk Assessment with the findings from each stage informing both the next level and the site Masterplan, throughout the development process. The staged approach comprises:

- Level 1 Screening Study
- Level 2 Scoping Study
- Level 3 Detailed Study

FRA Level	Description of Report Content
Level 1 **Screening Study**	The Level 1 Flood Risk Assessment is intended to identify any flooding or surface water management issues related to the development site that may require further investigation. The study should be based on readily available existing information, including: • SFRA, • Environment Agency Flood Maps, • Standing Advice The Level 1 Flood Risk Assessment will determine the need for a Level 2 or 3 FRA.
Level 2 **Scoping Study**	Where the Level 1 Flood Risk Assessment indicates that the site may lie in an area at risk of flooding, or may increase flood risk elsewhere due to runoff, a Level 2 Flood Risk Assessment should be carried out. This report will confirm sources of flooding which may affect the site and should include the following; • Appraisal of available and adequacy of existing information; • Qualitative appraisal of the flood risk posed to the site, the potential impact of the development on flood risk on and off the site; • An appraisal of the scope of possible measures to reduce the flood risk to acceptable levels. This Level may identify that sufficient quantitative information is already available to complete a Flood Risk Assessment appropriate to the scale and nature of the development.
Level 3 **Detailed Study**	Undertaken if the Level 2 Flood Risk Assessment concludes that further quantitative analysis is required in order to assess flood risk issues related to the development site. This Level should include: • Quantitative appraisal of the potential flood risk to the development; • Quantitative appraisal of the potential impact of development on the site under investigation on flood risk on and off the site; • Quantitative demonstration of the effectiveness of any proposed mitigation measures.

At all stages, Thurrock BC and where necessary the Environment Agency and Anglian Water should be consulted to ensure the Flood Risk Assessment provides the necessary information to fulfil the requirements for Planning Applications.

6.4 FRA Guidance

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

The Environment Agency provides flood risk standing advice for applicants and agents on their website http://www.environment-agency.gov.uk/research/planning/82587.aspx which includes a matrix to determine the level of assessment that is required based on Flood Zone classification and development type. Within this matrix are links to Flood Risk Assessment Guidance notes and advice for applicants as to which data they will need to purchase from the Environment Agency in order to carry out their FRA.

6.4.1 Flood Risk Assessment Content

Annex E of PPS25 presents the minimum requirements for a Flood Risk Assessment. These include:

- Consider the risk of flooding off-site arising from the development in addition to the risk of flooding on-site to the development;
- Identify and quantify the vulnerability of the development to flooding from different sources and identify potential flood risk reduction measures;
- Assess the remaining 'residual' risk after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular development;
- Consider the vulnerability of those that could occupy and use the development, taking account of the Sequential and Exception Tests and the vulnerability classification, including arrangements for safe access as prescribed by Planning Policy Statement 25 (PPS25) and associated guidance;
- Consider the ability of the soil to receive surface water runoff generated on site, and how it would be stored and managed, along with how the proposed layout of development may affect drainage systems; and
- All calculations must fully account for current climate change scenarios and their effect on flood zoning and risk.

6.4.2 Risks of Developing in Flood Risk Areas

Developing in flood risk areas can result in significant risk to a development and site users. It is possible to reduce the risk through the incorporation of mitigation measures; however, these do not remove the flood risk altogether and developments situated in the floodplain will always be at risk from flooding. This creates Health and Safety considerations, possible additional costs and potential displacement of future residents during flood events, which could result in homes and businesses being uninhabitable for substantial periods of time.

The guidance in this chapter should identify the requirements of a Flood Risk Assessment and the main flood risks posed to the site; additional issues to consider include the following:

- Failure to consider wider plans prepared by the Environment Agency or other operating authorities may result in a proposed scheme being objected to;
- Failure to identify flood risk issues early in a development project could necessitate redesign of the site to mitigate flood risk;
- Failure to adequately assess all flood risk sources and construct a development that is safe over its lifetime could increase the number of people at risk from flooding and/or increase the risk to existing populations;
- Failure to mitigate the risk arising from development may lead to claims against the developer if an adverse effect can be demonstrated (i.e. flooding didn't occur prior to development) by neighbouring properties/residents;
- Properties may be un-insurable and therefore un-mortgageable if flood risk management is not adequately provided for the lifetime of the development;
- By installing SuDS without arranging for their adoption or maintenance, there is a risk that they will eventually cease to operate as designed and could therefore present a flood risk to the development and/or neighbouring property;
- The restoration of river corridors and natural floodplains can significantly enhance the quality of the built environment whilst reducing flood risk. Such an approach can significantly reduce the developable area of sites or lead to fragmented developments, however positive planning

and integration throughout the master planning process should resolve these potential issues.

6.4.3 Safe Development

For developments proposed in the Broad Regeneration Areas of East Tilbury, Grays, London Gateway, Purfleet, South Ockendon, Stanford-le-Hope and Corringham, Tilbury and West Thurrock, the following items should be addressed as part of a Flood Risk Assessment in order to demonstrate that proposed developments are 'safe' in line with PPS25.

It should be noted that the specific definition of a 'safe' development will vary for each individual site, based on location and development vulnerability. It is therefore recommended that developers consult the Environment Agency on a site by site basis to establish an appropriate definition of 'safe' development for specific sites.

Access and Egress

PPS25 requires that safe access and egress is provided to enable the evacuation of people from the development, at or above the 1 in 100 year (1%) fluvial and the 1 in 200 year (0.5%) tidal flood event up to the 1 in 1000 year (0.1%) flood event, in order to provide emergency services with access during a flood event and enable flood defence authorities to carry out their duties during periods of flood.

Wherever possible, access routes should be provided that are located above the design flood levels (see above). Where this is not possible limited depths of flooding may be appropriate, provided that the proposed access is designed with appropriate signage and other measures to make it safe. The acceptability of the proposed access should be assessed using Table 13.1 of Defra Research document FD2320/TR2: FRA Guidance for New Developments which takes into account the flood depth, velocities and risk of debris within the water. The access/egress route must fall within the "white cells" of this document.

This assessment should also consider the following:

- The vulnerability and mobility of those in danger of flooding; development for highly vulnerable users e.g. disabled or the elderly, should be located away from high-risk areas. Whilst the Sequential Test accounts for the vulnerability of the intended use of the development, no specific consideration is made for the vulnerability of the end users of the site. A proposed residential development for highly vulnerable end users (elderly, physically impaired etc) will still fall under the 'More Vulnerable' classification in Table D.2 of PPS25 and the Sequential and Exception Tests will apply accordingly. Where development for highly vulnerable end users cannot be avoided, safe and easy evacuation routes are essential.

- The time to peak inundation mapping relates to the amount of time it takes for a flood event to reach its maximum level, flow or height. Flood events with a very short time to peak provide very little time and opportunity for evacuation. This is typically the case if a defence structure is breached or fails because the inundation will be rapid, resulting in a short time to peak for the areas local to the breach. On the other hand, during tidal events, should a breach occur early in the tidal cycle, the time to peak could be a lot slower which would allow evacuation procedures to be put in place. Typically, areas immediately adjacent to a breach location will have a shorter time to peak than areas set back from the flood defence.

Due to the low lying topography and location of Thurrock adjacent to the River Thames, developments or redevelopments will be proposed where the building remains safe but safe access cannot be guaranteed during a flood. This is likely to be the case for developments within parts of Grays Urban Area, Tilbury Urban Area, West Thurrock Urban Area and Purfleet Urban Area. In view of this, when assessing the acceptability of proposals, the potential implications for development should be considered by assessing the following:

- Probability of flooding;
- Expected flood hazard;
- Likelihood of occupancy during flooding, based on the proposed use;
- Acceptability of disruption based on the proposed use;
- Availability of safe refuge;
- Potential for the provision of key services (e.g. water, electricity, telecommunications); and,
- Expected duration of inundation.

The findings within this Level 2 SFRA should, where appropriate, be used to assess proposed access routes with respect to the criteria listed above.

Finished Floor Levels

Where development in flood risk areas is unavoidable, which is the case in parts of Thurrock, the most common method of mitigating flood risk to people is to ensure habitable floor levels are raised above the maximum flood water level with an allowance of 300mm freeboard. This can substantially reduce the damage to property and risk of injury and fatalities.

In areas of minimal floodwater depth, raising finished floor levels may be included into the building design. Where the floodwater depth is more substantial, ground floor uses can be restricted to less vulnerable uses, such as commercial use, garage, utility areas and public space, with habitable areas above.

It should be noted that the Environment Agency are constantly reviewing their guidance based upon experience, increasing knowledge and the findings of new research and therefore the above criteria are subject to change in the future.

Sequential Approach

Paragraph D8 of PPS25 identifies the need for developers to apply the sequential approach when locating development within a site. This process should ensure that elements of the redevelopment that are of greater vulnerability are located in parts of the site at lowest risk.

Flood Warning and Emergency Plans

Thurrock BC is currently preparing a detailed Emergency Flood Plan specific to the risks and needs of their administrative area. The Plan will use the information generated by this SFRA to identify suitable evacuation routes and rest centres within the Borough.

Evacuation Plans for individual developments should be prepared in conjunction with the Borough-wide Flood Plan to direct people to safety during times of flood. This may include details of an evacuation route away from the site to an area outside the floodplain, or to a place of safe refuge within the development itself.

When submitting FRAs for developments within flood risk areas, developers should make reference to this strategic Emergency Flood Plan to demonstrate that their development will not impact on the ability of Thurrock BC and the emergency services to safeguard the current population.

Flow Paths and Floodplain Compensation

Where development plans result in a reduction of the floodplain, especially the fluvial floodplain, it is essential that new floodplain storage capacity is provided to compensate. The Environment Agency requires this to be provided on a 'Level for Level, Volume for Volume Basis'. This may need to be considered where land is raised to provide safe access and egress routes.

Any raising of the land as part of the development, for example, to achieve safe access, will need to be carefully considered as part of the Flood Risk Assessment to ensure that no obstruction is made to flood flow routes.

Potential overland flow paths should be determined and appropriate solutions proposed to mitigate the impact of the development, for example through the configuration of road and building layouts to preserve existing flow paths and improve flood routing whilst ensuring that flows are not diverted towards other properties.

Flood Storage Area, Tilbury

The area of land to the north of Tilbury has been designated a Flood Storage Washland Area by the Environment Agency and classified as a category C Reservoir under the Reservoirs Act, with capacity to store fluvial floodwaters from the 1 in 1000 year event. It is proposed to maintain the Flood Storage Area and raise the embankments along certain sections of the eastern and western sections to ensure the integrity of the Flood Storage Area in a 1 in 1000 year fluvial event.

For the purpose of spatial planning, this area is classified as functional floodplain and therefore many types of development will be inappropriate. It is essential that the Environment Agency is consulted regarding the location of future development within this area.

Flood Resilient Construction

The Association of British Insurers in cooperation with the National Flood Forum has published guidance on how homeowners can improve the food resilience of their properties (ABI, 2004). These measures not only reduce flood risk to properties, by reducing residual risk, but can also improve the insurability of homes in flood risk areas. The guidance identifies the key flood resistant measures for different construction methods, further details can be found in the DCLG's 2008 report, Improving the Flood Resilience of New Buildings and the ODPM's 2003 report, 'Preparing for Floods' (ODPM, 2003b).

6.4.4 Managing Residual Flood Risk

Sites located within the following Broad Areas for Regeneration face residual flood risk, resulting from a breach in the tidal flood defences along the Thames; East Tilbury, Grays, London Gateway, Purfleet, South Ockendon, Stanford-le-Hope and Corringham, Tilbury and West Thurrock.

Various methods can used to manage residual flood risk, such as those presented in the following sub-sections. These methods will not be appropriate for all development types or all geographical areas and should therefore be considered on a site-by-site basis. In addition, it is important that the use of techniques such as these do not exacerbate flooding elsewhere within the flood cell.

Recreation, Amenity and Ecology

Recreation, amenity and ecological improvements can be used to mitigate the residual risk of flooding either by substituting less vulnerable land uses or by attenuating flows or both. Examples include the development of parks and open spaces through to river restoration schemes. The aim of these techniques is to increase flood storage and the storage and conveyance of rainwater. Typical schemes include arrangements of pools, ponds and ditches.

These schemes may also improve the ecological and amenity value of an area; such environments may provide a haven for local wildlife and contribute to a sites amenity value both aesthetically and for recreation by providing attractive areas available for activities such as walking, cycling, water sports or wildlife watching.

The Preferred Option Report for the South East Thurrock Masterplan states that the Masterplan will encourage a Tidal Retreat project for part of the eastern coastline of South East Thurrock. This will involve the creation of a natural wetland and habitat and will be carried out in consultation with the Environment Agency.

Secondary Defences

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

Secondary defences can relocate floodwaters away from certain areas or reduce the rate of flood inundation following a residual event. Examples of secondary defences include embankments or raised areas behind flood defence walls, raised infrastructure e.g. railways or roads and, on a strategic level, canals, river and drainage networks. The latter are a form of secondary defence as they are able to convey or re-direct water away from flood prone areas even if this is not their primary function.

Land Raising

Land raising can have mixed results when used as a secondary flood alleviation measure. It can be an effective method of reducing flood inundation on certain areas or developments by raising the finished ground levels above the predicted flood level. However, it can result in the reduction in flood storage volume within the flood cell. As a result, floodwater levels within the remainder of the cell can be increased and flooding can be exacerbated elsewhere. Level for level compensatory storage should be provided where any loss of floodplain storage has occurred as a result of land raising or developing within the undefended floodplain.

Partial land raising can be considered in larger, particularly low lying areas such as marshlands. It may be possible to build up the land in areas adjacent to flood defences in order to provide secondary defences. However, again the developer should pay due regard to the cumulative effects of flooding such as increasing flood risk elsewhere.

It should also be remembered that although land raising may allow for development above the flood level, it may also create a 'dry island' which may still not overcome the issue of a safe access/egress route from the site. This must be considered where land raising is suggested as mitigation for developing in an area liable to flooding.

6.4.5 Sustainable Drainage Systems (SuDS)

Developers are required to reduce surface water runoff rates following development through the implementation of appropriate Sustainable Drainage Systems inline with the Management Train Hierarchy set out in the Level 1 SFRA (Scott Wilson 2009) and the Outline Water Cycle Study (Scott Wilson 2009). Developers should aim to achieve Greenfield runoff rates from their sites wherever possible.

The management of surface water is likely to be the sole focus of FRAs prepared for sites within the following Broad Regeneration Areas; Aveley Urban Area, Chadwell St Mary Urban Area, South Ockendon Urban Area, Stifford Clays / North Grays, and the Villages.

7 Policy Recommendations

7.1 Introduction

In order to encourage an holistic approach to flood risk management and ensure that flooding is taken into account at all stages of the planning process, the findings of this report need to be considered as part of Thurrock BC's LDF process.

The flooding policy recommendations build on national, regional and local policy which was reviewed as part of the Level 1 SFRA.

The local policy recommendations should be used during a review of Core Strategy policies and during the formulation of Site DPD proposals within the Borough of Thurrock. This process will ensure that flood risk continues to be considered throughout all stages of the planning and implementation phases of future regeneration and development across Thurrock.

7.2 National Policy

National policies including 'Making Space for Water' and 'Planning Policy 25: Development and Flood Risk' have been discussed in detail as part of the Level 1 SFRA which should be referred to. These national policies are in place to ensure that:

- Development is located in the lowest flood risk area through application of the Sequential Test;
- New development is safe, flood-proof to a satisfactory degree, and does not increase flood risk elsewhere;
- Surface water is managed effectively on site;
- Flood risk is suitably assessed for Windfall sites in accordance with PPS25 guidelines, as they will not have been through the Sequential Test as part of the SFRA process;
- Greenfield floodplain areas that are important flood risk management assets are protected from future development;
- Sites where developer contributions could be used to fund future flood risk management schemes are identified. However, it should be noted that developer funded defences should not wholly justify development in unsuitable locations.

7.3 Regional Policy

Regional policies that should be considered throughout the planning process within the Borough of Thurrock include the East of England Plan and the Essex Thames Gateway Sub-Regional Strategy. These provide more detailed policies that will need to be adhered to when planning in Thurrock including the careful location of development according to the variation of flood risk across the Borough, protection of floodplains and land prone to flooding, flood risk management measures and surface water management techniques. Further details are included in the Level 1 SFRA.

7.4 Local Policy

Information and recommendations contained in this Level 2 SFRA should be used to inform policy, development control and technical issues. To this end, the following points should be used as guidance for informing local policy specific to Thurrock BC to ensure that flood risk considerations are included as part of the LDF process and future strategic planning.

7.4.1 Building Design

A large proportion of Thurrock is at risk of tidal flooding associated with a breach in the defences alongside the River Thames.

- PPS25 does not permit self contained basement dwellings to be located within Flood Zone 3a, as they provide no means of escape to higher floors within a development thereby presenting an unacceptable risk to life.
- Under PPS25 basements can be provided for non-residential uses with lower flood risk vulnerability, however, a satisfactory means of escape to above the floor level is absolutely essential. If escape cannot be provided then, in accordance with PPS25, the basement should not be permitted;
- Single storey residential development should not normally be considered in flood risk areas as they offer no opportunity for safe refuge areas on upper floors;
- When re-developing existing buildings in flood risk areas, the use of flood resilient measures should be promoted at the individual property level.

7.4.2 Flood Risk Assessments and Vulnerability

Flood Risk Assessments (FRAs) should be undertaken for all developments located in Flood Zones 2 and 3 to assess the risk of flooding to the development and identify options to mitigate the flood risk to the development, site users and surrounding area.

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

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

In Flood Zone 1, FRAs are required for all development sites greater than 1 hectare to ensure that flood risk is not increased to other properties due to increased site runoff.

If development is to be constructed with Less Vulnerable uses on the ground level, agreements need to be in place to prevent future alteration of these areas to More Vulnerable uses without further study into the associated flood risks to the site.

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

7.4.3 Developments behind Flood Defences

- When proposing development behind flood defences, which is the case for the majority of development in Thurrock, the impact on the residual flood risk posed to other properties should be considered. In the event of a breach in the flood defences, new development behind the defences can increase the residual risk by disrupting flow paths and / or displacing floodwater. If conveyance routes that allow flood water to pass back into a river following failure of a flood defence become blocked, there is potential to increase flood risk to existing properties;
- Residual risk should be managed through emergency planning, site design and mitigation measures;
- Flood defences should continue to be maintained, inline with the policies prepared as part of the Thames Estuary 2100 Project.
- Where possible opportunities should be taken to improve the design of flood defences and incorporate them into the landscaping of the site in order to open up the river frontage for public use.

7.4.4 Residual Risk and Emergency Planning

- A robust strategic Emergency Flood Plan should be developed for Thurrock which identifies suitable rest centres and evacuation routes based on the flood hazard mapping produced in this report;
- Evacuation plans for individual developments should be prepared in conjunction with the Borough-wide strategic Emergency Flood Plan to direct people to safety during times of flood;
- Where development within flood risk areas is absolutely necessary flood proof construction methods should be utilised to reduce the impact of flooding;
- Where a development is applying for a change of use, flood evacuation plans should be developed through liaison with the emergency planners and the emergency services. For lower to higher vulnerability properties a Flood Risk Assessment would be required.

7.4.5 Surface Water Flooding and the use of Sustainable Drainage Systems

- Sustainable Drainage Systems (SuDS) should be promoted as a preference in new developments as a way to manage surface water and should be considered in line with the Management Train hierarchy set out in the Level 1 SFRA;
- The vulnerability and importance of local ecological resources (such as water quality and biodiversity) should also be considered when determining the suitability of drainage strategies/SuDS in line with guidance produced as part of the Thurrock Water Cycle Study;
- Thurrock BC should ensure that new development in areas susceptible to surface water flooding does not increase the discharge to the existing drainage system either though restricting site discharge rates and/or through capital contributions to improvements works of the existing drainage infrastructure;

- In areas where the potential for surface water flooding has been identified, FRAs should ensure suitable SuDS techniques are incorporated as part of redevelopment;
- Potential overland flow paths should be considered to ensure that buildings do not obstruct flows;
- Where basements are proposed in areas of Flood Zone 1 and 2 the risk of surface water flooding should be considered, with potential mitigation to include raising thresholds and including storage for surface water in such developments;
- Where possible, developers should aim to achieve greenfield runoff rates using SuDS; and
- Thurrock BC should encourage the retention of soft landscaping in front gardens and other means of reducing, or at least not increasing the amount of hard standing associated with existing homes.

7.4.6 Surface Water Management Plan (SWMP)

The Level 1 SFRA (Scott Wilson, 2009) identified several areas in Thurrock that are recorded as facing surface water flooding issues. These include the main urban centres of Purfleet, Grays, Thurrock, Tilbury and Stanford-le-Hope. The proposed increase in development in each of the Broad Areas for Regeneration has the potential to increase the quantity, intensity and timing of surface water runoff from these areas. To ensure that there is no downstream increase in flood risk to neighbouring areas it is recommended that surface water flood risk is fully assessed and managed on a strategic scale.

To this end we recommend that Thurrock BC undertake a Surface Water Management Plan (SWMP) in order to fully identify the suitability of a strategic SuDS scheme, which could, for example, incorporate regional flood attenuation, rainwater harvesting and property-level SuDS.

One of the objectives of a SWMP is to extend the identification of known localised problems determined in the Level 1 SFRA (Scott Wilson 2009) and build upon data collected during the Summer 2007 event, examining the causes, extent and effects of surface water flooding events. This will culminate in the identification and the prioritisation of Critical Drainage Areas (CDAs). This information will be used to establish a shared understanding of flood risk from all sources which will aid in future drainage asset management and will help with coordination of future investments and the operational response to future flooding events.

8 References

BRE. Digest 365 (2003) Soakaway Design. Building Research Establishment.

British Water (2005) Technical Guidance, Guidance to Proprietary Sustainable Drainage Systems and Components – SuDS. In partnership with the Environment Agency

BSRIA Ltd. (1997) Water Conservation: Implications of Using Recycled Greywater and Stored Rainwater in the UK. Report 13034/1. Drinking Water Inspectorate, Department of the Environment.

CIRIA 625 (2003) Model Agreements for Sustainable Water Management Systems – Review of Existing Legislation. RP664.

CIRIA 626 (2003) Model Agreements for Sustainable Water Management Systems – Model Agreement for Rainwater and Greywater Use Systems. P Shaffer, C Elliott, J Reed, J Holmes and M Ward.

CIRIA C521 (2000) Sustainable Urban Drainage Systems - Design Manual for Scotland and Northern Ireland. Sustainable Urban Drainage Scottish Working Party.

CIRIA C522 (2000) Sustainable Urban Drainage Systems - Design Manual for England and Wales. Department of Environment Transport Regions.

CIRIA C523 (2001) Sustainable Urban Drainage Systems, Best Practice Manual for England, Scotland, Wales and Northern Ireland.

CIRIA C539 (2001 Rainwater and Greywater Use in Buildings: Best Practice Guidance. D J Leggett, R Brown, D Brewer, G Stanfield and E Holiday. Department of Trade and Industry.

CIRIA C609 (2004 Sustainable Drainage Systems, Hydraulic, Structural and Water Quality Advice. S Wilson, R Bray and P Cooper. Department of Trade and Industry.

CIRIA C697 (2007) The SuDS Manual. Woods Ballard B; Kellagher R et al.

Construction Industry Research and Information Association. 1996. Report 156 – Infiltration Drainage – Manual of Good Practice. Roger Bettess. Highways Agency and National Rivers Authority.

National SuDS Working Group. 2004. Interim Code of Practice for Sustainable Drainage Systems. National SuDS Working Group. ISBN 0-86017-904-4.

DCLG. May 2008. East of England Plan: The Revision to the Regional Spatial Strategy for the East of England

ODPM, 2003b. Preparing for Floods.

DCLG. 2008. Flood Performance of New Buildings,

Flood Risk Assessment Guidance for New Development: Phase 2, R&D Technical Report FD2320/TR2, DEFRA/Environment Agency, 2005

Scott Wilson (2007) Sustainability Appraisal: Core Strategy and Policies for Development Control and Site Specific Allocations and Policy Development Plan Documents: Non-technical Summary Thurrock Council

Scott Wilson, 2006, Thames Gateway South Essex Strategic Flood Risk Assessment

Scott Wilson, 2009, Level 1 Strategic Flood Risk Assessment for Thurrock Borough Council

South Essex Catchment Flood Management Plan, Final Plan, Environment Agency, August 2008

Thames Tidal Defences Joint Probability Extreme Water Levels 2008, Final Modelling Report, Halcrow (for the Environment Agency), April 2008

9 Appendices