

Southend-on-Sea Borough Council



Rochford District Council



Thames Gateway South Essex

THURROCK COUNCIL



ENVIRONMENT AGENCY

Basildon Council
BASILDON • BILLERICAY • WICKFORD

Thames Gateway South Essex

Appendix C



Castle Point Borough Council



Prepared by Scott Wilson Ltd for The Thames Gateway South Essex Partnership

November 2006

Thames Gateway South Essex

Appendix C – Castle Point Council

D111658
Project Manager: Jon Robinson

November 2006

Collated and edited by: Elizabeth Williams

Reviewed by: Jon Robinson

Approved by: David Dales

Disclaimer

This document has been prepared in accordance with the scope of Scott Wilson's appointment with its client and is subject to the terms of that appointment. It is addressed to and for the sole use and reliance of Scott Wilson's client. Scott Wilson accepts no liability for any use of this document other than by its client and only for the purposes, stated in the document, for which it was prepared and provided. No person other than the client may copy (in whole or in part) use or rely on the contents of this document, without the prior written permission of the Company Secretary of Scott Wilson Ltd. Any advice, opinions, or recommendations within this document should be read and relied upon only in the context of the document as a whole. The contents of this document are not to be construed as providing legal, business or tax advice or opinion.

© Scott Wilson Group plc 2006

Scott Wilson
8 Greencoat Place
London
SW1P 1PL

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

PREFACE

Purpose:

The purpose of this report is to provide Strategic Flood Risk Assessment (SFRA) information specific to the Castle Point Borough. It outlines the main flood risks posed to the authority's area by breaches in the tidal defences and fluvial flood sources. This information can then be used in conjunction with guidance in the SFRA to apply the sequential test.

It is presumed throughout this report that the reader is familiar with the contents of the SFRA main report and the methodologies presented therein.

Objective:

The SFRA objective is to aid the partner boroughs in their development process through the application of the Sequential Test as required by PPG25 and the impending PPS25. It assesses the flood risks posed to the region and outlines the main hazard zones in order to further aid the development planning process.

The objective of this report is to assess the flood risks posed to the Castle Point Borough by breaches in the tidal defences and to assist the Council in applying the sequential test.

Limitations:

The SFRA approach was outlined in the Phase 1 Inception Report (Faber Maunsell, 2005). All methodologies, including breach parameters, have been agreed with the Environment Agency in accordance with the current best practice at the time of completion.

Contents

1	INTRODUCTION AND BACKGROUND	1
1.1	Scope and Objectives.....	1
1.2	Castle Point Borough Council Area	1
2	SOURCES OF FLOODING IN CASTLE POINT	3
2.1	Fluvial	3
2.2	Tidal.....	4
3	RESULTS.....	6
3.1	General	6
3.2	Combined Breach Results.....	6
3.3	Individual Breach Results	6
4	FLOOD MAPPING AND APPLICATION	36
4.1	Introduction.....	36
4.2	Flood Mapping	36
4.3	Hazard Zones.....	37
4.4	Suggested Application of the Sequential Test in South Essex.....	37
4.5	Examples of Application	39
4.6	Development ‘Vulnerability’	39
5	SPECIFIC AREA RECOMMENDATIONS	42
5.1	Introduction.....	42
5.2	General	42
5.3	Proposed Development Areas	42
5.4	Security of Access During a Flood Event	45
5.5	Drainage Areas	46

Annex A: Canvey Island Probability Report: Consideration of different causes of a breach event.

LIST OF FIGURES

FIGURE C1 CASTLE POINT BOROUGH

1 IN 200 YEAR COMBINED BREACHES HAZARD MAPPING

FIGURE C2-1 HAZARD MAP OF CASTLE POINT- CANVEY ISLAND (1 IN 200 YEAR)

FIGURE C2-2 HAZARD MAP OF SOUTHEND- HADLEIGH MARSH (1 IN 200 YEAR)

FIGURE C2-3 HAZARD MAP OF THURROCK- FOBBING MARSH/ SOUTH BENFLEET (1 IN 200 YEAR)

1 IN 1000 YEAR COMBINED BREACHES HAZARD MAPPING

FIGURE C3-1 HAZARD MAP OF CASTLE POINT- CANVEY ISLAND (1 IN 1000 YEAR)

FIGURE C3-2 HAZARD MAP OF SOUTHEND- HADLEIGH MARSH (1 IN 1000 YEAR)

FIGURE C3-3 HAZARD MAP OF THURROCK- FOBBING MARSH/ SOUTH BENFLEET (1 IN 1000 YEAR)

1 IN 200 YEAR INDIVIDUAL BREACHES HAZARD MAPPING

FIGURE C4-1 HAZARD MAP OF CAS01 (1 IN 200 YEAR)

FIGURE C4-2 HAZARD MAP OF CAS02 (1 IN 200 YEAR)

FIGURE C4-3 HAZARD MAP OF CAS03 (1 IN 200 YEAR)

FIGURE C4-4 HAZARD MAP OF CAS04 (1 IN 200 YEAR)

FIGURE C4-5 HAZARD MAP OF CAS05 (1 IN 200 YEAR)

FIGURE C4-6 HAZARD MAP OF CAS06 (1 IN 200 YEAR)

FIGURE C4-7 HAZARD MAP OF CAS07 (1 IN 200 YEAR)

FIGURE C4-8 HAZARD MAP OF CAS08 (1 IN 200 YEAR)

FIGURE C4-9 HAZARD MAP OF CAS09 (1 IN 200 YEAR)

FIGURE C4-10 HAZARD MAP OF SOU05 (1 IN 200 YEAR)

1 IN 1000 YEAR INDIVIDUAL BREACHES HAZARD MAPPING

FIGURE C5-1 HAZARD MAP OF CAS01 (1 IN 1000 YEAR)

FIGURE C5-2 HAZARD MAP OF CAS02 (1 IN 1000 YEAR)

FIGURE C5-3 HAZARD MAP OF CAS03 (1 IN 1000 YEAR)

FIGURE C5-4 HAZARD MAP OF CAS04 (1 IN 1000 YEAR)

FIGURE C5-5 HAZARD MAP OF CAS05 (1 IN 1000 YEAR)

FIGURE C5-6 HAZARD MAP OF CAS06 (1 IN 1000 YEAR)

FIGURE C5-7 HAZARD MAP OF CAS07 (1 IN 1000 YEAR)

FIGURE C5-8 HAZARD MAP OF CAS08 (1 IN 1000 YEAR)

FIGURE C5-9 HAZARD MAP OF CAS09 (1 IN 1000 YEAR)

FIGURE C5-10 HAZARD MAP OF SOU05 (1 IN 1000 YEAR)

1 IN 200 YEAR MAXIMUM DEPTHS OF FLOODING IN FLOOD CELL:

FIGURE C6-1 CANVEY ISLAND (1 IN 200 YEAR)

FIGURE C6-2 HADLEIGH MARSH (1 IN 200 YEAR)

FIGURE C6-3 SOUTH BENFLEET (1 IN 200 YEAR)

1 IN 1000 YEAR MAXIMUM DEPTHS OF FLOODING IN FLOOD CELL:

FIGURE C7-1 CANVEY ISLAND (1 IN 1000 YEAR)

FIGURE C7-2 HADLEIGH MARSH (1 IN 1000 YEAR)

FIGURE C7-3 SOUTH BENFLEET (1 IN 1000 YEAR)

FIGURE C8-1 CANVEY ISLAND PUMPING STATION CATCHMENTS

LIST OF TABLES

TABLE 2.1: FLOOD CELLS IN CASTLE POINT BOROUGH.....	4
TABLE 2.2: INDICATIVE STANDARD OF PROTECTION OF DEFENCES FROM FLUVIAL SOURCES IN THE CASTLE POINT BOROUGH	5
TABLE 3.1: FLOOD CELL CASTLE POINT – CANVEY ISLAND.....	10
TABLE 3.2: FLOOD CELL SOUTHEND – HADLEIGH MARSH	12
TABLE 3.3: FLOOD CELL THURROCK – FOBBING MARSH/ SOUTH BENFLEET	13
FIGURE 4-1 SUGGESTED STAGED SEQUENTIAL TEST FOR SOUTH ESSEX	38
FIGURE 4-2 DEFINITIONS OF HAZARD ZONES	41
TABLE 5.1. PLANNED HOUSING DEVELOPMENT IN CASTLE POINT	44
TABLE 5.2. TIME TO INUNDATION FOR KEY ACCESS ROADS ON CANVEY ISLAND	46

1 INTRODUCTION AND BACKGROUND

The Thames Gateway is an area of national priority for regeneration and has been earmarked for major development over the next 10 years. With such development come particular challenges with regard to sustainable development and flood risk.

Scott Wilson was commissioned by the Thames Gateway South Essex (TGSE) Partnership to undertake A Strategic Flood Risk Assessment (SFRA) on behalf of the local authorities of Thurrock Council, Castle Point Borough Council, Basildon District Council, Southend Borough Council and Rochford District Council.

The SFRA identifies flood risk issues relevant to both existing and proposed developments within the area of South Essex. The SFRA process also aids local authorities to meet the requirements of Planning Policy Guidance Note 25 (PPG25) 'Development and Flood Risk' and the emerging replacement Planning Policy Statement 25 (PPS 25), expected to be published in Autumn 2006.

In addition to the main SFRA report, Scott Wilson was commissioned to produce five reports to address the flood risk concerns specific to each local authority. This is the report for Castle Point Borough Council. The scope and objectives for Castle Point Borough are addressed in the following section.

1.1 Scope and Objectives

This report has been undertaken for the local authority of Castle Point Borough Council.

The purpose of this report is to:

- Provide information and guidance to enable the local planning authority (LPA) to apply the sequential test within their district;
- Present the detailed results of breach analysis undertaken for the SFRA to provide the LPA with a more comprehensive planning tool specific to their district;
- Provide a strategic assessment of the flood risk within the potential development area of Canvey Island; and
- Consider the security of access to and from Canvey Island in a flood event.

This report is comprised of one volume that forms an appendix to the main SFRA report:

Appendix C – Castle Point Borough Council

1.2 Castle Point Borough Council Area

1.2.1 *Human Geography/Demographics*

The Castle Point Borough is bordered by the Thames River and Vange Creek to the south, and the council areas of Rochford, Southend, and Basildon to the north, east and west respectively. Figure C1, shows the extent of the Castle Point Borough Council Area.

The majority of the Borough is intensely populated especially the eastern edge of Canvey Island. The exceptions to this are the Hadleigh Castle Country Park and surface water storage areas in the west of Canvey Island.

The population of the Castle Point Borough is approximately 86,000, with over 37,500 living on Canvey Island. Residential land use centres around the eastern end of Canvey Island and on the higher ground towards the north of the Borough. The southern most edge of Canvey Island is subject to industrial land use in the form of an oil storage depot.

As Canvey Island is low-lying, surface water drains to 12 surface water pumping stations and gravity outfalls that are tide locked at high tides. The grazing marshes in the west of the island have extensive networks of channels to provide storage when the gravity outfalls are tide locked.

Castle Point is required to deliver 4,000 homes and 2,000 jobs between 2001 and 2021, and is considered by the Thames Gateway as an important area for regeneration and business growth. The Council is therefore particularly concerned about flood risks in Canvey Island following the 1953 flood event when Canvey Island was subject to a large number of fatalities. The island is surrounded by flood defences and all surface water run off from the Island is drained by pumping into tidal waters.

The area is entirely situated within the Anglian Region of the Environment Agency (EA).

1.2.2 Physical Geography

The Castle Point Borough covers a small area that consists of two distinct portions of land, Canvey Island (approximately 16km²) and an area of the mainland that covers approximately 27km². These two areas are divided by Benfleet Creek, a tidal estuary that runs from the A130 to the Thames. The River Thames borders the southern edge of Canvey Island. The remaining sides of the island are bordered by Vange Creek and East Haven Creek.

The River Thames flows from the Cotswolds through London and divides the southeast into the counties of Essex and Kent before meeting the sea at Southend. The Thames is a tidal estuary in the vicinity of the Castle Point Borough and can be seen in Figure C1. Benfleet Creek and Vange Creek flow into the Thames and in high tide events provide natural pathways for floodwater from the Thames. East Haven Creek flows between Benfleet Creek and Vange Creek and provides a pathway for floodwaters between the two creeks in the event of a breach in flood defences.

Much of Canvey Island is at or below mean high tide level and in response to this, sea defences protect the entire island. The undeveloped area of the Borough, known as Hadleigh Marsh is also close to mean high tide level. Areas of significantly higher ground exist in the north of the Borough. There are a number of flood barriers across major channels within the Castle Point Borough that serve to protect the Borough from flooding namely the East Haven, Benfleet and Fobbing Horse Barriers.

Canvey Island is particularly vulnerable to breaches of flood defences as it is possible that the island could be cut off from the mainland during tidal flood events. There appears to be only one area of higher ground on the Island, on the eastern end in the vicinity of the Caravan Park and King's Camp, however this area is not significantly above mean high tide level.

There are limited fluvial flood sources within the Borough. The main source of fluvial flooding is the Benfleet Hall Sewer that flows from the high ground of South Benfleet to Hope's Green. More details of the hydrology of this watercourse – are given in Section 2 of this report.

2 SOURCES OF FLOODING IN CASTLE POINT

The Castle Point Borough contains coastal, fluvial and estuary systems, including a small number of creeks and two large marsh areas, posing a range of flood risks. This document focuses on the flooding sources within the Borough that have the largest consequences.

Only major rivers have been assessed as sources of fluvial flood risk. Likewise structural failures i.e. breaches in sea defences or the failure of barriers have been assessed only at specific points identified at the initial tender stage. The mechanical or structural failure of localised defence barriers or mechanisms such as demountable flood boards, pumps designed to drain individual properties and the like has not been considered in this report as it is not appropriate for a district level study. Flood risk associated with smaller localised streams and failure of property specific flood defence systems will require specific Flood Risk Assessments as and when appropriate.

The most significant events in this area, in terms of potential flooding, tend to be storm surges, coinciding with high spring tides to produce high tidal water levels.

2.1 Fluvial

2.1.1 Sources

The main source of fluvial flooding in the Castle Point Borough would be the River Thames however the river is tidal throughout the district and a fluvial flood would be insignificant compared to a tidal flood event on this watercourse. Tidal barriers would therefore protect development from a fluvial flood in the Thames and it is no longer considered as a fluvial flood source in this report.

In addition to the River Thames there are several small watercourses that run off the high plateau of Thundersley and Hadleigh and into Benfleet Creek. Watercourses flowing from Hadleigh are of little importance as flood sources as they flow through open parkland and flooding here is of little consequence. The Benfleet Hall Sewer, which flows through Hope's Green is the most significant fluvial flood source on the mainland portion of the Borough.

There several watercourses and dykes that form the drainage system for Canvey Island within the Borough. Fluvial flooding from this system is possible due to the flat and low lying topography of the Island and the restrictions on flow caused by sea defences and pump drains at the downstream end of these watercourses.

Fluvial flooding results from large rainfall in the upper reaches of the catchment causing flows in excess of the carrying capacity of the channel. Where land is protected by fluvial flood defences, flooding can occur as a result of a breach in the defences or overtopping when a flood event is larger than what the flood defence is designed for.

A large flood event in 1968 caused fluvial flooding within the Castle Point Borough from Benfleet Hall Sewer. Following this event structural flood mitigation measures were undertaken along the watercourse to improve the standard of protection against flooding.

2.1.2 Pathways

At Benfleet Hall Sewer floodwater is conveyed down the steep gradient of the upper reaches to the flat playing fields at Hope's Green. When it reaches Hope's Green water slows suddenly due to the flat gradient. The outflow of water is restricted by a tidal flap valve located at the confluence with Benfleet Creek. This causes floodwaters to back up and fill Hope's Green inundating properties adjacent to the playing fields.

On Canvey Island, floodwater is conveyed down main channels by a system of Dykes designed to keep water in channel. When water overtops the dykes it generally discharges over a large area as the island is very flat. The volume of water in the channel is restricted by the catchment size of the channel.

2.1.3 Receptors

The Environment Agency inundation extent, presented as the brown hatching on Figures A8 1-22, Appendix A, shows the predicted receptors from fluvial flooding. These extents are based on the Environment Agency indicative flood plain maps. The flooding receptors shown on the brown hatching extend only slightly further upstream on the East and West arms of the Benfleet Hall Sewer than the tidal floodplain extents predicted by the breach analysis undertaken in this study.

A report produced by Posford Duvivier into defence standards of protection at Canvey Island concluded that approximately 89 properties are at risk of fluvial flooding in the 1 in 100 year flood event for watercourses within the island. The report did not take into account the effects of pump drains at the downstream end of watercourses or tide locking of tidal outfalls. Flooding consequences could be much greater if these elements were taken into account.

2.2 Tidal

2.2.1 Sources

The North Sea is the body of water that causes tidal flooding in Castle Point. Tidal flooding can result from a storm surge, high spring tides or both events combined over undefended land. In the case of land protected from flooding by sea defences, tidal flooding can occur through either a breach in the sea defences, failure of a mechanical barrier or overtopping of defences.

2.2.2 Pathways

The main pathways for tidal flow in Castle Point are Benfleet Creek and Hole Haven. In the event of a breach in the sea defences, the low-lying marshland and drainage channels on Canvey Island provide pathways for floodwater. Drainage channels within Canvey Island include channels west of the A130, The Lake, A creek adjacent to the Dutch Village and Thorney creek Fleet. Given the wide flat topography of the island, large areas are inundated very quickly following a breach event as flooding pathways are not very well defined.

2.2.3 Receptors

Based on the methodology presented in the SFRA, the defended areas for Castle Point Borough have been separated into a single flood cell embayment of Canvey Island, which was defined by topographic features, flooding characteristics and potential flood pathways. In addition to this, adjacent flood cells in the Southend and Thurrock Boroughs influences flooding in the Castle Point Borough. Figure C1, shows the flood cell in Castle Point Borough and the two adjacent flood cells. Table 2.1 gives details of the flood cell names.

TABLE 2.1: FLOOD CELLS IN CASTLE POINT BOROUGH

Flood cell Reference	Grid Reference (Cell centre)	Approximate Area (km ²)
Thurrock-Fobbing Marsh/ South Benfleet	574074, 184524	31
Castle Point- Canvey Island	578562, 184068	16
Southend-Hadleigh Marsh	580902, 185597	3

2.2.4 Standard and Condition of Tidal and Fluvial Defences

Data from the NFCDD database provided indicates that although the design defence standard is 1 in 1000 years along the Thames, only a limited number of defence crest levels in the Castle Point Area have been checked. In addition to this the NFCDD database showed that; the condition of defences on Canvey Island is between Grade 1 – Excellent Condition and Grade 3 – Good Condition in need of maintenance, the condition of defences protecting the Hadleigh Marsh flood cell has not been recorded and where the condition of defences surrounding Fobbing Marsh flood cell has been recorded defences are Grade 3 – Good Condition in need of maintenance.

Data was included on the Standard of Protection for some defences surrounding Canvey Island. Crest levels for these defences varied from 6.4 to 6.7m. In this area the level of the 1 in 200 year event is between 4.9 and 5.0mAOD and the level of the 1 in 1000-year event is between 5.3 and 5.4mAOD. This shows that the limited number of defences for which electronic data is available is higher than the design flood standard.

A series of reports were undertaken by Halcrow in 2000 on behalf of the Environment Agency to assess the standard of fluvial defences within the Essex region. Extensive flooding in 1968 in South Benfleet prompted a flood defence scheme was built in the early 1970's to protect South Benfleet from flooding up to a 1 in 10 year standard. The Standard of Protection (SoP) was reassessed in 2000 following concerns regarding development in the upper reaches of catchments since the early 1970's. FEH techniques were used to reassess the flow rates for watercourses and LIDAR data supplemented by fieldwork was used to determine the topography of channels and floodplains.

In addition to this Posford Duvivier were commissioned to undertake a study into SoP for flood defences on Canvey Island. This report, also produced in 2000 used the Flood Studies Report to assess fluvial flow in watercourses on the Island and existing topographic survey to determine defence SoP. Table 2.2 summarises the results for defences within the Castle Point Borough.

TABLE 2.2: INDICATIVE STANDARD OF PROTECTION OF DEFENCES FROM FLUVIAL SOURCES IN THE CASTLE POINT BOROUGH

Fluvial Flood Source	Catchment Area (km²)	Defended	Existing SoP (2000)	Indicative SoP (2000)
Knightswick Dyke	-	No	50	100
St Anne's Dyke	-	No	30	100
Rainbow Dyke	-	No	<5	100
Remaining fluvial flood sources on Canvey Island	-	-	>100	100
Benfleet Hall Sewer, East Arm	5.3 (Total catchment)	No	100	100
Benfleet Hall Sewer, West Arm	5.3 (Total catchment)	Yes	>100	100
Benfleet Hall Sewer, Downstream Reach to Benfleet Creek	5.3 (Total catchment)	Yes	>100	100

3 RESULTS

3.1 General

Ten breaches were specified over three flood cells in the Castle Point Borough. Castle Point Borough Council specified eight breach locations within their district boundary, and an additional breach within Thurrock, the adjoining Southend Borough Council specified one other location.

Man-made features such as roads, embankments, walls and bridges may strongly affect the free flow of floodwater across the floodplain. The hydraulic model uses LIDAR and SAR topographical information that presents ground levels in 2 metre and 5 metre square grids. Linear features of widths less than two metres such as stone walls or small creeks may not be represented in the topographical data. Where desktop studies revealed the presence of significant linear features, these were added into the model however smaller linear features that do not readily show up on aerial photography and individual buildings have not been included in this model. If required, more detailed models can be produced at a later stage based on detailed survey information to refine results in specific areas of interest.

The flood events chosen for analysis of tidal breaches were the 1 in 200 year extreme tide, the 1 in 1000-year extreme tide and the 1 in 200 year tide allowing for climate change. Inundation maps have been produced for all of these events and are presented in Appendix A of the main SFRA report. Hazard maps have also been produced which show the flood hazard (depth x velocity) divided into high medium and low categories. Hazard maps were produced for the 1 in 200 year and the 1 in 1000-year events. Flood hazard maps are presented in this report for each of the flood cells across the Castle Point District and for each individual breach that causes flooding in the Castle Point District.

A detailed modelling methodology is presented in Section 7 of the SFRA Report.

3.2 Combined Breach Results

Inundation maps showing the extent and depth of inundation and hazard maps showing zones of high medium and low hazard have been produced for each flood cell. The methodology used to distinguish between high, medium and low hazard is included in Chapter 7 of the SFRA report.

General inundation maps are presented in Appendix A of the SFRA report. General hazard maps for Castle Point are presented in this report. The flood cell maps (Figures C2 1-4 and C3 1-4) present the results of all breaches occurring within a flood cell simultaneously. The C2 series presents the 1 in 200 year event and the C3 series presents the results of the 1 in 1000-year event.

The flood cell results tables on pages 10 to 14 accompany the combined breach maps and summarise the main results for each flood cell. Each table includes a detailed description of the flood cell, the location and depth of the maximum inundation, the location of flood hazard zones, the effects of climate change and the relevance to development.

3.3 Individual Breach Results

The flooding source sheets present the results for each breach location. They should be read in conjunction with the breach hazard maps (Figures C4 1-9 and C5 1-9). The C4 series presents the 1 in 200 year event and the C5 series presents the results of the 1 in 1000-year event for each breach. Hazard zones of high, medium and low hazard have been identified for each breach. Each sheet

includes the details of that breach, the maximum floodwater depths resulting from the breach, a summary of the hazard zone analysis and a discussion of the relevance to development.

These results may be used to determine which breaches have the worst consequences and how individual breaches contribute to the combined breach map.

Each sheet in this section discusses the hazard zones resulting from a single breach. Breaches in other locations along the defences may result in different hazard zoning. This should be taken into account when determining whether a particular property is within the hazard zone. In addition to this, the hazard zone results for this study were produced at a regional scale not appropriate for assessment of whether individual properties on the edge of the zones are within a flood hazard zone or not. A precautionary approach is recommended when using the study results at the fringes of hazard zones.

CASTLE POINT BOROUGH COUNCIL FLOOD CELL RESULTS

TABLE 3.1: FLOOD CELL CASTLE POINT – CANVEY ISLAND

Name and Number of Flood Cell	Canvey Island		
NGR	578562, 184068		
Area (km ²)	16		
Corresponding Maps	Figure C2-1 Hazard Map of Castle Point – Canvey Island (1 in 200 year), Figure C3-1 Hazard Map of Castle Point – Canvey Island (1 in 1000 year)		
Flood Cell Description	This flood cell incorporates Canvey island from Holehaven to Benfleet Creek. The topography is very flat, characterised by the areas of marshland surrounding the town.		
Breach Details	Ref Number	Location	NGR
	CAS01	In Holehaven/ Vange Creek	575200, 183400
	CAS02	In Holehaven/ Vange Creek. South of Canvey Village.	577100, 182600
	CAS03	On the riverfront of the Thames. Eastern Oil Storage Jetty.	578100, 182000
	CAS04	On the riverfront of the Thames. At Thorney Bay.	579500, 182500
	CAS05	On the riverfront of the Thames.	581600, 182700
	CAS06	In Benfleet Creek, north Canvey Island. Adjacent to Sunken Marsh	580900, 184300
	CAS07	In Benfleet Creek, north Canvey Island. Adjacent to Castle Point Golf Course	579000, 185000
Flood Extent	Floodwaters extend throughout Canvey Island and cover the A130 surrounding the main roundabout in the north west of the island. The B1013 is completely inundated from the main roundabout, across the Island. A small section of land to the north of Smallgains Creek is free of inundation as is the industrial estate at Canvey Village and a small area of land to the south of Northwick Road.		
Main Flood Depth	Floodwaters cover much of Canvey Island and are generally between 0.5-1.0m deep. Much deeper water is located along the line of watercourses with water depths of over 3 metres in some places. Deeper floodwaters tend to be located at the edges of the island with shallower depths in the centre.		
Hazard Zones	The majority of development on the island lies in the medium and low hazard zones, with high hazard zones generally following watercourses. However there are some areas of land in Sunken Marsh and towards Leighbeck Point		
Impacts of Climate Change	There are minimal increases in inundation area as a result of climate change due to the fact that the vast majority of the island is inundated in the present flood event. The main impact of climate change is to increase the flood depth in that area		

	already inundated.
Relevance to Development	The flood inundation covers a wide area of current development, i.e. Canvey Island. According to the Adopted Local Plan, issued in 1998, there are two main areas of long-term residential development, one to the northeast of Canvey Island, between the town and Hadleigh Ray, an area known as King's Camp Holiday Park and one on the riverfront to the south, on Thorney Bay. These areas are both within the flood inundation zone. There is also an area proposed for long-term employment generation south of Canvey Vallage/Charfleets Industrial Estate. This area is also within the inundation zone.

TABLE 3.2: FLOOD CELL SOUTHEND – HADLEIGH MARSH

Name and Number of Flood Cell	Hadleigh Marsh		
NGR	580902, 185597		
Area (km ²)	3		
Corresponding Maps	Figure C2-2 Hazard Map of Castle Point – Hadleigh Marsh (1 in 200 year), Figure C3-2 Hazard Map of Castle Point – Hadleigh Marsh (1 in 1000 year)		
Flood Cell Description	A small flood cell located on the flat marshland before the land rises fairly steeply to the south of South Benfleet. The cell is dominated by marshland and has no development, only a minor road and parking area in the far eastern corner of the cell.		
Breach Details*	Ref Number	Location	NGR
	SOU05	At the far eastern limit of this flood cell	584200, 185600
Flood Extent	The main inundation zone covers the majority of Hadleigh Marsh, bordered by the watercourse that runs adjacent to Benfleet Creek and that separates Hadleigh Marsh from Two Tree Island. There is an area outside of the inundation zone in the east of the flood cell and to the west of the breach location, bordered by the small road, car park and golf driving range. The rail track to the north of Hadleigh Marsh forms a barrier, preventing northerly migration of flooding. However, some floodwater does cover the eastern portion of the rail track		
Main Flood Depth	Floodwaters are approximately 1m deep throughout the flood cell with a trend towards deeper water in the east and shallower water in the west.		
Hazard Zones	The hazard zone for the 1 in 200 year event covers the majority of the flood cell and follows the same pattern as the flood depths, with the hazard zone for the 1 in 1000 year event covering the additional areas that the climate change effects covered.		
Impacts of Climate Change	With climate change, the 1 in 200 year event will result in inundation crossing the entire length of the rail track, rather than just at the eastern extent. In addition, floodwater will extend further to the west of the breach, over the minor road but is prevented from migrating onto the golf driving range by the southern branch of the road.		
Relevance to Development	There are no developments, current or planned, in the inundation area		

* The only breaches outlined in these tables are those tested in the SFRA. Other breaches were not included.

TABLE 3.3: FLOOD CELL THURROCK – FOBBING MARSH/ SOUTH BENFLEET

Name and Number of Flood Cell	Fobbing Marsh/ South Benfleet		
NGR	574074, 184524		
Area (km ²)	31		
Corresponding Maps	Figure C2-3 Hazard Map of Castle Point – Fobbing Marsh/South Benfleet (1 in 200 year), Figure C3-3 Hazard Map of Castle Point – Fobbing Marsh/South Benfleet (1 in 1000 year)		
Flood Cell Description	This is a fairly large cell extending from the riverside and following Vange Creek and East Haven Creek until the A13 road. It has flat topography mainly, with areas of marshland (Fobbing and Bowers Marches). The only residential area is the small area of South Benfleet. There are extensive industrial areas along the riverfront, including an oil refinery and various jetties and wharfs.		
Breach Details [*]	Ref Number	Location	NGR
	CAS08	Benfleet Barrier.	579100, 185500
	CAS09	Fobbing Horse Barrier.	574045, 184305
	THU07	North of the Oil Refinery, downstream of Benfleet Barrier.	574400, 183800
	THU10	At Shell Haven Refinery Docks.	574615, 181784
Flood Extent	Floodwaters extend over Shell Haven Oil Refinery, Fobbing Marshes, Vange Marshes, Pitsea Marshes, Bowers Marshes, Benfleet Marsh and Hope's Green. Flooding extends over the A1014 and is bordered by the A13 and the Railway line in the north. Although the inundation area is extensive, with the exception of the Shell Haven Refinery, there is little development within the flood extent.		
Main Flood Depth	The deepest floodwaters are located in Vange Creek and Benfleet Creek with depths of over 3 metres. Floodwater depths of between 2 and 3 metres are experienced across land in the north of the floodcell adjacent to the A13 and rail line and across land adjacent to Benfleet Creek. Floodwater depths vary greatly across the Shell Haven refinery.		
Hazard Zones	In general the high hazard zone follows watercourses and drainage lines, spreading out into Bowers Marshes and the south end of Fobbing Marshes. Benfleet Marsh is also an area of high hazard, however most development within the inundation area is within the medium and low hazard zones. The Oil Refinery and Storage Depot are within zones of mixed high, medium and low hazard. The high hazard zone is more extensive in the 1 in 1000 year event than in the 1 in 200 year event however this does not significantly affect hazard zones surrounding development areas.		
Impacts of Climate Change	Large increase in flood extent in the north of the flood cell around Vange Marshes. Additional areas of flooding close to THU07 at the northern end of the Oil Refinery. Slight increase in flood extent along the northeastern edge of the food extent		

* The only breaches outlined in these tables are those tested in the SFRA. Other breaches were not included.

	across Pitsea and Vange Marshes. There is a slight increase in flood extent around the Hope's Green area, which causes increased inundation to residential zones. In the south west of the flood cell there is a large increase in flood extent due to climate change however there is minimal development in this area.
Relevance to Development	The only planned development in the flood cell includes a slight extension of the industrial area, extending north of the existing industrial areas (e.g. oil refinery and fuel depot). This area would be subject to inundation from the breach scenarios used in this study. The remaining areas are allocated as landscaping and natural areas (Fobbing Marshes)

CASTLE POINT BOROUGH COUNCIL

INDIVIDUAL BREACH RESULTS

FLOOD RISK SOURCE: CAS01 – Canvey Island 1	
FLOOD RISK TYPE: TIDAL	
FLOOD CELL(S): Canvey Island	
FIGURES: Figure C4-1 Hazard Map of CAS01 (1 in 200 year), Figure C5-1 Hazard Map of CAS01 (1 in 1000 year)	
BACKGROUND	
OS Location: 575200, 183400	
DTM Generation: From LIDAR data	
Source of Flood Level Information: Thames 2100	
Defence Type: Hard Defence	
BREACH DETAILS	
Location: In Holehaven/ Vange Creek. South of Canvey Village.	
Breach Width: 20m	
Base Level of Breach: 2mAOD	
Repair Time (hrs): 30	
RESULTS	
<p>Location of Main Flood Depth: CAS01 covers the areas in the west of Canvey Island, up to the East Haven Creek and inundates all but the most eastern edges of development on Canvey Island. Floodwaters spread from west to east and cross the A130 at approximately 5 hours and 45 minutes. Approximately 7 hours and 30 minutes after the simulation starts, both the A130 and the B1014 are inundated cutting off Canvey Island from the mainland. Floodwaters cover much of the northwest of Canvey Island, with floodwaters generally around 0.6m deep. The most widespread inundation is experienced at the end of the simulation although this is not necessarily the time when the worst depth is experienced.</p>	
Return Period:	1 in 200 Yr
Max Depth of Floodwater:	2-2.5m
Location of Max Depth:	Creeks and drains west of A130
Time Max Depth first occurs:	17hrs 30mins
Hazard Zone Results:	
<p>1 in 200 Year event: The hazard map associated with breach CAS01 for the 1 in 200 year event shows the areas of high hazard are located to the northeast of the breach and extent mainly over farmland, marshes and drainage channels to the A130. Localised areas of High Hazard also occur around the Lake and the creek that borders the Dutch Village.</p> <p>The remaining flood hazard zone resulting from this breach is categorised as low and medium Hazard. The medium hazard areas are mainly in the north west of the island in the marshes and drainage channels. Thin fringes of medium hazard surround the lake and the creek that runs passed the Dutch Village. Most of the area surrounded by the A130 and the B1014 is shown to be within low hazard category. Some sections of low hazard cross the A130 and extend south towards Thornycreek Fleet. Low flood hazard zones also cross the B1014 towards Sunken Marsh.</p>	
<p>1 in 1000 Year event: The 1 in 1000 year hazard zone covers much the same area as the 1 in 200 year zone however a low hazard zone extends across the A130 in the northeast corner of the Island and areas of low hazard spread out to the east and south of the main residential area. The boundaries of high hazard areas are extended slightly. The areas of medium hazard surrounding the western end of the lake are extended especially to the south of the A130. Inundation extends to Thornycreek Fleet in the 1 in 1000-year event and west towards Brick House Farm. Low lying land close to the creek is shown to be within the medium hazard zone</p>	

and slightly higher land is shown to be within the low hazard zone. Most of the land bordered by the B1014 and Nevada Road is shown to be in the low flood hazard category.

RELEVANCE TO DEVELOPMENT

The Current Local Plan, adopted in 1998 shows two main areas on Canvey Island allocated for long-term residential development, Kings Camp and Thorney Bay Caravan Park. There is one area designated for long term Employment, south of Charfleets Industrial Estate. Two areas are allocated for residential sites for development (H3) within the plan life of the current plan, Thorney Bay Road and Point Road. Thorney Bay road already had extant planning permission and Point Road was considered appropriate for conversion from industrial to residential development. For the purposes of this report it is assumed that these areas have already been converted to residential land use. An additional area on the western end of the esplanade is allocated for seafront entertainment. It is assumed that this area also has been developed.

Those areas designated for long-term development and employment purposes were not to be developed during the life of the current plan but held over in case of future employment and development pressures. The results of this strategic flood risk assessment should feed into future development decisions within these and other areas on the island. The hazard maps show that the King's Camp area is outside the flood hazard zones generated as a result of breach CAS01. Thorney Bay Caravan Park area is bordered by the edge of the high medium and low hazard zones generated by the 1 in 1000-year breach at CAS01.

Low flood hazard zones in the south as a result of breach CAS01 border the area south of Charfleets Industrial Estate, identified as appropriate for long-term employment development, in the 1 in 1000-year event.

Access to and from the island is inundated very soon after the breach CAS01, although the B1014 is crossable until approximately 15 hours and 20 minutes after the breach.

Access to the breach is very difficult because there is widespread inundation across the island although it may be possible to reach the breach via fields with shallow inundation.

FLOOD RISK SOURCE: CAS02 – Canvey Island 2	
FLOOD RISK TYPE: TIDAL	
FLOOD CELL(S): Canvey Island	
FIGURES: Figure C4-2 Hazard Map of CAS02 (1 in 200 year), Figure C5-2 Hazard Map of CAS02 (1 in 1000 year)	
BACKGROUND	
OS Location: 577100, 182600	
DTM Generation: From LIDAR data	
Source of Flood Level Information: Thames 2100	
Defence Type: Hard Defence	
BREACH DETAILS	
Location: In Holehaven/ Vange Creek	
Breach Width: 20m	
Base Level of Breach: 2.7mAOD	
Repair Time (hrs): 30	
RESULTS	
<p>Location of Main Flood Depth: CAS02 results in fairly extensive inundation throughout Canvey Island, particularly in the west and following the rivers and drains throughout this area of the town. The maximum extent of inundation occurs at the end of the model run. There are four main creeks where the water depth is the greatest, Thorneycreek Fleet, Adjacent to Charfleets Industrial Estate, the Lake and the creek that runs alongside the Dutch Village. Other than at these locations water generally inundates residential areas to depths of 0.3-0.6m and covers most of the central part of the island.</p> <p>The A130 and the B1014 are inundated although the average depth of flooding on the B1014 is approximately 0.3m.</p>	
Return Period:	1 in 200 Yr
Max Depth of Floodwater:	1.5-2m
Location of Max Depth:	Thorneycreek Fleet and South of Charfleets Industrial Estate
Time Max Depth first occurs:	16hrs 25mins
Hazard Zone Results:	
<p>1 in 200 Year event: The hazard map associated with breach CAS02 for the 1 in 200 year event shows the areas of high hazard are located to the northeast of the breach and extend to Monkswick in the west and almost reach the B1014 in the north. Dovervelt Road, Point Road (B1014) and Seaview Road border the eastern extent of the hazard resulting from this breach.</p> <p>The hazard zone resulting from this breach only affects the fringes of Canvey Village however the area south of Charfleets Industrial Estate is shown to be in a area of mixed medium and high flood hazard. The area north of the A130 is predominantly low hazard with strips of high hazard along watercourses with localised medium hazard areas south of the lake. Thin fringes of medium hazard surround the lake and the creek that runs passed the Dutch Village.</p> <p>East of Kitkatts Road is mostly an area of low hazard with small sections showing no hazard or medium hazard. West of Kitkatts road flood hazard is predominantly medium with the exception of areas adjacent to Thorneycreek Fleet, which are shown as high hazard zones. Some sections of the works and the Oil Storage depot are shown as being outside the hazard zone or within a low hazard area.</p>	

1 in 1000 Year event: The 1 in 1000 year hazard zone covers a slightly larger area than the 1 in 200 year hazard zone. The main difference being north of Monksfield where the low hazard zone extends much farther into the fields and drainage channels areas of high and medium hazard follow the drainage channels within the fields. The low hazard zone also crosses over the B1014 at the Tewkes Creek School, over Point Road near Leigh Beck and east Seaview Road towards Southfalls Road.

The area immediately to the west of Seaview Road is shown to be within a medium hazard zone. There is little change in the hazard categories west of Furtherwick Road apart from slightly larger areas of high hazard at the head of Thornycreek Fleet and south of Canvey Village. The low hazard zone encroaches further into Canvey Village than in the 1 in 200 year event.

RELEVANCE TO DEVELOPMENT

The Current Local Plan, adopted in 1998 shows two main areas on Canvey Island allocated for long-term residential development, Kings Camp and Thorney Bay Caravan Park. There is one area designated for long term Employment, south of Charfleets Industrial Estate. Two areas are allocated for residential sites for development (H3) within the plan life of the current plan, Thorney Bay Road and Point Road. Thorney Bay road already had extant planning permission and Point Road was considered appropriate for conversion from industrial to residential development. For the purposes of this report it is assumed that these areas have already been converted to residential land use. An additional area on the western end of the esplanade is allocated for seafront entertainment. It is assumed that this area also has been developed.

Those areas designated for long-term development and employment purposes were not to be developed during the life of the current plan but held over in case of future employment and development pressures. The results of this strategic flood risk assessment should feed into future development decisions within these and other areas on the island. The hazard maps show that the King's Camp area is outside the flood hazard zones generated as a result of breach CAS02. Thorney Bay Caravan Park area is within an area of predominantly medium hazard and bordered by the high hazard zone generated by the breach at CAS02.

The area south of Charfleets Industrial Estate, identified as appropriate for long-term employment development, is shown to be in an area of mixed medium and high hazard zones as a result of breach CAS02.

Most development on the island is cut off from the mainland by floodwaters resulting from this breach except for a small area north of the B1014 at the Castle Point Golf Course. Access to the breach is difficult because the area is surrounded by floodwater and especially because of the deep floodwaters in the creek north of the breach that runs along the coastline for a short section.

FLOOD RISK SOURCE: CAS03 – Canvey Island 3	
FLOOD RISK TYPE: TIDAL	
FLOOD CELL(S): Canvey Island	
FIGURES: Figure C4-3 Hazard Map of CAS03 (1 in 200 year), Figure C5-3 Hazard Map of CAS03 (1 in 1000 year)	
BACKGROUND	
OS Location: 578100, 182000	
DTM Generation: From LIDAR data	
Source of Flood Level Information: Thames 2100	
Defence Type: Hard Defence	
BREACH DETAILS	
Location: On the riverfront of the Thames. Eastern Oil Storage Jetty.	
Breach Width: 20m	
Base Level of Breach: 1.5mAOD	
Repair Time (hrs): 30	
RESULTS	
<p>Location of Main Flood Depth: CAS03 results in widespread inundation throughout Canvey Island and reaches East Haven Creek, north of Northwick Road. The floodwaters spread quickly after the first tidal cycle following breach CAS03. The central portion of the island is inundated rapidly however access is possible from the island via the B1014 until approximately 15 hours after the breach.</p> <p>The maximum extent of inundation occurs at the end of the simulation however deeper floodwaters occur in some areas before the maximum extent is reached i.e. Thornycreek Fleet. Inundation up to 1m depth occurs in these areas however at the maximum extent of inundation the depth reduces to around 0.6m in most areas.</p>	
Return Period:	1 in 200 Yr
Max Depth of Floodwater:	1-1.5m
Location of Max Depth:	Creeks and Drains West of A130
Time Max Depth first occurs:	22hrs 30mins
Hazard Zone Results:	
<p>1 in 200 Year event: The hazard map associated with breach CAS03 for the 1 in 200 year event shows most of the island is within the hazard zone. The main area of high hazard is located immediately to the north of the breach across the works and connects with a high hazard zone surrounding Thornycreek Fleet. Additional areas of high hazard surround the lake and the creek that runs passed the Dutch Village. To the north of Northwick Road, areas of high hazard follow the drainage channels that run through the fields. The majority of development on the Island is within a medium or low hazard zone except where development is immediately adjacent to a watercourse. Canvey Village is predominantly flood free with low and medium hazard zones on the fringes of the village. Immediately south of Canvey Village is an area of mixed medium and high hazard.</p> <p>The B1014 is shown to be within a low hazard zone. The A130 is shown to be out of the hazard zone until the intersection with Northwick Road with the exception of a couple of short sections shown to be in high hazard zones.</p> <p>1 in 1000 Year event: The 1 in 1000 year hazard zone covers a slightly larger area than the 1 in 200 year hazard zone. The main difference being that the hazard extends further in the north to the A130 north of Monksfield and west passed Northwick. In the east, the low hazard area</p>	

extends to cover all but two or three streets in the eastern extreme of the island and a few isolated pockets above the hazard zone. Kings Camp Holiday park is shown to be mostly within the low hazard zone with some small areas of medium and high hazard in the south west of the camp. There are a greater number of high hazard zones in the Canvey Island Golf Course than in the 1 in 200 year hazard extent. The majority of Canvey Village remains out of the hazard zone, however the low hazard zone encroaches further into Canvey Village than in the 1 in 200 year event.

RELEVANCE TO DEVELOPMENT

The Current Local Plan, adopted in 1998 shows two main areas on Canvey Island allocated for long-term residential development, Kings Camp and Thorney Bay Caravan Park. There is one area designated for long term Employment, south of Charfleets Industrial Estate. Two areas are allocated for residential sites for development (H3) within the plan life of the current plan, Thorney Bay Road and Point Road. Thorney Bay road already had extant planning permission and Point Road was considered appropriate for conversion from industrial to residential development. For the purposes of this report it is assumed that these areas have already been converted to residential land use. An additional area on the western end of the esplanade is allocated for seafront entertainment. It is assumed that this area also has been developed.

Those areas designated for long-term development and employment purposes were not to be developed during the life of the current plan but held over in case of future employment and development pressures. The results of this strategic flood risk assessment should feed into future development decisions within these and other areas on the island. The hazard maps show that approximately half of the King's Camp area is in the low hazard zone for the 1 in 200 year event and most of the area is within the low hazard zone for the 1 in 1000-year event as a result of breach CAS03. Thorney Bay Caravan Park area is within an area of mixed medium hazard and high hazard generated by the breach at CAS03.

The area south of Charfleets Industrial Estate, identified as appropriate for long-term employment development, is shown to be in an area of mixed medium and high hazard zones as a result of breach CAS03.

The A130 is first inundated north of Thorneycreek Fleet approximately 2 hours and 40 minutes after the simulation begins. The B1014 is first inundated at approximately 6 hours and 45 minutes near the junction with the A130 and Point Road. Access from the eastern suburbs is still possible via minor roads to the northern section of the B1014 until about 15 hours after the simulation starts.

Access to breach CAS03 is difficult because it is surrounded by floodwaters and access roads are inundated up to the main roundabout onto the Island.

FLOOD RISK SOURCE: CAS04 – Canvey Island 4	
FLOOD RISK TYPE: TIDAL	
FLOOD CELL(S): Canvey Island	
FIGURES: Figure C4-4 Hazard Map of CAS04 (1 in 200 year), Figure C5-4 Hazard Map of CAS04 (1 in 1000 year)	
BACKGROUND	
OS Location: 579500, 182500	
DTM Generation: From LIDAR data	
Source of Flood Level Information: Thames 2100	
Defence Type: Hard Defence	
BREACH DETAILS	
Location: On the riverfront of the Thames. At Thorney Bay.	
Breach Width: 20m	
Base Level of Breach: 1.0mAOD	
Repair Time (hrs): 30	
RESULTS	
<p>Location of Main Flood Depth: CAS04 covers much the same area as CAS03, except it stretches further east and north by reaching the saltmarshes of Hadleigh Ray and Canvey Point. The maximum extent of floodwaters is reached at the end of the simulation.</p> <p>Most of the floodwater remains below 1m except areas corresponding with watercourses. Inundation up to 1m occurs at about 16 hours and 40 minutes in the south of Thorneycreek Fleet. At the maximum extent of flooding most areas experience floodwater depths of up to 0.6m.</p>	
Return Period:	1 in 200 Yr
Max Depth of Floodwater: Location of Max Depth:	1.5-2m ThorneyCreek Fleet and South of Charfleets Industrial Estate
Time Max Depth first occurs:	15hrs 30mins
Max Depth of Floodwater: Location of Max Depth:	1.5-2m The Lake
Time Max Depth first occurs:	16hrs 55mins
Max Depth of Floodwater: Location of Max Depth:	1.5-2m Creeks and Drains West of A130
Time Max Depth first occurs:	23hrs 30mins
Hazard Zone Results:	
<p>1 in 200 Year event: The hazard map associated with breach CAS04 for the 1 in 200 year event is similar to that for CAS03 and shows most of the island is within the hazard zone. The main area of high hazard is located immediately to the west of the breach across Canvey Island Golf Course, Thorney Bay Caravan Park and Thorneycreek Fleet. Additional areas of high hazard surround the lake, the creek that runs passed the Dutch Village and drainage channels to the north of Northwick Road. The majority of development on the Island is within a medium or low hazard zone except where development is immediately adjacent to a watercourse. Canvey Village is predominantly flood free with low and medium hazard zones on the fringes of the village. Immediately south of Canvey Village is an area of mixed medium and high hazard.</p> <p>The B1014 is shown to be crossed by the low hazard zone north of Winter Gardens and east of Tewkes Creek. The A130 is shown to be out of the hazard zone until the intersection with</p>	

Northwick Road with the exception of a couple of short sections shown to be in high hazard zones. East of the Northwick Road intersection the road is shown to be crossed by low and medium hazard zones.

1 in 1000 Year event: The 1 in 1000 year hazard zone covers a slightly larger area than the 1 in 200 year hazard zone. The main differences being that the hazard extends further in the north towards the A130 north of Monksfield, across the B1014 towards Waterside Farm and to the eastern end of Kings Camp Caravan Park. The Canvey Island Golf Course is shown to be predominantly an area of high hazard. The majority of Canvey Village remains out of the hazard zone, however the low hazard zone stretches around to the west of the village and encircles the area with low of medium flood hazard.

RELEVANCE TO DEVELOPMENT

The Current Local Plan, adopted in 1998 shows two main areas on Canvey Island allocated for long-term residential development, Kings Camp and Thorney Bay Caravan Park. There is one area designated for long term Employment, south of Charfleets Industrial Estate. Two areas are allocated for residential sites for development (H3) within the plan life of the current plan, Thorney Bay Road and Point Road. Thorney Bay road already had extant planning permission and Point Road was considered appropriate for conversion from industrial to residential development. For the purposes of this report it is assumed that these areas have already been converted to residential land use. An additional area on the western end of the esplanade is allocated for seafront entertainment. It is assumed that this area also has been developed.

Those areas designated for long-term development and employment purposes were not to be developed during the life of the current plan but held over in case of future employment and development pressures. The results of this strategic flood risk assessment should feed into future development decisions within these and other areas on the island. The hazard maps show that approximately half of the King's Camp area is in the low hazard zone for the 1 in 200 year event and most of the area is within the low hazard zone for the 1 in 1000-year event as a result of breach CAS04. Thorney Bay Caravan Park area is within an area of mostly high hazard generated by the breach at CAS04.

The area south of Charfleets Industrial Estate, identified as appropriate for long-term employment development, is shown to be in an area of mixed medium and high hazard zones as a result of breach CAS04.

The first inundation of the A130 occurs north of Thorney Bay approximately 2 hours and 50 minutes after the simulation starts. The first inundation of the B1014 occurs to the west of the junction with Dovervelt Road at 6 hours. This gives little time between the breach event and widespread inundation.

Access to the breach is difficult for similar reasons as CAS03.

FLOOD RISK SOURCE: CAS05 – Canvey Island 5	
FLOOD RISK TYPE: TIDAL	
FLOOD CELL(S): Canvey Island	
FIGURES: Figure C4-5 Hazard Map of CAS05 (1 in 200 year), Figure C5-5 Hazard Map of CAS05 (1 in 1000 year)	
BACKGROUND	
OS Location: 581600, 182700	
DTM Generation: From LIDAR data	
Source of Flood Level Information: Thames 2100	
Defence Type: Hard Defence	
BREACH DETAILS	
Location: On the riverfront of the Thames	
Breach Width: 20m	
Base Level of Breach: 2.5mAOD	
Repair Time (hrs): 30	
RESULTS	
<p>Location of Main Flood Depth: Floodwaters extend throughout Canvey Island and cover the A130, almost reaching East Haven Creek. The maximum extent of inundation occurs at the end of the simulation.</p> <p>The rate of inundation increases fairly rapidly in the second tidal cycle following the breach. The deepest inundation occurs in the eastern and southern residential areas of the island with the deepest inundated in the eastern residential area at approximately 1m depth at around 17 hours. As the floodwaters spread west the depth reduces to around 0.3-0.6m across the island.</p>	
Return Period:	1 in 200 Yr
Max Depth of Floodwater:	1.5-2m
Location of Max Depth:	Adjacent to breach
Time Max Depth first occurs:	14hrs
Hazard Zone Results:	
<p>1 in 200 Year event: The hazard map associated with breach CAS05 for the 1 in 200 year event shows most of the development on the island is within the hazard zone. The main area of high hazard is located immediately to the north of the breach across Leigh Beck and Point Road. Additional areas of high hazard surround the watercourses and larger drainage channels on the Island.</p> <p>The majority of development on the Island is within a medium or low hazard zone except where development is immediately adjacent to a watercourse and development in the eastern end of the island adjacent to the breach. Canvey Village, development between the B1014 and the Castle Point Golf Course, parts of the oil storage depot and the works in the southern side of the island are predominantly flood free with low and hazard zones on the fringes of the village. Immediately south of Canvey Village is an area of mixed low, medium and high hazard. The Canvey Island Golf Course is within an area of medium hazard.</p> <p>The B1014 is shown to be crossed by the low hazard zone east of Tewkes Creek. The A130 is shown to be out of the hazard zone until the intersection with Northwick Road with the exception of a couple of short sections shown to be in medium and high hazard zones. East of the Northwick Road intersection the A130 is shown to be crossed by low and medium hazard zones.</p>	

1 in 1000 Year event: The 1 in 1000 year hazard zone covers a slightly larger area than the 1 in 200 year hazard zone. The main differences being that the hazard extends further in the west towards East Haven Creek and in the north across the B1014 towards Waterside Farm and the Castle Point Golf Course. The Canvey Island Golf Course remains in an area of predominantly medium hazard. The majority of Canvey Village remains out of the hazard zone with an area of low, medium and high hazard to the south.

RELEVANCE TO DEVELOPMENT

The Current Local Plan, adopted in 1998 shows two main areas on Canvey Island allocated for long term residential development, Kings Camp and Thorney Bay Caravan Park. There is one area designated for long term Employment, south of Charfleets Industrial Estate. Two areas are allocated for residential sites for development (H3) within the plan life of the current plan, Thorney Bay Road and Point Road. Thorney Bay road already had extant planning permission and Point Road was considered appropriate for conversion from industrial to residential development. For the purposes of this report it is assumed that these areas have already been converted to residential land use. An additional area on the western end of the esplanade is allocated for seafront entertainment. It is assumed that this area also has been developed.

Those areas designated for long term development and employment purposes were not to be developed during the life of the current plan but held over in case of future employment and development pressures. The results of this strategic flood risk assessment should feed into future development decisions within these and other areas on the island. The hazard maps show that the King's Camp area is in the medium and low hazard zone for the 1 in 200 year event and most of the area is within the medium hazard zone for the 1 in 1000-year event as a result of breach CAS05. Thorney Bay Caravan Park area is within an area of mostly medium hazard generated by the breach at CAS05.

The area south of Charfleets Industrial Estate, identified as appropriate for long-term employment development, is shown to be in an area of mixed low, medium and high hazard zones as a result of breach CAS05.

The A130 and the B1014 are inundated after the main roundabout onto the island at the maximum extent of the floodwaters. The eastern end of Point Road is inundated at approximately 1 hour and 25 minutes after the breach and the eastern end of the A130 is inundated at approximately 4 hours and 40 minutes.

Access to the breach is very difficult because it is on the extreme eastern side of the island and is therefore furthest away from the only access points to the mainland. The only access to the breach may be by sea or air.

FLOOD RISK SOURCE: CAS06 – Canvey Island 6	
FLOOD RISK TYPE: TIDAL	
FLOOD CELL(S): Canvey Island	
FIGURES: Figure C4-6 Hazard Map of CAS06 (1 in 200 year), Figure C5-6 Hazard Map of CAS06 (1 in 1000 year)	
BACKGROUND	
OS Location: 580900, 184300	
DTM Generation: From LIDAR data	
Source of Flood Level Information: Thames 2100	
Defence Type: Hard Defence	
BREACH DETAILS	
Location: In Benfleet Creek, north Canvey Island. Adjacent to Sunken Marsh	
Breach Width: 20m	
Base Level of Breach: 2.0mAOD	
Repair Time (hrs): 30	
RESULTS	
<p>Location of Main Flood Depth: The maximum extent of inundation occurs at the end of the simulation at which point most of the development on the island is inundated except for an area near Charfleets Industrial Estate in the south west of the island.</p> <p>The deepest inundation generally follows watercourses. The deepest inundation over development is associated with CAS06 is located between the shore of Benfleet Creek and to the B1014 in the north of Canvey Island. At 15 hours and 40 minutes King's Camp and the adjoining suburb reach their maximum inundation depth of approximately 0.6-1m. The average depth of inundation at the maximum extent of floodwaters is 0.3m.</p>	
Return Period:	1 in 200 Yr
Max Depth of Floodwater:	1.5-2m
Location of Max Depth:	King's Camp
Time Max Depth first occurs:	14hrs 40 minutes
Hazard Zone Results:	
<p>1 in 200 Year event: The hazard map associated with breach CAS06 for the 1 in 200 year event shows most of the development on the island is within the hazard zone with the exception of Canvey Village, a small area of land south of Castle Point Golf Course, The Oil Storage Depot and some small isolated development areas. The main area of high hazard is located immediately south of the breach across Sunken Marsh and King's Camp. Additional areas of high hazard surround the watercourses and larger drainage channels on the Island.</p> <p>The majority of development on the Island is within a low hazard zone except for the section between the breach and the Lake, which is medium and high hazard. Land immediately adjacent to a watercourse is also high or medium flood hazard as a result of this breach. The Canvey Island Golf Course is within an area of low hazard with isolated points of medium hazard. This is bordered by a section of high hazard that runs along Thornycreek Fleet.</p> <p>The B1014 is shown to be crossed by the low hazard zone in several sections east of the main roundabout into Canvey Island. East of Tewkes Creek the B1014 is within mixed low and medium hazard zones. The A130 is shown to be out of the hazard zone until the intersection with Northwick Road with the exception of a couple of short sections shown to be in medium and high hazard zones. East of the Northwick Road intersection the A130 is shown to be</p>	

crossed by low and medium hazard zones.

1 in 1000 Year event: The 1 in 1000 year hazard zone covers much the same area as the 1 in 200 year hazard zone with the exception of land south of Canvey Village. This land is free from hazard in the 1 in 200 year event but is shown as an area of low hazard with medium and high hazard following drainage channels in the 1 in 1000 year event. The high hazard area south of the breach extends further into Sunken Marsh and King's Camp. In other locations the high and medium hazard extents increase in area slightly.

The medium hazard zone extends across much of the Canvey Island Golf Course. The majority of Canvey Village remains out of the hazard zone however the low hazard zone begins to encroach on the area in the north and south.

RELEVANCE TO DEVELOPMENT

The Current Local Plan, adopted in 1998 shows two main areas on Canvey Island allocated for long-term residential development, Kings Camp and Thorney Bay Caravan Park. There is one area designated for long term Employment, south of Charfleets Industrial Estate. Two areas are allocated for residential sites for development (H3) within the plan life of the current plan, Thorney Bay Road and Point Road. Thorney Bay road already had extant planning permission and Point Road was considered appropriate for conversion from industrial to residential development. For the purposes of this report it is assumed that these areas have already been converted to residential land use. An additional area on the western end of the esplanade is allocated for seafront entertainment. It is assumed that this area also has been developed.

Those areas designated for long-term development and employment purposes were not to be developed during the life of the current plan but held over in case of future employment and development pressures. The results of this strategic flood risk assessment should feed into future development decisions within these and other areas on the island. The hazard maps show that the King's Camp area is in the medium and high hazard zone for the 1 in 200 year and the 1 in 1000-year event as a result of breach CAS06. Thorney Bay Caravan Park area is within an area of medium and low hazard generated by the breach at CAS06.

The area south of Charfleets Industrial Estate, identified as appropriate for long-term employment development, is shown to be outside the hazard zones for the 1 in 200 year event but within an area of predominantly low hazard for the 1 in 1000-year event as a result of breach CAS06.

The B1014 is the first access road to be inundated close to the Sunken Marsh area at 2 hours and 40minutes. Inundation spreads quickly from here to the Lake and reaches the junctio with Point Road at approximately 3 hours. Floodwaters begin to cross the southern A130 20 minutes later. At 10 hours and 30 minutes after the simulation starts, floodwaters have crossed the A130 north of the junction with Northwick Road. At the maximum extent of flooding the A130 and the B1014 are cut off after the main roundabout onto Canvey Island.

Access to the breach is very difficult because the breach is located on the eastern end of the island furthest from the access roads to the mainland. The only access to the breach may be by sea or air.

FLOOD RISK SOURCE: CAS07 – Canvey Island 7	
FLOOD RISK TYPE: TIDAL	
FLOOD CELL(S): Canvey Island	
FIGURES: Figure C4-7 Hazard Map of CAS07 (1 in 200 year), Figure C5-7 Hazard Map of CAS07 (1 in 1000 year)	
BACKGROUND	
OS Location: 579000, 185000	
DTM Generation: From LIDAR data	
Source of Flood Level Information: Thames 2100	
Defence Type: Hard Defence	
BREACH DETAILS	
Location: In Benfleet Creek, north Canvey Island. Adjacent to Castle Point Golf Course	
Breach Width: 20m	
Base Level of Breach: 1.9mAOD	
Repair Time (hrs): 30	
RESULTS	
<p>Location of Main Flood Depth: Inundation from CAS07 covers much the same area as CAS06, except it doesn't reach the far east and southeast of Canvey Island. Inundation extends from East Haven Creek in the west to Northwick Road in the south and across to approximately Normans Road, Florence Road and May Avenue in the east.</p> <p>The maximum extent of inundation occurs at the end of the simulation with an average depth of 0.3m across development areas. The maximum depth occurs in marshland to the west of and crossing the A130 although inundation is also quite deep over the land immediately south of the breach. Floodwater depths reach up to 1m to the south of the breach at times. The eastern edges of development on the Island and Charfleets Industrial Estate are not inundated by floodwaters resulting from the breach.</p>	
Return Period:	1 in 200 Yr
Max Depth of Floodwater:	1-1.5m
Location of Max Depth:	Over A130 and marshland west of A130
Time Max Depth first occurs:	14hrs 45 minutes
Hazard Zone Results:	
<p>1 in 200 Year event: The hazard map associated with breach CAS07 for the 1 in 200 year event shows that much of the development in the central and southern parts of the island is in the low hazard zone with isolated areas of medium hazard. Land immediately adjacent to watercourses or drainage channels is shown as high or medium flood hazard as a result of this breach. An additional area of high hazard is located immediately south of the breach across Castle Point Golf Course to the B1014. The fields and marshes to the west, bordered by the A130 and Northwick Road are within an area of mixed low hazard in the fields and medium to high hazard surrounding the drainage channels and watercourses.</p> <p>Approximately half of the King's Camp area is shown to be within the 1 in 200 year low hazard zone. Resulting from this breach. The Canvey Island Golf Course is within an area of low hazard with isolated points of medium hazard. This is bordered by a section of high hazard that runs along Thornycreek Fleet.</p> <p>The B1014 is shown to be within the low and medium hazard zones east of the main</p>	

roundabout into Canvey Island with two places south of the breach and north of Winter Gardens shown as being in the high hazard zone. The A130 is shown to be out of the hazard zone until the intersection with Northwick Road with the exception of a couple of short sections shown to be in the high hazard zone. East of the Northwick Road intersection the A130 is crossed by the low and medium hazard zones.

1 in 1000 Year event: The 1 in 1000 year hazard zone covers a slightly larger area than the 1 in 200 year hazard zone. The main differences being that the hazard extends further in the south covering much of Brick House Farm and in the east around Furtherwick Road. This land is free from hazard in the 1 in 200 year event but is shown as areas of low and medium in the 1 in 1000 year event. The high hazard area south of the breach increases in size but does not influence any additional development. In other locations the high and medium hazard extents increase in area slightly.

The low hazard zone extends across the whole of King's Camp and the medium hazard zone extends across much of the Canvey Island Golf Course. Canvey Village remains out of the hazard.

RELEVANCE TO DEVELOPMENT

The Current Local Plan, adopted in 1998 shows two main areas on Canvey Island allocated for long term residential development, Kings Camp and Thorney Bay Caravan Park. There is one area designated for long term Employment, south of Charfleets Industrial Estate. Two areas are allocated for residential sites for development (H3) within the plan life of the current plan, Thorney Bay Road and Point Road. Thorney Bay road already had extant planning permission and Point Road was considered appropriate for conversion from industrial to residential development. For the purposes of this report it is assumed that these areas have already been converted to residential land use. An additional area on the western end of the esplanade is allocated for seafront entertainment. It is assumed that this area also has been developed.

Those areas designated for long term development and employment purposes were not to be developed during the life of the current plan but held over in case of future employment and development pressures. The results of this strategic flood risk assessment should feed into future development decisions within these and other areas on the island. The hazard maps show that the King's Camp area is in the low hazard zone for the 1 in 200 year and the 1 in 1000 year event as a result of breach CAS07. Thorney Bay Caravan Park area is within an area of medium and low hazard generated by the breach at CAS07.

The area south of Charfleets Industrial Estate, identified as appropriate for long term employment development, is shown to be outside the hazard zones generated by this breach.

At the maximum flood extent the B1014 and the A130 are inundated up to the main roundabout onto the island and the edges of the A130 are inundated from the main round about to the western edge of the island. The B1014 is first crossed south of the breach 1 hour and 20 minutes after the breach. The A130 is first crossed south of the main round about onto the island at approximately 3 hours after the breach.

Access to the breach is very difficult because access roads to the island are inundated. Some sections of access roads would be passable in vehicles however floodwaters along other sections would prevent vehicle access.

FLOOD RISK SOURCE: CAS08 – Benfleet Marshes, Failure of Benfleet Barrier	
FLOOD RISK TYPE: TIDAL	
FLOOD CELL(S): Fobbing Marshes/South Benfleet	
FIGURES: Figure C4-8 Hazard Map of CAS08 (1 in 200 year), Figure C5-8 Hazard Map of CAS08 (1 in 1000 year)	
BACKGROUND	
OS Location: 579100, 185500	
DTM Generation: From LIDAR data	
Source of Flood Level Information: Thames 2100	
Defence Type: Hard Defence	
BREACH DETAILS	
Location: Benfleet Barrier	
Breach Width: 20m	
Base Level of Breach: -0.5mAOD	
Repair Time (hrs): 20	
RESULTS	
<p>Location of Main Flood Depth: The initial inundation occurs in the northern arm into Castle Point District covering Benfleet Marsh and the fringes of the residential land surrounding Benfleet Marsh. Maximum depths of up to 1.5m occur in public spaces at about 15 hours and 30 minutes. There is an initial peak and then floodwater depth reduces as flooding extends into the main marshlands to the west. Depths increase again on the second tidal cycle. Floodwater depths are also quite high to the south of the breach towards the A130. Water is prevented from flowing over the A130 towards Canvey Island by the defences set back from Benfleet Barrier.</p>	
Return Period:	1 in 200 Yr
Max Depth of Floodwater:	+2.5m
Location of Max Depth:	Watercourses in marshland
Time Max Depth first occurs:	2hrs 30 minutes
Hazard Zone Results:	
<p>1 in 200 Year event: The hazard map associated with this breach for the 1 in 200 year event shows the areas of high hazard are located to the west of the breach. The main arm of the flood hazard extends over marshland and farmland in the area known as Bowers Marshes to the west of East Haven Creek. A secondary arm of high hazard extends across Benfleet Marsh and towards Hope's Green. The high hazard zone in Benfleet Marsh and Hope's Green is surrounded by areas of medium and low hazard that extend over development that borders the Marsh, Playing field and Hope's Green. Scattered areas of low and medium hazard extend over the vacant area of land containing the Manor Way Track. Mixed high, medium and low hazard areas extend over the Pitsea Marsh Area north of the Manor Way Track.</p> <p>The sewage Works adjacent to Benfleet Marsh is shown to be outside the Hazard Zone resulting from this breach for the 1 in 200 year event.</p> <p>The A130 is shown to be in the high hazard zone as it crosses East Haven Creek and the B1014 is also shown to be in the high hazard zone as it crosses Benfleet Creek.</p> <p>1 in 1000 Year event: The main hazard zone covers a similar area to the 1 in 200 year event. In general the boundaries of the hazard zone extend only a little ways from the boundaries in</p>	

the 1 in 200 year event. The major difference between the hazard zone resulting from the two events is the extent of the high and medium hazard zones. The high hazard zone encompasses a large area of Pitsea Marsh and extends further into the middle of Bowers Marsh. There is little change in the hazard zones in the Benfleet Marsh arm of the hazard map.

RELEVANCE TO DEVELOPMENT

Flood hazard resulting from breach CAS08 covers an area that spans Castle Point and Basildon Council Areas. There is no development planned for areas of flood hazard within Basildon or Castle Point however this does not prevent ad hoc planning applications being received for redevelopment at individual properties.

The Northern arm of the hazard zone covers an area of existing residential and Public Open Space.

The requirements for documentation that must be submitted with planning applications within a hazard zone are given in the guidance contained in section 8.

This report shows the hazard zones resulting from a single breach. Breaches in other locations along the defences may result in different hazard zoning. This should be taken into account when determining whether a particular property is within the hazard zone. In addition to this, the hazard zone results for this study were produced at a regional scale not appropriate for assessment of whether individual properties on the edge of the zones are within a flood hazard zone or not. A precautionary approach is recommended when using the study results at the fringes of hazard zones.

From a purely flood risk point of view, further development within flood hazard zones should be discouraged however it may be preferable to the council to allow redevelopment on existing sites to avoid leaving properties derelict. If planning applications are received for these areas, the council could look upon it as an opportunity to reduce flood risk below existing levels by careful application of mitigation techniques.

The western and southern parts of the hazard zone are within the Basildon Council District, the land is variously zoned as SSSI, zone 3 flood liable land, county wildlife site, green belt and waste allocation area. These designations mean that it is highly unlikely that there will ever be any development within the Basildon part of the hazard zone.

Only small areas of developed land are inundated by the failure of Benfleet Barrier. Houses on the fringes of inundation would possibly have to evacuate to higher ground. Floodwater also cross the A130 north of East Haven Creek and therefore cut off a major access route to Canvey Island. The B1014 access road may also be in use during a barrier failure for equipment to repair the barrier, which would leave Canvey Island without a vehicle access point.

Access to the barrier is possible via the B1014 road from the north.

FLOOD RISK SOURCE: CAS09 – Failure of Vange Creek Barrier	
FLOOD RISK TYPE: TIDAL	
FLOOD CELL(S): Fobbing Marshes/South Benfleet	
FIGURES: Figure C4-9 Hazard Map of CAS09 (1 in 200 year), Figure C5-9 Hazard Map of CAS09 (1 in 1000 year)	
BACKGROUND	
OS Location: 574045, 184305	
DTM Generation: From LIDAR data	
Source of Flood Level Information: Thames 2100	
Defence Type: Hard Defence	
BREACH DETAILS	
Location: At Vange Creek Barrier.	
Breach Width: 20m	
Base Level of Breach: -3.9mAOD	
Repair Time (hrs): 20	
RESULTS	
Location of Main Flood Depth: Initial inundation at the first tide cycle is limited to creek line and a small area of land south of the railway line and the A13 that runs from Vange Wharf to Marsh Farm. The deepest inundation in this area is approximately 2m. At the second tide cycle, inundation spreads from the creek edges across the marshland of Pitsea, Fobbing, Vange and Bowers. The maximum extent of flooding occurs at the end of the model simulation with an average depth of approximately 0.3m. Minimal development is inundated as a result of the barrier failure.	
Return Period:	1 in 200 Yr
Max Depth of Floodwater:	+2.5m
Location of Max Depth:	Vange Creek
Time Max Depth first occurs:	2hrs
Hazard Zone Results:	
1 in 200 Year event: The hazard map associated with this breach for the 1 in 200 year event shows the areas of high hazard are located to the north of the breach and follow the general line of Vange Creek. Localised areas of High Hazard occur in Fobbing Marshes and Pitsea Marshes.	
1 in 1000 Year event: The 1 in 1000 year hazard zone follows the same pattern as the 1 in 200 year hazard zone with areas of high hazard concentrated around Vange Creek and its tributaries. The hazard zone extends further into Vange and Fobbing Marshes in the west and Bowers Marshes in the east. There are much larger areas of high hazard within the Vange, Fobbing and Pitsea marshes than for the 1 in 200 year event and the remaining marsh area for these three marshes is predominantly within the medium hazard zone. Bowers Marshes remain mostly within the low hazard zone.	
RELEVANCE TO DEVELOPMENT	
The only planned development in the flood cell includes a slight extension of the industrial area within the Thurrock District, extending north of the existing industrial areas (e.g. oil refinery and fuel depot). This area is outside the flood hazard zone resulting from this breach. The remaining areas of the Thurrock district are allocated as landscaping and natural areas (Fobbing Marshes).	

The parts of the hazard zone within the Basildon Council District, is variously zoned as zone 3 flood liable land, county wildlife site, green belt and SSSI. These designations mean that it is highly unlikely that there will ever be any development within the Basildon part of the hazard zone.

No major access routes are affected by this breach although floodwaters come close to the southern side of the A130 and railway lines.

Access to the barrier failure point is possible via roads and tracks to the south of the barrier in Thurrock.

FLOOD RISK SOURCE: SOU05 – Old Leigh	
FLOOD RISK TYPE: TIDAL	
FLOOD CELL(S): Hadleigh Marsh	
FIGURES: Figure C4-10 Hazard Map of SOU05 (1 in 200 year), Figure C5-10 Hazard Map of SOU05 (1 in 1000 year)	
BACKGROUND	
OS Location: 584200, 185600	
DTM Generation: From LIDAR data	
Source of Flood Level Information: Thames 2100	
Defence Type: Earth Embankment	
BREACH DETAILS	
Location: At the far eastern limit of the Hadleigh Marsh flood cell, south of Leigh-on-Sea Railway Station.	
Breach Width: 60m	
Base Level of Breach: 3.2mAOD	
Repair Time (hrs): 30	
RESULTS	
<p>Location of Main Flood Depth: The main inundation zone covers the majority of Hadleigh Marsh, bordered by the watercourse that runs adjacent to Benfleet Creek and that separates Hadleigh Marsh from Two Tree Island. There is an area outside of the inundation zone in the east of the flood cell and to the west of the breach location, bordered by the small road, car park and golf driving range. The rail track to the north of Hadleigh Marsh forms a barrier, preventing northerly migration of flooding. However, some floodwater does cover the eastern portion of the rail track.</p> <p>The average depth across the hazard zone is approximately 0.6m in the 1 in200 year event.</p>	
Return Period:	1 in 200 Yr
Max Depth of Floodwater:	2-2.5m
Location of Max Depth:	Southern edge of flood cell
Time Max Depth first occurs:	28hrs 35mins
Hazard Zone Results:	
<p>1 in 200 Year event: The majority of the flood cell is the medium flood hazard zone that results from breach SOU05. The seaward side of the flood cell is bordered by a strip of high hazard and the landward side by a strip of low hazard. The golf driving range and the playing fields are shown to be outside the hazard zone however a strip of high hazard cuts runs behind this land cutting it off from the mainland.</p> <p>1 in 1000 Year event: The extent of inundation changes little compared to the 1 in 200 year event however the high hazard zone extends over most of the flood cell. At the western end of the flood cell the medium hazard zone crosses over the railway. In the eastern end of the flood cell areas of low and medium hazard are shown on the Golf Driving Range and the Playing field although small pieces of land in this area remain flood free.</p>	
RELEVANCE TO DEVELOPMENT	
Development within the flood cell is limited to a railway station, playing fields, car park and golf	

driving range.

There is no development planned within the hazard zone. The land within the hazard zone is variously zoned as green belt, Coastal Protection Belt, SSSI, public open space and Hadleigh Marshes Special Landscape. Sections of the hazard zone are proposed as extensions to Hadleigh Castle Country Park. Given these land designations it is highly unlikely that there will ever be pressure for development within the hazard zone. Any development proposed would increase the flood risk within this flood cell.

Any proposed development within the hazard zone requires additional documentation such as a flood risk assessment. The requirements for documentation that must be submitted with planning applications within a hazard zone are given in the guidance contained in section 8.

Access to the breach for repair is possible via the access road from Belton Gardens.

4 FLOOD MAPPING AND APPLICATION

4.1 Introduction

The following section is intended for use in conjunction with the flood zone and hazard zone mapping presented in the SFRA (Chapters 7 and 8) and Appendices B-F of this report. Planning guidance indicating what type of development is likely to be appropriate in which flood zones is presented for both PPG25 (DTLR, 2001) and table D2 of the Draft PPS25 (ODPM, 2005). These tables can then be viewed in conjunction with the hazard zone mapping for specific areas to inform planning decisions and enable the LPA to go beyond the sequential test for planning or control of development within Flood Zones 2 and 3.

4.2 Flood Mapping

The strategic flood risk mapping of South Essex and the preparation of hazard maps for 14 flood cells, has been primarily based on the results of the breach modelling, carried out specifically for the purposes of this study. In addition to the PPG25 flood zone maps produced by the EA, and the breach modelling within this study (see Appendices B-F), the authorities within Thames Gateway South Essex were keen to see a breakdown of Zone 3 into High, Medium and Low hazard to facilitate land allocation and assist in the local development framework production for these areas.

The depths for each hazard zone were selected subjectively in the context that they represent the risk to someone caught in floodwater, required to move a distance to safety. Other considerations in definitions of depth include range of heights and weights, people having to care for young children, the elderly, restricted movement and debris. The classification is however necessarily subjective in these respects.

The maps have been presented on an individual flood cell basis, and present a combined output of the breach model results within that flood cell (for individual breach model results refer to the DVD supplied in Chapter 11). Outside the boundary of the presented flood cell the modelling results are not displayed. To see a particular area's hazard map please refer to the relevant flood cell. The mapping does not include any flood or hazard mapping for the Kent area, for this information refer to the relevant Kent Thameside SFRA.

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

- Not all possible breach locations in any given authority area have been considered. Necessarily, the modelling study had to be limited to those locations thought most likely to lead to flood risk for specific development areas.
- Breach width and depth, though based on 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.

4.3 Hazard Zones

To facilitate detailed spatial planning, including site allocations, an in-depth assessment of flood risk in South Essex is required, taking into account the existing flood defences and including a more detailed consequence 'hazard' map for Flood Zones 2 and 3.

Hazard mapping presents the results of breach modelling within each flood cell of South Essex as defined in Table 7-1 of the main SFRA, the graph in Figure 4-3 shows the breakdown of Hazard Zones. These hazard maps enable a further breakdown of the EA flood Zone 3 into Low, Medium and High Hazard, using a consequence and risk methodology detailed in Chapter 7.

4.4 Suggested Application of the Sequential Test in South Essex

With the production of the Hazard Maps, the particular flood risk status of many areas within South Essex is recognised. Large areas of some authorities lie within Flood Zone 2 and 3 and thus, based upon the Sequential Test, are unsuitable for the majority of development types. However, such blighting is unacceptable in some key development areas, e.g. for socio-economic reasons, and the Hazard Zone system allows an appreciation of differing levels of hazard within the Sequential Test. The 'full' sequential test tailored for South Essex therefore becomes as shown in Figure 4-1.

The concept of the Sequential Test for South Essex relies on the user's understanding that when selecting a site for a given development type, or selecting from a range of development types for a specific location, the test must be followed in strict sequence.

Stage 1 of figure 4-1 represents the PPG25/PPS25 Sequential Test. Steps A to C are to be followed, with each, from a flood risk point of view, being less desirable than the previous for a given development type (i.e. Flood Zone 2 is less desirable than Flood Zone 1). In every movement sequentially through the steps, the user must be confident that no site of a lesser flood risk is appropriate for the specific development under consideration.

Stage 2 of Figure 4-2 represents the additional Hazard Zone test for South Essex. To move to Stage 2 the user must again be confident that no site of a lesser flood risk is appropriate for the specific development under consideration. As before, each step represents, from a flood risk point of view, a less desirable site than the previous step.

As can be seen from the above schematic, the interrogation of Hazard Zone information is a series of further steps beyond the usual procedure of applying the PPG25/PPS25 Sequential Test. It is intended that the Hazard Zones classification of low-medium-high remains subjective and is inherently relative to a specific site. A planning authority's decision to allocate development land within areas where Hazard Zone maps have been produced in this Strategic Flood Risk Assessment should examine all of 1) the vulnerability of the proposed development type to flooding, 2) the residual risk to the development and, 3) the options for management of residual risk.

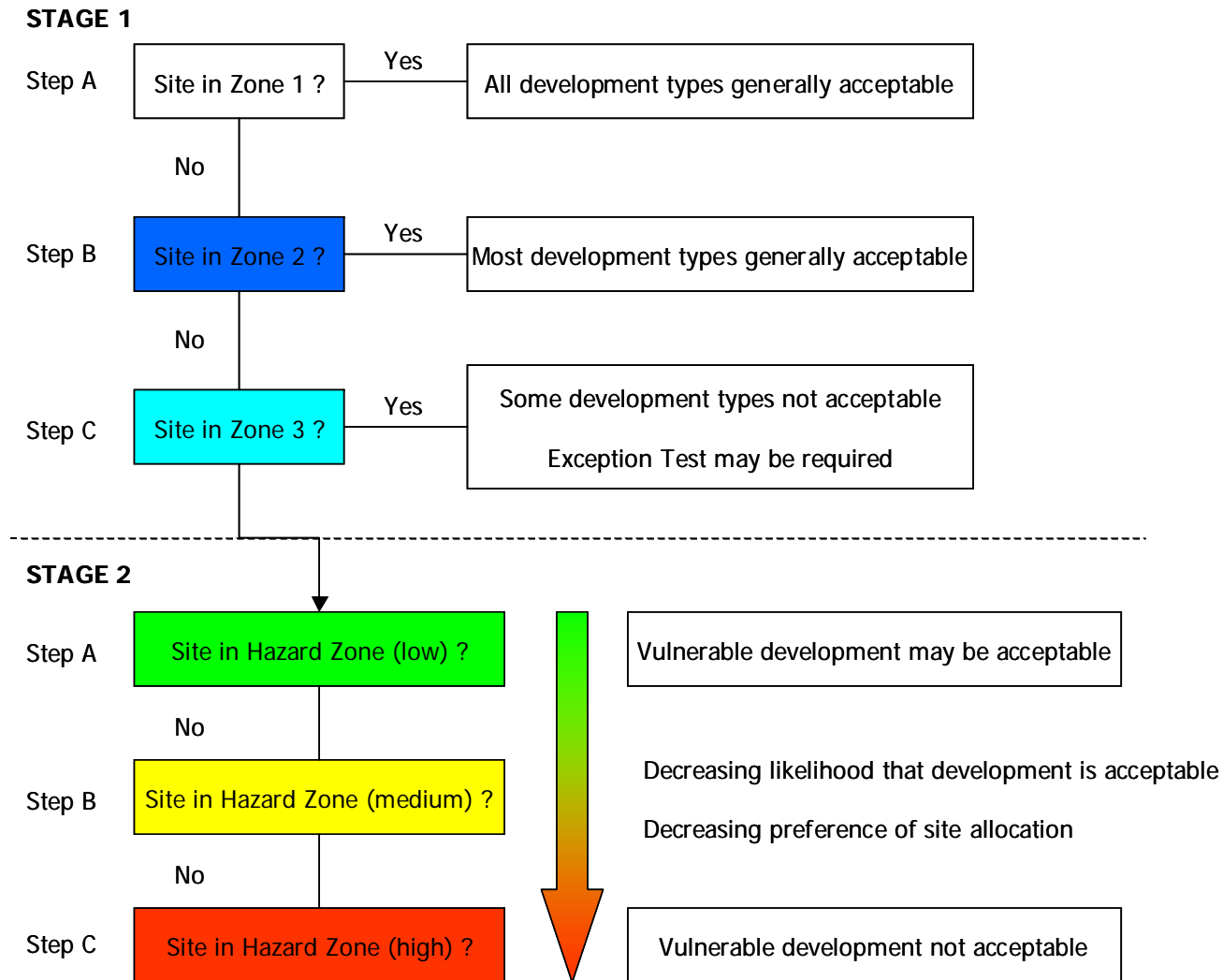


FIGURE 4-1 SUGGESTED STAGED SEQUENTIAL TEST FOR SOUTH ESSEX

4.5 Examples of Application

Application of the Sequential Test for South Essex is straightforward for those development proposals where site location is flexible and can be placed within a flood zone suitable for their intended use. Likewise, in an idealised situation, those areas highlighted by mapping as being of higher flood risk should be prioritised for non-sensitive use such as parks, playing fields etc, perhaps themselves providing part of local flood storage solutions or being integrated within the wider development goals of the region.

However, South Essex has many locations across all five of the authorities involved in this study, where flood risk cannot be avoided and locating development in Flood zone 2, or even 3, is necessary. For such cases, typical examples of application of Stage 2 of the Sequential Test for South Essex are provide below:

Example 1: New School, - no available locations within Flood Zone 1. The authority is required to locate this development within a specific population catchment area and is therefore constrained as to location. Application of the Sequential Test to the available sites finds that one site is in Flood Zone 2, the others in Flood Zone 3. The Flood Zone 2 site is preferred, flood mitigation considered and a Flood Risk Assessment prepared.

Example 2: New School – no available locations outside of Flood Zone 3. The authority is required to locate this development within a specific population catchment area and is therefore constrained as to location. Application of the Sequential Test to the available sites finds no site available outside of Flood Zone 3. The Exception Test (PPS25) is applied to justify location in Flood Zone 3. Various sites are considered and using the hazard zone maps the lowest hazard site is identified and selected. Flood mitigation and mitigation of residual risk (Flood warning, evacuation routes etc) are considered in a Flood Risk Assessment.

Example 3: Large Housing Development – proposed in Flood Zone 3 and high hazard zone. The authority considers alternative locations but no suitable location is available within Flood Zones 1 or 2 that also satisfies other planning objectives. The Exception Test is applied to justify location in Flood Zone 3. Review of the potential locations within Zone 3 using the hazard maps reveals a site in low hazard zone. This location is selected in preference to the high and medium hazard zone alternatives. Flood mitigation and mitigation of residual risk (Flood warning, no single-storey dwellings, raised finished floor levels etc) are considered in a Flood Risk Assessment.

Example 4: Large Housing Development – situation as example 3, above, but no alternative locations outside of Flood Zone 3, high hazard zone can be identified. The authority will require a full justification of the site selection, balancing flood risk and other planning objectives. If the need for the development is considered to outweigh flood risk issues then a detailed Flood Risk Assessment will be required, almost certainly including further site-specific flood modelling and mapping aimed at addressing residual risk concerns through comprehensive mitigation proposals.

A number of further considerations in addition to flood Hazard should be taken into account when allocating specific areas for development or placing one area ahead of another in terms of suitability for development. Potential evacuation routes, flood warning times and the time to peak flood hazard are some of the additional factors that should be taken into account. Further details are provided in Chapter 9.

4.6 Development 'Vulnerability'

Guidance regarding appropriate development in flood risk zones is provided in Table 1 of PPG25 and additional advice is given in the Flood Risk Matrix published by the Environment Agency. PPG25 is due to be replaced by PPS25 in autumn of 2006. At that time the guidance contained in

section 6.3 will supersede the guidance given in this section, however at the development control level the requirements for flood Risk Assessments will remain similar.

At the time of writing PPS25 was only available in Draft form however it is due for final publication in Autumn 2006. Guidance in relation to appropriate types of development in Flood Risk Zones is provided in Table D2 of Draft PPS25. Development types are grouped according to their vulnerability to flooding. It is vulnerability information such as this, which it is suggested is assessed with reference to Hazard Zones.

Definition of hazard zones

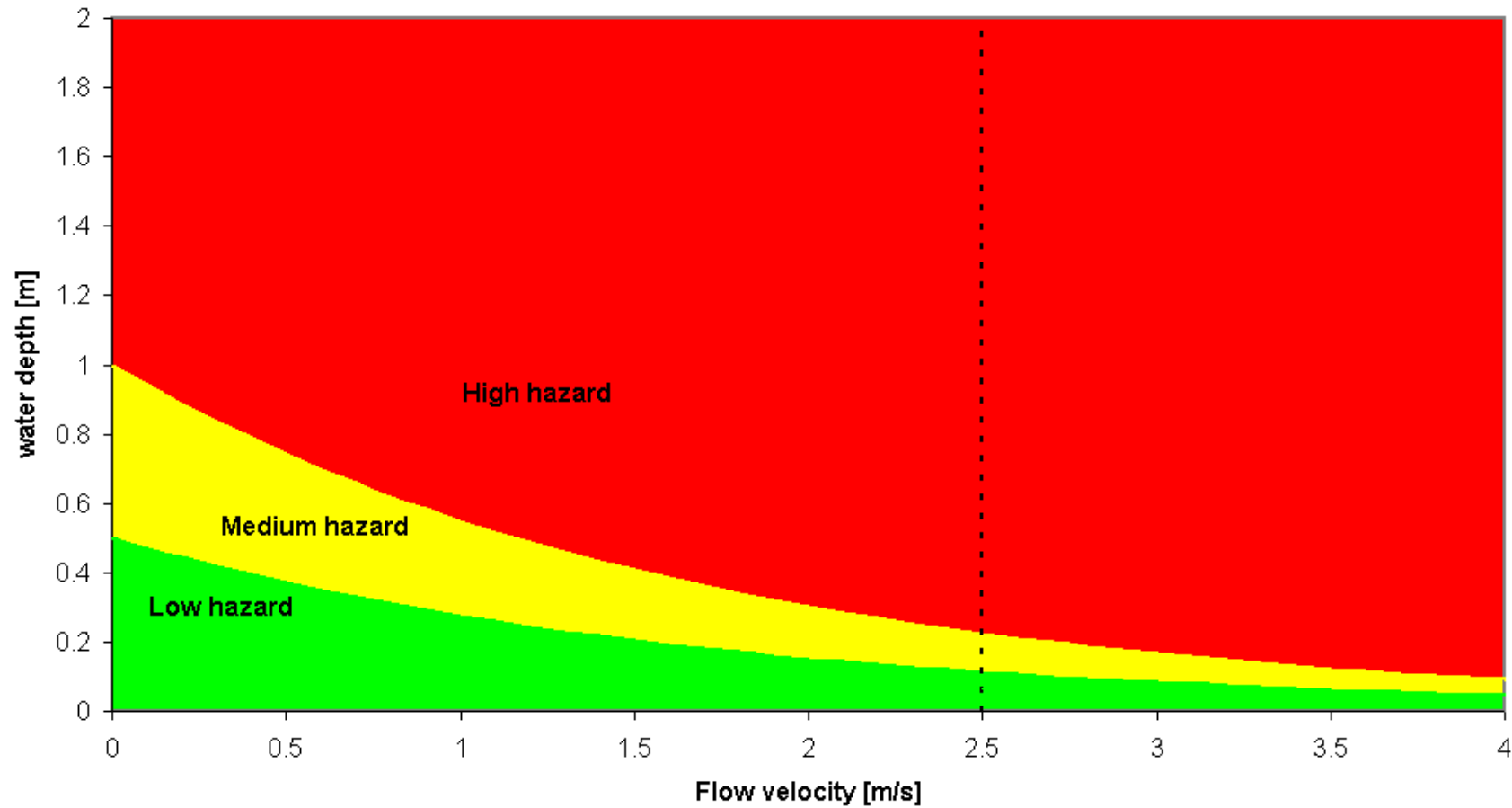


FIGURE 4-2 DEFINITIONS OF HAZARD ZONES

5 SPECIFIC AREA RECOMMENDATIONS

5.1 Introduction

Castle Point Borough Council contains several areas of low-lying land that would be inundated in the event of a breach in flood defences. The most significant of these areas is Canvey Island, which is intensively developed, and largely below high tide level. In addition to Canvey Island, the area of parkland at Hadleigh Marsh, small area of Benfleet Marsh and some surrounding development would be inundated in a flood event.

Given the highly developed nature of Canvey Island, the consequences of a flood event in terms of risk to life and property are extensive. The borough has plans to redevelop some sections of land on Canvey Island for uses that may be considered more flood sensitive than at present. Given that the majority of Canvey Island relies on the integrity of its sea defences for flood protection and a breach could generate significant inundation in a short space of time, security of access to Canvey Island is an important part of strategic flood risk planning for Canvey Island. This section addresses the specific points that have been shown to be at risk in the study and some of the issues that may face the Council as a result.

5.2 General

From a flood risk perspective, further development within flood hazard zones should be discouraged however it may be preferable to the council to allow redevelopment on existing sites to avoid leaving properties derelict. Where planning applications are received for redevelopment within an area of existing development, the council could look upon it as an opportunity to reduce flood risk below existing levels by careful application of mitigation techniques.

Applications for certain types of redevelopment within the hazard zone will be objected to by the Environment Agency. The Guidance provided in Section 8 of the SFRA gives more details of which types of redevelopment are more appropriate than others.

5.3 Proposed Development Areas

The following table (Table 5.1) summarises the flood zone and hazard categories for proposed development allocations within the Castle Point District. Information is presented for the 1 in 200 year event including climate change i.e. the flood zone and hazard category for a 50-year design horizon. Information was collated from the Castle Point Adopted Local Plan, Nov 1998.

In addition to the Local Plan the council has recently produced a Key Issues and Options Report. This document was produced for public consultation through January and February of 2006. Three strategic options are presented in the report for future development in Castle Point. The options presented are as follows:

Option 1 – Intensification of the Urban Area.

All new development including employment and residential would take place within the existing urban area. There would be no new land take from green belt areas however roading and infrastructure to existing areas would need to be improved.

Option 2 – Reallocation of Business Land and use of Urban Periphery Green Belt

Redevelopment of employment land for housing and allocation of some green belt land for employment.

Option 3 – Large Urban Extension with New Infrastructure

Allow Ad hoc development in existing urban sites. Additional housing and employment land will be provided by a single large reallocation of green belt land.

Any new development will have some effect on flooding in the district. A major consideration in the case of fluvial flooding is that increased land take will cause increased runoff unless SUDS measures are put in place. SUDS drainage is not possible on Canvey Island because of its low-lying topography. Redevelopment of existing brown field or hard standing sites will in general have a neutral impact on surface water runoff.

In the case of tidal flooding, increased development within defended areas increases the residual risk to life and property from a flood event therefore increased care and attention will need to be paid to the maintenance of defences, access and egress from the Island and flood compatibility of buildings.

TABLE 5.1. PLANNED HOUSING DEVELOPMENT IN CASTLE POINT

Location	Proposed Development Type	Size/No. of Dwellings	Flood Zone	Hazard Category
Point Road, Canvey Island	Residential - proposed	50 dwellings	3	Med-high
203 - 223 London Road, Thundersley	Residential - proposed	Data not available	1	-
Thorney Bay Holiday Camp	Long term housing site	Data not available	3	High
South of Thorney Bay, Canvey Island	Residential - proposed	Data not available	3	Med-high
Land south of the Chase and east of Wensley Road	Long-Term Residential proposal	Data not available	1	-
Land south of Scrub Lane	Long-Term Residential proposal	Data not available	1	-

Reference : Adopted Local Plan, Nov 1998

5.4 Security of Access During a Flood Event

Animations of hydraulic model runs were used to determine the approximate time lapse between the range of breach events modelled and inundation of major access roads to and from the island. Table 4.2 shows the modelling results. The two access roads that were considered in this analysis are the A130 from the mainland to the junction with Furtherwick Road and the B1014 from the mainland to Point Road.

5.4.1 Depth of Inundation

Spot heights of the A130 and the B1014 taken from LIDAR data indicate that road levels on the Island north of the main roundabout onto the Island vary between 1.8m AOD to 5.9m AOD. South of the main roundabout, main road levels appear to fluctuate between 1.6m and 3.3m AOD. The high tide levels for breaches on Canvey Island are 4.9-5.0m for the 1 in 200 year event and 5.3-5.4m for the 1 in 200 year event after 50 years of climate change.

Given the difference in levels between the current access roads and the 1 in 200 year event it is easy to see that it is extremely likely access to and from the Island as well as within the island would be inundated and impassable during a flood event. The modelling assumes that hard defences such as those that protect Canvey Island are repaired by 20 hours after the breach. This limits the volume of water that inundates the island. It is possible that water depths could be greater if it were to take longer to repair a breach.

The assessment of security of access to the Island could be further refined by undertaking a comprehensive topographic survey of the A130 and the B1014. This would then be incorporated into the hydraulic model results to provide a more accurate assessment of the depth of inundation across access roads.

5.4.2 Time to Inundation

The results show that for many breaches there is less than 3 hours from the start of the tidal cycle and i.e. the start of the simulation and the first inundation of an access road. If a breach occurred suddenly at the peak of an extreme event, this time could be even further reduced. The time taken for the A130 to become impassable on Canvey Island is less than 10 hours for all breaches of the island sea defences. In the case of a failure of Benfleet Barrier, the B1014 is inundated very quickly and the A130 becomes impassable less than one and a half hours after the failure of the barrier.

For breaches at the eastern end of the island, although the B1014 or the A130 may be inundated very shortly after the breach event, western parts of the island would still have access to the mainland for several hours. For breaches in the western half of the island the first inundation of the A130 or the B1014 effectively blocks that route off the island for all traffic to the east. For some breaches access to and from the island is blocked very shortly after the breach however it takes more time for developed areas further away from the breach to become inundated and some areas remain flood free.

A threshold of 0.3m was used as the level at which roads become impassable. This is a conservative approach based on research showing that people can lose stability at depths as low as 0.25m in fast flowing water with velocities of greater than 2m/s and vehicles can become buoyant at depths greater than 0.3m even in slow flowing water.

TABLE 5.2. TIME TO INUNDATION FOR KEY ACCESS ROADS ON CANVEY ISLAND

Breach ID	Breach Name	Time to First inundation of B1014 (Hrs:Mins)	Time to first inundation of A130 (Hrs:Mins)	Time to inundation of A130 and B1014 Roundabout (Hrs:Mins)	Time to A130 road impassable (Hrs:Mins)	Time to B1014 road impassable (Hrs:Mins)
CAS01	Canvey Island 1	7:25	5:40	16:30	5:55	15:35
CAS02	Canvey Island 2	17:10	3:55	N/A	6:35	18:20
CAS03	Canvey Island 3	6:45	2:45	19:40	3:25	15:20
CAS04	Canvey Island 4	6:00	2:55	N/A	3:50	15:00
CAS05	Canvey Island 5	1:25	4:40	N/A	6:15	2:30
CAS06	Canvey Island 6	2:40	4:10	N/A	8:20	3:25
CAS07	Canvey Island 7	1:20	3:00	4:20	3:20	1:55
CAS08	Benfleet Marshes, Failure of Benfleet Barrier	Instant	0:40	N/A	1:25	Instant
CAS09	Failure of Vange Creek Barrier	N/A	N/A	N/A	N/A	N/A
SOU05	Old Leigh	N/A	N/A	N/A	N/A	N/A

5.4.3 Advanced Warning of Flood Events

Flood warnings are issued by the Environment Agency (EA). The EA informs the County Council and individual property owners who are connected to the EA's early warning telephone system. In the case of large flood events the police operate a public address system, warning sirens are sounded by Essex County Council and local radio stations broadcast information bulletins. When Essex County Council receives a flood warning from the EA they will make a decision about whether to activate the warning sirens and other general broadcasting systems.

The published standard for advanced warning of general flooding is 2 hours however the EA aim to give 11 hours warning of tidal flood events. In the case of an extreme tidal flood event such as the 1 in 200 year or the 1 in 1000-year event it is likely that the EA would provide advanced warning earlier than this to enable more comprehensive preparation.

In the event of an emergency, Castle Point Borough Council have a Emergency Plan (Castle Point Borough Council Emergency Plan 1998, Castle Point Borough Council, 1998) which outlines the roles and responsibilities of organisations and individuals in the event of an emergency. In the event of an emergency the Environmental Services Directorate of the Essex County Council can implement the Passenger transport plan for emergencies. This utilises mostly buses and coaches to move people away from affected areas.

5.5 Drainage Areas

Drainage Areas for pumping stations in Canvey Island have been mapped and are shown in Figure C8-1.

Initially the information provided by the Castle Point Council along with information from the Environment Agency regarding main watercourses was digitised. Both sets of information could then be presented on a single map. This information was then used along with a review of available drainage study reports and Anglian Water asset maps to derive an estimate of catchment boundaries for Canvey Island.

There is insufficient topographical relief to enable the use of LIDAR to map catchment boundaries. The density of development on the Island further compounded the difficulties in using LIDAR. A walk over survey was conducted however this was not of assistance in defining catchment boundaries largely due to encountering the same problems as with the LIDAR data.

Boundaries were roughly defined by reference to watercourses and using the limited topographical information that was available. Surface water drainage records for Anglian water were then used to refine these boundaries. In general surface water drainage boundaries followed natural catchment boundaries except in some cases where a development area appears to be designed for runoff to flow into a single watercourse instead of splitting flows across two watercourses. Figure C8-1 shows the catchment boundaries along with the Environment Agency Pumping Stations and Anglian Water Pumping Stations on Canvey Island.

ANNEX A-

CANVEY ISLAND PROBABILITY REPORT: CONSIDERATIONS OF DIFFERENT CAUSES OF A BREACH EVENT

Thames Gateway South Essex

Strategic Flood Risk Assessment

CANVEY ISLAND PROBABILITY REPORT: CONSIDERATIONS OF DIFFERENT CAUSES OF A BREACH EVENT

D111658
Project Manager: Jon Robinson

October 2006
Collated and edited by: Peter Stebbings

Reviewed by: Jon Robinson

Approved by: David Dales

Disclaimer

This document has been prepared in accordance with the scope of Scott Wilson's appointment with its client and is subject to the terms of that appointment. It is addressed to and for the sole use and reliance of Scott Wilson's client. Scott Wilson accepts no liability for any use of this document other than by its client and only for the purposes, stated in the document, for which it was prepared and provided. No person other than the client may copy (in whole or in part) use or rely on the contents of this document, without the prior written permission of the Company Secretary of Scott Wilson Ltd. Any advice, opinions, or recommendations within this document should be read and relied upon only in the context of the document as a whole. The contents of this document are not to be construed as providing legal, business or tax advice or opinion.
© Scott Wilson Group plc 2006

Prepared for:
Castle Point Borough Council

Prepared by:
Scott Wilson Ltd
Scott House
Basing View
Basingstoke
RG21 4JG

Tel: + 44 (0)1256 310200
Fax: + 44 (0)1256 310201

www.scottwilson.com

INTRODUCTION

Castle Point Borough Council have expressed concern regarding the increase in shipping traffic due to developments such as Thames Gateway Port on the Thames and the probability of damage to the sea defence of Canvey Island and South Benfleet.

This section of the SFRA addresses those concerns and considers: -

1. Breach caused by tanker / freighter collision with a tidal wall;
2. Breach caused by a floating object such as a partly submerged container;
3. Breach caused by damage to a pipeline running through a tidal wall;
4. Breach caused by damage or explosion of an installation on the landward side of the tidal wall; and
5. Other potential sources of damage leading to a breach.

BASIC SHIPPING TRAFFIC CONSIDERATIONS

All commercial traffic contained in vessels over 40 metres in length and also all passenger carrying vessels are required by law to report their position and speed at certain points on the River Thames and also to take directions from the Port of London Authority Traffic Control.

The whole of the River Thames is under radar surveillance. The shipping is thus well controlled and managed 24 hours a day seven days a week. In addition, the Port of London Authority has a Safety Management System, which is designed to ensure the orderly and safe passage of all craft using the River Thames.

All vessel movements are monitored continuously and the radar operators would be immediately alerted to any out of course movement of vessels either by direct report contact with the vessel or the identification of out of course movement from the radar surveillance.

The risk of collision or potential collision between vessels and between vessels and the fixed structures on both sides of the River Thames is thus reduced.

The greatest risk to the tidal walls is when the sea defences are resisting the forces from the extreme water levels caused by High Spring Tides and Surge.

The foreshore, immediately in front of the tidal walls, varies in height around Canvey Island with the lowest alongside elevation being approximately 1.6 metres above chart datum and the highest +4 metres above chart datum.

The tidal height at Canvey Island is approximately 6 metres above chart datum so that any approaching vessel would have to have a shallow draft of less than 4 metres in order to not run around before approaching the seaward slopes of the tidal defences even at surge and high spring tide water levels.

Reference to the Fairplay Lloyds Shipping Register show that there are only approximately 1500 vessels world wide that have a draught of less than 4 metres out of a world fleet of 56,000 vessels registered.

The bulk of shipping in the Thames Estuary is carried in vessels with a draught far exceeding the 4 metres. Even the Short Sea and Coastal Shipping vessels now exceed this draught.

Should a vessel of this shallow draught (less than 4 metres) or a length less than 40 metres deviate from the navigation channels and head towards a tidal wall, the vessel would not strike the structure of the flood defence, but ground short of the crest structure when the elevation of the sea bed is higher than the water level minus the draught of the vessel.

The sea defences around Canvey Island are typically of bund construction topped by a tidal wall. Any errant vessel, even with a shallow draught, would impact on the outer extremities of the bund slope.

No significant damage or reduction in the performance of a Flood Defence, so attacked, is foreseeable.

The probability of a breach being caused by a tanker / freighter is so small as to be negligible on Canvey Island.

The Benfleet foreshore is not used by commercial traffic due to its shallow depth. Therefore no tanker / container vessel impact could take place.

FLOATING OBJECTS OTHER THAN VESSELS

Objects other than vessels which float can, during extreme water levels, reach the crest of any flood defence. Any potential damage would be caused by water induced movements of the object causing repeated impact on the sea defence.

The foreshore run up in front of the sea defences of Canvey Island is shallow as is the foreshore run up to Benfleet on both the mainland and island shores.

It follows that for any object to reach the crest it must be of shallow draft and as a consequence of little mass. This being so, the damage that can be caused to the sea defence would not be sufficient to cause a breach in the tidal wall.

The probability of a breach being caused by a floating object is negligible for any tidal wall.

PIPELINES RUNNING THROUGH TIDAL WALLS

The only pipes that are permitted through the tidal walls are surface water outfalls. These are traditionally either concrete or cast iron with a tidal flap on the seaward side.

Damage could be inflicted by either a floating object of some weight such as a partially submerged container or a pleasure vessel such as a converted fishing vessel, which would have some mass. The damage envisaged would be such as to fracture the exposed pipe, but this would be no worse than a malfunctioning tidal flap.

No breach could be caused by damage to a pipeline running through a tidal wall, but local flooding could take place by back flow through the outfall pipe causing localised damage.

EXPLOSION OF LANDSIDE INSTALLATIONS

There are a number of petrochemical installations on Canvey Island and there is a possibility of an explosion occurring during their lifetime.

The severity of such an explosion is beyond the experience of the author for quantitative assessment. However, any blast produced by such an explosion would be baffled by the containment bunds and then be deflected upwards by the slope of the 'ramp up' on the shoreside of the sea defences of Canvey Island. Again the inherent mass of the tidal walls makes their chance of survival in the path of a blast from explosion considerable.

It is not probable that the tidal walls could be damaged by any foreseeable explosion within the petrochemical installations on Canvey Island.

OTHER POTENTIAL SOURCES

So far, the only unnamed source of damage that could occur is impact from an Airbus A380 or Boeing 747 large aircraft. The Airbus A380 has an all up weight of approximately 560 tons and impact speeds would be in the order of 400 knots taking into account likely flight paths and routes.

The air space above Canvey Island is used by approaching / departing aircraft from both Heathrow and Stanstead, depending upon the wind direction. In addition, over flight of this air space by corridor traffic from the North of England and the West of England is also undertaken from time to time. Any pure impact is likely to cause significant damage such as craters etc in the crest, but explosion on impact could have more severe consequences.

It is considered that the most severe damage likely to cause a breach of the tidal walls is that of explosion on impact of an Airbus A380 or to a lesser extent a Boeing 747 aircraft. The probability of such an impact occurring at a tide height or on a rising tide in advance of a surge event is, however, so small as to be considered negligible.