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Medway Strategic Flood Risk Assessment

Main Report

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Main Report

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List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

Glossary and Abbreviations

SFRA	Strategic Flood Risk Assessment
The Council	Medway Council
The Agency	The Environment Agency
SuDS	Sustainable Drainage Systems
IDB	Internal Drainage Board
FRA	Flood Risk Assessment
LPA	Local Planning Authority - The local authority or council that is empowered by law to exercise planning functions.
UKCIP	United Kingdom Climate Impacts Programme
DTLR	Department for Transport Local Government and the Regions
DEFRA	Department for Environment Food and Rural Affairs
FZMs	National Flood Zone Maps (FZMs). Maps produced by the Environment Agency to identify planning zones in accordance with PPG25. Distributed to councils, these maps ignore all flood defences and are used in the first instance to consider whether the Environment Agency should be consulted on a particular planning application because of the risk of fluvial or coastal flooding.
IFM's	Indicative Floodplain Maps (IFMs). These maps have been superseded by the FZM's and are no longer in circulation.
Flood Map	Available on the Environment Agency website, this mapping shows the fluvial and coastal flood extent boundary. In some specific areas this mapping does take account of existing flood defences e.g. those around Greater London.
LiDAR	Light Detection and Ranging - this is an airborne mapping technique which uses a laser to measure the distance between the aircraft and the ground.
Freeboard	The vertical distance between the expected river still water level for a particular return period event, and the crest level of the defence.
Tide-locked drainage	A surface water drainage system with constrained discharge during periods of high tide because of the submergence of the outfall.

1 Introduction

1.1 Purpose of this Document

This report presents the findings of the Strategic Flood Risk Assessment (SFRA) carried out by Mott MacDonald for Medway Council (the Council).

The guidance provided by the Environment Agency (the Agency) to Local Planning Authorities for Strategic Flood Risk Assessments sets out the purpose of such assessments as:

> *"To identify the areas within a development plan that are at risk of flooding. To identify and detail those factors that are relevant to current and future flood risks and to outline polices to be applied to such areas to minimise and manage that risk."*

In addition, the SFRA has specific objectives, to:

- provide a detailed and robust assessment of the extent and nature of the risk of flooding in the areas likely to accommodate significant growth in the next plan period.
- ensure the Council meets its obligations under the Planning Policy Guidance Note 25: Development and Flood Risk (PPG25).

The SFRA further provides the Council with the necessary data to undertake the sequential test described in PPG 25 and to identify development opportunities on that basis. It is, however, recognised that there are relatively few opportunities in Medway for major development on land that is outside the high-risk flood zone. Where such opportunities do exist these sites should be pursued first. The SFRA ranks those sites within the high risk areas and preference should be given to the lowest risk sites.

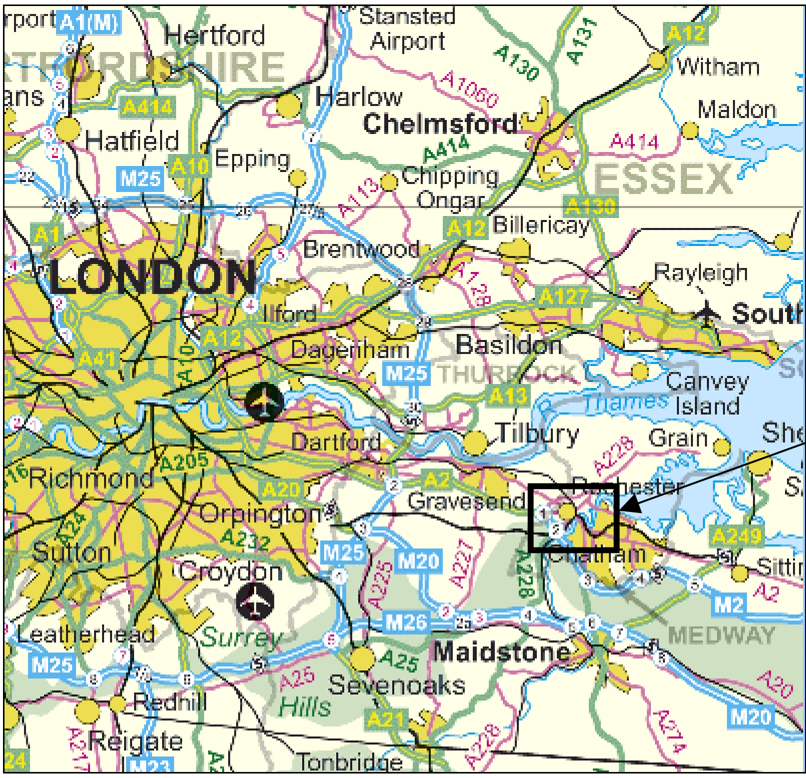
Data used in the study has been collected on the basis of best available within the timescale available. It is inevitable that the outputs from a study such as this will require updating as additional and more accurate data becomes available.

1.2 The Medway District

The Medway Council district lies some 50 km south-east of London, see Figure 1.1 overleaf, and comprises the towns of Strood, Rochester, Chatham, Gillingham and Rainham together with more rural areas, including the Hoo Peninsula. The district covers an area of some 220 km^2 with ground levels ranging from around 200 m AoD in the south to just above sea level along the River Medway frontage.

The district contains the lower reaches of the River Medway, from which the area is named. The river flows for a total of some 112 km (70 miles); rising in Sussex and meeting the North Sea at Sheerness. The lower reaches of the river have a naval history going back to the 15th Century and, although there is now no naval presence at Rochester or Chatham, the lower Medway is still busy commercially.

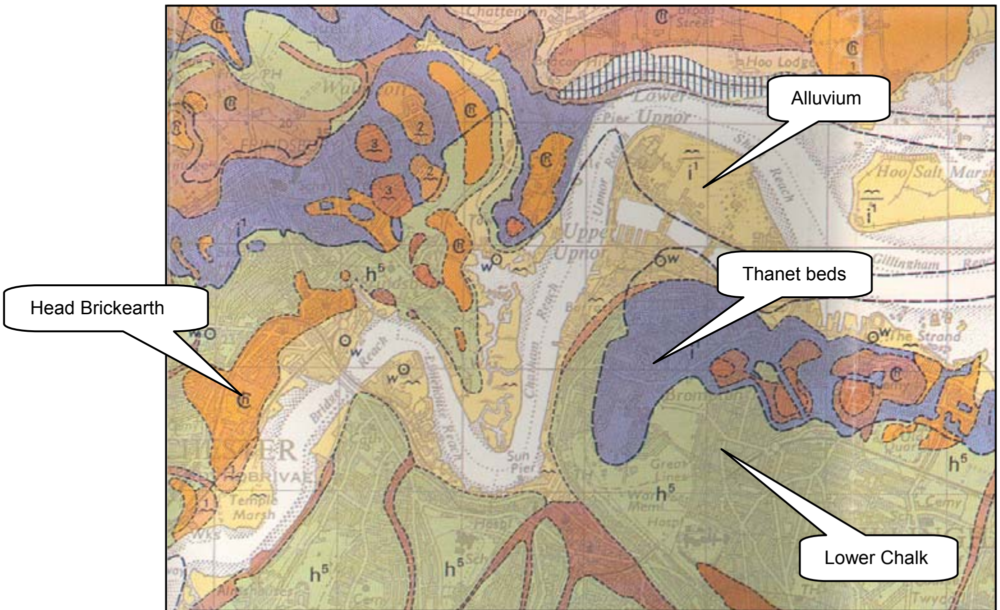
Figure 1.1: Medway Location Plan



Medway Council district, see Figure 1.2 for geological details.

The geology of the area is dominated by the London Basin chalks. Immediately bordering the River Medway the chalk is overlain by river alluvium with occasional pockets of terrace gravels. An extract from the British Geological Survey Map of the area is presented in Figure 1.2.

Figure 1.2: Geology of the Medway District



Medway is recognised by Government as part of the Thames Gateway and is striving to become the centre for learning, culture, tourism and high technology within the Gateway. The population of 250,000 is set to grow to 300,000 in the next 20 years and there is an ambitious regeneration programme which is deemed fundamental for growth, change and reconnection to the river. This programme will see the redevelopment of brownfield sites to deliver the required expansion of housing and employment facilities.

As part of this redevelopment initiative Medway Council has been instrumental in preparing the Medway Waterfront Renaissance Strategy, which sets out a development approach for the waterfront area of the district for the next 20 years. The Waterfront consists of over 900 hectares of brownfield land across 15 sites along 11 km of the River Medway. These principal development areas are shown in Figure 1.3 overleaf, and listed in Table 1.1 below:

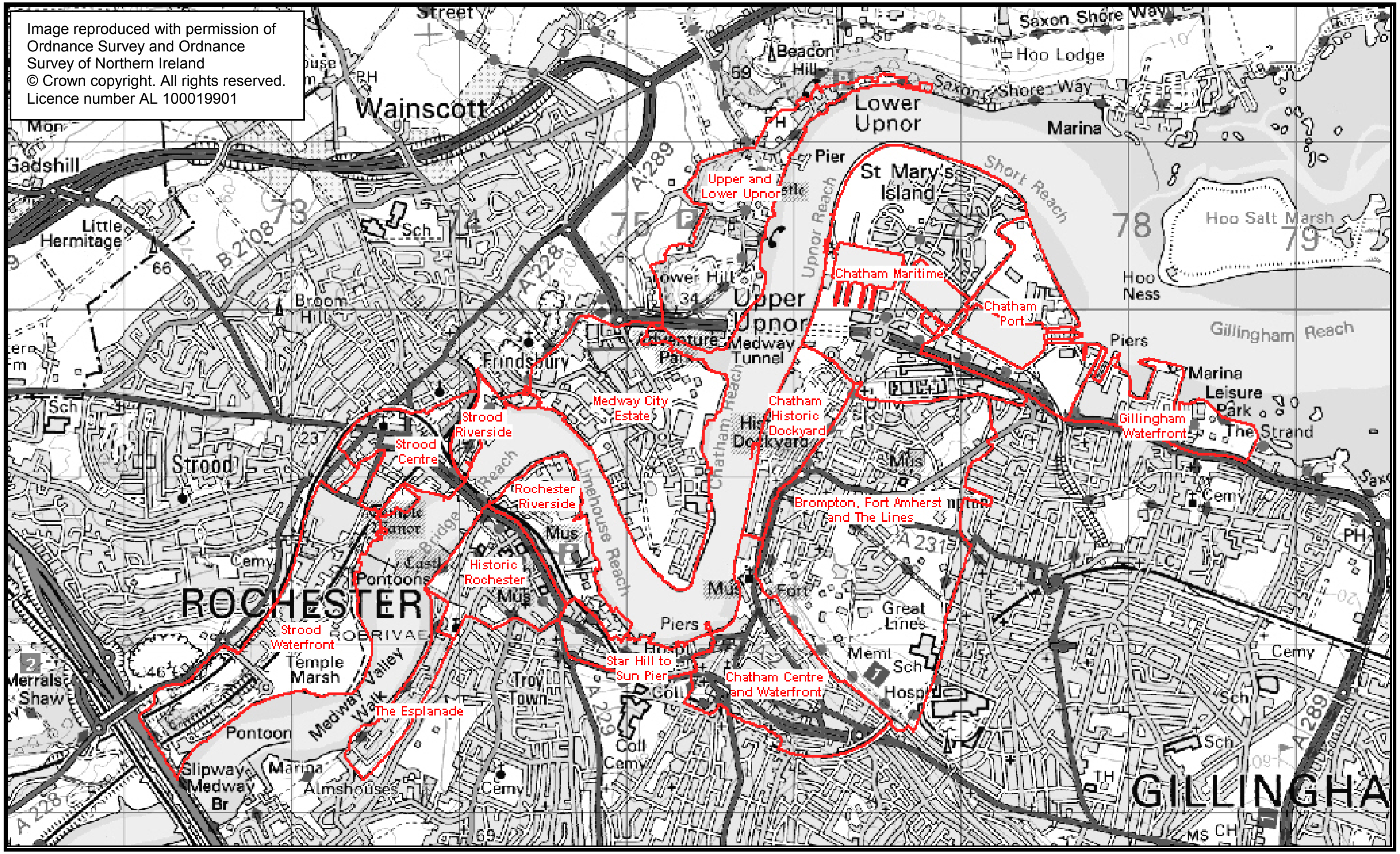
Table 1.1 Principal Development Areas

Ref	Principal Development Area
1.	Rochester Riverside
2.	Chatham Waterfront
3.	Star Hill to Sun Pier
4.	Historic Rochester
5.	Medway City Estate
6.	Brompton, Fort Amherst and The Lines
7.	Chatham Historic Dockyard
8.	Chatham Maritime and St Mary's Island
9.	The Upnors
10	Strood Riverside
11	Strood Centre
12.	Strood Waterfront
13.	The Esplanade
14.	Gillingham Waterfront
15.	Chatham Port

In addition to these areas, Medway Council has also identified a new settlement of approximately 5,000 houses for an area of Ministry of Defence land at Chattenden on the Hoo Peninsula.

It is these fifteen principal development areas and the new settlement at Chattenden that this SFRA has been tasked with considering.

Figure 1.3: Medway Principal Development Area Locations



1.3 Historic Flooding

There has been a long history of flooding within the Thames and Medway Estuary the most significant of which, in modern times at least, was the East Coast Flooding in 1953. 300 people lost their lives in these floods and historical information from the Agency indicates that the Medway area was subject to low level tidal flooding during this event with levels at the A2 Rochester Bridge reaching 4.85m above Ordnance Datum (AOD).

Information obtained from water levels recorded at the same location indicate that flooding events also occurred in 1927 (3.92 m AoD), 1949 (4.54 m AoD), 1960 (3.80 m AoD), 1965 (4.60 m AoD) and 1978 (4.51 m AoD).

Most recently, on 16 December 2005, a tidal surge caused low level flooding of Strood with Cuxton Marina, Janes Creek and Canal Road affected by inundation. Recorded river levels at Strood pier (some 200m downstream of the A2 bridge) peaked at 4.22 m AoD.

1.4 Scope of the SFRA

It is recognised that this SFRA is being carried out at a time when a number of other flood risk products are under development. In October 2004, the Environment Agency replaced its Indicative Flood Map (IFM), which had been in use for the previous five years, with a range of new products covering England and Wales. Of these products the Flood Zone Maps are of particular relevance to the SFRA work, since they show flood risk in terms of the PPG 25 Zones, as defined in Section 2 below. The Agency first issued the Flood Zone Maps to Local Planning Authorities on 29 June 2004.

The principal difference between the Agency Flood Zone Maps and the SFRA maps is that the former do not take account of flood defences, whereas for the SFRA the effect of defences is specifically included. As a result the SFRA maps identify the functional floodplain on modelled main rivers.

In addition, there will be some differences arising from the different methodologies used to derive the zone boundaries. The SFRA has used results from detailed hydrological and 2-D hydraulic modelling of the River Medway to obtain flood levels, and has combined this with ground level information which is predominantly sourced from LiDAR techniques giving a vertical accuracy of +/- 15cm. For the Agency Flood Zone maps, the basic zoning has been based on a relatively coarse national hydrological model combined with a new national Digital Terrain Model sourced from Interferometric Synthetic Aperture Radar (IFSAR) techniques, giving a vertical accuracy of +/- 50cm.

The SFRA outputs should be used in conjunction with the Flood Zone Maps, given that the Flood Zone maps include floodplain assessment on watercourses not covered by the SFRA. The Flood Zone Maps are intended for planning consultation purposes only, and these remain the main public dataset. Note that future versions of the Flood Zone Maps will include the locations of some defences and areas that benefit from new/high standard flood defences, when each has been thoroughly assessed.

In addition to the changes in flood risk products outlined above, the Government has now decided to replace PPG 25 with Planning Policy Statement 25 (PPS 25). The consultation draft of PPS 25 was published in December 2005. Although the content of the draft PPS 25 is broadly similar to PPG 25, albeit with a stronger and clearer requirement for Flood Risk Assessments, a detailed assessment of the differences has been postponed until the final version of the Statement is published later in 2006.

1.5 How to Use the Document

This guidance document is divided into five parts:

Chapter 1:	Introduction
Chapter 2:	Flood Risk
Chapter 3:	Planning Principles and Policy of Medway Council
Chapter 4:	Technical Considerations
Chapter 5	SFRA Mapping
Chapter 6	Results and Recommendations of the SFRA
Appendices	Site Specific Guidance to Developers

Chapter 1 sets out the purpose of the guidance document and outlines recent trends in flood risk management within the planning process and the construction industry.

Chapter 2 includes a brief background to development and flood risk issues and gives an overview of the FRA process. This section introduces the tiered three-level approach to FRA as recommended by CIRIA in their report C624, *Development and flood risk – guidance for the construction industry*, which was published in September 2004.

Chapter 3 is intended as a concise guidance document for the Local Planning Authority (LPA) and for Developers, with particular emphasis on providing practical advice on the type of measures that may be required to be incorporated into specific development proposals for the Medway region.

Chapter 4 discusses specific technical considerations for flood risk management in the Medway area.

Chapter 5 presents the Flood Risk Mapping, identifying flood extent, flood depth, flood elevation and rapid inundation zones for the Medway district.

The *Appendices* provide site specific guidance to developers wishing to undertake works in the Medway area.

1.6 Status of the SFRA Document including Consultation

The current Development Plan for Medway Council comprises the Kent and Medway Structure Plan and the Medway Local Plan (adopted 2003). Land allocation and planning applications should be in accordance with the Development Plan unless other material planning considerations outweigh it.

Local Plan Policy CF13 deals with proposed development within tidal flood risk areas while Chapter 3 of this SFRA document - Planning Principles and Policy of Medway Council - amplifies and builds on this current Local Plan guidance.

The Local Development Framework (LDF) is currently being written to form part of the new Development Plan and will have a general core strategy policy ensuring development will only be permitted provided that flood risk is properly managed and mitigated. Again, the detailed flood risk policies and principles in this SFRA document will support and expand on the core policy. However, the new policy will not be formally adopted until the LDF is adopted in 2007.

The SFRA planning policy has been subject to a six week public consultation in line with Medway's Statement of Community Involvement, and has been drawn up with input from the Office of the Deputy Prime Minister (ODPM) and the Environment Agency. As the document has been subject to scrutiny, Medway Council will use the SFRA findings in land allocation decisions and determining planning applications, prior to formal adoption, as it represents the best available information.

2 Flood Risk

2.1 Development and Flood Risk

The report CIRIA C624 "Development and flood risk – guidance for the construction industry" provides in its Section A, a detailed background to various issues relating to development and flood risk. It includes causes and mechanisms of flooding and its impact on different types of developments. These are reviewed briefly below.

2.1.1 Components of Flood Risk

Flood risk is a combination of the **probability** of a flood hazard occurring and the magnitude of the potential **consequences** of the flood.

The **probability** of a flood hazard can be described as the chance that it will happen in any year. It is recommended that annual probability of flooding should be expressed as a percentage probability of a flood of a given magnitude being equalled or exceeded in any year rather than the expression of return periods. Table 2.1 below gives examples of annual flood probability expressions.

Table 2.1: Expressions of Annual Flood Probability

Annual flood probability as percentage likelihood	Basis of expression	Equivalent return period for flood event
1%	1 in 100 chance of being equalled or exceeded in any year	100 years
0.5%	1 in 200 chance of being equalled or exceeded in any year	200 years
0.1%	1 in 1000 chance of being equalled or exceeded in any year	1000 years

The **consequences** of flooding will depend upon the nature of the flood hazard and the vulnerability of an area.

The nature of the flood hazard affects the potential for the flood to cause damage, and will be influenced by factors such as depth, velocity, duration, wave action, rate of onset and water quality.

The vulnerability of the area flooded affects the potential for damage to be caused and will be influenced by factors such as:

- The number of properties and / or size of area affected;
- The type of development (e.g. more damage would be caused during the flooding of a supermarket than during the flooding of a playing field or an open public space);
- The nature of the population at risk (e.g. elderly or infirm people are more likely to suffer during flooding); and
- The presence and reliability of mitigation measures to manage flood risk.

The combined influence of the factors affecting probability and consequences will determine flood risk at a particular site.

2.1.2 Sources and Mechanisms of Flooding

Flooding can arise from a variety of sources and is not just due to tidal flooding caused by the sea. Flooding occurs naturally, when specific environmental factors or combinations of factors occur. It can also result from human interference with natural processes, such as changes to river channels, increases in runoff from and / or blocked drainage systems. *Box 1* below provides the principal categories of flooding mechanisms that can potentially affect development sites.

Box 1: Categories of flood mechanisms

Category	Mechanism
Fluvial flooding	Exceedence of the flow capacity of the channel of a river, stream or other natural watercourse, typically associated with heavy rainfall events. Excess water spills onto the floodplains
Coastal and tidal flooding	High tides, storm surges and wave action, often in combination
Estuarial flooding and watercourses affected by tidelocking	Often involving high tidal levels and high fluvial flows in combination
Groundwater flooding	Raised groundwater levels, typically following prolonged rain (may be slow to recede). High groundwater levels may result in increased overland flow flooding
Flooding from overland flow	Water flowing over the ground surface that has not reached a natural or artificial drainage channel. This can occur when intense rainfall exceeds the infiltration capacity of the ground, or when the ground is so highly saturated that it cannot accept any more water
Flooding from artificial drainage systems	Blockage or overloading of pipes, sewers, canals, and drainage channels or failure of pumping systems. Typically following heavy rain or as a result of high water levels in a receiving watercourse
Flooding from infrastructure failure	Structural, hydraulic or geotechnical failure of infrastructure that retains, transmits or controls the flow of water

Source: C624, CIRIA 2004

2.1.3 Implications of Flood Risk

Developments that are designed without regard to flood risk may endanger lives, damage property, cause significant disruption to the wider community, damage the environment, be difficult to insure and require additional expense on remedial works. Such developments are therefore not sustainable. A variety of development types, such as residential and commercial properties, public facilities, transport links and other infrastructure may be vulnerable to flood damage.

Flooding can have several impacts on the development such as physical damage and economic impacts, but the developments may also have an impact on flood risk and environment in general; such as a change in the surface water runoff that alters downstream flood risk.

2.2 Flood Risk Assessment within the Planning Process

2.2.1 General

Government requires assessment of flood risk at various levels: regionally, strategically and locally. The SFRA is the strategic approach and a site specific FRA is the local. The following gives information regarding the local FRA and further advice is contained in Chapter 3.

2.2.2 Why do we need a FRA?

Flood risk is a "material planning consideration" to be taken into account when determining planning applications. PPG25 confirms that planning authorities should apply the precautionary principle to the issue of flood risk, using a risk-based approach to avoid such risk where possible and managing it elsewhere. The sequential test, promotes the risk-based approach to the assessment of whether a particular type of development is acceptable in an area subject to a given level of flood risk and in order to decide on appropriate development, the Local Planning Authority will expect the developer to provide an assessment of flood risk, including runoff implications which is appropriate to the nature and scale of the development and the risks involved. This assessment should be submitted with the planning application.

Table 1 of PPG 25 sets out the Flood Zones that should be considered in this test and states the permitted types of developments within each flood zone. Appendix F of PPG25 gives the minimum requirements of a FRA.

2.2.3 What is a FRA?

A FRA should consider all types of flooding (*Box 1*) to satisfy the following three key objectives:

- To assess flood risk to the proposed development and to demonstrate that any residual risks to the development and its users would be acceptable;
- To assess the potential impact of the proposed development on flood risk elsewhere and to demonstrate that the development would not increase flood risk elsewhere; and
- To satisfy the requirements of national planning policy guidance, which requires FRAs to be submitted in support of planning applications.

The FRA should demonstrate that a development proposal is good enough to approve. Acceptable development proposals should meet a number of key criteria (Box 2).

You are referred to Chapter 3 - Planning Principles and Policy of Medway Council, of this document for specific guidance.

Box 2: Key aims for a development that is sustainable in flood risk terms

- The development should not be at a significant risk of flooding, and should not be susceptible to damage from flooding.
- The development should not be exposed to flood risk such that health, safety and welfare of the users of the development, or the population elsewhere, is threatened.
- Normal operation of the development should not be susceptible to disruption as a result of flooding.
- Safe access to and from the development should be possible during flood events.
- The development should not increase flood risk elsewhere.
- The development should not prevent safe maintenance of watercourses or maintenance and operation of flood defences.
- The development should not be associated with an onerous or difficult operation and maintenance regime to manage flood risk.
- The development design should be such that future users will not have difficulty obtaining insurance or mortgage finance, or in selling all or part of the development , as a result of flood risk issues.
- The development should not lead to degradation of the environment.
- The development should meet all of the above criteria for its lifetime, including consideration of the potential effects of the climate change.

Source: C624, CIRIA 2004

2.2.4 The Impact of Climate Change on Flood Risk

Increasing global temperatures and changing weather patterns indicate that human-induced climate change is a reality. Climate change has important implications for the assessment of flood risk and for the design of mitigation measures such as flood defences.

The United Kingdom Climate Impacts Programme (UKCIP) is assessing the implications of climate change on the United Kingdom and, as part of this, the impacts on flood risk are being assessed. There is considerable uncertainty associated with the results, but current best practice (DTLR, 2001; DEFRA, 2003) is to make an allowance for climate change impacts, based on the latest predictions, when carrying out flood risk assessments.

2.3 The Flood Risk Assessment Process

2.3.1 General

The flood risk assessment process is outlined in a flow diagram in Section 3 of this report.

A FRA should be carried out under the direction of a qualified and competent professional as recommended by the EA, LPA or relevant professional institution for example, the Institution of Civil Engineers. An appropriate level of FRA should be undertaken as soon as a site is considered for development. CIRIA publication C624, recommends three levels of FRAs which can be undertaken at increasing levels of detail, as development proposals progress.

- **<u>Level 1</u>** can be described as a screening study to identify whether any flood issues should be considered. The purpose of a Level 1 FRA is to determine: the potential flooding hazards which may pose a risk to the development, or which the development may affect so as to increase flood risk elsewhere; whether the proposed development may obstruct access to watercourses or flood defences or affect the integrity of a flood defence; and whether the development may lead to an increase in runoff.
- **<u>Level 2</u>** can be described as a scoping study to follow on from a Level 1 assessment. The study should include the following: an assessment of the availability and adequacy of existing information; a qualitative assessment of the flood risk to the site, and the impact of the site on flood risk elsewhere; and an assessment of the possible scope for appropriate development design and to scope additional work required.
- **<u>Level 3</u>** can be described as a detailed study to follow on from a Level 2 assessment and should include a quantitative assessment of the potential flood risk to the development; a quantitative assessment of the potential impact of the development site on flood risk elsewhere; and a quantitative demonstration of the effectiveness of any proposed mitigation measures.

CIRIA publication C624 gives a flowchart to illustrate the overall process associated with each level of FRA for development proposals. It is important that the Council, the Agency, Internal Drainage Boards (IDBs), other responsible bodies (e.g. Southern Water) and the local community including other relevant stakeholders, are consulted at all levels of the FRA. Sections 2.3.2, 2.3.3 and 2.3.4 present further technical guidance on undertaking FRAs for Levels 1, 2 and 3 respectively.

The website at pipernetworking contains the Agency's national standing advice to local planning authorities in England on development and flood risk. This includes advice for making decisions on low risk planning applications which can be dealt with without directly consulting the EA for an individual response, and identifies those higher risk development situations where by case consultation with the EA should continue. Technical guidance notes on FRAs for different types of developments in different locations are also available at this website. This information was most recently updated in October 2005 following the publication of the CIRIA C624 guidance note. It is intended that the website will be further updated on a regular basis, at least annually. Agency requirements are presented in the form of a flood risk matrix for the following development categories, depending on their location within Main River bye-law area or flood zones 1, 2 and 3:

- Domestic extensions;
- Industrial/ Commercial extensions less than 250m^2;
- Change of use to a more ‘flood risk sensitive’ use;
- Camping and Caravan sites;
- Operational development between 1ha and 5ha;
- Civil emergency infrastructure less than 5ha; and
- All operational developments greater than 5ha.

CIRIA publication C624 also gives guidance on how to carry out a Level 1 FRA and includes a summary of the key factors that need to be considered within a Level 1 FRA. The decision not to proceed with a Level 2 FRA should only be taken when a Level 1 FRA clearly demonstrates that a development is not at risk of flooding and will not result in an increase in flood risk elsewhere. If the report concludes a very low risk of flooding, then it may be submitted to the LPA or FDA with the planning application, otherwise a Level 2 FRA should be undertaken or consideration given to an alternative site / development proposal.

Sources available for Level 1 FRA are described in detail in Section A of Report C624. Principal data sources are:

- The Agency's National Flood Zone Maps (FZMs). Indicative Floodplain Maps (IFMs) are no longer available for fluvial and tidal flooding for England and Wales on the Agency's website (www.environment-agency.gov.uk) as they are now replaced with FZMs, which will also be updated at regular intervals. Modelling reports associated with the mapping may be available from the local EA offices;
- Medway SFRA;
- Existing documentation relating to flooding problems and flood risk management;
- Flood alleviation scheme design reports/ project appraisal reports/ strategy studies that may be available from the EA or the Council;
- The Agency's flood defence asset survey information;
- The Agency's catchment flood management plans (if available);

2.3.2 Level 2 Flood Risk Assessment

The objectives of the Level 2 FRA are to:

- Develop an understanding of the mechanisms of flooding at the site;
- Develop an understanding of the proposed development site within the context of the catchment;
- Identify available data;
- Confirm the classification of the site according to PPG25 flood zones 1, 2 or 3;
- Produce a preliminary qualitative assessment of the potential impact of, and constraints to, the proposed development;
- Develop an understanding of the potential development design that may be employed at the site; and
- Define additional work required to produce a Level 3 FRA and/or produce a level 2 FRA report if appropriate.

A Level 2 FRA should be undertaken for each potential flood risk issue that is identified as being associated with a site during a Level 1 FRA. The assessment must consider the potential interaction of different flooding hazards to assess the potential cumulative effects that the site may be subjected to in terms of flood risk related issues.

The process of undertaking a Level 2 FRA is detailed in Section 6 of CIRIA report C624. The report contains a flowchart to provide guidance on the procedures to be followed when undertaking a Level 2 FRA. Depending on the conclusion of this assessment a Level 3 FRA may be undertaken or an alternative site / development proposal be considered.

If sufficient information has been obtained and reviewed to progress the outline design of the development in sufficient detail, it may be possible to submit a Level 2 FRA report in support of a planning application in consultation with the LPA / FDA. A Level 2 FRA Report often provides an adequate level of detail for a development in a low to medium flood risk Zone 2, unless the development is of such a type that PPG25 recommends that it should be avoided (e.g. hospitals, fire stations, emergency depots etc.). If a Level 3 FRA is required then it may be advantageous to submit a Level 2 FRA to the LPA/ FDA to obtain agreement as to the potential viability both of the development and the proposed methodology for the Level 3 FRA.

If it is considered that sufficient information exists to fully assess flood risk issues relating to a proposed development, the Level 2 FRA Report should contain the same information as a Level 3 FRA.

2.3.3 Level 3 Flood Risk Assessment

A Level 3 FRA should provide a quantitative assessment of the flood risk issues identified and scoped in FRA Level 2. Typically, the objectives of a Level 3 FRA include:

- Review of Level 1 and 2 FRAs;
- Modelling to define the existing flood hazard, including assessment of conditions with probable climate change over the lifetime of the development;
- Modelling to assess the potential impact of the proposed development;
- Outline design of flood mitigation measures, and associated modelling to demonstrate that the development will not lead to an increase in flood risk elsewhere;
- Sensitivity testing to demonstrate that the estimates of flood risk to and arising from, the site are not overly dependent on the assumed model parameters; and
- Preparation of report.

The process of undertaking Level 3 FRA is further detailed in Section 6 of CIRIA report C624. The report contains a flowchart to provide guidance on the procedures to be followed when undertaking a Level 3 FRA including the recommended contents. Depending on the conclusion of the assessment, the Level 3 report should be submitted as a part of the planning application or consideration given to an alternative site / development proposal. The report should be cross-referenced with the requirements of PPG25 and any supplementary guidance produced by the LPA and FDA.

3 Supplementary Planning Policy Guidance

3.1 General

3.1.1 Purpose and Scope of this Document

This guidance document has been produced as a part of the Medway Strategic Flood Risk Assessment (SFRA) undertaken by Mott MacDonald (MM) on behalf of Medway Council (the Council). The SFRA planning policy has been subject to public consultation in line with the Statement of Community Involvement and has been drawn up with input from the Office of the Deputy Prime minister (ODPM) and the Environment Agency.

It is intended as a concise guidance document for the Local Planning Authority (LPA) and for Developers, with particular emphasis on providing practical advice on the type of measures that may need to be incorporated into specific development proposals for the Medway region.

Due to the major flood risk in the Medway Council area being associated with the sea, the SFRA is predominantly a tidal study and concentrates on providing advice in this respect.

3.1.2 Introduction

Flooding is a natural process that can have far reaching effects on people and communities. Development should be planned to avoid the risk of flooding, but where development is necessary in risk areas it should be designed to minimise the impacts of flooding. Medway has a significant area of regeneration land at risk of flooding and this section of the SFRA seeks to reduce that risk by setting out policy and design principles for safe development.

The current Development Plan for Medway Council comprises the Kent and Medway Structure Plan and the Medway Local Plan (adopted 2003). The Council will decide planning applications in accordance with the Development Plan unless other material planning considerations outweigh it.

The Flood Risk Planning Principles in Section 2 of this document amplify Policy NR9 and NR10 of the Kent and Medway Structure Plan. However, Medway has very few development sites that are currently defended to an appropriate standard and this means that new defences will be needed in some areas or significant regeneration and strategic defending of the area will not be possible. Currently, no shoreline policy exists for the tidal Medway but the regeneration sites are brownfield and within the urban area where traditionally the option of 'hold the defence line' is adopted.

Local Plan Policy CF13 deals with proposed development within tidal flood risk areas and the Flood Risk Planning Principles expand on this Local Plan guidance.

The Local Development Framework (LDF) is currently being written to form part of the new Development Plan and will have a general core strategy policy ensuring development will only be permitted provided that flood risk is properly managed and mitigated. The detailed policies in Section 3 of this document will be formally adopted at the time the LDF is adopted in 2007.

3.1.3 Policy Context

(i) Planning Policy Guidance Notes

The Government has published a series of Planning Policy Guidance Notes (PPGs), which set out its policies on various planning subjects. The guidance in PPGs can be a "material consideration" in assessing particular development proposals. PPGs are currently being replaced by Planning Policy Statements (PPSs). A full list of current PPGs and PPSs can be found at http://www.planning.odpm.gov.uk/ from which the documents can also be viewed and downloaded. The PPGs and PPSs of most relevance to development and flood risk for the Medway region are:

- PPS 1: Delivering Sustainable Development
- PPG 3: Housing
- PPS 12: Local Development Frameworks
- PPG 25: Development and Flood Risk

Planning Policy Statement 1 (PPS 1) sets out the overarching planning policies on the delivery of sustainable development through the planning system. These policies complement, but do not replace or override, other national planning policies and should be read in conjunction with other relevant statements of national planning policy. This PPS replaces *Planning Policy Guidance (PPG) Note 1, General Policies and Principles*, published in February 1997.

Within PPS 1 the Government has set out four key aims for sustainable development:

- social progress which recognises the needs of everyone;
- effective protection of the environment;
- the prudent use of natural resources; and,
- the maintenance of high and stable levels of economic growth and employment.

Planning guidance on housing (PPG 3) advises LPA's to take account of physical and environmental constraints on the development of land for housing, including flood risk. It further requires priority to be given to re-using previously developed land within urban areas, bringing empty homes back into use and converting existing buildings in preference to the development of greenfield sites. The principles of PPG 25 and PPG 3 are complementary and nothing in PPG 25 should be taken as departing from the principles of PPG 3.

Planning Policy Statement 12 (PPS 12) replaces Planning Policy Guidance Note 12: Development Plans (PPG12), except that PPG12 will remain in operation for development plans still being prepared under the 1999 Development Plan Regulations. PPS12 sets out the Government's policy on the preparation of local development documents, which will comprise the local development framework (LDF). Local development frameworks are intended to streamline the local planning process and promote a proactive, positive approach to managing development. PPS12 sets the principles under which the LDF should be developed, provides information on the components which will constitute the LDF and provides information on transitional arrangements.

Planning Policy Guidance Note (PPG) 25 – Development and Flood Risk was issued in July 2001 by the Department of Transport, Local Government and the Regions (DTLR). It provides guidance on how flood risk should be considered at all stages of the planning and development process in order to reduce future damage to property and loss of life. It conveys the importance the Government attaches to the management and reduction of flood risk in the land-use planning process, the need to act on a precautionary basis and the need to take account of climate change.

The Government has now decided to replace PPG 25 with Planning Policy Statement 25 (PPS 25). The consultation draft of PPS 25 is expected to be published towards the end of 2005. It is envisaged that the new Policy Statement will:

- provide a stronger and clearer requirement for Flood Risk Assessments;
- be drafted on the basis that it will be followed, subject to consultation, by a standing Direction related to sustained objections by the Environment Agency on flood risk grounds;
- clarify the sequential test that relates types of appropriate development to the degree of flood risk at any particular location;
- reflect the importance of taking account of the consequences, not just the probability of, future flooding events;
- maintain the strong requirement that current and future flood risk is taken into account at all stages in the planning process, in development plans at regional and local authority level, and in framing and considering applications for planning permission;
- clarify the relationship of policy on flooding with other planning guidance; and clarify how flood risk from sources other than rivers and the sea, such as flash flooding, groundwater, sewers and the drainage system, can be taken into account in the planning process.

source: Making Space for Water, Defra

(ii) South East Plan

The South East Plan is being undertaken by the South East England Regional Assembly (SEERA). It aims to set out a vision for the region through to 2026, focusing on improvements that we need to make to ensure the region remains economically successful and an attractive place to live.

It will address important issues such as housing, transport, economy and the environment. The Draft South East Plan Part 1: Core Regional Policies, was handed to Government on 29 July 2005, following extensive public consultation and approval by the Assembly's annual meeting on 13 July 2005.

The full Plan, to include Part 2: Sub-regional Details, will be submitted for Government approval in Spring 2006. Once it has Government approval it is anticipated that it will become a legal document that local authorities and other government agencies in the region will have to follow. District and Unitary Councils will still deal with local planning applications, but they will have to ensure their decisions do not conflict with the principles in the South East Plan.

(iii) Kent and Medway Structure Plan (September 2003)

The Structure Plan is a long-term statutory land-use policy document for the County, which guides development, protects important features of the environment, and influences the location and type of private and public investment. The plan sets out general policies and proposals of strategic importance but does not contain detailed policies or site specific proposals.

Chapter 9 of the plan addresses climate change and managing our natural resources including flooding. The document has been under review and Kent and Medway Councils have carefully considered the report and recommendations of the Examination in Public (EIP) Panel following its publication in February 2005. The Councils produced 2 documents for formal consultation "Councils' Response to the Recommendations of the EIP Panel" and "Proposed Modifications to the Kent and Medway Structure Plan". The consultation period was completed at the end of October 2005 and Kent and Medway Councils are now considering the response to this consultation and determine whether further modifications are required or whether the Structure Plan should proceed to adoption. At this stage it is hoped that the Kent and Medway Structure Plan can be adopted by early 2006.

(iv) Local Development Framework

Through the Planning and Compulsory Purchase Act, 2004, the Government introduced a new plan system to manage how development takes place. It is a two-tiered system made up of:

- Regional Spatial Strategies (RSSs) - prepared by regional planning bodies these consider broad spatial planning strategy.
- Local Development Frameworks (LDFs) - a folder of local development documents prepared by district councils or unitary authorities which outline spatial planning strategies for a local area.

Medway Council is currently engaged in the changeover from a Local Plan led development strategy, to one encompassing the requirements of a Local Development Framework. The process is due to be completed in 2007 and the principal changes that this approach will bring are summarised below:

Table 3.1: The Changeover from Local Plan to Local Development Frameworks

Local Plan	Local Development Framework
Finite process	Continuous process
Sequential process - 'project' management	Scope for overlapping Local Development Documents - 'programme' management
Ad hoc approach to community consultation	Requires a clear approach to community involvement in the preparation, alteration and continuing review of all local development documents through the preparation of a Statement of Community Involvement (SCI) -
The evidence base and monitoring not always fully integrated into the plan preparation process	Requirement for comprehensive evidence base
Managing representations towards the end of the preparation process	'Front loading' of community involvement

Local Plan	Local Development Framework
No formal requirement for a Strategic Environmental Assessment	Requirement for a Strategic Environmental Assessment which should include: • the preparation of an environmental report • carrying out of consultations • taking into account the environmental report and the results of the consultations in decision making • provision of information when the plan or programme is adopted • showing that the results of the environment assessment have been taken into account
Land-use planning documents-with Development Control the key implementation tool	Wider spatial planning approach identifying other delivery mechanisms
Lack of certainty at outset on timetables and contents	The Local Development Scheme will set out the programme for Local Development Document preparation

3.1.4 Thames Gateway

In February 2003 the Government launched 'Sustainable Communities – building for the future' which outlines proposals for concentrated growth in four areas predominantly in the South East of England. Medway Council area is within the Thames Gateway growth area. The susceptibility of land to flooding is a material planning consideration and the Council, in consultation with the Environment Agency, will apply the sequential test set out in paragraph 30 of PPG25 in allocating sites for development and in determining applications for planning permission. However, the growth areas have been allocated for wider sustainability reasons and the Council will employ the principle of 'balanced management' in relation to flood risk, allowing development which serves the social and economic needs of the community to proceed whilst ensuring that flood risk is properly managed and mitigated. It should therefore be noted that the flood risk sequential approach may not be an over-riding factor as flood risk is one component, however, the Council will not permit development at an unacceptable risk of flooding or that potentially increases flood risk elsewhere.

The Thames Estuary 2100 (TE2100) Project is aimed at protecting London and the people living in the Thames Estuary from flooding now and into the next century. As sea levels are continuing to rise and our changing climate makes heavy rainfall and stormy conditions in the future more likely, it means a greater risk of flooding from both higher water levels in the rivers, and surges of sea water being pushed by storms into estuaries. The answer is not to rely on building ever larger defences but to consider a variety of flood risk management methods to find ways of reducing both the risks of flooding and the effect it has. The TE2100 Project will produce a plan to tackle flooding that is affordable and that improves the environment. Regeneration will need to be taken into account when deciding on future flood management options. Alternative options could include allowing some floodplain areas to flood naturally; moving back defences so that they are more easily maintained or raised in the future; and avoid development in the highest risk flood areas. The developments themselves will need to be located and designed to minimise any flood risks. **The first draft plan is anticipated in 2008 and will have implications for all Thames Gateway sites.**

3.1.5 Flood Risk Zones

In order to categorise the risk of flooding, PPG 25 defines a series of flood risk zones ranging from Zone 1 which represents land least prone to flooding, to Zone 3c which represents land situated directly in an active floodplain and therefore at the highest risk. For each zone, permitted types of development are defined.

In order to develop areas at risk of flooding, mitigation measures are required. These may include the construction of strategic flood defences or perhaps a general increase in site ground levels.

Where flood defences are proposed, developers must also consider residual flood risk, i.e. the risk of flooding that remains after construction of the defences. This risk is usually associated with the possible breaching of the defence, or overtopping brought about by a flood event of a greater magnitude than that for which the defences were designed.

Any development must also consider whether there is an enhanced risk of flooding in the future. For this, consideration should be given to the anticipated life of the development, the likely effects of sea level rise, the potential for changing weather patterns, and the impact of these on the assessment of flood risk.

A flow chart is included in Section 3.5 to indicate the thought process and what should be considered when developing sites in flood risk areas. However, the first step is to determine which Flood Zone the site lies within and you are advised to contact the Environment Agency.

3.2 Flood Risk Planning Principals

3.2.1 Sustainability, Urban Design and Flood Risk

Within Medway there is a presumption that all development will be contained within the urban boundary as defined by the Council and that development should focus on the regeneration of brownfield sites.

Development should avoid flood risk areas, but where this is not possible, there are three primary objectives for sustainable development in flood risk areas. These are to ensure that:

(a) Development should not take place which has an unacceptable risk to life or an unacceptable risk of damage to property.

(b) Development should not create or exacerbate flooding elsewhere.

(c) Development should not take place which prejudices possible flood control works and maintenance activities or commit future generations to inappropriate flood defence options.

The Council will require that any flood defence or mitigation measure accompanying development proposals be subject to an appraisal that addresses sustainability. There will be a presumption in favour of measures, which employ good standards of urban design with high flood resilience; enhance local recreation and amenity; protect ecology; safeguard water resources and utilise Sustainable Drainage Systems (SuDS).

3.2.2 Development in Flood Risk Areas

Flood risk is a “material planning consideration” to be taken into account when determining planning applications. There are uncertainties inherent in flood mapping and assessment and as such, the precautionary principle should be applied. This means that if we are initially unsure of the risk, we need to more accurately determine this risk and develop appropriately, or don’t build.

A risk-based approach should be adopted and development should be located according to vulnerability; those with the greatest vulnerability or risk to life should be sited in the lowest risk areas. All Medway planning applications should reflect this development principle. Development, however small, should not be inappropriate as the adverse effects are cumulative and can lead to significant problems in the long term. Experience shows that allowing one such development is likely to create a precedent for other developments in the vicinity.

Table 1 of PPG25 sets out the flood zones and states the permitted types of developments within each flood zone. There is a presumption that sites will be developed in flood zone order i.e. Flood Zone 1 has priority, followed by Zone 2 etc. Developers should demonstrate that no reasonable options are available in a lower-risk category.

Flood zones are identified ignoring the presence of defence. However, even where an appropriate flood defence serves the site, residual flood risk must be assessed.

Residual flood risk is the risk of flooding usually associated with breaching of a defence, or overtopping brought about by a greater magnitude flood event than that for which the defence was designed. New flood defences along the River Medway are likely to be considerably higher than existing land levels, in which case, a breach of such a tidal defences could lead to rapid flooding and consequently a high risk to life. Areas that have this type of characteristic are known as Rapid Inundation Zones (RIZs) and for the Medway Council area, are defined as the area likely to be flooded to a depth of at least 30 cm within 30 minutes of a breach of a tidal or fluvial defence. Medway Council will not permit inappropriate development within the RIZ. These areas are most suitable for amenity open space but where, in the wider interest, formal development is given permission it will be wholly exceptional.

The following three points are perhaps most relevant to fluvial flood risk areas, however they should also be considered in sensitive tidal flood locations:

- Development should not obstruct flood flows. If it does, flood levels upstream of the development are increased and this increases upstream flood risks.
- Development should not reduce the amount of land available for flood water storage. Loss of flood water capacity storage results in an increase in downstream flood levels.
- Development should not significantly increase the amount and rate of surface water run-off entering the river catchment, which if unmanaged can increase river flows and the risk of flooding.

The Council will resist development that would impose an additional burden on the emergency services if permitted, or if it clearly increases the risk to life with greater human occupancy. This may also include the development of a single dwelling if considered to be inappropriate although in general, applications by individual householders for replacement dwellings, minor extensions or alterations should not raise significant issues.

3.2.3 Flood Risk Assessments for Individual Development Proposals

The SFRA addresses flood risk strategically along the river corridor, however, a site specific Flood Risk Assessment (FRA) is designed to consider all flooding issues relevant to a development proposal. It should be proportionate to the size of development and the level of risk. In order to satisfy planning requirements an FRA will demonstrate that a development is suitable for approval and that residual risks are managed appropriately. Existing property owners may reasonably expect that their property should not suffer any direct detriment as a result of new development or be subject to an unacceptable increase in flood risk.

A FRA is required for all development within Flood Zones 2 and 3 and for a major development in Flood Zone 1, although the FRA in Flood Zone 1 is only required to determine the flood risk from surface water run-off. Major development is defined as 10 or more houses; or 0.5 Ha or more; or 1000 sqm or more of industrial development. The applicant or promoter of a development is responsible for the production of the required FRA.

In line with PPG 25, the Council requires the submission of the FRA **with** a planning application for development, including an outline application.

The range of issues to be considered by a FRA is set out in Appendix F of PPG 25 and should be used as a guide for the requirements for site specific FRA's. Particular attention should be given to the impacts of climate change and to the provision of safe evacuation measures.

3.2.4 Climate Change

Changes in flood risk and the implications for flood defence have been identified as one of the top five national concerns arising from climate change predictions. DEFRA has been providing guidance for incorporating sea level rise into the design of sea defences since 1989. The UK is also subject to post-glacial geological land movement. The DEFRA guidance combines these land movements with the sea level rise estimates to give a net figure for relative sea level rise.

It should be recognised that there is uncertainty in flood estimates, however, the accepted prediction for affective sea level rise due to global warming and land level adjustment for the Medway Council area is 6mm per annum.

In addition to sea level rise, climate change is also expected to result in an annual rainfall increase of between 0 and 10% by 2050 with autumns and winters becoming up to 20% wetter. It is also suggested that the number of rain-days and the average intensity of rainfall are expected to increase slightly and that average seasonal wind speeds could increase over most of the country.

From initial research, rivers and drainage systems could experience increases in peak flow of up to 20% for a given return period within 50 years. For the predominantly fluvial flood risk area within Medway this should be adopted as the allowance for climate change.

More detailed information on climate change adaptation measures that may be required as part of the development can be found in the SFRA main report. In addition, Appendix A of PPG 25 provides additional guidance on the likely impact of climate change, and the Planning Toolkit, prepared for the Environment Agency and the South East England Regional Assembly (SEERA), provides guidance on measures such as grey water systems and any other specific water related climate change issues.

3.2.5 Appropriate Flood Defences

An appropriate defence in Medway's tidal locations is a primary wall or embankment with a minimum standard of the 0.5% (200-year) level plus freeboard to account for wave action. This standard should be for the lifetime of the development so climate change should be incorporated for typically, at least 60 years. Alternatively, land raising can be used to provide a development platform above the 0.5% flood level. With this option the developer should demonstrate that neighbouring sites are not worse off as a result of the proposal and you are referred to Policy FR1 and FR6 in Section 3.3 of this SFRA.

For fluvial locations in Medway, development should also be appropriately defended for its lifetime. This means a primary wall or embankment with a minimum standard of the 1% (100 year) level plus freeboard and account for climate change to 2065.

Provision of additional flood defences are not required for land within Flood Zone 1 but it may be necessary to provide surface water management systems to mitigate flood risk. In general, a flood defence is not required for development within Flood Zone 2, however, appropriate protection measures may be required such as, nominally raising floor levels. Both a flood defence and protection measures will be required for development within Flood Zone 3.

A strategic approach should be adopted for any flood defence required as part of a development and there will be a presumption against the piecemeal erection of private defences or the formation of 'islands'. Medway Council will favour any proposal that provides a flood risk benefit to the surrounding area.

Freeboard requirements within the estuary will vary according to the position along the River Medway. Those areas that are exposed to wind action will have a greater requirement than sheltered sites. It will also depend on the flood defence construction. Soft defences such as an earth embankment will have a greater freeboard than a hard defence like a structural wall. For a structural wall, freeboard will be in the order of 300mm to 850mm while for earth embankments freeboard will be between 600 and 1150mm, see Table 4.5 below. Climate change requirements are for a relative sea level rise of 6mm per annum (see Section 3.2.4 above).

For fluvial locations in Medway, the site specific FRA should determine the 1.0% (100 year) flood level including climate change. The freeboard recommendation will then be derived from the flood level information.

Stilts are not a flood defence in the same way as embankments or walls. Stilts are a method of flood resistant construction, and are not an acceptable means of allowing new development in unsustainable locations. However, in fluvial risk areas they may be appropriate for redeveloping an existing site within the footprint of the original buildings. A planning condition is likely to be placed on the planning consent to ensure a restrictive covenant is placed on each property deed to maintain clear waterway at ground level.

The Council will tend to avoid the use of demountable flood defences, as they are dependent on good operational procedures and manpower availability. They should be seen as wholly exceptional.

The construction of flood defences or land raising reduces the storage potential of a floodplain. For fluvial conditions compensatory flood storage will be required while for tidal conditions it may be required, but the developer will be asked to assess the impacts of his proposal to determine the necessary compensation. Replacement fluvial storage must be fully equivalent (level for level) to the lost storage in terms of general location and volume.

Developers shall fund the provision and maintenance of all flood defences that are required to protect the development.

Developers will be expected to provide 'as built drawings' to the Council to enable the updating of the SFRA document and planning permission is likely to be conditioned accordingly.

Past flood defences have resulted in the reduction of intertidal areas, which have allowed the land behind to be drained for agriculture or development. Saltmarsh and mudflats absorb wave energy and fens and low-lying marsh provide natural washlands to hold flood waters and slow the rate of flow to rivers. Attention has therefore turned to adapting and supplementing natural coastal processes, with the aim of creating a more environmentally acceptable and sustainable coastline. This approach has become known as 'soft' engineering. However, given the diversity of the coastline, no one method of defence will hold good in all circumstances. 'Hard' defences will continue to be appropriate in many cases. The Council will expect a developer to promote an appropriate flood defence design for the proposed location. In some cases it will be 'wharf' like, in others it will need to be 'terraced' in nature and stepped back or 'retired' from the existing river bank. However, there shall be a presumption against encroachment into inter-tidal areas of the river.

3.2.6 Managing Residual Risk

This section gives guidance on the further protection or mitigation measures that may be necessary to enable development. Although a site can be defended it does not mean that flood risk has been eliminated. An event in excess of that designed for could occur or there could be a failure in the flood defence.

The Council expects that where a residual risk is present, the developer will consider the following:

Land raising – where appropriate. Land raising can significantly reduce the depth of flooding and hence reduce flood risk in tidal areas. It is unlikely that land raising will be acceptable in the fluvial floodplain. Although it may be possible by undertaking earthworks to rationalise the floodplain but still maintain the area available for flood water storage.

Building design to include:

- Raising floor levels;
- Flood proofing of walls and floors through replacement of timber floors with concrete and replacement of gypsum plaster with more water-resistant material, such as lime plaster or cement render;
- Replacing chipboard/MDF kitchen and bathroom units with waterproof alternatives;
- Raising service meters, boiler and electrical circuitry;
- Installing one-way valves into drainage pipes;
- Creating safe exit from basement parking areas;
- Flood proofing gardens.

Creating specific flood flow routes – to ensure the safe conveyance of flood water.

Removing permitted development rights - to prevent expansion of the development in the future.

The developer should pay for any work which is required to mitigate the effects of flooding.

In the absence of information to the contrary in the site specific FRA, floor levels for residential development in tidal Medway areas shall be a minimum of 600mm above the 0.5% (200-year) still water level for all habitable rooms. The 0.5% (200-year) level should have climate change incorporated for the next 100 years. This requirement shall also apply to all sleeping accommodation in any form of development including hotels or similar. For schools, living areas in retirement homes or similar, or for any use where the occupiers or contents are considered vulnerable or where the use of the building is likely to be essential in times of flood, all floor levels should be raised to at least 600mm above the 0.1% (1000-year) still water level (with climate change incorporated for the next 100 years). These types of development should be considered wholly exceptional.

In fluvial flood risk areas of Medway, floor levels may need to be raised by up to 600mm above the 1% (1 in 100 year) flood level and the site specific FRA will need to identify the 100 year flood level.

For disabled access requirements, early consultation with the Council is essential.

You are referred to Parts H and C of the Building Regulations which address measures to reduce flooding and measures to reduce damage from flooding. Further guidance is available from the Environment Agency, CIRIA and the Association of British Insurers.

3.2.7 Safe Access and Exit from New Development during Flood Conditions

A FRA should consider access and exit measures and should have input from the emergency services.

To ensure safe access, the route should ideally be dry in the event of the design flood (0.5% (200 year) for tidal conditions or 1.0% (100 year) for fluvial conditions). The need for an individual to enter flood water, as part of a modern development, should be avoided. Access routes should be safe to use at the volition of the occupier and not dependent upon the intervention of the emergency services or others. The minimum access requirement is that the route should be safely accessible to pedestrians.

Where a dry access cannot be achieved full details should be provided in the site specific FRA. The main parameters to be considered are depth, velocity, turbidity, contamination and duration of flooding. The hazards associated with flood water even at small depths are: concealed obstacles including dislodged manhole covers, kerb edges and ditches. This issue is the subject of continuing R& D and the latest guidance should be sought.

Any raising of ground levels will need to be considered in the FRA to ensure flood risk to others is not increased.

Basement and semi-basement parking could be particularly hazardous, full details of potential flood depths and exit routes should be provided within the FRA for the site. The Council will not permit development that posses a significant risk to people's safety.

3.2.8 Maintenance and Access to the Flood Defences

Where a flood defence protects a development, long term maintenance arrangements for the defence and access to the defence for maintenance should be considered.

Developers should fund the long-term maintenance and the Council is likely to require full contributions to the cost of such works.

The Council has a preference for a commuted sum to be paid rather than the alternative option of tasking a management company with flood defence responsibility. The management company may not be in existence when repairs and improvements become necessary and they are unlikely to have, or collect, the quantities of money necessary for major remedial works to the flood defence. A Section 106 Agreement or Trust Fund are the suggested vehicles to use, planning permission is likely to be granted subject to appropriate conditions.

The Council will require new development to be set back sufficiently from a primary flood defence protecting the site to allow maintenance, repair and improvements. You are advised to consult with the Environment Agency as their consent will be required for works within 15m of the River Medway or within 15m of a tidal flood defence. For fluvial reaches of Main River or a fluvial flood defence access should be at least 8m.

The FRA needs to consider:

- Access arrangements from the highway to the flood defence and along the flood defence.
- The provision of a riverside walk.
- Access routes should have clear headroom; sufficient turning at points where there is a change of direction and no extreme changes in level that would obstruct access.
- A maintenance programme should be submitted with a planning application and include potential methods for improving the defence standard in the future.

3.2.9 Sustainable Drainage Systems

Medway Council will promote Sustainable Drainage Systems (SuDS) as the normal drainage practice, **where appropriate,** for all new developments. SuDS are techniques to manage surface and groundwater regimes sustainably. Traditional piped networks are avoided in favour of techniques that mimic natural flow patterns and there are clear benefits; reducing the flood risk from development; minimising pollution arising from surface water runoff that could enter a watercourse or groundwater; maintaining recharge to groundwater; enhancement to wildlife habitats, amenity and landscape quality.

Further guidance is available in the SFRA Main Report including how to design for tide-locked drainage.

3.2.10 Caravan Sites

Caravan and camping sites in floodplain areas are particularly vulnerable to flooding. In the interests of public safety the Council will resist the development of caravan sites both static and moveable in flood risk areas. The instability of caravans places their occupants at special risk and it may be difficult to operate an effective flood warning system. Floods can occur at any time of year and if development is permitted there would be an increase demand on the emergency services to warn, assist and rescue residents during flood times.

Where sites already exist there will be a presumption against their extension and having their conditions relaxed as there is an associated increase in risk.

In the exception where development is permitted, provision must be made to reduce the risk to public safety. Some suggested measures include:

- The site be equipped with an adequate flood warning system
- The site be restricted to summer occupancy only.
- The caravans should be firmly anchored.
- Pedestrian access should be available to the site during times of flood.
- You are referred to PPG 25 paragraph 70.

For fluvial flood risk locations further consideration must be given to the loss of floodplain storage and/or obstruction to flood flows that this type of development could represent. The raising of caravans on piers is not an acceptable alternative, as the voids beneath the caravan cannot be effectively policed to prevent their use for storage or from being walled off. The positioning of caravans on flow routes can cause obstruction to the passage of flood waters. In extreme events, the obstruction can be swept away to form greater blockages downstream.

3.2.11 Environmental Enhancements

Development proposals should clearly demonstrate that biodiversity interests are safeguarded. The Council will seek environmental enhancements as part of redevelopment schemes and in particular the creation of new habitat with the construction of a flood defence.

There shall be a presumption against encroachment into inter-tidal areas of the river. Any losses in habitat in this area will need to be compensated and, in general, a net gain in area should be provided as replacement habitat is difficult to achieve successfully.

Opportunity exists for enhancements in the areas identified as RIZ provided that suitable arrangements can be made for public safety.

3.2.12 Outfalls

Where an outfall passes through a flood defence structure, a flap valve should be provided. The Council will also consider other outflow control mechanisms such as non-return valves, tidal sluices or pumped evacuation systems, however, in all cases the advantages of these systems must be carefully balanced by any increased maintenance and operation costs and access requirements.

The number of outfall pipes passing through a flood defence structure should be kept to a minimum to ensure the integrity of the defence. Where possible, drainage works should be rationalised to reduce the number of small individual outfalls. It will be necessary for the integrity of the flood defence to be protected during construction and to ensure that the works do not weaken the flood defence.

The visual impact of the finished structure is an important consideration and construction materials should have regard for the local environment.

Outfall and headwall design should be agreed with the Environment Agency as their consent may be required for the construction and for the quantity and quality of discharge.

You are referred to the SFRA main report for guidance on how to design for tide locked drainage.

3.2.13 Ordinary Watercourses (OWCs)

The term Ordinary Watercourse includes every river, stream, ditch, drain, cut, dyke, sluice and passage through which water flows which does not form part of Main River. A Main River is usually a larger watercourse, for example, the River Medway or a smaller watercourse with strategic importance. They are defined on Main River Maps held at the Environment Agency. In Medway area, most OWCs will have fluvial flood risk associated with them.

Critical Ordinary Watercourses (COWs) are an unusual case. These watercourses have been identified as strategically important and will be reclassified as Main River through a programme that currently runs to 2006 but is likely to be an ongoing process. You are therefore advised to consult the Environment Agency for the status of any watercourse that may be affected by development proposals.

The SFRA study does not determine, in sufficient detail, the flood risk associated with all ordinary watercourses, with the exception of some tidal creeks of the River Medway, and for specific development proposals a FRA should be undertaken to investigate the flood risk further.

In general, development should be kept back from the top of the bank of any watercourse. Access width for maintenance of any watercourse including culverted sections should be a minimum of 4 m and significantly greater for tidal creeks. Particular attention should be given to boundary treatments near to watercourses such as walling and close-boarded fencing as they can obstruct flood flows.

The Council is opposed to culverting of watercourses because of the adverse effects associated with such a proposal. Culverting often leads to an increased likelihood of flooding due to blockage. Maintenance and repair is more difficult as are additional connections to the system. There is often a loss of wildlife habitat and pollution is more difficult to detect. Where appropriate, existing culverted lengths of watercourse should be opened.

Developers are advised to consult the Environment Agency at the earliest opportunity to discuss specific needs in relation to flood defence and development in floodplain.

3.3 Flood Risk Policy

3.3.1 Existing Medway Council Policy

Policy FR1:

Development within the floodplain will only be permitted if it can be demonstrated that:

- It is confined within the urban boundary;
- It is not at an unacceptable risk of flooding or that it would increase the risk of flooding elsewhere;
- It does not harm the integrity of the flood defences or prejudice the ability to carry out future flood control or maintenance works;
- Long-term flood defence maintenance arrangements are identified;
- The floodplain can still function appropriately by transmitting and storing flood water.
- There is a satisfactory means of escape during flood conditions;
- It does not introduce mobile homes, or static homes or caravans.

Policy FR2:

Proposals for development shall be accompanied with a Flood Risk Assessment that is appropriate to the scale and nature of the development at risk. The FRA should include the sequential test approach to land selection and demonstrate that no alternative lower risk site is more suitable and available.

Policy FR3:

Development will only be permitted in high-risk flood areas if the following are satisfied:

- There is an appropriate contribution to the community (social and economic);
- There is an appropriate contribution to the strategic defending of the area from flooding;
- The site is on brownfield land;
- The residual risk can be mitigated appropriately;
- There is an appropriate environmental improvement;
- The vulnerability of the proposed use is appropriate to the risk.

Policy FR4:

Proposals for development that would result in flooding or exacerbate flooding, due to surface water run-off, will only be permitted where effective preventative measures can be incorporated into the development that acceptably manage the flood risk.

Policy FR5:

Proposals for development will only be permitted where the Council is satisfied that suitable sustainable drainage methods and systems are included as an integral part of the development and the long term maintenance of such systems are identified.

Policy FR6:

Developments that include the proposal to raise land will only be permitted if:

- Accompanied by suitable compensation storage proposals, when required;
- It is part of a strategic flood defence improvement for the area;
- There is no environmental detriment demonstrated by an appropriate assessment.

3.3.2 Planning Policy Mapping

The Planning Policy Map for the Medway area can be viewed at the Medway Council website: http://www.medway/wwwlocalplan.gov.uk.

3.4 Helpful Contacts

Medway Council
Planning Department
Compass Centre
Chatham Maritime
Chatham
Kent ME4 4YH
Tel 01634 306000
Fax 01634 331062
Minicom 01634 333111
http://www.medway.gov.uk

Environment Agency
Kent Area Office
Environment Agency
Orchard House
Endeavour Park
London Road
Addington
West Malling
Kent
ME19 5SH
Tel 08708 506 506
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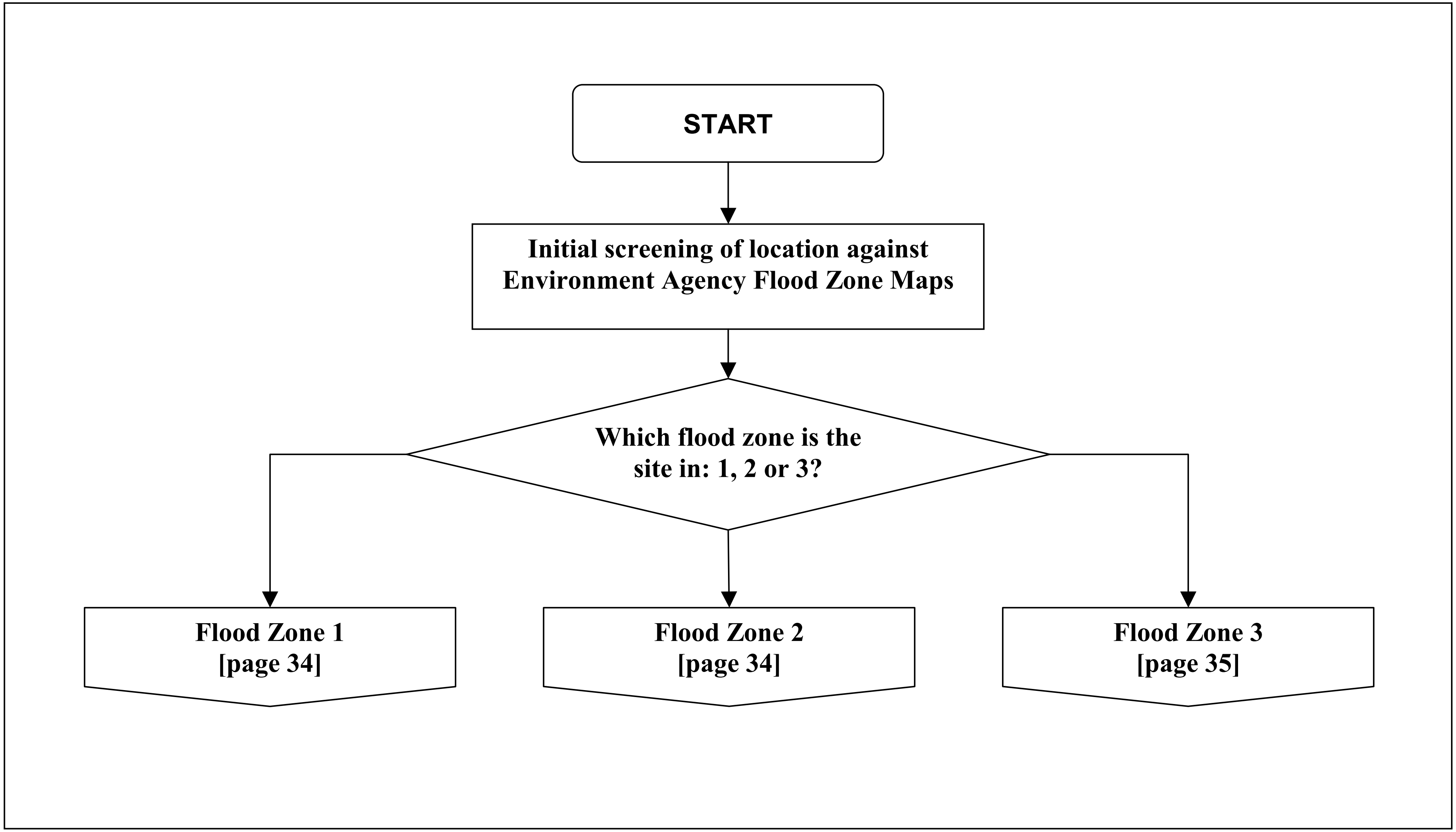
Lower Medway Internal Drainage Board
17 Albion Place,
Maidstone,
Kent
ME14 5EQ
Tel 01622 758345
Fax 01622 693665

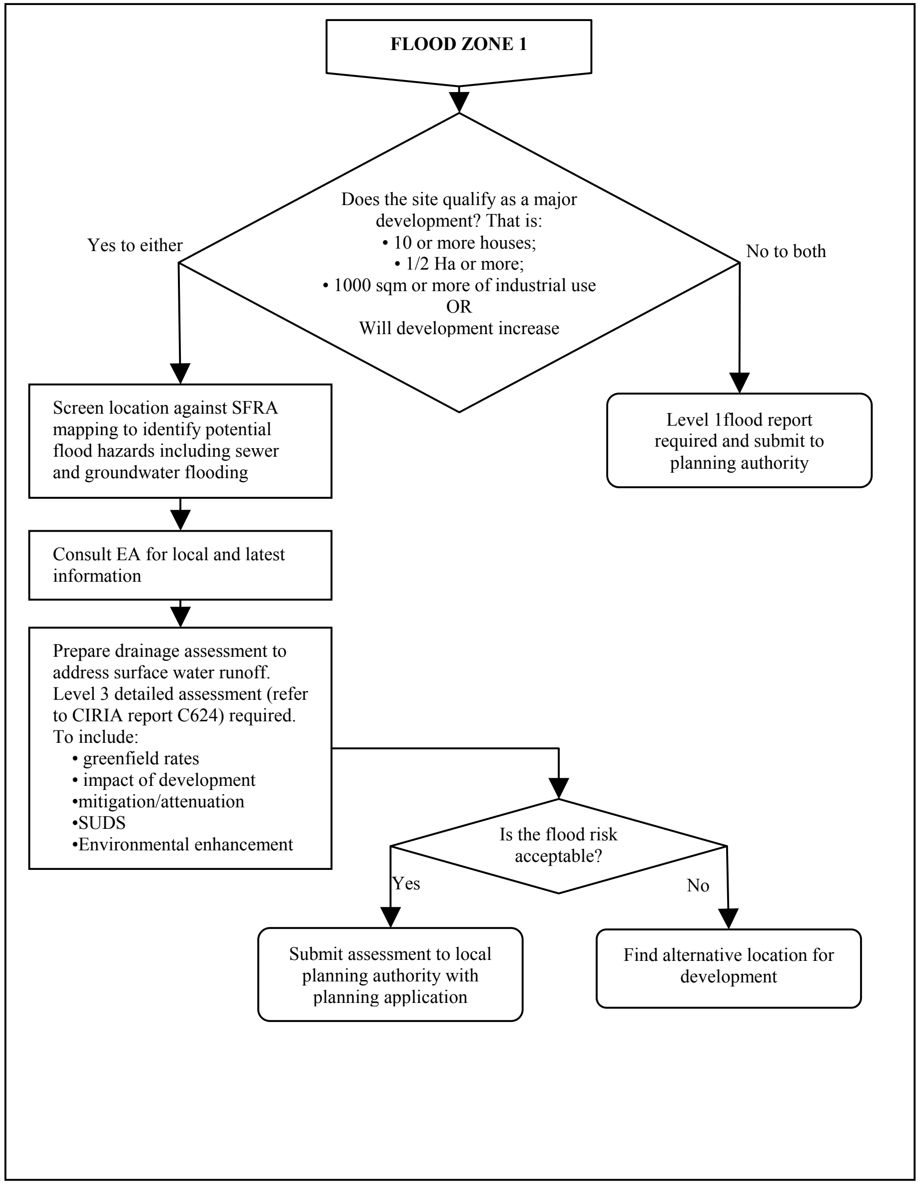
Southern Water
Customer Services
PO Box 41
Worthing
West Sussex
BN13 3NZ
Tel: 0845 278 0845
http://www.southernwater.co.uk

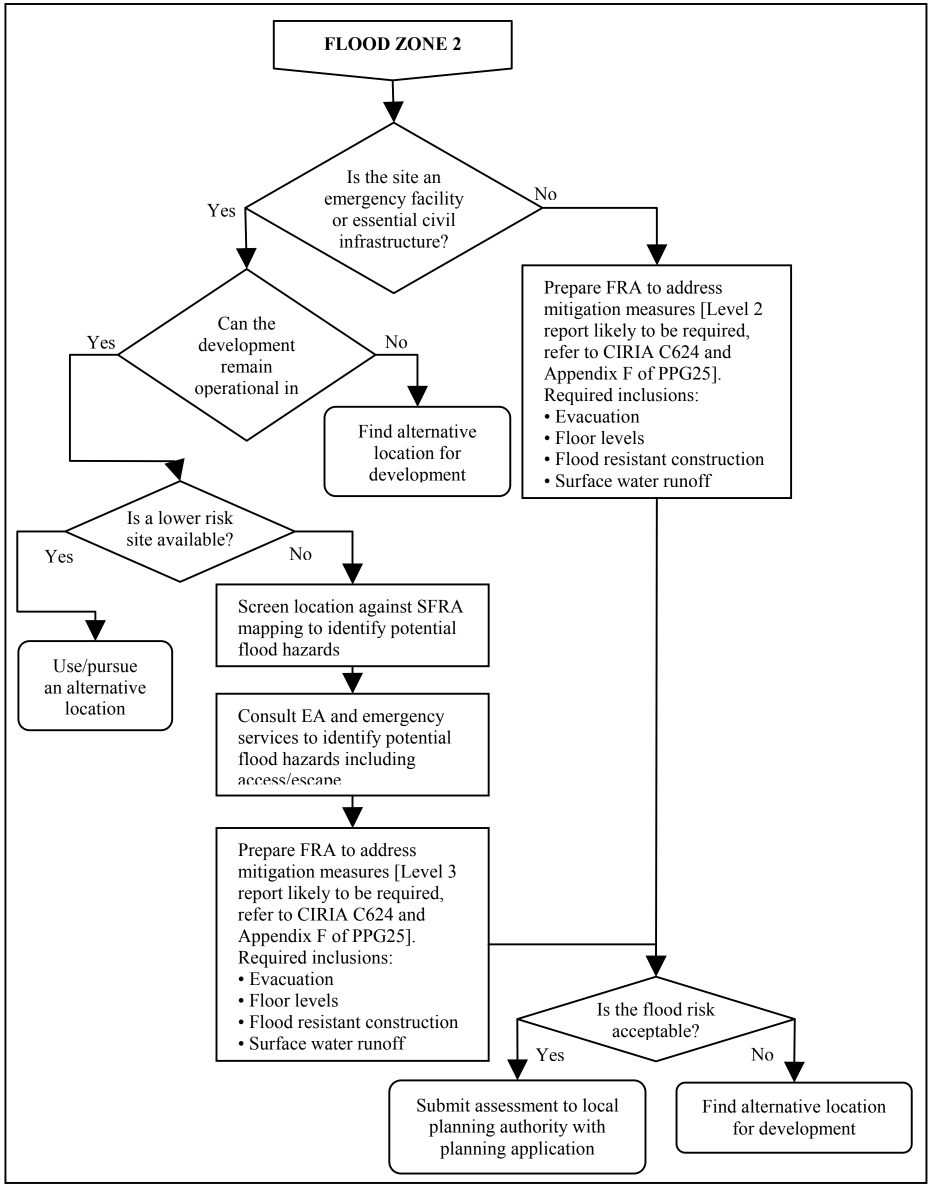
3.5 Flow Chart / Check List

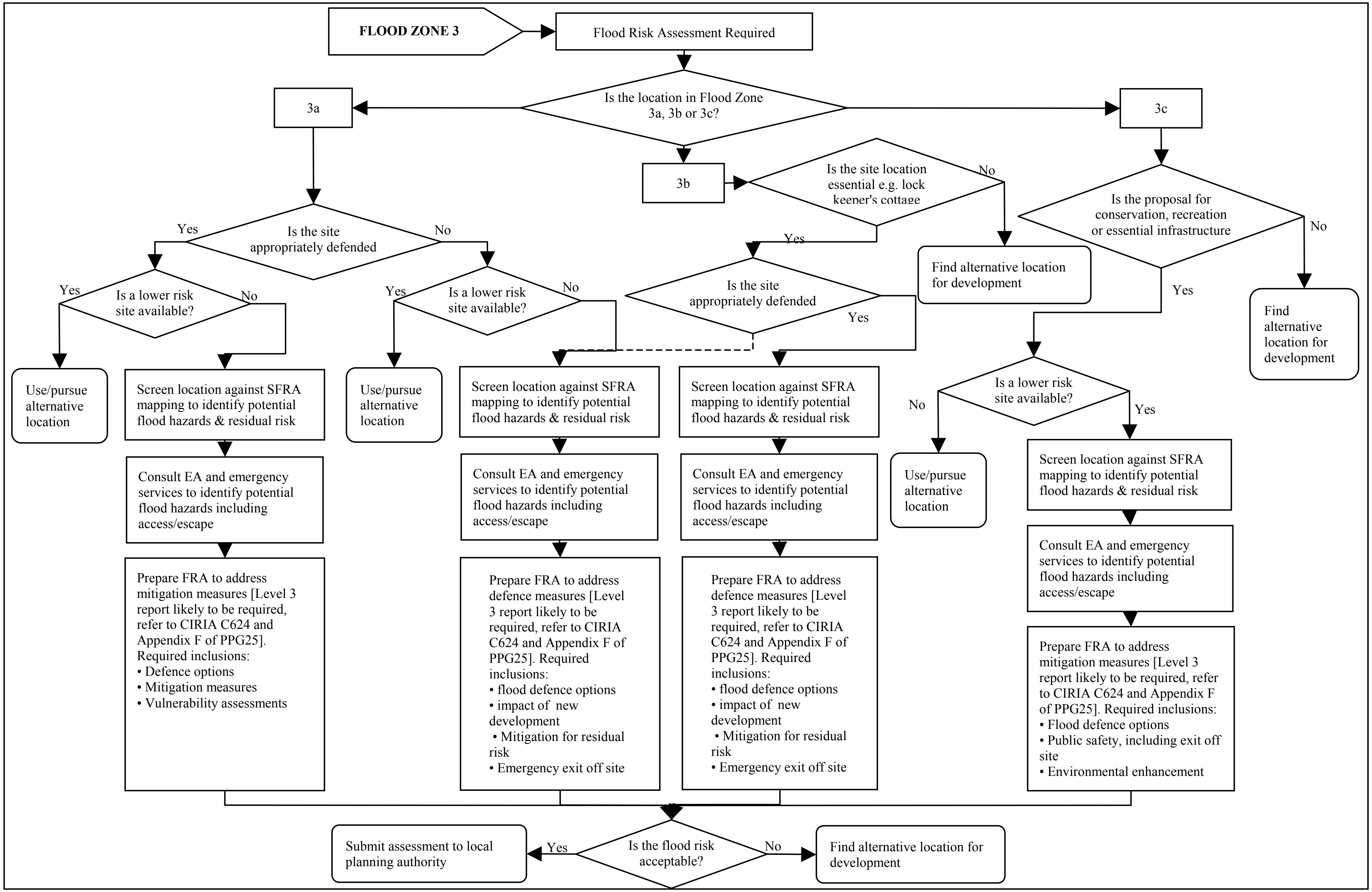
Figure 3.1 overleaf provides a flow chart for the key decision making aspects of the Flood Risk Assessment process.

Figure 3.1: Flood Risk Assessment Flow Chart




FLOOD ZONE 1
Does the site qualify as a major development? That is:
• 10 or more houses;
• 1/2 Ha or more;
• 1000 sqm or more of industrial use
OR
Will development increase
Yes to either
No to both
Screen location against SFRA mapping to identify potential flood hazards including sewer and groundwater flooding
Level 1flood report required and submit to planning authority
Consult EA for local and latest information
Prepare drainage assessment to address surface water runoff.
Level 3 detailed assessment (refer to CIRIA report C624) required.
To include:
• greenfield rates
• impact of development
•mitigation/attenuation
•SUDS
•Environmental enhancement
Is the flood risk acceptable?
Yes
No
Submit assessment to local planning authority with planning application
Find alternative location for development


FLOOD ZONE 2
Is the site an emergency facility or essential civil infrastructure?
Yes
No
Can the development remain operational in
Yes
No
Find alternative location for development
Prepare FRA to address mitigation measures [Level 2 report likely to be required, refer to CIRIA C624 and Appendix F of PPG25].
Required inclusions:
• Evacuation
• Floor levels
• Flood resistant construction
• Surface water runoff
Is a lower risk site available?
Yes
No
Use/pursue an alternative location
Screen location against SFRA mapping to identify potential flood hazards
Consult EA and emergency services to identify potential flood hazards including access/escape
Prepare FRA to address mitigation measures [Level 3 report likely to be required, refer to CIRIA C624 and Appendix F of PPG25].
Required inclusions:
• Evacuation
• Floor levels
• Flood resistant construction
• Surface water runoff
Is the flood risk acceptable?
Yes
No
Submit assessment to local planning authority with planning application
Find alternative location for development


FLOOD ZONE 3
Flood Risk Assessment Required
Is the location in Flood Zone 3a, 3b or 3c?
3a
3b
3c
Is the site appropriately defended
Yes
No
Is a lower risk site available?
Yes
No
Use/pursue alternative location
Screen location against SFRA mapping to identify potential flood hazards & residual risk
Consult EA and emergency services to identify potential flood hazards including access/escape
Prepare FRA to address mitigation measures [Level 3 report likely to be required, refer to CIRIA C624 and Appendix F of PPG25]. Required inclusions:
• Defence options
• Mitigation measures
• Vulnerability assessments
Is a lower risk site available?
Yes
No
Use/pursue alternative location
Screen location against SFRA mapping to identify potential flood hazards & residual risk
Consult EA and emergency services to identify potential flood hazards including access/escape
Prepare FRA to address defence measures [Level 3 report likely to be required, refer to CIRIA C624 and Appendix F of PPG25]. Required inclusions:
• flood defence options
• impact of new development
• Mitigation for residual risk
• Emergency exit off site
Is the site location essential e.g. lock keeper's cottage
No
Yes
Find alternative location for development
Is the site appropriately defended
Yes
Screen location against SFRA mapping to identify potential flood hazards & residual risk
Consult EA and emergency services to identify potential flood hazards including access/escape
Prepare FRA to address defence measures [Level 3 report likely to be required, refer to CIRIA C624 and Appendix F of PPG25]. Required inclusions:
• flood defence options
• impact of new development
• Mitigation for residual risk
• Emergency exit off site
Is the proposal for conservation, recreation or essential infrastructure
No
Yes
Find alternative location for development
Is a lower risk site available?
No
Yes
Use/pursue alternative location
Screen location against SFRA mapping to identify potential flood hazards & residual risk
Consult EA and emergency services to identify potential flood hazards including access/escape
Prepare FRA to address mitigation measures [Level 3 report likely to be required, refer to CIRIA C624 and Appendix F of PPG25]. Required inclusions:
• Flood defence options
• Public safety, including exit off site
• Environmental enhancement
Is the flood risk acceptable?
Yes
No
Submit assessment to local planning authority
Find alternative location for development

3.6 Planning Policy References

1. Planning Policy Guidance Note 25 – Development and Flood Risk (DTLR, July 2001)

2. Environment Agency's Standing advice to local authorities in England (EA, 2004)

3. C624 Development and flood risk – guidance for the construction industry (CIRIA, September 2004)

4. C609 Sustainable drainage systems – Hydraulic, structural and water quality advice (CIRIA, Wilson et al., 2004)

5. C522 Sustainable urban drainage systems – Design manual for England and Wales (CIRIA, Martin et al., 2000)

6. C523 Sustainable urban drainage systems – Best Practice Manual for England, Scotland, Wales and Northern Ireland (CIRIA, Martin et al., 2001)

7. C625 Model agreement for sustainable water management systems (CIRIA, Shaffer et al., 2004)

8. SR626 Operation and Maintenance of Sustainable Drainage Systems (and associated Costs) (HR Wallingford, 2004)

9. R & D Technical Report W5-074/A Preliminary rainfall runoff management for developments (DEFRA/ EA, Kellagher et al., 2004)

10. Environment Agency policy regarding culverts (EA, 1999)

11. B014 Design of Flood Storage Reservoirs (CIRIA, Hall et al.,1993)

12. Framework for sustainable drainage systems in England and Wales, Consultation document (National SUDS Working Group, 2003)

13. FR/ IP/45 Reducing the Impacts of Flooding – Extemporary Measures (CIRIA, Elliott & Leggett, 2001)

14. C623 Standards for the Repair of Buildings following Flooding (to be published in summer 2005)

4 Technical Considerations

4.1 Data Assessment Criteria and Processes

4.1.1 General Criteria

It is required that Flood Risk Zones are defined in accordance with the criteria set out in PPG25. For land at risk from flooding, these criteria require differentiation according to the "sequential characterisation of flood risk" described in PPG 25.

In addition, it is required that "Rapid Inundation Zones" are identified. It has been agreed that for the purposes of this study rapid inundation is defined as the filling of an area of land to a depth of 0.3m within 30 minutes of a defence overtopping or failing. Theses are the same criteria that have been applied to other SFRAs undertaken by Mott MacDonald.

For this study, the river Medway has been modelled using the Tuflow 2-D hydrodynamic software. The downstream model boundary has been defined in accordance with the work reported by JBA in "Extreme Sea Levels, Kent, Sussex, Hampshire and the Isle of Wight, Updated Summary Report, December 2004". The 2-D model extends from Allington Lock to Sheerness.

The SFRA has considered six combinations of water level and climate change. The mapping produced for each combination is summarised in Table 4.1 below. The maps themselves are presented in Section 5 of this report.

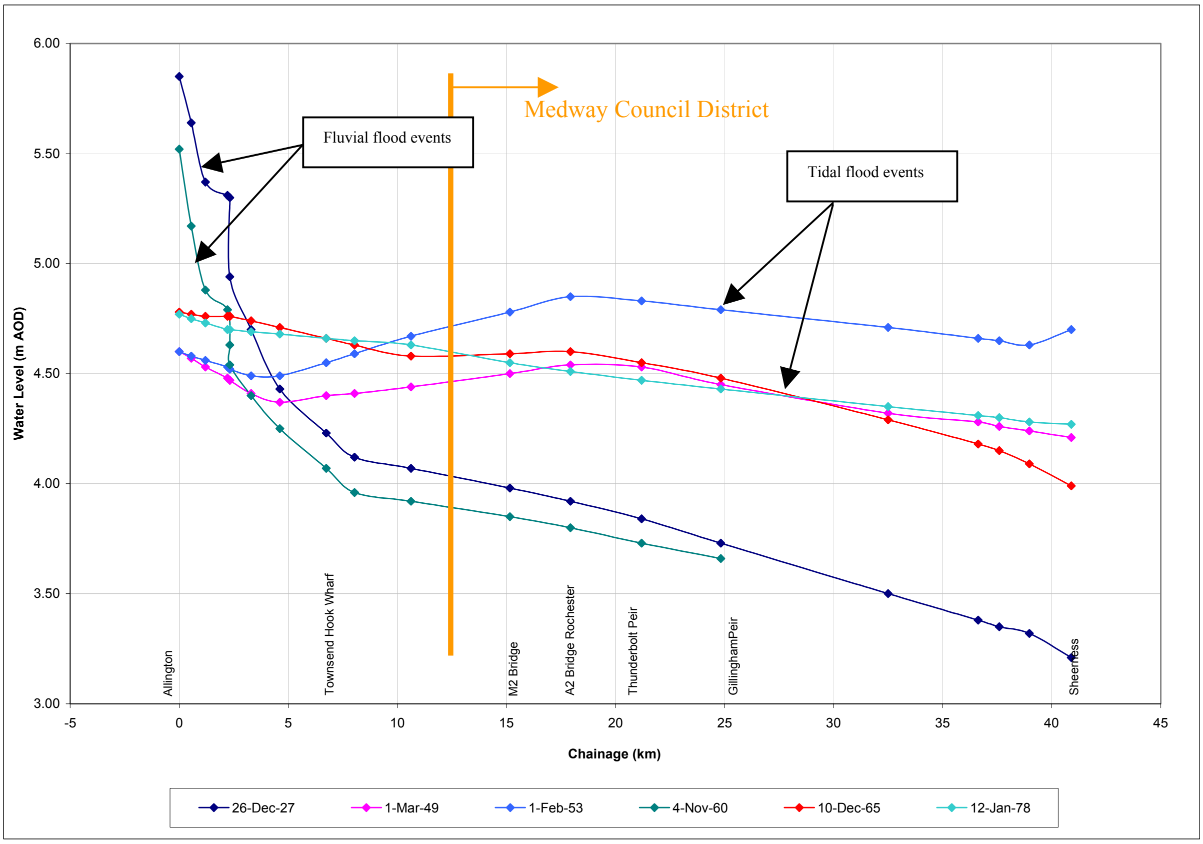
Table 4.1: Water Level and Climate Change Combinations

Ref	Return period water level	Year to which climate change is considered	Parameters displayed
1	200 yr	present day	Flood extent, flood depth
2	200 yr	2060	Flood extent, flood depth
3	200 yr	2100	Flood extent, flood depth, flood hazard, rapid inundation
4	1000 yr	present day	Flood extent, flood depth
5	1000 yr	2060	Flood extent, flood depth
6	1000 yr	2100	Flood extent, flood depth, flood hazard, rapid inundation

4.1.2 Source of Risk

Examination of historical flood events, see Figure 4.1 below, indicates that although the Medway is considered to be tidal as far upstream as Allington Lock, fluvial flooding is significant in the first 5-10km downstream of the lock. By the time the river reaches the M2 bridge, the risk of fluvial flooding is small compared to that of tidal inundation. Since all of the Council's primary development sites are downstream of the M2 bridge, tidal flooding is considered as the primary source of flood risk for the sites investigated in this SFRA.

Figure 4.1: Historical Flood Levels on the Medway



Secondary sources of flood risk include the following:

- Fluvial flooding;
- Inundation from groundwater rise;
- Flooding from excessive flow in surface water drainage sewers;

4.1.3 Rapid Inundation Zones

As stated above, rapid inundation has been taken as the development of 30cm depth of floodwater within 30 minutes of overtopping or breaching of defences. Breach widths have been taken as 20m in structural walls and 50m in earth embankments. It is assumed that a breach occurs every 600m in walls, and every 300m in embankments.

All sites have been examined for overtopping induced rapid inundation zones, however, only those sites where flood defences already exist have been examined for breach RIZ's. These breach sites are detailed in Table 4.2 below:

Table 4.2: Sites where Rapid Inundation Zones have been determined from Breach Scenarios

Site	Approximate length of defence (km)
Strood Town	2
St Mary's Island	3
Upnor	2

4.1.4 Ground Surface Data

(i) General

The following sources of survey data were utilised in the SFRA study:

- High level LiDAR of the Medway and Swale floodplains.
- Low level (helicopter based) LiDAR flown over flood defence assets.
- Bathymetry of the Medway and the Swale channels, but not the Swale creeks.
- Southern Water Infrastructure mapping

(ii) LiDAR

LiDAR stands for Light Detection and Ranging and is an airborne mapping technique which uses a laser to measure the distance between the aircraft and the ground. This technique was used to acquire the floodplain topographical data for the Lower Medway from Allington to Sheerness and it represents the primary source of data for the present study.

Two LiDAR surveys were conducted:

- A high level survey undertaken in 2001 by the Environment Agency's Twerton office (the data from this exercise was re-filtered by the Agency in 2003 using an updated filtering algorithm).
- A low level survey undertaken by the survey Contractor, BKS, specifically for the present study, in 2005.

The LiDAR sensor provides a very dense sample of ground levels, which are then converted into a grid. The resolution of these grids is determined by the density of the samples. For high level LiDAR coverage the horizontal grid resolution is generally 2m. Taken together with the accepted vertical accuracy of +/- 15cm this indicates that in the areas covered the LiDAR data provides a good representation of the ground surface. However, a key requirement of the present study is to determine flood defence levels and a 2m horizontal resolution is clearly inadequate for this task, particularly where defences are made up of walls or narrow crested embankments.

Because of the requirement for more detailed survey, a low level LiDAR was flown in the late Spring of 2005. This helicopter based approach provides a much higher horizontal resolution, between 5 and 10cm, and a ground level accuracy of +/- 3 cm. The low level LiDAR was flown from a height of 100m along a path some 60-70m wide on either bank of the Medway.

(iii) Bathymetry

Bathymetric data was obtained by hydrographic survey of the Medway by the Environment Agency's Twerton office.

Data for the section of river between Allington and the M2 bridge was collected in 2002 by a contractor for the Agency. Survey of the reach between the M2 and Sheerness was undertaken specifically for this SFRA study in April 2005.

(iv) Southern Water Infrastructure Plans

In areas which are not covered by either of the LiDAR surveys, Southern Water infrastructure plans were obtained and used to determine ground levels from the manhole data contained within the mapping.

4.2 Condition of Flood Defences

A review of the flood defence condition along the River Medway has been undertaken through a walkover inspection of the proposed development areas. The findings of this review are presented in the relevant Appendices to this report.

Further information may be obtained from the Agency's National Flood and Coastal Defence Database (NFCDD) which will be regularly updated to reflect the results of future asset surveys.

4.3 Impact of the Proposed Development on Fluvial or Coastal Morphology

The morphology of an estuary (its shape and underwater contours) affects, and is in turn affected by, issues relating to flood defence, water quality, conservation and navigation. Current research is being undertaken into the impacts of developments in the UK on the surrounding rivers and coastlines with a focus to reduce any negative effects they may cause.

Changes to the defences or alterations to drainage outlets along the River Medway catchment could impact on the morphology of the surrounding area. However, the proposed developments will not impact directly on the active floodplain and therefore it is unlikely that any morphological changes will be significant. Notwithstanding this, a developer is required to evaluate the impact of any alteration to an existing flood defence e.g. the removal of an old frontage wall, or construction of a new flood defence; on the morphology of the River Medway.

It is also important to note that there will always be a presumption against encroachment into the river beyond the existing flood defence line, during the redevelopment of any of Medway's sites.

4.4 Surface Drainage

4.4.1 General

Drainage issues at riverside locations will generally relate to problems associated with storage or pumped drainage requirements in tide lock conditions. There is limited opportunity for SuDS at these locations but some recreation use should be considered. Inland sites and perhaps sites not yet identified are more likely to find SuDS more appropriate especially where the infiltration, storage and water quality benefits can be utilised.

4.4.2 Sustainable Drainage Systems

The SUDS approach to drainage involves controlling the runoff from development sites so that it mimics greenfield runoff and maintains the natural drainage patterns as far as possible. SUDS aim to control runoff at source and are increasingly being used to mitigate the flows and pollution from new developments. They can also provide other environmental benefits such as enhanced bio-diversity and amenity value. PPG25 recommends the promotion of these systems through the planning system.

The growing interest in the use of SUDS has resulted in the publication of several guidance documents by CIRIA. They are listed under the references section of this guidance document.

SUDS techniques must meet a number of criteria before being considered for general use:

- the drainage triangle – a concept of meeting quantity, quality and amenity objectives
- the management train – a hierarchy of techniques used in series to improve quantity and quality:

    prevention (use of good site design and housekeeping measures)

    source control (control of runoff at or very near its source)

    site control (management of water from several subcatchments)

    regional control (management of runoff from several sites)

Table 4.3 below illustrates how the objectives of the drainage triangle can be achieved.

Table 4.3: Achievement of SUDS drainage triangle objectives

Element	How achieved?
Quantity	• minimise impermeable surfaces by good planning of development layout • control at source to reduce extra runoff • limit peak discharge to an agreed allowable runoff rate • attenuate excess water to an agreed storm return period (normally 1 in 100 year with allowances for climate change) • low flow routes for frequent storms and first part of volume of rare storms through treatment stage • high flow routes for extreme events with overland flood routes
Quality	• prevent pollution by good planning of development layout and site management • treatment stages, usually a minimum of one for housing • appropriate technique to treat runoff from roads and pavements • 'source control' preferred to control silt and pollution • 'first flush' treatment for all roads and pavements
Amenity	• techniques should maximise opportunities for amenity including environmental and bio-diversity where possible • techniques should protect amenity

For cost-effective SUDS designs they must be designed at the feasibility stage of any development to ensure that they can be integrated into the overall site design. There are four generally established methods of control related to SUDS. Traditionally used in-line or off-line storage within underground tanks or oversized pipes must be only considered as a last resort in conjunction with other SUDS measures. The five categories of SUDS include:

- filter strips and swales;
- filter drains and permeable surfaces;
- infiltration devices;
- basins, ponds and wetlands; and.
- green roofs.

CIRIA publication C609 details the common SUDS techniques and their function within the management train.

Examples of some simple techniques include:

- Underground storage
- Water butts

C609 Sustainable drainage systems – Hydraulic, structural and water quality advice (*Reference 5*) gives further information on SUDS from feasibility study to operation and maintenance, including the details of other relevant publications. CIRIA website www.ciria.org/suds also gives further useful information on SUDS and their ongoing projects on this subject. Their ongoing project, RP697: SUDS - updated guidance on technical design & construction, will "collate review and where necessary update research to deliver comprehensive and definitive best-practice guidance on the planning, design and construction of Sustainable Drainage Systems (SUDS) to assist engineers, designers, planners and developers with the incorporation of SUDS in developments."

4.4.3 Long-term Management of SUDS

A key factor for the successful implementation of SUDS is the ongoing operation and maintenance of the various system components. Effective maintenance helps ensure the hydraulic capacity and pollutant removal efficiency of SUDS as they were originally designed. Maintenance of SUDS is generally no more difficult than maintaining piped systems as they can easily be undertaken by a landscape contractor during general landscape maintenance visits. SUDS maintenance needs a minimum monthly site attendance for general site care by landscape contractors or site managers.

A handover inspection is needed to ensure that the client has a robust SUDS scheme which takes into account all potential defects attributed to design and / or implementation.

Table 4.4 gives a brief summary of maintenance requirements for SUDS. CIRIA report C625 Model agreements for sustainable water management systems – Model agreements for SUDS (*Reference 8*) provides background and a long-term framework for operation and maintenance of SUDS containing model agreements for specific scenarios:

- implementation and maintenance of SUDS through the planning process, either as a planning obligation under Section 106 of the Town and Country Planning Act 1990 or as a condition attached to planning permission; and
- implementation and maintenance of SUDS between two or more parties (outside of the requirements for planning permission), i.e. private SUDS model agreement.

Report C625 also discuss the adoption of SUDS and funding mechanisms that are available for local authorities, highway authorities, sewerage undertakers and private organisations for the operation and maintenance of these systems.

More detailed information on maintenance can be found in CIRIA publications C609, C523 and 522 and HR Wallingford report SR 626, "Operation and maintenance of sustainable drainage infrastructure and associated costs."

4.4.4 Surface Drainage Requirements for Medway

Re-development of brownfield sites generally opens up the possibility of increasing permeable areas, thereby reducing the risk of flooding from surface water.

Measures to minimise the volume of runoff from the new developments should therefore be considered before the storm-water drainage design is undertaken. Possible measures include

- Minimise paved areas

- Promote rainwater recycling, a water butt at each residence with a capacity of $2m^3$ could provide storage for roof runoff from a 20% event
- Minimise directly connected areas of hard-standing

Even following the inclusion of the above measures, the predicted volume of storm water for the 1% event will clearly remain high. As the development sites (with the exception of Chattenden) are immediately adjacent to the River Medway, surface water runoff could be rapidly directed into the river via surface drainage in all but the most extreme tidal conditions. Wherever possible the outlets into the river should be located above Mean High Water Level (MHWL) to ensure free discharge conditions.

Where drainage outlets are required to be below the MHWL, flows will become constrained as the tide level rises - this is termed a "tide-locked" condition. For tide-locked drainage the developer must consider the following key issues:

- Flap, or non-return, valves are required to prevent backing up of the surface water drainage system with tidal flows. Note that these valves will require routine maintenance to ensure that they do not become stuck either in the open or closed positions.
- Additional upstream storage may be needed to allow drainage flows to be retained during the period of high tidal water levels. For large developments this may require a dedicated storage area, either above or below ground, however for smaller sites the provision of over-sized pipework may be sufficient.
- Pumping facilities to maintain the requisite drainage discharge even during high tide conditions may also be needed.

Note that in some instances a combination of pumping and additional storage facilities will be required, but some form of non-return valve will be needed in all cases.

As discussed above, modern best practice stormwater drainage design focuses on Sustainable Urban Drainage Systems (SuDS) as a means to ensure that the impact on downstream and surrounding water courses is minimised. SuDS design incorporates methods to control the source of runoff and provide attenuation of runoff so that downstream systems are not inundated. One of their uses on sites adjacent to the River Medway may be to provide storage during tide-lock conditions, as described above.

Whilst there may be a few opportunities to implement these source control methods it is unlikely that major SuDS solutions, such as infiltration and soakaway systems, will be possible on the majority of the Medway sites. This is due to the ground conditions which restrict the effectiveness of such systems. The Environment Agency prefers that no infiltration/soakaways are used because:

- The water table is shallow in the chalk aquifer which could result in the soakaways not being effective.
- The Chalk Aquifer below the site is located in a designated SPA Source Protection Zone which is used for public water supply abstraction. Therefore the use of soakaways is undesirable as it increases the risk of pollution to the aquifer. See Figure 4.1 below

It is therefore proposed that surface water is generally picked up in a stormwater drainage system and gravity fed to a series of gated outlet pipes along the River Medway frontage.

In the extreme when a storm event coincides with a water level in the river above the MHWL, it is proposed that the new drainage system would have the capacity to attenuate the runoff and store it until the levels in the river reduce to a level such that the gated outlet could operate once more.

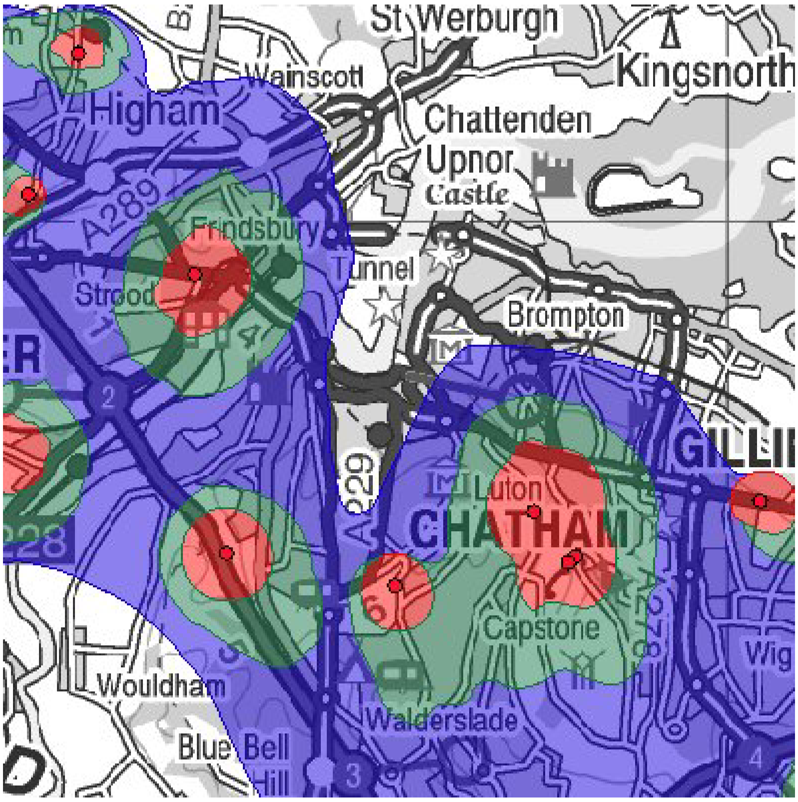


Figure 4.1: Source Protection Zones:

Key:

- Borehole
- Inner zone
- Outer zone
- Total catchment
- Special interest

Source: Environment Agency Website 13 December 2005. This information is regularly updated by the Environment Agency and the latest information should always be sought prior to use.

4.5 Freeboard

In flood risk terms, freeboard is the vertical distance between the expected river still water level for a particular return period event, and the crest level of the defence. In simple terms it is the safety margin that is added to a calculated river level to allow the designer to account for uncertainty and risk.

> *"Freeboard is an allowance not only to take account of physical processes such as waves but also a safety margin to allow for uncertainties in the prediction of physical processes. The safety margin gives confidence that the defence will provide the desired level of protection despite the uncertainty in how a catchment and river system will perform hydraulically and hydrologically." - Source: Fluvial Freeboard Guidance Note, EA R&D Technical Report W5A(97A).*

For this SFRA, flood defences are primarily required along the River Medway to protect existing and future developments from tidal, as opposed to fluvial, inundation. As such, in assessing required freeboard the recommendations of "Overtopping of Seawalls: Design and Assessment Manual (O.S.); HR Wallingford" have been adopted rather than those of the Agency's Fluvial Freeboard Guide.

This Wallingford methodology uses a statistical approach to determine the average wave overtopping discharge for a given set of defence conditions. The required freeboard is then determined by limiting the overtopping discharge to the following allowable values:

- No damage to an embankment seawall — 0.002 $m^3/s/m$
- No damage to a revetment seawall with unpaved promenade — 0.05 $m^3/s/m$
- No damage to a revetment seawall with paved promenade — 0.2 $m^3/s/m$

The above limits are based on requirements to prevent damage to the flood wall itself. This is obviously of crucial importance. For Medway, however, there is a second requirement, namely that the overtopping discharges themselves do not result in flood damage to the properties protected by the flood wall. The manual does not offer guidance on limitations to prevent low level inundation of properties; indeed it would be difficult to do so since the risk is dependent on the topography of the defended land, the type of properties and the drainage infrastructure in place to deal with overtopping discharges.

It is likely that along the Medway frontage all new defences will be of the revetted type with a paved promenade which would suggest an overtopping discharge limitation of 0.2 $m^3/s/m$. However, assuming that the overtopping flow continues for a period of 1 hour either side of the high tide mark then it would be expected that in one tidal cycle some 720 m^3 of water per metre of flood wall would overtop the defences. This is a significant quantity of water. Adopting the more severe requirement of limiting discharges to 0.05 $m^3/s/m$ would give rise to 180 m^3 of water, while limiting discharges to 0.002 m^3/s would result in 7 m^3 of water overtopping the defences per metre of flood wall.

Mean overtopping discharges were calculated for five points along the Medway frontage. In each case, the discharge is calculated on the basis of a 1 in 100 year (1%) return period wind speed. The results are presented in Table 4.4 below.

Table 4.4: Relationship between Freeboard and Mean Overtopping Discharge

Location	Freeboard (mm) required to limit overtopping discharges to:		
	0.002 $m^3/s/m$	0.05 $m^3/s/m$	0.2 $m^3/s/m$
Gillingham Pier	1690	550	60
Upnor Pier	1650	545	65
Chatham Ness	160	0	0
Rochester Bridge	105	0	0
Medway Bridge (M2)	195	0	0

The values presented in Table 4.4 above represent the freeboard requirements needed to account for the influence of waves and wave runup. In addition, an estimate is required for settlement of the defences and account taken of the uncertainty in the design still water level. On this basis, and assuming an overtopping mean discharge limit of 0.05 $m^3/s/m$, total recommended freeboard requirements are presented in Table 4.5.

Table 4.5: Recommended Freeboard Requirements

River reach	Wave freeboard (mm)	Settlement allowance (mm)		Uncertainty allowance (mm)	Recommended freeboard (mm)	
		Concrete defence	Earthfill defence		Concrete defence	Earthfill defence
Medway Bridge to Upnor Pier	0	0	300	300	300	600
Upnor Pier to Gillingham Pier	550	0	300	300	850	1150

It is a requirement of any future detailed Flood Risk Assessment to explain how a mean overtopping discharge of 0.05 m^3/s/m can be adequately contained within the development. If higher or lower volumes of water can be contained then a case could be put forward for the wave freeboard requirements to be altered accordingly.

4.6 Demountable Defences

The Council would prefer to avoid the use of demountable flood defences, as they are dependent on good operational procedures and manpower availability. They should be seen as wholly exceptional.

Notwithstanding the above, the river frontage between Sun Pier and Star Hill appears to represent a potential opportunity for demountable defences. This is primarily because existing development precludes land raising and the proximity of existing and replacement build to the river edge makes construction of permanent hard defences aesthetically difficult, especially when considering the character of the area.

A preliminary study of the feasibility of using demountable defences along this reach of the river has been undertaken by Mott MacDonald, in association with Bauer Inner City, a manufacturer of a type of demountable defence used by the Environment Agency in similar conditions. Bauer's report is attached to Appendix C of this SFRA.

The report by Bauer considers that demountable defences are viable at the location considered. The critical technical issue for demountable defences is usually related to the adequacy of the defence beneath the demountable. In the case of Sun Hill to Star Pier, the majority of the existing defence walls are of modern sheetpile design, and from a surface inspection appear to be more than adequate. Of the non-technical issues the principal reservation revolves around the need to maintain an appropriate labour force, capable of installing the demountable defences at short notice.

The Council has engaged in initial discussions with the Environment Agency regarding their availability for this work and negotiations are continuing. The Council expects that if demountable defences are proposed for the Sun Pier to Star Hill site then both the cost of the defences and a commuted sum to cover their operation will be furnished by the developer.

5 Flood Risk Mapping

5.1 Introduction

The Environment Agency is responsible for preparing Flood Maps and placing them in the public domain. All such outputs follow a standard format to ensure consistency nationally. The 2D model and the flood risk maps are an end product for the Environment Agency whereas they are a tool contributing to the SFRA required by the councils.

The maps prepared under this study cover a range of return periods and climate conditions as specified in Table 5.1.

Table 5.1: List of Model File Names for Design Runs

ID Nr	Return period (Tide)	Climate Conditions	File Name
1	200 yr	present day	200_existing
2	200 yr	2060	200_2060
3	200 yr	2100	200_2100
4	1000 yr	present day	1000_existing
5	1000 yr	2060	1000_2060
6	1000 yr	2100	1000_2100

5.2 Summary of Flood Maps

5.2.1 Flood Extent and Flood Depth Maps

Flood extent and depth maps have been prepared for all the design runs. They are available as paper copies, A1 size, and are provided in digital format on the accompanying CD.

The first locations to flood substantially, identified from the 200_Existing flood map, are:

- Gillingham Waterfront
- Rochester Riverside
- Strood Riverside
- Strood Centre

These sites are therefore regarded as having a high risk of flooding. The following locations also flood under the 200_Existing design run, but only to a minor extent:

- Upper and Lower Upnor
- Chatham Historic Dockyard

- Chatham Centre and Water Front
- Historic Rochester
- The Esplanade
- Scattered locations around the Medway City Estate

Under the 200_2060 and 1000_Exisiting design runs the flooding in the aforementioned areas increases in depth and extent to varying degrees, most notably around the Medway Estate, Strood Riverside and Strood Centre. Chatham Port and the eastern most basin are inundated where they were not under the previous design run.

Under the 200_2100 design run flooding in the majority of the aforementioned areas increases in depth and extent to varying degrees, most notably around Chatham Historic Dockyard, the Medway Estate and Rochester Riverside. The only additional location inundated is the central basin of Chatham Martime and St Mary's Island.

Under the 1000_2060 design run, flooding in the majority of the aforementioned areas increases in depth and extent to varying degrees, most notably within Chatham Port. The only addition location inundated is the land of Chatham Martime and St Mary's Island.

Under the 1000_2100 design run, flooding in the majority of the aforementioned areas increases in depth and extent to varying degrees, most notably within the Chatham Maritime and St Mary's Island area.

Detailed analysis of the extent and depth of flooding in the downstream section of the River Medway for design runs 200_2100 and 1000_2100 is presented in the relevant Appendices to this report.

5.2.2 Flood Hazard Maps

Categorising the flood hazard is a method to identify the potential danger or hazard associated with the flood. The hazard categorisation considers both the depth and velocity of the flood waters. The calculation of flood hazard is based upon the following formula:

$$\text{Flood Hazard Category} = (V \times D) + (D/2)$$

where:

V = velocity (m/s)

D = depth (m)

Table 5.2 outlines the flood hazard categories adopted for this study.

Table 5.2: Flood Hazard Categories

Flood Hazard Value	Flood Hazard Category
> 2.25	Extreme
1.25 – 2.25	Significant
0.75 – 1.25	Moderate
0 – 0.75	Low

According to the above formula and flood hazard categorisations, a flood depth greater than 4.5 m will be defined as ‘Extreme’ even if there is no velocity. For flood depths less than 4.5m the hazard category will depend on the velocity of the flood waters.

Flood hazard maps have been prepared for design runs 200_2100 and 1000_2100. They are available as paper copies, A1 size and are provided in digital format on the accompanying CD.

The Flood Hazard Map for the 200_2100 design run indicates that the majority of the flooded area is categorised as ‘Low’ or ‘Moderate’ with only a few isolated areas falling into the ‘Significant’ or ‘Extreme’ categories. These latter areas are located around the entrance to Chatham Port, a small area of Gillingham Waterfront, and small areas within Rochester Riverside, Strood Centre and Historic Rochester. Under the 1000_2100 design run the aforementioned areas assigned a hazard of ‘Moderate’ or ‘Significant’ enlarge slightly. In addition, parts of the Chatham Historic Dockyard area are categorised as ‘Moderate’ or ‘Significant’ and the majority of the land within St Mary’s Island and Chatham Maritime is categorised as ‘Low’ with a small area falling into the ‘Moderate’ category. The three basins within Chatham Maritime are categorised as ‘Significant’ and ‘Extreme’.

5.2.3 Flood Rapid Inundation Zone Maps

Within this study Rapid Inundation Zones (RIZ) are defined as the areas flooded to 30 cm depth within 30 minutes of breaching or overtopping of defences.

RIZ maps have been prepared for design runs 200_2100 and 1000_2100. They are available as paper copies, A1 size and are provided in digital format on the accompanying CD.

The following regions have significant areas categorised as Rapid Inundation Zones under the 200 year return period scenario:

- Strood Centre
- Strood Riverside
- Rochester Riverside
- Historic Rochester

In addition to the above regions, the following regions have significant areas categorised as Rapid Inundation Zones under the 1000 year return period scenario:

- Medway City Estate

- Chatham Historic Dockyard
- Chatham Maritime and St Mary's Island
- Chatham Port
- Gillingham Waterfront

Appendix A Rochester Riverside

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

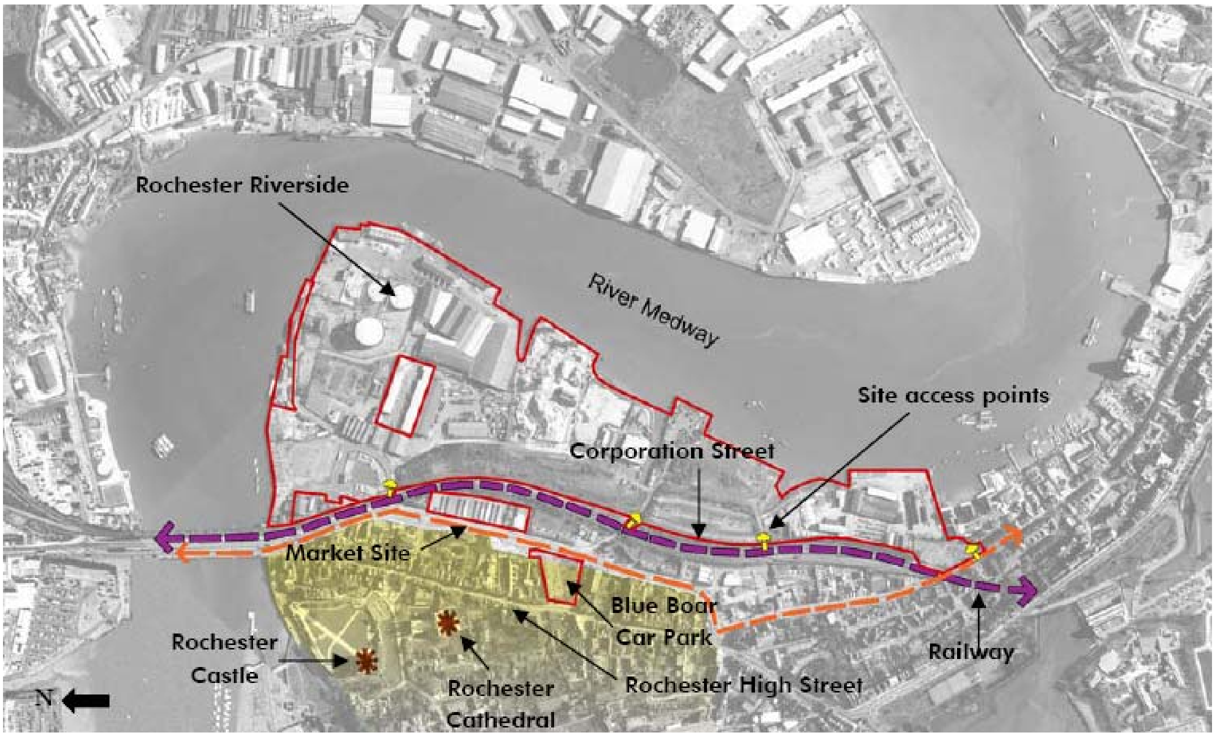
A.1 Introduction

A.1.1 Study Area

The Rochester Riverside site is located on the River Medway along a stretch known as Limestone Reach. The site forms part of the Rochester Peninsula and has an area of approximately 30 hectares with a river frontage around 1.6 km in length (See Figure A.1). The site lies on the southern (right) bank of the River Medway and is bounded to the West by the London Victoria and Canterbury Rail track as well as the A2 Corporation Road. The Ship Pier and Stanley Wharf sit to the South of the site.

The northern portion of the peninsula is made up of low lying landscaping surrounding a British Gas Site, a coach park, Castle View Business Park and some large warehouses. The southern area of the site is similar in that it is predominantly used for builders' yards and warehouses with some minor landscaping. Between these areas the peninsula accommodates an aggregate works with waste management facilities and an area used for fly tipping. The only other significant area is that of the foreshore which consists of mudflats, tidal creeks and rocky outcrops.

Figure A.1: Rochester Riverside Site Location Plan



Rochester Riverside, Development Brief, Medway Council, 2004

A.1.2 The Development

The development site, which is owned by Medway Council, will include:

- between 1700 and 2000 new homes of which a quarter will be 'affordable' homes for rent, shared ownership and key workers;
- a hotel and conference centre on the north-west of the site close to Rochester Bridge;

- a school and community centre;
- start-up and grow-on space for small businesses ;
- a neighbourhood store;
- a riverside walk and cycleway;
- new town squares;
- a multi-storey car park in Corporation Street on the site of the current market; and
- the relocated market to Blue Boar Lane laid out as a new square.

A.2 Existing Conditions

A.2.1 Proposed Development Site

A.i Location

The site is approximately 30 hectares in size with a water frontage onto the River Medway of approximately 1.6km. It is enclosed on its southern boundary by the rail line and embankment with the aforementioned frontage to the north and west of the site.

A.ii Present and Previous Land Use

In the early 1800s there was little or no development on the site which was predominantly covered in swampy marshland. During the mid 1800s the site underwent extensive improvement works including significant reclamation to raise land and subsequent construction, mainly for industrial use.

Since the beginning of the 19th Century the Rochester Riverside site and surrounds have been used for a wide mixture of commercial, industrial and maritime activities. Over time many of these activities have deteriorated or closed down and the site now accommodates a few small industries with the remainder in a derelict state. Much of the land has been exposed to various types of contamination from past usage.

A.iii Topography

In the main area of the site the levels vary between 3 and 5m AoD with the A2 embankment rising to between 8 and 10m AoD. There are a few raised points within the site having levels of around 10 to 14m AoD, with the site falling away gently to the northern tip where the ground level is consistently around 3m AoD. At the southern end of the site levels are predominantly around 5m AoD while the levels along the base of the railway embankment undulate between 4 and 8m AoD.

A.iv Geology

The site consists of a variety of made ground with depths varying between 1 and 6 m. This made ground overlies soft clay/silt alluvium up to 10m thick which contains inconsistent layers of peat. The alluvium overlies river terrace gravels varying in thickness between 1 and 7m. A major geological structure called the London Basin, which has chalk as its major characteristic, lies beneath the gravel.

As is expected with reclaimed land, the site provides poor shallow foundation conditions. This is exacerbated by the soft alluvium layer beneath. High rates of settlement can also be expected should the developer consider extensive land raising on the site.

A.2.2 Existing drainage

Over the years the Rochester Riverside site has been developed in the normal adhoc manner with the system of natural creeks being infilled or culverted and a system of pipes being used to carry surface water out to the River Medway via four outfalls.

It is understood that the existing pipe system consists of the following:

- Existing pipe and outlet between Acorn Wharf and A2;
- Existing pipe and outlet to the north of Cory's Wharf;
- Existing dual pipe and outlets adjacent to Blue Boar Wharf;
- Existing pipe at Stanley Wharf;
- Existing pipework along Bath Hard Wharf;
- Existing pipe along Furrell's Road.

The surface drainage network is managed by Southern Water plc and it is understood that the existing system is gravity fed with the assumption that, due to the tidal nature of the downstream environment, each of the outlets is likely to have flapped gated outfalls.

The catchment area of the Rochester Riverside site, and indeed the entire peninsula, is relatively small in comparison to the full area to the west of the A2 (Corporation Road). The system drains via gravity to the river and at present has capacity to cope with the undeveloped site.

Anecdotal information suggests that the existing drainage system within the site has the capacity to accommodate storm events even when the outfalls are tide locked. Whilst this suggests the system has some potential for attenuation, feedback from Southern Water plc indicates that the system would need to be updated to cater for any future developments.

A.2.3 Flood Defences

It is understood that the existing frontage along the River Medway has been constructed over time to provide docking facilities for the various industries that have been there over time. There are still four suspended wharves on piers that project out into the River Medway. Whilst not directly considered a flood defence structure these have, over time, provided limited flood protection to the site.

The River Medway frontage is approximately 1.6 km long as indicated above and consists of a number of different structures including:

- reinforced concrete walls;
- concrete walls infilled with pre-cast panels;
- earth retaining timber crib walls;
- steel sheet piles;
- and earth embankments.

It is understood that the Environment Agency believe the existing river frontage structures will provide adequate flood protection for a 5% (1 in 20 year) storm event.

In principal the control of flooding along the River Medway is the responsibility of the Environment Agency, however the Medway Ports Authority was assigned statutory responsibility for this section of the river as part of the Medway Ports Authority Act 1973.

Medway Council, as the riparian owner of the land at Rochester Riverside, hold the responsibility for the maintenance of the frontage to the River. This is with the exception of the Union Transport plc owned land at Gashouse Point.

The Medway Council Development Brief Report (2004) indicates that any new development would require the construction of new flood defences as well as the raising of ground levels to 5.8m AoD.

A.2.4 Historic Flooding

Information obtained from recorded water levels at the A2 Rochester Bridge indicate that flooding events occurred in 1927 (3.92m AoD), 1949 (4.54m AoD), 1953 (4.85m AoD), 1960 (3.80m AoD), 1965 (4.60m AoD) and 1978 (4.51m AoD).

A.3 Tidal Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak levels attained during these tidal cycles for Rochester Roverside are shown in Table A.1.

Table A.1: Expected Maximum Tidal Levels at Rochester Riverside

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.7 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	5.9 m AoD

A.4 Flood Risk under Existing Conditions

There are two main sources of flooding to be considered for any development proposed for the Rochester Riverside site. The two are tidal and surface water, of which it is anticipated that tidal flooding will be the more critical.

A.4.1 Surface Water Flooding

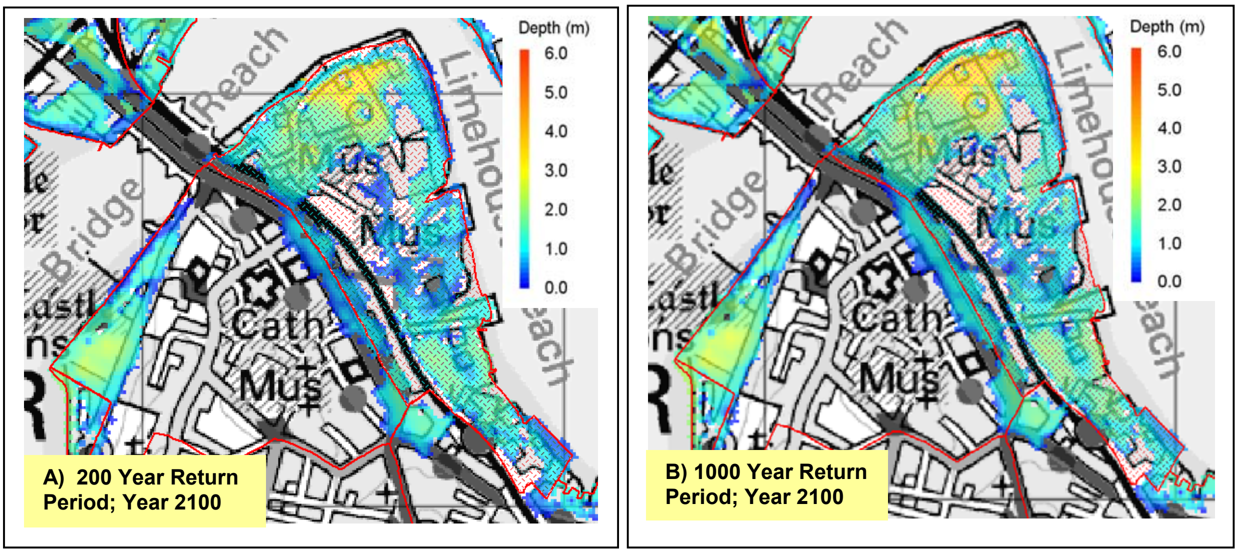
The Environment Agency has indicated that in its present state, the existing surface water drainage system in the area would not have the capacity to cater for any new developments. Therefore, under existing conditions, any further development may cause a back up of the system to occur in storm events resulting in flooding to the site.

A.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

The defences will be first overtopped at high tide just to the north-west of Rochester station, near Blue Boar Lane and at Bath Hard Wharf, and between Cory's Wharf and Limehouse Wharf, extending in a downstream direction as the tide continues to rise. One hour after the first overtopping there will be extensive flooding of the former gas works area and the A2 in the east. Within 1.5 hours the entire length of river frontage along Rochester Riverside will be underwater and floodwaters break through under the railway, inundating the length of the A2 within the Rochester Riverside area within 2.5 hours. The modelling predicts that water will begin to recede some 3 hours after the initial overtopping of the defence and that flood waters will be trapped on land over the majority of the area once the tide level has receded.

Figure A.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure A.2: Extent of Flooding in Rochester Riverside (200_2100 & 1000_2100 events)



The key flooding characteristics for Rochester Riverside area are summarised in Table A.2.

Table A.2: Summary of Rochester Riverside Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.7	2	2.2	4.5	3	0.3	0.5
1000	2100	5.9	2.2	2.2	5	4	0.3	0.5

Note:

Typical existing flood defence levels = 3.7 m AoD to 5.5 m AoD

Length of river frontage = 2.2 km

A.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- The entire river frontage would be overtopped during a 200 year and a 1000 year tide under 2100 climate conditions;
- The majority of the Rochester Riverside site is subject to extensive flooding, with a maximum inundation depth of 4m around the former gas works area;
- The flood water could spread further inland, and even extend beyond the Rochester Riverside site and cause flooding to the A2 Corporation Road.

From the above it can be concluded that prior to development on this site there is a need to improve the existing flood defences. There appear to be two alternatives:

- Construct a new flood defence along the River Medway site frontage.
- Land raising throughout the site.

In terms of the former, such flood defences would require a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table A.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Note that if an embankment defence is considered then a freeboard of 0.6 m is required and the minimum defence crest level should be 5.9m.

For the land raising option it is suggested that the land would need to be raised as follows:

Flood level for 200 year 2060 situation (refer to Table A.1 above)	5.3m
Freeboard to account for uncertainty in the prediction of flood levels (refer to Table 4.5 above)	0.3m
Minimum level of raised ground:	5.6 m

Whichever option is chosen the following will also be required:

- Construction of main site roads to a level sufficient for access and evacuation in emergencies;
- Implementation of agreed flood warning and evacuation procedures for the proposed development;
- Construction of a separate surface water drainage system for the proposed development capable of attenuating flows in high tide events.

Plate A.1: Rochester Riverside - Central Area taken from Railway Embankment

Plate A.2: Rochester Riverside - Extreme Eastern End

Appendix B Chatham Waterfront

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

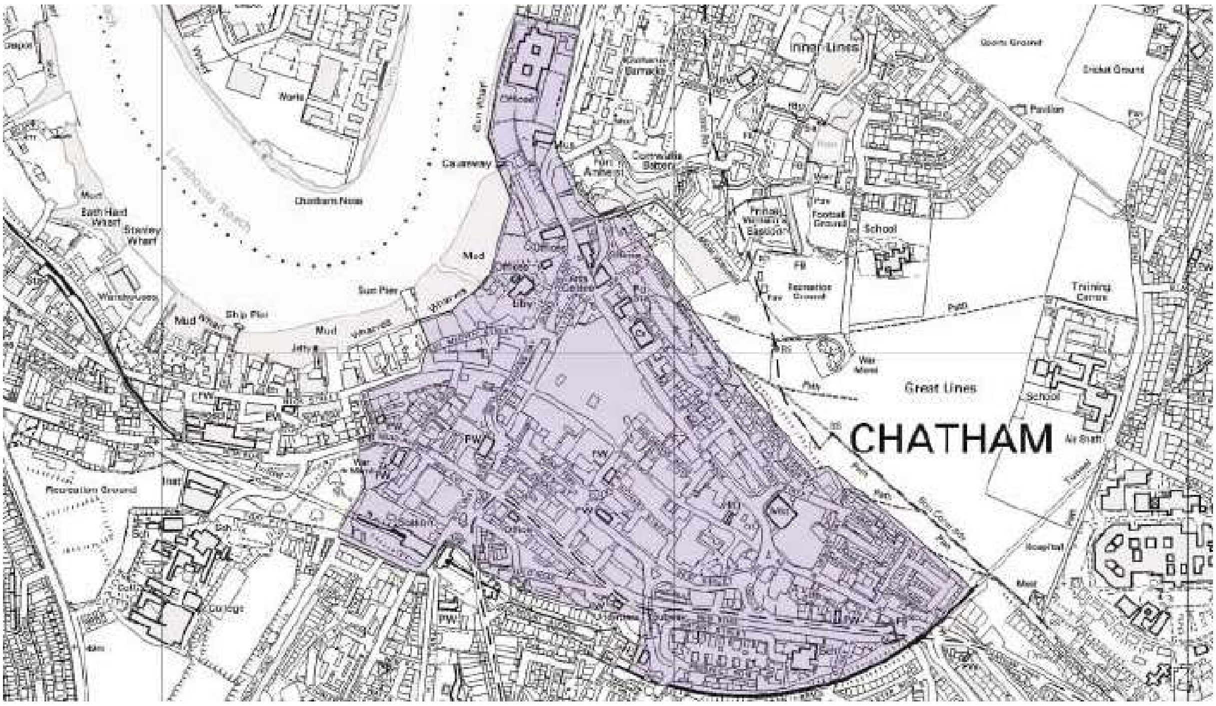
B.1 Introduction

B.1.1 Study Area

Chatham Centre and Waterfront is defined by its boundaries with the Chatham Reach of the River Medway and inland by the Railway line. The site has a 0.7km frontage from Sun Pier up to and including Gun Wharf. The total site area is 64 Hectares and is currently Medway's major shopping centre with some commercial and residential settlement. A prominent feature of the Waterfront area is the large surface water pumping station. The Development site borders three of the Medway Waterfront sites, namely, Star Hill to Sun Pier to the west, Chatham Historic Dockyard to the north and Brompton, Fort Amherst and the Lines to the northeast.

The Waterfront area is situated on relatively flat low lying land with the ground rising to the southeast towards Chatham Centre. The foreshore consists partly of mudflats with sheet pile retaining walls defining the channel behind the mud flats and at Gun Wharf.

Figure B.1: Chatham Centre and Waterfront Site Location Plan



Development Brief, Medway Council, 2004

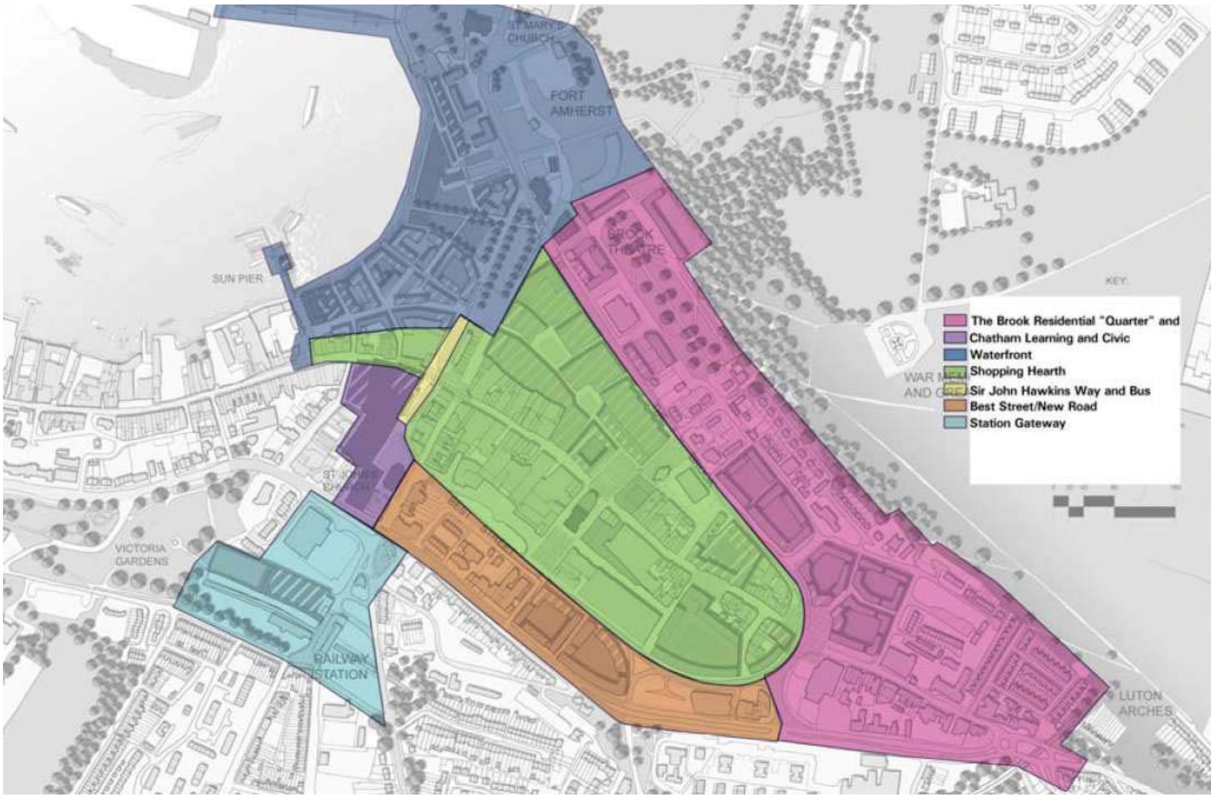
B.1.2 The Development

The development site will provide a strategic commercial, cultural and civic centre, serving a population of over a quarter of a million people in Medway. The proposed development is as follows:

- Mixed use
- Commercial

- Shopping (expansion of the Pentagon Centre, new food store and small scale shopping space)
- Housing
- Cultural and Creative
- Education – central library and learning
- Civic hub
- Waterfront park, riverside promenade and public square

Figure B.2: Development Type



Source: Supplementary Planning Guidance: Chatham Centre and Waterfront Development Framework, 2005

B.2 Existing Conditions

B.2.1 Proposed Development Site

B.i Present and Previous Land Use

The historical use of this land is unclear, however, currently the site is occupied by Medway's major shopping centre with a combination shops, commercial and residential. There is good access to the Waterfront where additional shopping, residential wharves, recreational space and a surface water pumping station are notable features.

B.ii Topography

The waterfront area is the lowest lying, with levels typically being 5 m AoD. This low lying land extends inland by a maximum of 300m towards Globe Lane and the north-eastern section of the A2 (The Brook). Inland the levels climb fairly steeply to 20 m AoD and above. The current sea defence levels vary between about 4.5 m and 5.0 m AoD.

B.iii Geology

The underlying geology of Chatham Centre and Waterfront is mainly made up of Upper Chalk, overlain along the waterfront by alluvium and in other areas by head deposits. On the higher land towards the eastern side of the development site there is also an area of Thanet Bed sands overlying the chalk.

The Thanet beds are known to be approximately 30m thick in this area, while the alluvium and head deposits range in thickness up to around 11m. The Upper chalk is some 90m thick and it is predominantly made up of soft white limestone with flints present as layers or nodules.

B.2.2 Existing Drainage

Over the years the Chatham Waterfront has been developed in the normal adhoc manner with the system of natural creeks being infilled or culverted and a system of pipes being used to carry surface water out to the River Medway. The sewer network is managed by Southern Water plc. The public sewer network comprises separate foul and surface water sewers. Combined surface and foul sewers may exist, but these have not been identified from Southern Waters sewer records.

The foul water sewers gravitate towards the New Brook/Chatham Pumping Station in King Street. Sewage is then pumped to the southwest via a 450mm Cast Iron rising main.

Surface water is discharged into the River Medway. Chatham Centre is served by Southern Water's Rats Bay Pumping Station, which enables surface water to be pumped during tide locked conditions. A 1050mm diameter sewer and three 450mm diameter sewers outfall at the pumping station, where water is pumped over a weir and into the River Medway. In addition there are several outfalls, most with small catchments which outfall by gravity directly to the River Medway. It is presumed that these outfalls are protected by flap valves

B.2.3 Flood Defences

It is understood that the existing frontage along the River Medway has been constructed over time to provide wharves for the various industries that have been there over time. The River Medway frontage is approximately 0.7 km long and consists of a number of different structures, these include:

- reinforced concrete walls;
- concrete walls infilled with pre-cast panels;
- earth retaining timber crib walls; and
- concrete capped steel sheet piles.

The Chatham Town Defences were constructed post 1953 at a level of 5.5m AoD. This site however appears to fall outside the extent of these flood defences with recent LiDAR survey work indicating that the level of the defences at this site range between 4.5 m and 5.0 m AoD.

In principal the control of flooding along the River Medway is the responsibility of the Environment Agency however the Medway Ports Authority was assigned statutory responsibility for this section of the river as part of the Medway Ports Authority Act 1973.

Medway Council, as the riparian owner of the land at Chatham Waterfront, hold the responsibility for the maintenance of the river frontage.

B.2.4 Historic Flooding

Information obtained from recorded water levels at Sun Pier indicate that flood events occurred in 1927 (3.84m AoD), 1949 (4.53m AoD), 1953 (4.83m AoD), 1960 (3.73m AoD), 1965 (4.55m AoD) and 1978 (4.47m AoD). The mean high water level at this location is 3.20m AoD.

B.3 Tidal Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak level attained during these tidal cycles for Chatham Centre are shown in Table B.1.

Table B.1: Expected Maximum Tidal Levels at Chatham Centre

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.8 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	6.0m AoD

The modelling indicates that for the 1000-2060 and 1000-2100 scenarios, peak tidal levels at this site are increased by up to 0.1m if proposed land raising to 5.8 m AoD at Strood Riverside, Temple Marsh and Rochester Riverside go ahead. This increase is accounted for in Table B.1 above.

B.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the Chatham Centre and Waterfront site: tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two but will only affect the low lying land which represents a small proportion of the total site.

B.4.1 Surface Water Flooding

Since the scale of the proposed development is small relative to the current development, the existing surface water drainage system may have sufficient capacity to cater for any new development. However, applications for any new connections must be made to Southern Water in the usual manner so that they can ensure the sewers have adequate capacity and can arrange for new works where required.

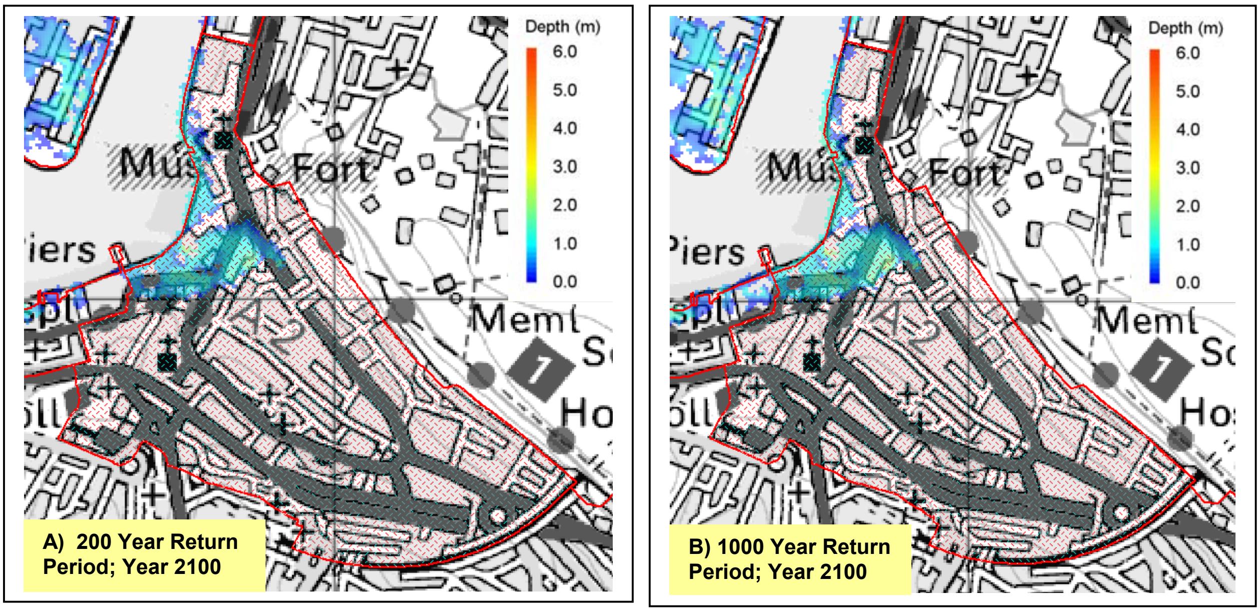
The Rats Bay Pumping Station is understood to be designed such that surface water can be pumped into the River Medway during tide locked conditions and the risk of self flooding from surcharged sewers is therefore low in the sewers discharging directly to the pumping station. Tidal water is not likely to enter the sewers at Rats Bay due to the elevated weir design of the outfall. All other outfalls will presumably be closed during tide-locked conditions. The spare capacity in these sewers is not known, but it is likely that some localised surface water flooding may occur during a rainfall event if the flapped outfalls close for extended periods, whereupon the surface water sewer will become surcharged. While it is understood that there are separate foul and surface water sewers on this site, there is a possibility that surface water drains may connect into the foul sewer. If surface water connections are widespread there may be a risk of foul water sewer flooding due to insufficient capacity.

B.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

The model results indicate that the defences will be first overtopped at the northern end of the site, with further overtopping taking place just to the east of Sun Pier within a further 30 minutes. The extent of overtopping increases throughout the next 2 hours, with the inundation extending across the A2 some 60 minutes after the defences are first overtopped. The flood water will begin to recede some 3.5 hours after the initial overtopping of the defence. Flood water remains trapped behind the flood defences from the A231 (Medway Street) to the A2 near the Arts Centre.

Figure B.3 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure B.3: Extent of Flooding in Chatham Centre Area (200_2100 & 1000_2100 events)



The key flooding characteristics for Chatham Centre are summarised in Table B.2.

Table B.2: Summary of Chatham Centre Flooding

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.7	1.3	0.7	3.5	1.9	0.07	0.27
1000	2100	6.0	1.5	0.7	4	2.2	0.07	0.27

Note:

Typical existing flood defence levels = 4.4 m AoD to 5.0 m AoD

Length of river frontage = 0.7 km

B.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- 100% of the flood defences would be overtopped during a 200 year and 1000 year tides under 2100 climate conditions;
- The areas at risk are primarily adjacent to the water frontage;
- The maximum inundation depth could reach 2.2 m.

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. These defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table B.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Note that if an embankment defence is considered then a freeboard of 0.6 m is required and the minimum defence crest level should be 5.9m.

Plate B.1: Chatham Waterfront - North

Plate B.2: Chatham Waterfront - South

Plate B.3: Rats Bay Surface Water Pumping Station

Plate B.4: Medway Street

Appendix C Star Hill to Sun Pier

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

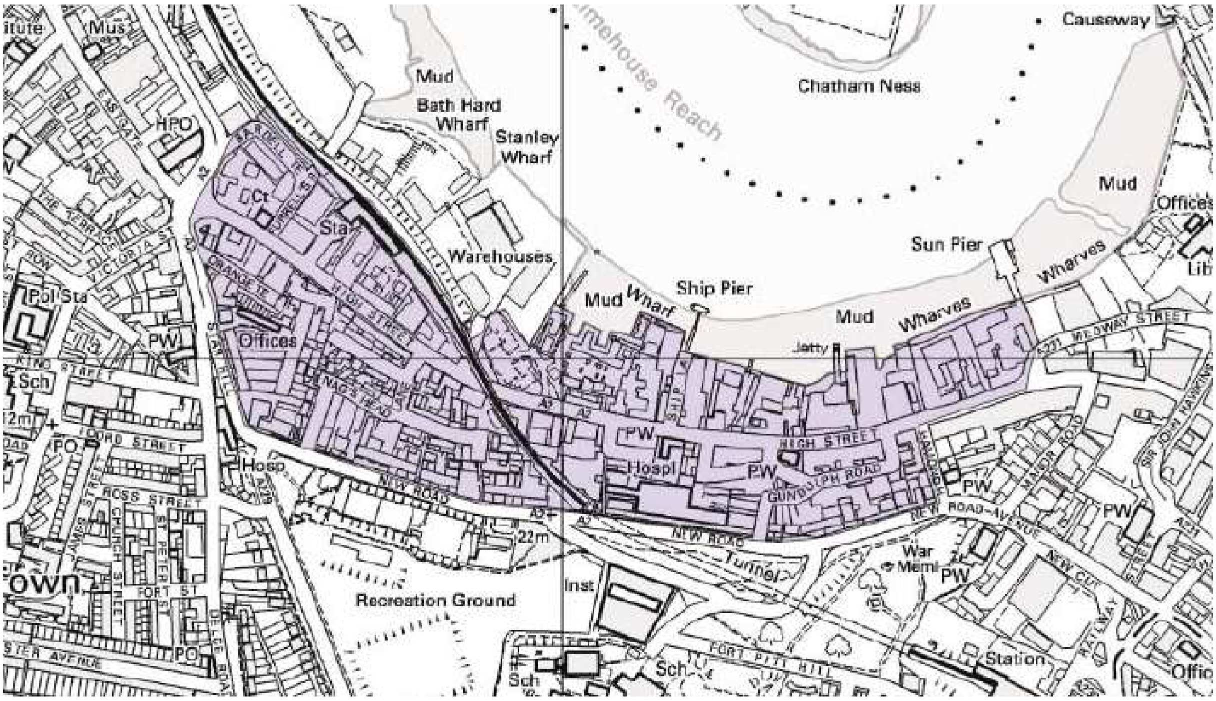
C.1 Introduction

C.1.1 Study Area

This development site is situated on the Limehouse Reach of the River Medway. The site stretches from Star Hill to Sun Pier as its name implies. The total site area is 13 Hectares and currently comprises residential, commercial and industrial development. This strip development is confined by the New Road and the River Medway, and has a total river frontage of approximately 0.5km.

The site is on a reasonable incline with levels ranging from 4 m AoD to over 20 m AoD. The foreshore consists of mudflats with sheet pile retaining walls behind and a number of piers and jetty's.

Figure C.1: Star Hill to Sun Pier Site Location Plan



Development Brief, Medway Council, 2004

C.1.2 The Development

The site is intended to provide mixed use developments as follows:

- Mixed Use – refurbishment and restoration of historic buildings and warehouses
- Commercial
- Housing
- Small scale creative and cultural activities
- Education
- Riverside Walk

C.2 Existing Conditions

C.2.1 Proposed Development Site

C.i Present and Previous Land Use

Historically the site is understood to have contained industrial warehouses and wharves. It now provides examples of Georgian and early Victorian terraced residential buildings with a combination of industrial, commercial and minor shopping facilities. The High Street has long been secondary to the New Road as the through route, and has consequently suffered economically leaving many of its buildings unused and in a poor state of repair.

C.ii Topography

The site has a reasonable incline from the waterfront towards the south. The waterfront levels are between 4 m and 6 m AoD, rising gradually inland. Site levels reach 20 m AoD in places although the majority of the site is lower than this. The current sea defences have crest levels generally between 4.0 and 4.5 m AoD with localised areas marginally above this.

C.iii Geology

The underlying geology of Star Hill to Sun Pier is mainly made up of Upper Chalk, overlain along the waterfront by alluvium and in other areas by head deposits.

The alluvium and head deposits range in thickness up to around 11m. The Upper chalk is some 90m thick and it is predominantly made up of soft white limestone with flints present as layers or nodules.

C.2.2 Existing drainage

Over years the site has been developed in the normal adhoc manner with the system of natural creeks being infilled or culverted and a system of pipes being used to carry surface water out to the River Medway. The sewer network is managed by Southern Water Plc. The public sewer network comprises separate foul and surface water sewers. Combined surface and foul sewers may exist, but these have not been identified from Southern Waters Sewer Records.

The foul water sewers gravitate towards a pumping station on the corner of Blue Boar Lane and Corporation Street. Sewage is pumped from here to the west via a 300mm Cast Iron rising main. Surface water is discharged into the River Medway via a number of separate sluices and flapped outfalls. The surface water from a small area in the northwest of the site flows to a second pumping station, also located on the corner of Blue Boar Lane and Corporation Street, where it is understood the water can either discharge by gravity or can be pumped into the River Medway during tide-locked conditions.

C.2.3 Flood Defences

The River Medway frontage is approximately 0.5 km long and consists of a number of different structures which define the edge of public walkway along the river frontage. The defences are made up of:

- reinforced concrete walls;
- concrete walls infilled with pre-cast panels;
- earth retaining timber crib walls;
- and concrete capped steel sheet piles.

The Environment Agency identifies that there are no formal Flood Defences serving this site. What defences there are, are privately maintained and are generally in a poor condition. Recent LiDAR survey work indicates that the level of the frontage at this location range between 4 m and 6.9 m AoD.

In principal the control of flooding along the River Medway is the responsibility of the Environment Agency however the Medway Ports Authority was assigned statutory responsibility for this section of the river as part of the Medway Ports Authority Act 1973. The riparian owner of the land holds the responsibility for the maintenance of the frontage to the River.

C.2.4 Historic Flooding

Information obtained from recorded water levels at Thunderbolt Pier indicate that flood events occurred in 1927 (3.84m AoD), 1949 (4.53m AoD), 1953 (4.83m AoD), 1960 (3.73m AoD), 1965 (4.55m AoD) and 1978 (4.47m AoD). The mean high water level at this location is 3.20m AoD.

C.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak level attained during these tidal cycles for Star Hill to Sun Pier are shown in Table C.1.

Table C.1: Expected Maximum Tidal Levels at Star Hill to Sun Pier

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.8 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	6.0 m AoD

The modelling indicates that for the 1000-2060 and 1000-2100 scenarios, peak tidal levels at this site are increased by up to 0.1m if proposed land raising to 5.8 m AoD at Strood Riverside, Temple Marsh and Rochester Riverside go ahead. This increase is accounted for in Table C.1 above.

C.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the Star Hill to Sun Pier site being tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two but will only affect the low lying land which represents a small proportion of the total site.

C.4.1 Surface Water Flooding

Where the outfall from a surface water gravity sewer is closed due to tide locked conditions, it is possible that the sewer may become surcharged and cause localised flooding. Sewer systems may be designed to overcome this by either pumping surface water into the River Medway or by providing storage within the sewer system with which surface water can be attenuated until tide-locked conditions subside. Some surface water flooding would occur during extreme flood events above a 1 in 30 year return period since the public sewer network would not normally be designed to convey flows of this magnitude.

Since the scale of the proposed development is small relative to the current development, the existing surface water drainage system may have sufficient capacity to cater for any new developments. However, applications for any new connections must be made to Southern Water in the usual manner so that they can ensure the sewers have adequate capacity and can arrange for new works where required.

The area to the northwest of the site has a surface water pumping station and should therefore not experience surface water flooding during tide locked conditions. All other surface water sewers are presumed to flow by gravity only and their outfalls will presumably be closed during tide-locked conditions. The spare capacity in these sewers is not known, but it is likely that some localised surface water flooding may occur during a rainfall event if the outfalls closed for extended periods, whereupon the surface water sewer will become surcharged.

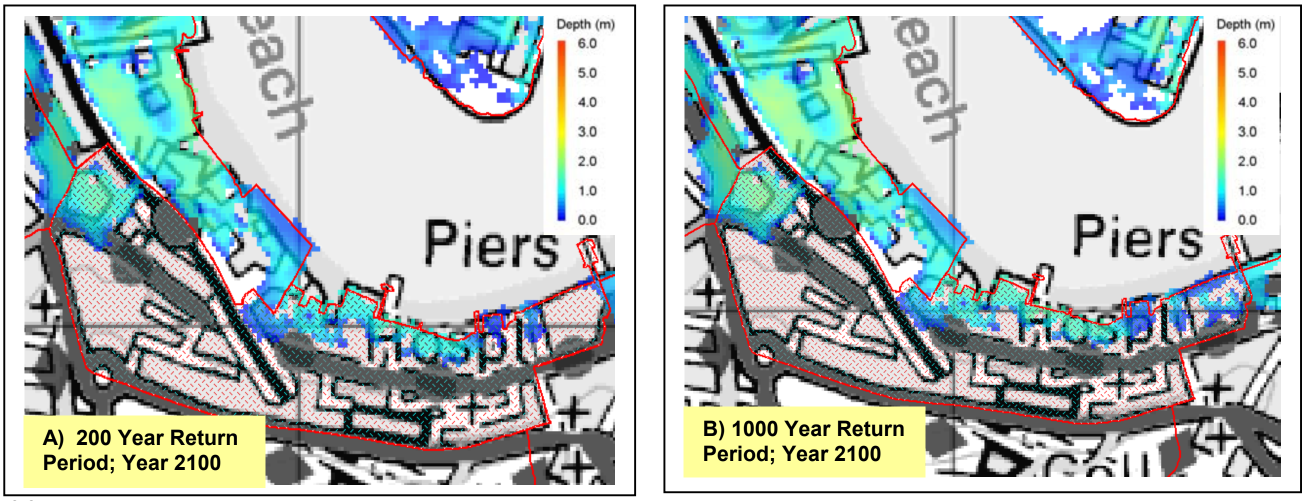
While it is understood that there are separate foul and surface water sewers on this site, there is a possibility that surface water drains may connect into the foul sewer. If surface water connections are widespread there may be a risk of foul water sewer flooding due to insufficient capacity.

C.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

The defences will be first overtopped along the northern bank either side of Ship Pier. Inundation reaches the A2 less than 60 minutes after first overtopping, but indications are that the A2 itself remains just above the water level. Flood waters begin to recede some 2 to 3 hours after the initial overtopping of the defences and isolated areas of flood waters remain.

Figure C.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure C.2: Extent of Flooding Star Hill to Sun Pier (200_2100 & 1000_2100 events)



The key flooding characteristics for Star Hill to Sun Pier are summarised in Table C.2.

Table C.2: Summary of Star Hill to Sun Pier Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.7	1.7	0.55	3	1.2	0.04	0.09
1000	2100	6.0	1.9	0.65	4	1.5	0.04	0.09

Note:

Typical existing flood defence levels = 4 m AoD to 6.9 m AoD

Length of river frontage = 0.65 km

C.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- 85% and 100% of the river frontage would be overtopped during a 200 year and 1000 year tide respectively, under 2100 climate conditions;
- The areas at risk are primarily adjacent to the water frontage, the flooding extent is approximately within 100 m from the river bank;
- The maximum inundation depth due to the existing flood defences being overtopped could be 1.5m.

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. These defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table C.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Note that if an embankment defence is considered then a freeboard of 0.6 m is required and the minimum defence crest level should be 5.9m.

The river frontage between Sun Pier and Star Hill appears to represent a potential opportunity for demountable defences. This is primarily because existing development precludes land raising and the proximity of existing and replacement build to the river edge makes construction of permanent hard defences aesthetically difficult, especially when considering the character of the area.

A preliminary study of the feasibility of using demountable defences along this reach of the river has been undertaken in association with Bauer Inner City, a manufacturer of a type of demountable defence used by the Environment Agency in similar conditions. Bauer's report is attached to Appendix C of this SFRA.

The report by Bauer considers that demountable defences are viable at the location considered. The critical technical issue for demountable defences is usually related to the adequacy of the defence beneath the demountable. In the case of Sun Hill to Star Pier, the majority of the existing defence walls are of modern sheetpile design, and from a surface inspection appear to be more than adequate. Of the non-technical issues the principal reservation revolves around the need to maintain an appropriate labour force, capable of installing the demountable defences at short notice.

The Council has engaged in initial discussions with the Environment Agency regarding their availability for this work and negotiations are continuing. The Council expects that if demountable defences are proposed for the Sun Pier to Star Hill site then both the cost of the defences and a commuted sum to cover their operation will be furnished by the developer.

Plate C.1: Star Hill to Sun Pier - Wharf adjacent to Ship Pier

Plate C.2: Star Hill to Sun Pier - Wharf adjacent to Ship Pier (close-up)

Bauer-IBS Demountable Flood Defence Systems

Preliminary Technical & Operational Evaluation

Proposed Tidal Flood defences, River Medway, Rochester

Prepared for – Mott MacDonald
Prepared by – Karl Hall
July 2005
Bauer Inner City Limited

Demountable Flood Defences – Bauer-IBS BSHI 100

Technical & Operational Evaluation – Proposed Tidal Flood Defences, River Medway, Rochester

1 Overview

The site examined forms part of the existing frontage to the River Medway adjacent to High Street and Medway Street, and currently has a mix of existing development including relatively new mixed use elements and older commercial property. The existing asset value is not considered particularly high, and as such the site would not currently score highly in terms of priority score, although basic benefit:cost appraisal would probably be a positive. Possible extensive re-development of the site would however significantly change the asset value and thus increase benefits accordingly.

A brief appraisal of the site has determined that it is eminently suitable for the use of demountable type flood defence barriers, being consistent in terms of levels, having recently emplaced sheet piling, and with good open access to the site. Additionally, the calculated maximum defence level is relatively low, such that the most simple of the demountable system types can be employed. Favourable existing site conditions also allows the minimum of required site works and disruption, avoiding what is often a significantly expensive civil engineering requirement.

The site shares a common theme with other locations in which demountables have either been used, or are being evaluated, having waterside amenities which would be compromised by the siting of large hard-engineered flood walls. Despite the proven effectiveness of demountable systems in general, in appropriate locations, the relative newness of the technology in the UK does require a degree of public awareness-raising, and our attendance at many events has reinforced the fact that the public are acutely sensitive to significant urban re-modelling or aesthetic change, even in locations that are subject to repeated flood events, but nevertheless they are still keen to opine on flood defence options. Chief amongst questions raised in the past have been does the technology work, and how will the area or catchment be affected.

A final scheme for the proposed site might include some areas of permanent flood wall (where the amenity value is less), some full-height demountable sections, and possibly some areas of dwarf wall/demountables. Dwarf wall/demountable hybrid options are generally considered only where advance warning times are low, allowing a degree of passive defence whilst demountables are being erected.

2 Operational Factors

Demountable Systems can only be regarded as passive if they are left in place permanently (thus somewhat defeating the object), although on some sites they are left in place for the duration of high-risk periods. For nearly all sites though, the entire superstructure will be installed and demounted as required in response to flood risk. The large number of variables does require that every site is considered specifically as no two will ever be the same.

Key operational considerations should include as a minimum the following:

- The System should be kept ideally in storage as near to the site of deployment as possible, or, stored in such a way (i.e. on trailers) such that it can be taken to site as quickly as possible
- Availability of manpower – one of the most critical factors, and one that must be assured in order to minimise risk, especially during high-risk times in Springtime

- Careful storage is essential such that there is no risk of the system being sent to site with any essential components missing. Purpose-designed storage systems are provided as a means of minimising this risk factor. CAD drawings are supplied at design stage to illustrate the likely required minimum storage area.
- Access – open access to the site at all times is an essential prerequisite, although for public safety, road or footpath closure is often considered desirable – where this is achieved in conjunction with other authorities, then this must also be considered an operational factor. Where the system crosses into, say private commercial premises that have secure external perimeters, then appropriate measures must be taken to ensure that full-time access to those areas in possible in emergency situations.
- Training is both an operational requirement, and an operational cost – generally it would be expected that the system would be installed fully on site at least one every year, whether there is a flood event or not
- Handling – the speed of installation ultimately affects the degree of risk, and generally the smaller the system in terms of height, the easier and quicker it would be to install on site – manpower requirements are lower for smaller height systems.

3 Additional Considerations

The following factors need to be considered in respect of a demountable defence application. These may or may not apply in all cases to the site in question:

- **Permeability** of strata on site (poor ground conditions and permeable strata can require the provision of a cut-off wall, significantly influencing the capital cost of the scheme, the programme of works, and disruption). These are not likely to be problems on the proposed site.
- **Site levels** – significant declination of the site along the length of the defence needs to be carefully considered where a full-height demountable system is used (i.e. no dwarf flood wall). Such systems require that the design is based on the lowest level on site, this then setting the system height for the whole length (for operational reasons, all post heights should be the same, unless there is a significant step in system height at any one point[1]). Again, this is not likely to be a problem for the proposed site.
- **Security** – is considered by some authorities to be an important issue as any determined party could dismantle part of the System and remove components, rendering the System ineffective. Systems that form a continuous defence in a prominent position are not however a high-risk in this sense, although the police or local authority may elect to provide a watch on the system overnight
- **Drainage** – subversion of the defences by surcharging of drains is an obvious likelihood, and re-engineering of the existing drainage, combined with additional or new pumping arrangements are a significant consideration.
- Storage requirements comprise one of the larger on-going whole-life cost elements in that secure storage is required for the System over its design life (of 50 years). This storage should ideally be within easy reach of the site, and not subject to any risks whatsoever in terms of access restrictions
- **Extendability** (and reversibility) is a feature of demountable Systems, and they can be extended in future both in height or length, or both. It should be noted however that to increase the height of the System in response to worsened future conditions does require the complete replacement of all superstructure items, but, providing that the increase is within certain parameters, the existing permanent and cast-in items would require no modification[2]

[1] Posts of different height will normally have different anchor plates set into the ground, so incorrect positioning of posts is not possible

[2] A change in height of for instance 1300mm to 1500mm would require no change, but a change from 1300 to 1600mm takes the system beyond the design limits of the cast-in anchor plates. Where future extendability beyond pre-determined step-up points in the design is a possibility, then higher-capacity cast-in anchor plates would be specified in the first instance.

- **Resourcing** - The appropriate operating entity needs to be considered at an early stage. In many cases, this will be the local authority on the basis that it has existing direct labour resources. Future changes in policy could however create operational difficulties, in particular if local authority services are contracted-out to the private sector in future.

4 Technical Considerations

The following are possible technical failure modes. No Bauer-IBS System installed to date has suffered failure, but these factors are nonetheless technically possible and therefore should be considered.

- **Impact** – Impact on the demountable System by vehicles is to be guarded against – the System is designed to accept a maximum operational impact load of 20 kN/m^2 (allowing for instance impacts from floating objects).
- **Overtopping** – incorrect design criteria or an unexpectedly extreme event. Important to the System only where back supports are used as when the water to the river side falls back, the System is then holding back water to the land side with the back supports acting in the wrong direction – this is not likely to be a consideration to any part of the proposed site
- **Breach failure** – only likely if the System supporting structures have not taken all loads into account
- **Overturning** – inadequate design to foundations
- **Operational** – System not installed in time
- **Operational** – missing items
- **Excessive leakage** – System not installed properly

Storage of the System

The System is delivered in purpose-made storage pallets, and, after deployment, the system must be re-stored in the same fashion – the storage equipment supplied with the system has been designed to allow appropriate ventilation and drying-out of the system after use, obviating any possibility of contact corrosion.

The dam beam profiles and central supporting posts/panels should be stored inside (e.g. small industrial unit) in special pallets to ensure speed of recovery for subsequent installation. The purpose-made pallet arrangement that is supplied with the system does not allow direct contact between components - this facilitates aeration and drying of individual components after use, and prevents any contact corrosion.

Storage of the supporting posts (up to 1.5 metres, i.e. without back supports) is also in pallets in upright position in a manner that prevents damage to the post base seals.

In terms of actual physical storage, the enclosed drawings show the dimensions of storage pallets. These can be stacked 2-high to reduce floor area. The pallets require fork-lift handling.

The system (assuming full 800 linear meters x 1350mm system height) requires approximately 2043 dam beams, each 3500mm long (nominal), stored on pallets each containing 35 beams. This requires 58 pallets of size shown on drawings (x 3500mm long). The posts would be stored on pallets shown, each containing 8 posts, so 28 pallets required as drawing. The compressible ground seals require separate pallets – 227 seals x 35 per pallet = 7 pallets.

5 Analysis

Baseline assumption:

Defence length - 800 linear metres
Defence height, total, including freeboard – 1350mm
Demountable system module length – 3500mm[3] (can be varied to suit preference)

Anchor plates – for 800 metres at 3500mm centres to module, 227 support posts are required, which require 227 cast-in stainless steel anchor plates.

Assuming that each support post requires a maximum of five minutes to fit, and that three teams of two men (working from each end and centre) are employed, then a maximum time to fit all the posts of 378 minutes is required, or 6.3 hours. The fitting of posts is the most time-consuming part of the installation and sets the minimum time in which the system can be installed whether or not other required operations are concurrent.

During the installation of the posts, a follow-up team of two operatives can be fitting the dam beams (a quick process requiring no specialist tools or equipment). To achieve the quickest initial protection, beams can be partially-installed, say to 4 beams high, then followed up with the remaining dam beams to the full 9 beam high level.

6 Operations Team

A suggested minimum operations team might comprise the following.

- 1 operative to load System onto trailers for delivery to site (unless System is actually stored adjacent to site, in which case the installers will take out of store)
- 1 driver for taking System to site
- 3 x 2 person team to install the demountable posts
- 1 x 2 person team to install beams & pressing devices (if the timescale is short), otherwise beams & pressing devices may installed by the post-fitting team after posts are all installed.

The System is effective as soon as the minimum number of dam beams are in place.

Total manpower (maximum) – depending on the storage location of the system, operational manpower may be from 8-10. Where a longer erection time on site can be allowed, then the operational manpower can be appropriately reduced.

7 Capital Costs & Payback

The initial capital costs will include *inter alia* the following:

- Consultant fees (including evaluation of the suitability & serviceability of existing sheet pile wall elements)
- Construction of new river wall element at existing area of disused land
- Possible upgrading of existing site drainage provision with anti-backflow
- Break out existing surfaces & cast in stainless steel plates to accept the demountable posts in reinforced concrete pads[4]
- Construction of end piers to accept the permanent end posts where the demountable system terminates

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[3] Longer module lengths require less number of demountable posts, thus reducing erection time on site prior to a flood event
[4] Alternatively, a continuous concrete ground beam can be formed, but is not likely to be considered essential

- Cost of new vehicles/trailers to transport the system to site
- Cost of storage for the system (rental cost of space or cost of new storage building including running costs, business rates etc.)
- The one-off demountable system cost

In terms of payback, it is likely that the (capital) cost of the scheme would be recouped after the first use of the system to defend against a flood event[5]. Operational costs over the life of the scheme need to be set against benefits however.

8 Operational Costs

Factors to consider include the following.

- Fuel costs (if stored any distance from site)
- Supervision costs
- Call-out costs
- Storage costs over design life
- Capital replacement costs (essentially limited only to replacement seals to the System half way through design life)
- Renewal & maintenance of vehicles & equipment

9 Preliminary recommendations

1 Initial FRA, future risk scenarios, morphology, impact on other areas etc
2 LPA comment on PPG25 implications
3 Benefits appraisal, current (& future based on re-development)
4 Appraisal of proposed scheme costs (capital costs ground works, demountable system), operational costs over 60 years, NPV'd.
5 Site investigation (stability of existing river wall, required improvements etc)
6 Preliminary public consultation, introduction of scheme options

10 Summary

There are technical risks associated with demountables, but these should not be considered necessarily prohibitive providing that the System is well-considered and that there is a reasonably well-resourced local operations team, as has been the case in other locations where these Systems have been commissioned.

There are a number of key issues that need to be addressed before deciding on a demountable option, particularly as indicated in items 3, 4 above.

The whole-life cost of a wall-demountable option may be slightly more than that of a permanent full-height defence wall, predominantly due to the operational and storage costs, though these costs might be partially offset by reduced long-term maintenance requirements. Future costs of the demountable option beyond the anticipated design life of the scheme would be reduced where extendability is considered, as the straight substitution of a higher demountable defence would probably be less than the cost of re-engineering a permanent wall.

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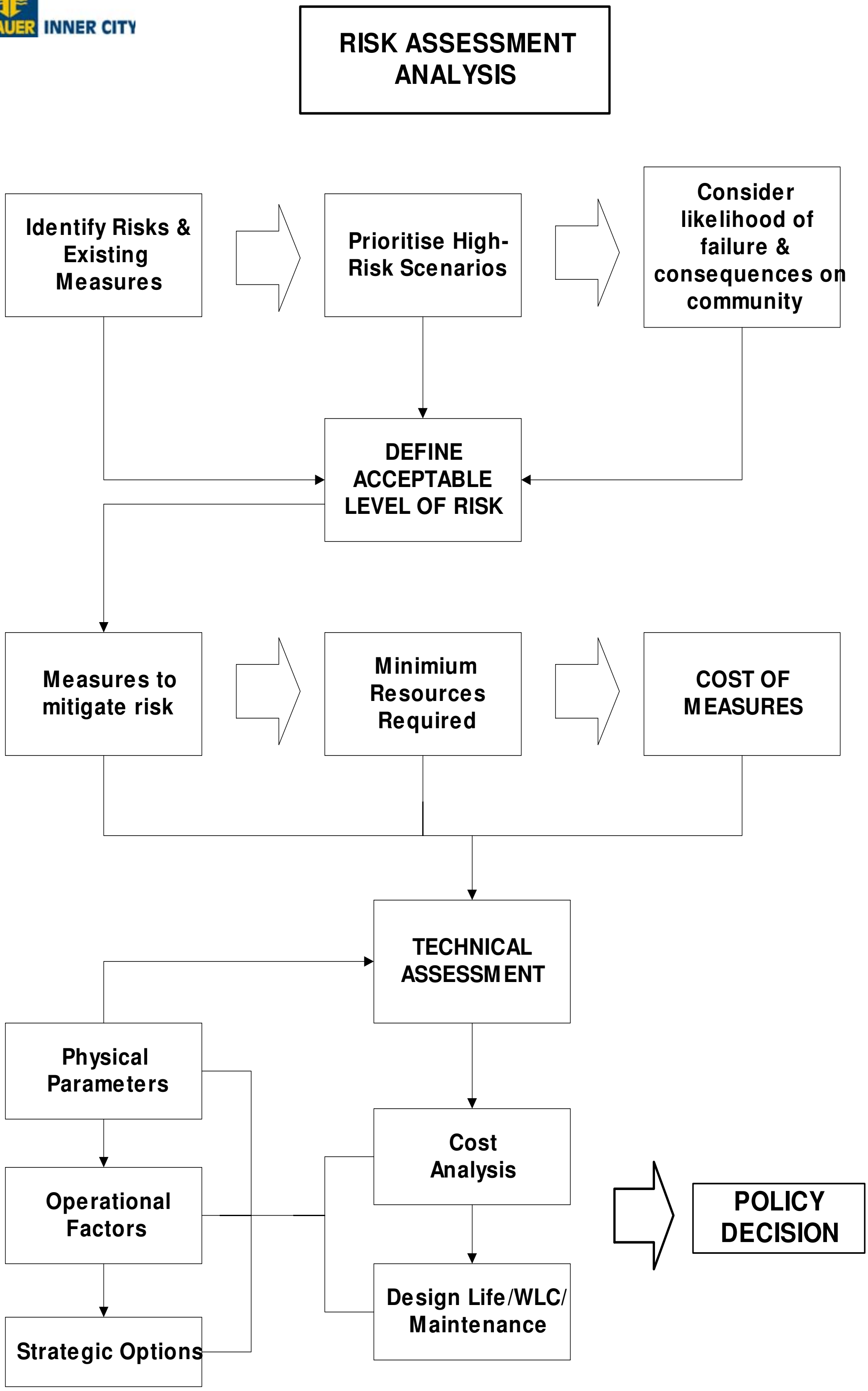
[5] Assuming re-developed site


RISK ASSESSMENT ANALYSIS
Identify Risks & Existing Measures
Prioritise High-Risk Scenarios
Consider likelihood of failure & consequences on community
DEFINE ACCEPTABLE LEVEL OF RISK
Measures to mitigate risk
Minimium Resources Required
COST OF MEASURES
TECHNICAL ASSESSMENT
Physical Parameters
Operational Factors
Strategic Options
Cost Analysis
Design Life/WLC/ Maintenance
POLICY DECISION

Appendix D Historic Rochester

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

D.1 Introduction

D.1.1 Study Area

The Historic Rochester site is located on the River Medway along a stretch known as Tower Reach. Part of the Rochester Peninsula, the site is approximately 38 hectares with a river frontage around 0.64 km in length. Located in the central area of the Medway Development Strategy, the site lies on the southern bank of the River Medway and is bounded to the East by the London Victoria and Canterbury Rail track as well as the A2 Corporation Road.

Access to the site comes from various points including the A2, Blue Boar Road, Bardell Terrace and the Esplanade.

Figure D.1: Historic Rochester Site Location Plan

Medway Strategy, Development Brief, Medway Council, 2004

D.1.2 The Development

The development of the site, which is owned by Medway Council, will include:

- Improved use of the castle and other historic buildings to attract tourists
- Encourage the fullest economic use of vacant properties to enhance opportunities and restore the historic fabric of the centre;
- Enhance Corporation Street to complement the proposed development at Rochester Riverside;
- Possibly re-develop the car park as a site for markets;

- Improve accessibility for tourists and visitors by moving the coach park to Corporation Street;
- Possible creation of 50-200 new jobs;

D.2 Existing Conditions

D.2.1 Proposed Development Site

D.i Present and Previous Land Use

The Historic Rochester site has been built on since Roman times and the land has been put to a wide variety of uses in the intervening period. Now predominantly commercial the site also includes most of Rochester's historic sites of interest, including the castle and cathedral, making it a townscape of national importance. It also contains a certain amount of residential properties plus various public open spaces.

D.ii Topography

On the western fringe is a riverside park which occupies the majority of the low lying land which, at a level of 4m AoD, is at risk of flooding. The majority of the site, however, is situated on high land rising to, at its highest, 22 m AoD. The only other area of low lying land is along the eastern fringe along the A2 Corporation Road, which lies at around 5m AoD.

D.iii Geology

Historic Rochester lies, almost exclusively, directly onto the Upper Chalk except for an area immediately adjacent to the river where there is an overlying alluvial deposit, and in the extreme western edge of the site where small deposits of head may be found.

The alluvium and head deposits range in thickness up to a maximum of around 11m in Medway but it is likely that both are significantly thinner in this location.

D.2.2 Existing drainage

The existing drainage system comprises of:

- Surface water drainage with three outlets directly into the Medway;
- Surface water draining into neighbouring drainage systems;
- Foul water system which drains via a rising main out through the main foul water pipe from Rochester centre;
- The main rising foul water drain from the Vicarage Road Pump Station which also drains out via the main foul water pipe;
- A second foul water system which drains via a rising main out through the main foul water pipe from Rochester centre;

The surface drainage network is managed by Southern Water Plc and it is understood that the existing system is gravity fed with the assumption that, due to the tidal nature of the downstream environment, all outfalls are likely to have flapped gated outfalls. The existing surface water drainage system should be designed to a 1 in 30 year level.

D.2.3 Flood Defences

Historic Rochester has only a short river frontage along the Medway. This frontage consists of a small park with limited flood defences consisting of a low concrete wall with a crest elevation of around 5.5 m AoD. However, this wall only covers two thirds of the entire frontage with the remaining one third left as natural shoreline with a level of around 4.2 m AoD.

D.2.4 Historic Flooding

Information obtained from recorded water levels at the A2 Rochester Bridge indicate that flooding events occurred in 1927 (3.92m AoD), 1949 (4.54m AoD), 1953 (4.85m AoD), 1960 (3.80m AoD), 1965 (4.60m AoD) and 1978 (4.51m AoD).

D.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak level attained during these tidal cycles for Historic Rochester are shown in Table D.1.

Table D.1: Expected Maximum Tidal Levels at Historic Riverside

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.7 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	5.9 m AoD

D.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the Historic Rochester site: tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two.

D.4.1 Surface Water Flooding

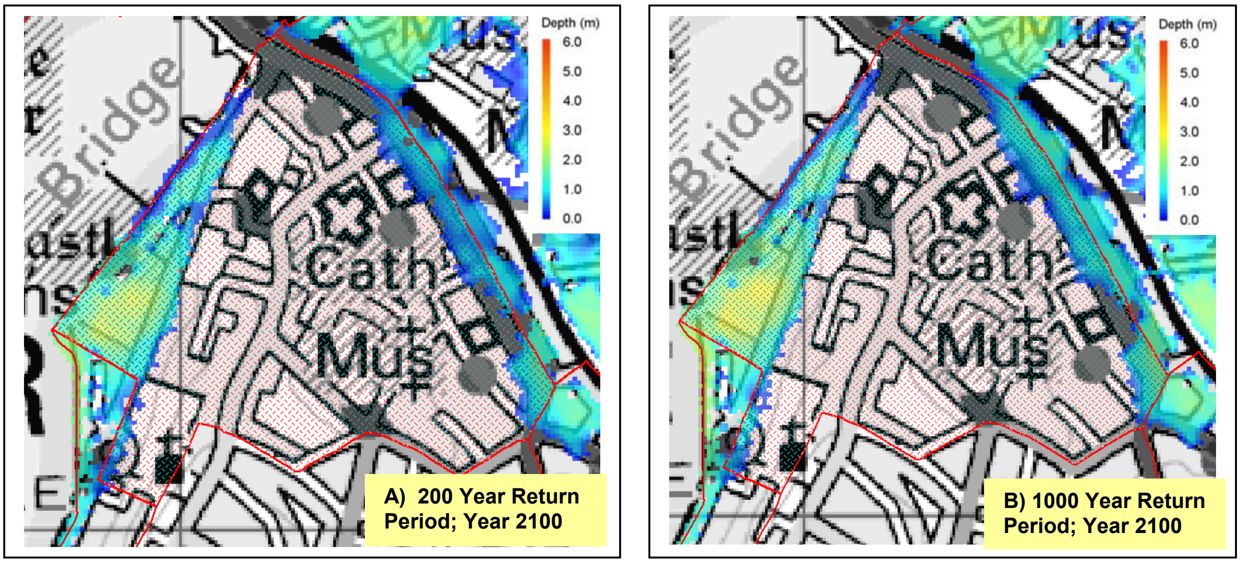
The main source of surface water flooding is as a result of backing up within the surface water drainage system as a result of insufficient storage capacity during the high tide, i.e. when the outlet flap valves are closed. However, due to the steep rise in ground levels away from the river, surface flooding would only be considered likely in the low lying land adjacent to the River Medway which is currently made up of green open space.

D.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

Initial overtopping of the flood defences occurs in the south west corner of The Esplanade and then along the river bank parallel to the Medway Valley Walk for 0.25km approximately 0.5 hours after initial overtopping. The whole of the area between the Esplanade road and the river is flooded within approximately 0.5 hours after initial overtopping including sections of the road. Flood waters begin to recede some 4 hours after the initial overtopping of the defences and isolated patches of flood water remain.

Figure D.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure D.2: Extent of Flooding Historic Rochester (200_2100 & 1000_2100 events)



The key flooding characteristics for Rochester Riverside are summarised in Table D.2.

Table D.2: Summary of Historic Rochester Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.7	2.1	0.25	4.5	2.5	0.06	0.18
1000	2100	5.9	2.3	0.25	5.0	2.7	0.06	0.18

Note:

Typical existing flood defence levels = 3.6m AoD to 5.8 m AoD

Length of river frontage = 0.6 km

D.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- 60% of the river frontage would be overtopped during a 200 year and a 1000 year tides under 2100 climate conditions;
- The areas at risk are adjacent to the water frontage, approximately confined to a 50 to 200 m wide strip parallel to the river bank;
- The maximum inundation depth could reach 2.7 m.

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. These defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table D.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Note that if an embankment defence is considered then a freeboard of 0.6 m is required and the minimum defence crest level should be 5.9m.

Plate D.1: Historic Rochester - Unprotected shoreline

Plate D.2: Historic Rochester - Protected Shoreline

Appendix E Medway City Estate

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

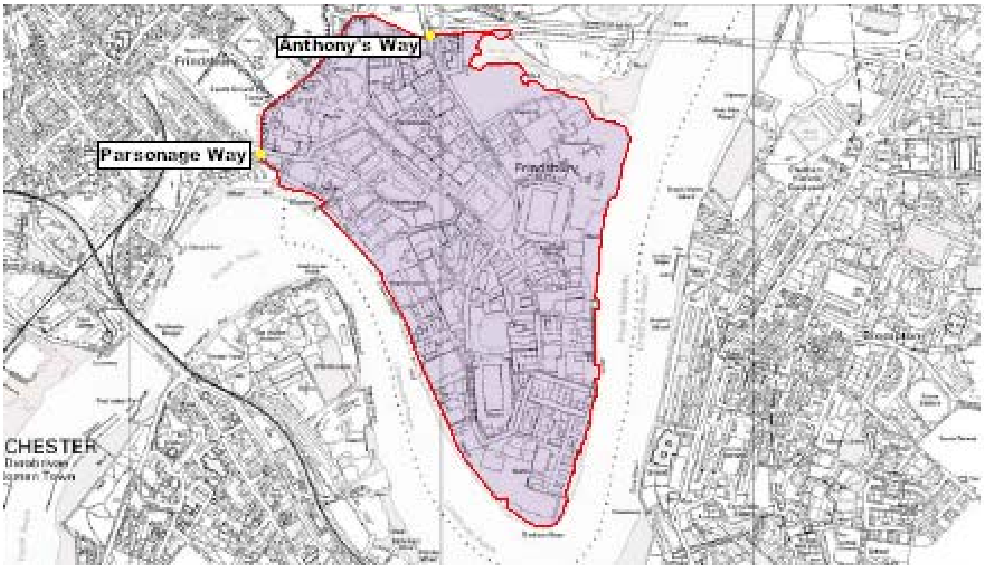
E.1 Introduction

E.1.1 Study Area

The Medway Estate site is located on the River Medway along Limestone and Chatham Reaches. The site is approximately 106 hectares with a river frontage of around 4.3 km in length. Located in the central area of the Medway Development Strategy, the site lies on the northern bank of the River Medway and is bounded to the South, East and West by the Medway River and to the North by recreational spaces and a disused pit.

Access is from one of only two points, Anthony's Way or Parsonnage Way.

Figure E.1: Medway Estate Site Location Plan



Medway Strategy, Development Brief, Medway Council, 2004

E.1.2 The Development

The development site, which is owned by Medway Council, will include:

- Environmental enhancements such as lighting, landscaping and views onto Historic Rochester and Chatham Historic Dockyard;
- Pedestrian and public transport bridge to Chatham waterfront and centre;
- Improved inter-vehicular and pedestrian/cycle routes as well as public transport routes;
- Improve wharfage;
- Park and ride at Whitewall Creek;
- Riverside walk;
- Improvement to open spaces;
- Introduction of other facilities to extend evening uses;

- 20-100 new jobs;

E.2 Existing Conditions

E.2.1 Proposed Development Site

E.i Present and Previous Land Use

Originally marshland this area was reclaimed and in 1975 in-filled to increase the land level.

The area currently has a mixed industrial usage. Home to approximately 600 businesses employing more than 6,000 staff, it has a network of roads which provide access to all parts of the site.

E.ii Topography

The Medway Estate site occupies a spit of low lying land with ground levels generally between 4 and 5 m AoD. Only at its northern end does the site rise in elevation where chalk cliffs mark the site boundary.

E.iii Geology

The southern and eastern parts of the site are made up of river alluvium overlying the Lower Chalk. Alluvium in the region has been found to be up to 12 m in depth and owing to the geography of the site as a river spur, this layer could prove to be significant.

The geology of the northern part of the site is made up of the Lower Chalk with some localised deposits of Head.

E.2.2 Existing drainage

Medway Estate is serviced by an extensive foul water and surface runoff drainage system. From plans supplied by Southern Water it has been seen that the existing pipe system consists of the following:

- Surface water drainage system with 4 outlets all situated on the western side;
- Foul water drainage leaving via a rising main to the north of the site;

There are no details as to the drainage system in the western half of the peninsular.

The surface drainage network is managed by Southern Water Plc and it is understood that the existing system is gravity fed with the assumption that, due to the tidal nature of the downstream environment, all outfalls are likely to have flapped gated outfalls. The existing surface water drainage system should be designed to a 1 in 30 year level.

E.2.3 Flood Defences

Medway Estate has nothing in the way of official flood defence. The shoreline itself consists of a relatively high embankment with a crest level of around 4.6 m AoD which would offer some protection in the event of a flood. The reclaimed land is understood to have been in-filled in 1975 to roughly the 0.1% (1 in 1000 year) flood level *at the time*, however once reached, water above this level would quickly inundate the area.

E.2.4 Historic Flooding

The nearest measurable point to Medway Estate is that of the A2 Rochester Bridge. Information obtained from recorded water levels indicate that flooding events occurred in 1927 (3.92m AoD), 1949 (4.54m AoD), 1953 (4.85m AoD), 1960 (3.80m AoD), 1965 (4.60m AoD) and 1978 (4.51m AoD).

E.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak level attained during these tidal cycles for Medway City Estate are shown in Table E.1.

Table E.1: Expected Maximum Tidal Levels at Medway Estate

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.8 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	6.0 m AoD

The modelling indicates that for the 1000-2060 and 1000-2100 scenarios, peak tidal levels at this site are increased by up to 0.1m if proposed land raising to 5.8 m AoD at Strood Riverside, Temple Marsh and Rochester Riverside go ahead. This increase is accounted for in Table E.1 above.

E.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for Medway Estate site: tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two.

E.4.1 Surface Water Flooding

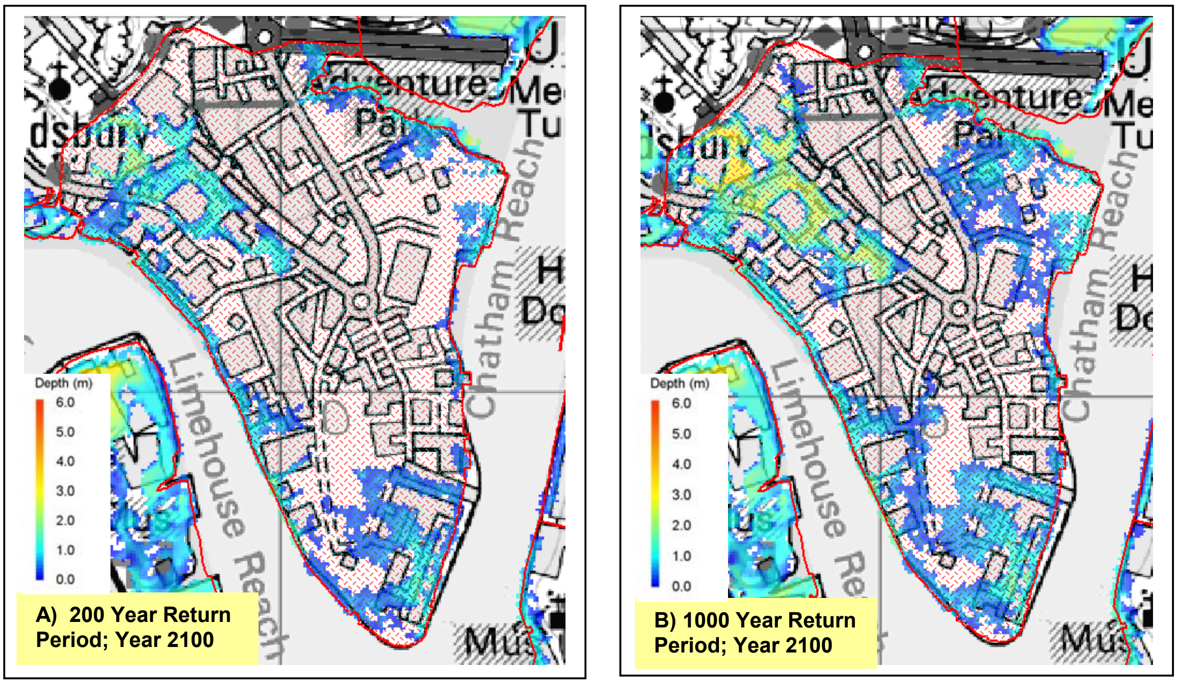
The main source of surface water flooding is as a result of backing up within the surface water drainage system as a result of insufficient storage capacity during the high tide, i.e. when the outlet flat valves are closed.

E.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

Initial overtopping occurs around Phoenix Industrial Estate, the works east of Medway City Estate Park, east of Sir Thomas Longley Road, around the southern tip of Riverside Works, and along Anthony's Way and George Summers Close. Within an hour of initial overtopping most of the western bank and several additional locations along the eastern bank are also overtopped. Flooding extends inland around Phoenix Industrial Estate, the works west of Medway City Estate Park, Riverside works in the south and to the north-east up to 2.5 hours after initial overtopping of the defences. Flood waters begin to recede some 3 hours after initial overtopping and isolated patches of water remain.

Figure E.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure E.2: Extent of Flooding Medway City Estate (200_2100 & 1000_2100 events)



The key flooding characteristics for Medway City Estate are summarised in Table E.2.

Table E.2: Summary of Medway City Estate Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.7	2.1	3.0	4	2.5	0.35	0.4
1000	2100	6.0	2.3	3.0	4	2.8	0.5	0.52

Note:

Typical existing flood defence levels = 3.6m AoD to 6.2 m AoD

Length of river frontage = 3.7 km

E.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- Over 75% of the river frontage would be overtopped during a 200 year and a 1000 year tide under 2100 climate conditions;
- The areas at risk are primarily adjacent to the water frontage. However, in the north west and north eastern corners, and in the southern point of the site, flooding could spread further inland for over 400 m in distance from the river bank;
- The maximum inundation depth due to overtopping could reach 2.8 m;

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. These defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table E.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Note that if an embankment defence is considered then a freeboard of 0.6 m is required and the minimum defence crest level should be 5.9m.

Plate E.1: Medway Estate - Typical shoreline

Appendix F Brompton, Fort Amherst and The Lines

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

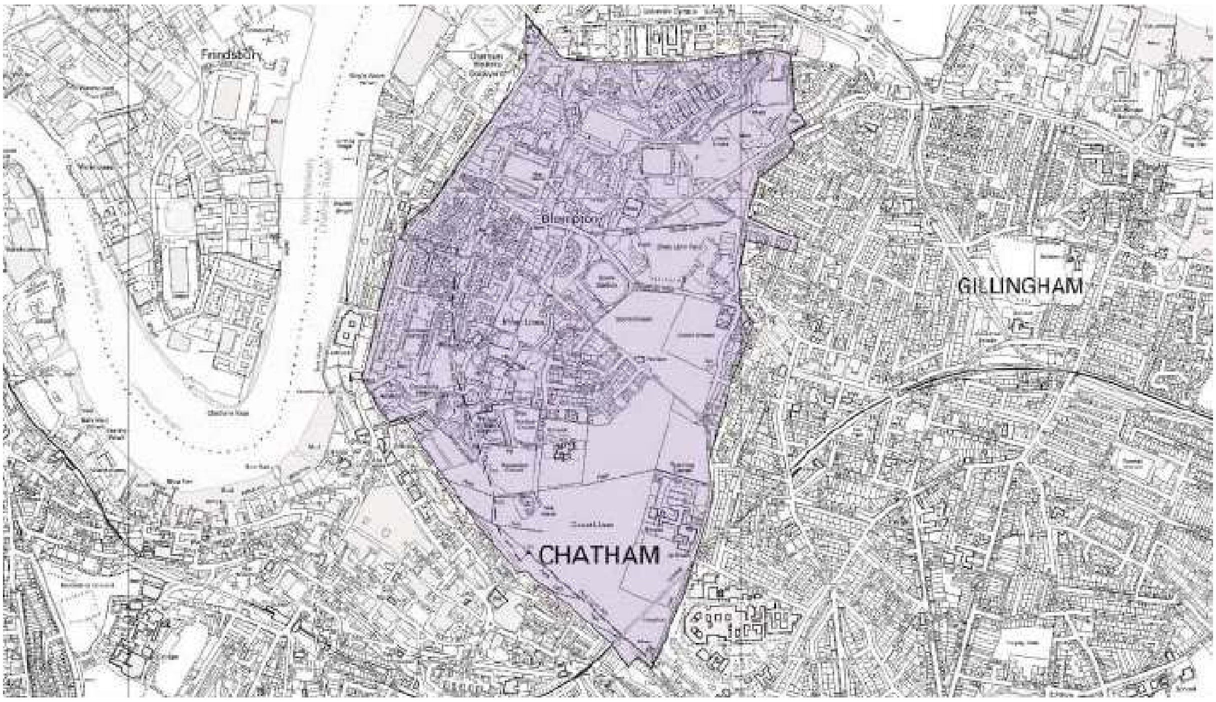
F.1 Introduction

F.1.1 Study Area

The Brompton, Fort Almherst and The Lines site is landlocked to the east of the Chatham Historic Dockyard. The total site area is 176 Hectares comprising residential and recreational space. The Waterfront area is represented by four distinct areas, namely Gillingham Waterfront Site, Gillingham Marina, the Gas Holder Station and the Strand Leisure Park, as represented in Figure F.1 below.

The site occupies a hilltop and consequently the majority of the land in this development site is well elevated from the water levels in the River Medway. Other than one small area in the north-west corner of the site, minimum ground levels are 15m AoD and above, with the land rising significantly above this in places.

Figure F.1: Brompton Site Location Plan



Development Brief, Medway Council, 2004

F.1.2 The Development

The development site will provide mixed use developments as follows:

- Housing
- Further Education facilities
- Enhanced Access to open spaces and fortifications
- Enhanced Leisure Facilities.

F.2 Existing Conditions

F.2.1 Proposed Development Site

F.i Present and Previous Land Use

The lines date from the 1750s, intended to protect the Naval Dockyard from landward attack. Since then the site has been used both for military and civil purposes with limited industrial usage.

Much of the site is currently left as open space for use as sports grounds and parks. Fort Amherst and The Lines remain as valuable historic structures, while the old Georgian army barracks is now the headquarters of the Royal School of Military Engineering. The remainder of the site is predominantly occupied by residential development, of which the rather dated former MoD housing is ready for redevelopment.

F.ii Topography

The site occupies a hilltop with no river frontage; consequently all levels are generally above 15 m AoD, with some fairly steep gradients in places. The exception is a small area to the north west of the site which has levels as low as 5 m AoD, this low lying land is not believed to affect more than 200m^2 of the site.

F.iii Geology

The underlying geology of the area is made up of Upper Chalk with the high ground to the east being overlain by an area of Thanet Bed sands understood to be up to 30m thick in places.

F.2.2 Existing drainage

The public sewer network is managed by Southern Water Plc. and comprises extensive combined foul and surface water sewers and some separate surface water and foul water sewers. Due to its hilltop position the sewers drain in several directions from the site; the main sewer being a 300mm diameter combined sewer flowing northwards along Dock Road.

A large part of the site is occupied by the Ministry of Defences Royal School of Military Engineering, sewers at this location are not included in Southern Waters sewer records; these sewers would normally be maintained by the MoD.

F.2.3 Flood Defences

This site has no river frontage. The flood defences most relevant to this site are situated in the Chatham Historic Dockyard site. The ground levels are generally elevated above 15 m AoD with the exception of a small area to the northwest of the site which has levels as low as 5 m AoD.

F.2.4 Historic Flooding

Information obtained from recorded water levels at Thunderbolt Pier indicate that flood events occurred in 1927 (3.84m AoD), 1949 (4.53m AoD), 1953 (4.83m AoD), 1960 (3.73m AoD), 1965 (4.55m AoD) and 1978 (4.47m AoD). The mean high water level at this location is 3.20m AoD.

F.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak levels of these tidal cycles for Chatham Historic Dockyard (the river frontage most closely associated with Brompton) are shown in Table F.1 below.

Table F.1: Expected Maximum Tidal Levels at Chatham Historic Dockyard

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.8 m AoD
200 (0.5%)	2100	5.8 m AoD
1000 (0.1%)	2100	6.0 m AoD

The modelling indicates that for the 1000-2060, 200-2100 and 1000-2100 scenarios, peak tidal levels at this site are increased by up to 0.1m if proposed land raising to 5.8 m AoD at Strood Riverside, Temple Marsh and Rochester Riverside go ahead. This increase is accounted for in Table F.1 above.

F.4 Flood Risk under Existing Conditions

Since the site is elevated and has no river frontage, the primary risk of flooding to the site is from surface water.

F.4.1 Surface Water Flooding

The site is well elevated above the surface water outfalls and is therefore unlikely to be affected directly by tide-locked conditions of sewer outfalls. Some surface water flooding would occur during extreme flood events above a 1 in 30 year return period since the public sewer network would not normally be designed to convey flows of this magnitude.

Any surface water flooding will probably be shallow and localised due to the sloping topography at this site which will not permit significant ponding to occur.

F.4.2 Tidal flooding

The 2-D hydraulic modelling of the River Medway indicates that none of the Brompton site will be inundated under tidal flood conditions.

F.5 Guidelines for Development

There are no restrictions on development within the Brompton site on the grounds of tidal flooding.

Plate F.1: Aerial view of Brompton

Appendix G Chatham Historic Dockyard

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

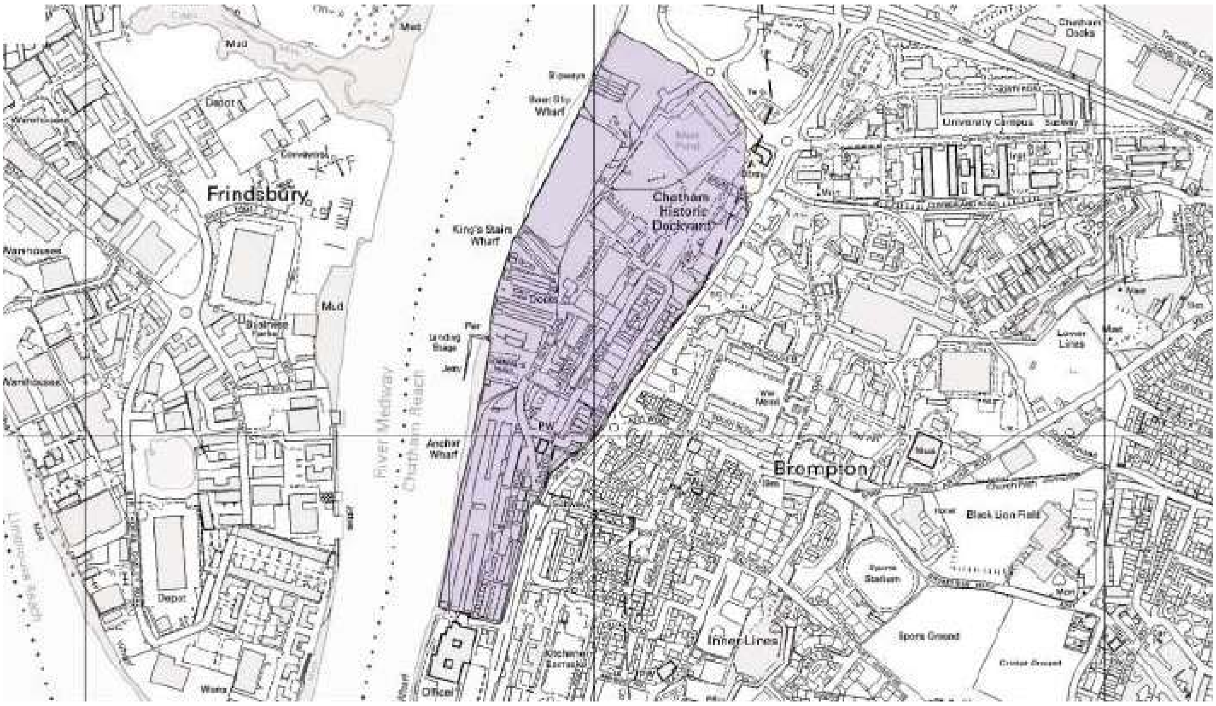
G.1 Introduction

G.1.1 Study Area

Chatham Historic Dockyard is located on the Chatham Reach of the River Medway. The site stretches from Chatham Port in the north to Danes Hill in the south. The total site area is 26 Hectares comprising tourism, commercial and residential development. The site has a total river frontage of approximately 1.3 km in length. The site is bordered by Chatham Centre to the south, Chatham Maritime to the north, and Brompton to the east. Dock Road runs along a large proportion of this eastern boundary.

The north of the site is low lying with the ground rising to the south and east of the site. The foreshore consists of a few small mudflats, while the frontage is described by its three wharfs; namely Anchor Wharf, King's Stairs Wharf and Boat Slip Wharf.

Figure G.1: Chatham Historic Dockyard Site Location Plan



Development Brief, Medway Council, 2004

G.1.2 The Development

The development site is in the custodianship of an independent charitable trust. The proposed development is as follows:

- Leisure and Tourism Activities
- Small Business Development
- Development complementary to Medway's maritime history

G.2 Existing Conditions

G.2.1 Proposed Development Site

G.i Present and Previous Land Use

Historically this site has always been associated with the naval dockyard. Probably started during the reign of Henry VIII the dockyard was originally known as Jillingham Water then Jillingham Dockyard before changing its name to Chatham in 1567.

The site remains dominated by the Dockyard, which now serves the tourism trade through its historic Naval interest. The site also accommodates more than 100 small businesses and organisations and some 400 residents. In addition the restored Clock Tower building is now incorporated into the Kent University campus.

G.ii Topography

The northern end of the site is flat and low lying with levels generally around 4 m AoD. Other areas along the waterfront are slightly higher at around 5 m AoD, with no significant increase in ground level for 200m from the river frontage. To the south and east of the site the ground slopes upwards reaching around 20 m AoD. The current sea defences along the waterfront are generally at around 5.6 m AoD.

G.iii Geology

The underlying geology of the area is made up of the Upper Chalk deposits. In the south eastern corner of the site the chalk is overlain by the Thanet Bed sands and by a thin band of head deposits.

The north western half of the site sits on the river alluvium which in places along the Medway is known to be up to 12m thick.

G.2.2 Existing drainage

The sewer network is managed privately and therefore is not shown on the Southern Water Sewer Records. There are two public surface water sewers to the south of the site of 225mm and 1200mm diameter. The full catchment of these sewers is not known but they are believed to be gravity sewers which outfall directly into the River Medway.

It is understood that surface water from this site is attenuated in the Mast Pond, which has a storage capacity of approximately 2000m^3. Surface water can be stored in this pond until tide locked conditions have subsided, at which time surface water will outfall into the River Medway.

These ponds may also attenuate flood water in the event of a minor breach in the flood defences.

G.2.3 Flood Defences

The River Medway frontage is approximately 1.3 km long and consists of a number of different structures; due to restricted access these could not be examined but are presumed to include:

- reinforced concrete walls;
- concrete capped steel sheet piles.

There appears not to be public knowledge of the flood defences at this location since they were previously owned and maintained by the Ministry of Defence and are currently privately maintained. From the LiDAR data it appears that the flood defences have a crest level of 5.6 m AoD.

G.2.4 Historic Flooding

Information obtained from recorded water levels at Thunderbolt Pier indicate that flood events occurred in 1927 (3.84m AoD), 1949 (4.53m AoD), 1953 (4.83m AoD), 1960 (3.73m AoD), 1965 (4.55m AoD) and 1978 (4.47m AoD). The mean high water level at this location is 3.20m AoD.

G.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak levels of these tidal cycles for this site are shown in Table G.1.

Table G.1: Expected Maximum Tidal Levels at Chatham Historic Dockyard

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.8 m AoD
200 (0.5%)	2100	5.8 m AoD
1000 (0.1%)	2100	6.0 m AoD

The modelling indicates that for the 1000-2060, 200-2100 and 1000-2100 scenarios, peak tidal levels at this site are increased by up to 0.1m if proposed land raising to 5.8 m AoD at Strood Riverside, Temple Marsh and Rochester Riverside go ahead. This increase is accounted for in Table G.1 above.

G.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the Chatham Historic Dockyard, these being tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two.

G.4.1 Surface Water Flooding

Where the outfall from a surface water gravity sewer is closed due to tide locked conditions, it is possible that the sewer may become surcharged and cause localised flooding. Sewer systems may be designed to overcome this by either pumping surface water into the River Medway or by providing storage within the sewer system within which surface water can be attenuated until tide-locked conditions subside. Since the sewers on this site are managed privately it is not possible to assess the full impact of surface water flooding. It is evident however that the two public sewers to the north of the site are not pumped systems and may be prone to surcharging during tide-locked conditions. For public sewers it is expected that some surface water flooding would occur during extreme rainfall events above a 1 in 30 year return period since these would not normally be designed to convey flows of this magnitude.

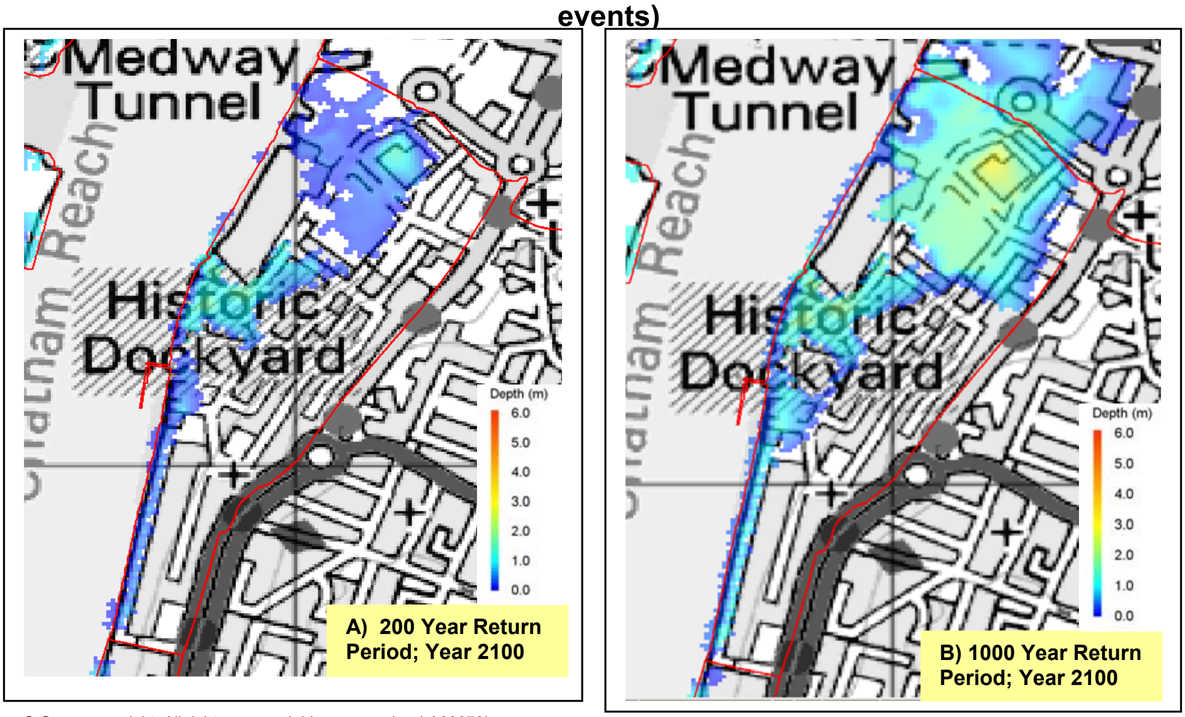
Since there is very limited information regarding surface water drainage it is not possible to assess the capacity of the existing sewers to convey additional flows from the new development.

G.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

Initial overtopping occurs by King Stairs Wharf with further overtopping occurring approximately 0.5 hours later to the north of the area around Boat Slip Wharf and to the south along Anchor Wharf. The flooding extent spreads south along the bank within the flood defence and east reaching East Road and Dock Road 1.5 and 2.0 hours respectively after initial overtopping of defences. Flood waters begin to recede 3 hours after flood defences are overtopped and some is trapped behind the flood defences.

Figure G.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure G.2: Extent of Flooding Chatham Historic Dockyard (200_2100 & 1000_2100 events)



The key flooding characteristics for Chatham Historic Dockyard are summarised in Table G.2

Table G.2: Summary of Chatham Historic Dockyard Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.8	1.3	0.5	3.5	1.6	0.15	0.28
1000	2100	6.0	1.5	1.3	3.5	3.0	0.18	0.37

Note:

Typical existing flood defence levels = 4.4 to 5.6 m AoD

Length of river frontage = 1.3 km

G.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- 40% of the river frontage would be overtopped during a 200 year tide under 2100 climate conditions and the entire river frontage would be overtopped during a 1000 year tide under 2100 climate conditions;
- The areas at risk are primarily adjacent to the river frontage. However, in the north east corner of the site, flooding could spread further inland for approximately 400 m in distance from the river bank;
- The maximum inundation depth due to overtopping could reach 3m.

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. These defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table G.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Note that if an embankment defence is considered then a freeboard of 0.6 m is required and the minimum defence crest level should be 5.9m.

Plate G.1: Chatham Historic Dockyard - Anchor Wharf

Plate G.2: Chatham Historic Dockyard - Parking and Industrial area

Appendix H Chatham Maritime and St Mary's Island

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

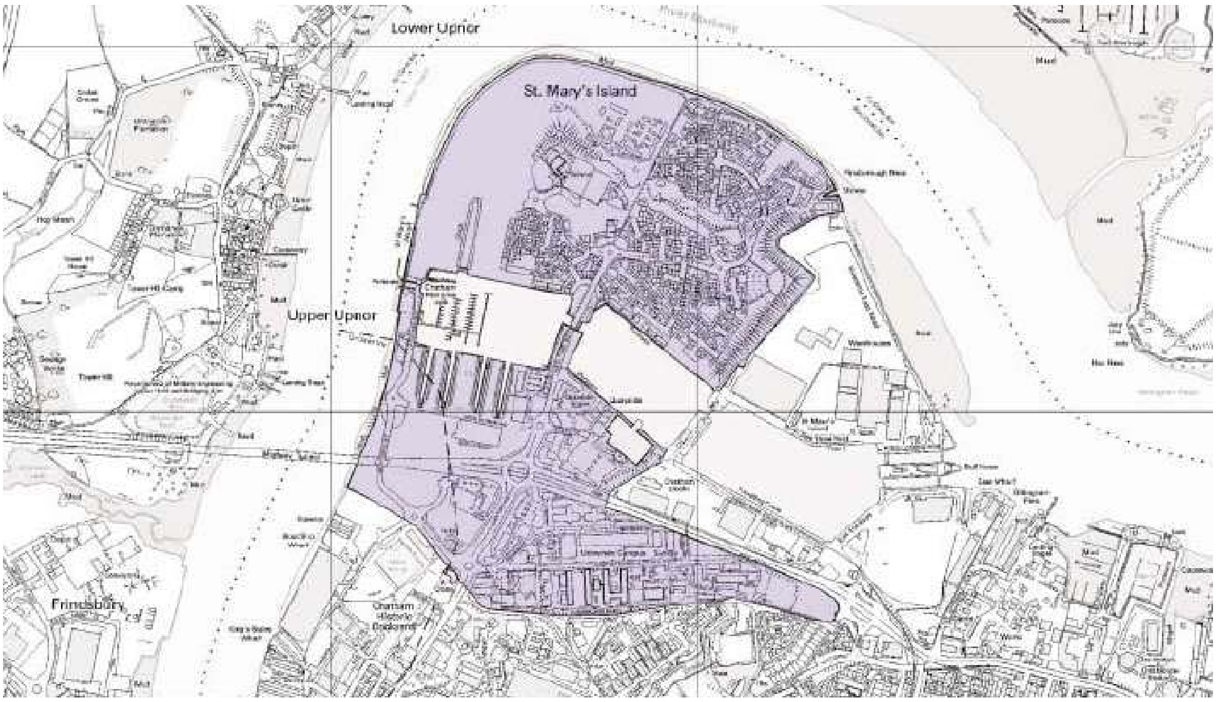
H.1 Introduction

H.1.1 Study Area

Chatham Maritime and St Mary's Island is located to the north of the Chatham Historic Dockyard and is bordered on the east by Chatham Port. The site straddles the Upnor and Short Reaches of the River Medway, where the river transitions to the estuary. The total site area is 136 Hectares comprising a large residential development on St Mary's Island with the Kent University campus and high quality commercial and leisure facilities at Chatham Maritime. The site has a total river frontage of approximately 2.3km in length. The two areas are separated by the large marina ponds. Access to the Medway Tunnel is obtained through this development site, providing a key transport link.

The majority of the site is low lying with the ground rising at the University campus to the south of the site. St Mary's Island and the Marina benefit from extensive flood defences, these will be described in more detail in section H.2.3.

Figure H.1: Site Location Plan



Development Brief, Medway Council, 2004

H.1.2 The Development

The development promises to be a showpiece living and working environment with buildings of innovative and eye-catching design. The proposed development is as follows:

- University expansion
- Office Development
- Hotel and Conference Facility

- Housing
- Leisure, entertainment and tourism uses.

H.2 Existing Conditions

H.2.1 Proposed Development Site

H.i Present and Previous Land Use

St Mary's Island is exclusively given to residential development, there are currently over 1000 properties, with the remainder of the site currently being undeveloped wasteland. The former Royal Naval base is now occupied by a high class development known as Chatham Maritime, the marina is bounded by several large industrial and commercial facilities. The former Pembrooke Barracks buildings are now occupied by the University of Greenwich with a possible student population of 6000.

H.ii Topography

The Flood Extents Map shows contour lines for the site as well as the expected extents of flooding to the area. St Mary's Island is very low lying, with levels generally between 4m-5m AoD, there are a few localised high spots with levels up to 13m AoD. Levels at Chatham Maritime are equally very low lying, with levels generally between 3m-5m AoD. Levels only rise significantly towards the University of Greenwich campus where levels climb to 10m AoD and above.

The current sea defences have a crest level of between 6.1m-6.2m AoD along the entire river frontage.

H.iii Geology

The underlying geology of Chatham Maritime has a mixture of initial layers; Alluvium and River Gravels, Thanet Bed sands, and Upper Chalk. Of the initial layers, the Thanet Beds are approximately 30m thick. The Underlying geology of St Mary's Island is initially Alluvium, underlain by Thanet Beds. The River Gravels and Alluvium are generally made up of flints and slits and are found in the floodplains of the Medway; this layer may be in the region of 11m in depth.

Below the initial layers lies the Upper, Middle and Lower layers of Chalk. The Upper chalk is mainly soft, white limestone but nodular beds. At around 90m thick, flint is present as layers or nodules. The Middle Chalk is also mainly soft but flint is rare in the lower half. This occurs for a thickness of 60m - 75m Lower Chalk is capped by a thin bed of dark grey-green marl and consists primarily of blocky, light to dark grey chalk. It generally occurs with a thickness of between 58m – 77m. The underlying Gault is a thin layer of dark, blue-grey clay.

H.2.2 Existing drainage

Over years the site has been massively redeveloped with the system of natural creeks being infilled or culverted and a system of pipes being used to carry surface water out to the River Medway. The Southern Water Sewer Records have no information on the sewers for the site. The Maritime site is most probably privately maintained, however the large residential development is new and as such the sewers have probably not yet been adopted by Southern Water.

It is understood that surface water from these sites is attenuated in the ponds to the south of St Mary's Island. Surface water can be stored in this pond until tide locked conditions have subsided, upon which surface water will outfall into the River Medway via the Port. These ponds may also attenuate minor breaches of the flood defences.

H.2.3 Flood Defences

It is understood that the existing frontage along the River Medway has been constructed over time to provide docks for the various industries that have been there over time. Latterly the Ministry of Defence constructed flood defences in 1973 at 5.6m AoD. These defences were improved to 6.2m AoD in 1993 when the design standard was considered to be a 1 in 1000year return period flood event. Recent LiDAR survey work indicates that the level of defence may be slightly lower than the design standard at 6.1m AoD. The site is apparently not protected from flooding from neighbouring sites, this significantly lowers the standard of flood protection at this site.

The River Medway frontage is approximately 2.3km long as indicated above and consists primarily of:

- reinforced concrete walls;
- concrete filled brick walls;
- and earth embankments.

The frontage can be seen in the photographs in section H.6

In principal the control of flooding along the River Medway is the responsibility of the Environment Agency however the Medway Ports Authority was assigned statutory responsibility for this section of the river as part of the Medway Ports Authority Act 1973. The riparian owner of the land is responsible for the maintenance of the flood defences, which upon brief inspection are generally in a good state of repair.

The Environment Agency confirms that Medway Tunnel has flood defences along the approach roads to a standard of a 1 in 1000year return period event. These defences were constructed mid to late 1990's.

H.2.4 Historic Flooding

Information obtained from recorded water levels at Gillingham Pier indicate that flood events occurred in 1927 (3.73m AoD), 1949 (4.45m AoD), 1953 (4.79m AoD), 1960 (3.66m AoD), 1965 (4.48m AoD) and 1978 (4.43m AoD). The mean high water level at this location is 3.16m AoD.

H.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak levels of these tidal cycles for Chatham Maritime are shown in Table H.1 below.

Table H.1: Expected Maximum Tidal Levels at Chatham Maritime

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.7 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	5.9 m AoD

H.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the Chatham Maritime and St Mary's Island, these being tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two, particularly from neighbouring sites.

H.4.1 Surface Water Flooding

Where the outfall from a surface water gravity sewer is closed due to tide locked conditions, it is possible that the sewer may become surcharged and cause localised flooding. Sewer systems may be designed to overcome this by either pumping surface water into the River Medway or by providing storage within the sewer system with which surface water can be attenuated until tide-locked conditions subside. Since the sewers on this site are currently managed privately it is not possible to assess the full impact of surface water flooding. For the yet to be adopted sewers, it is expected that some surface water flooding would occur during extreme rainfall events above a 1 in 30 year return period since the sewer network would not normally be designed to convey flows of this magnitude.

Since there is very limited information regarding surface water drainage it is not possible to assess the capacity of the existing sewers to convey additional flows from the new development.

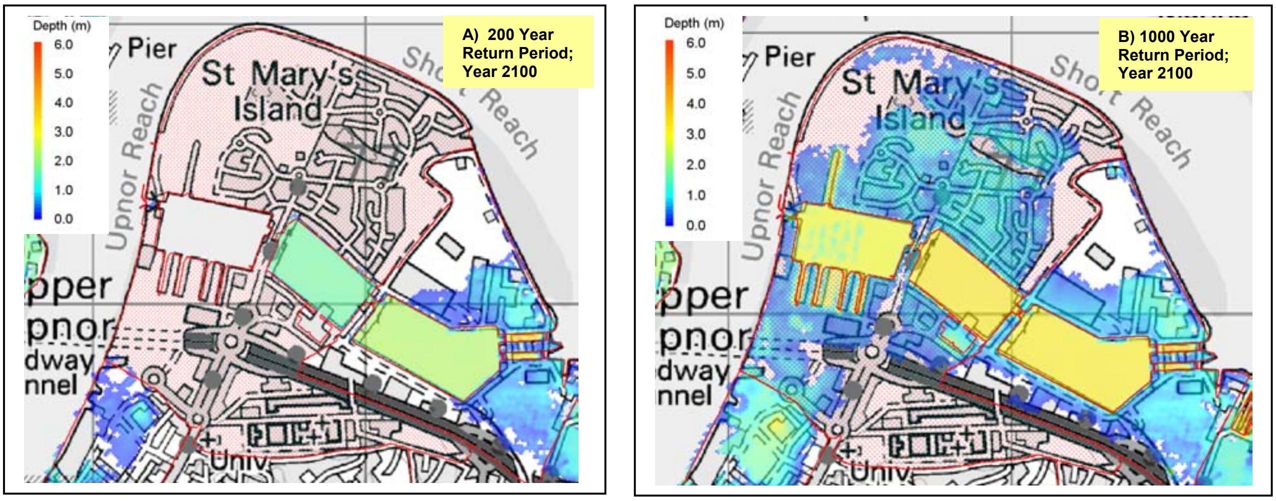
H.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

No tidal flooding occurs in St Mary's Island under the 200 year return period conditions for the year 2100.

Under 1000 year return period conditions for the year 2100 initial overtopping occurs at the lock between the eastern basin and the central basin. Flood waters flow into the central basin and are contained. Flood waters extend into the far western basin half an hour after initial overtopping of the central basin and extend north of the middle basin into St Mary's Island and south towards the A289. Approximately half an hour later, flood waters spread further north reaching the northern flood defence wall of St Mary’s Island and flow south west into the western basin from the land. At the same time flood waters flow north into the western basin from the Chatham Historic Dockyard area. The flood extent decreases slightly some 2.5 hours after initial overtopping as the tide levels fall but a significant volume of water remains trapped across the area.

Figure H.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure H.2: Extent of Flooding Chatham Maritime and St Mary’s Island (200_2100 & 1000_2100 events)



The key flooding characteristics for Chatham Maritime and St Mary’s Island are summarised in Table H.2.

Table H.2: Summary of Chatham Maritime Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1000	2100	5.9	1.9	0.015	2.5	1.5	0.9	0.8

Note:

Typical existing flood defence levels = 6.2 m AoD along the west and north, 4.3 m AoD to 12 m AoD along the eastern side.

Length of river frontage = 2.3 km

H.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- The flood defence level along the river frontage of Chatham Maritime and St Mary's Island site is higher than the model predicted water levels in the river during a 200 year and a 1000 year tide under 2100 climate conditions, therefore, there is no direct overtopping in this reach;

- However, the model results suggest that majority of the Chatham Maritime and St Mary's Island site is subject to flooding during a 1000 year tide under 2100 climate conditions. The flooding in this area is predominantly due to the flood defences along adjacent sites, particularly Chatham Ports to the east, being overtopped, thus causing flooding in Chatham Ports area. The flood waters then spread from Chatham Ports into Chatham Maritime and St Mary's Island;

- The maximum inundation depth could be around 1.5m on land.

Defences along St Mary's Island should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table H.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.85m
Minimum defence crest height:	6.15 m

Note that if an embankment defence is considered then a freeboard of 1.15 m is required and the minimum defence crest level should be 6.45m.

The existing defences comprise concrete flood walls which have been constructed with a crest level of 6.2m. These are therefore satisfactory.

There are. however, requirements to raise the defences in the adjacent Chatham Port area to 6.15m to prevent flood waters from bypassing the islands river defences.

H.6 Photographs of the development site and area

Plate H.1: Marina

Plate H.2: Flood Defences at St Mary's Wharf

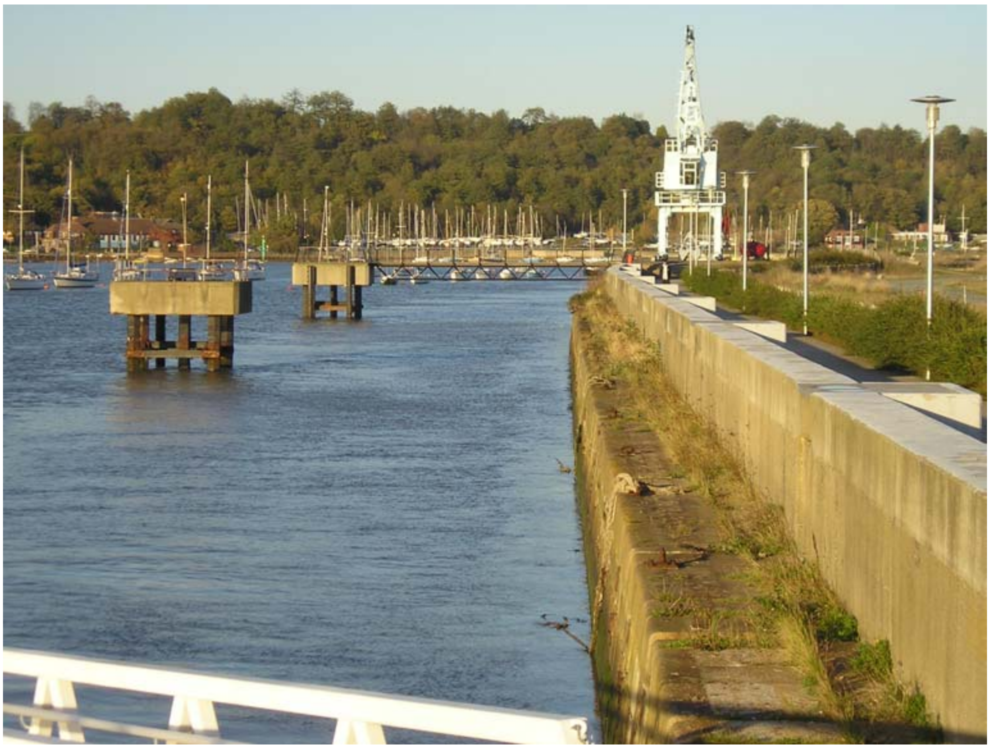


Plate H.3: Lock entrance to Marina

Plate H.4: Undeveloped area of St Mary's Island

Plate H.5: St Mary's Island Flood Defences

Plate H.6: Flood defences at boundary with Chatham Port

Appendix I The Upnors

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

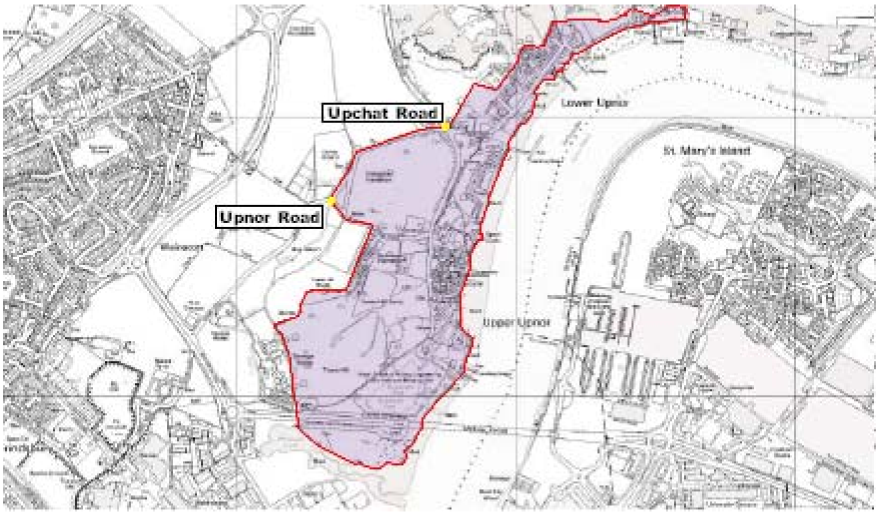
List of Plates

I.1 Introduction

I.1.1 Study Area

The Upnors site is located on the River Medway covering an area of approximately 70 hectares with a river frontage of around 2.6 km in length (See Figure I.1: The Upnors Site Location Plan). Located in the northern area of the Medway Development Strategy, the site lies on the northern bank of the River Medway and is bounded to the East by the Medway. Access to the site is restricted to two roads, Upnor and Upchat. Access to Medway tunnel is through the Upnors Site

Figure I.1: The Upnors Site Location Plan



Rochester Riverside, Development Brief, Medway Council, 2004

I.1.2 The Development

The development site, which is owned by Medway Council, will include:

- 60-100 new dwellings;
- 60-100 new jobs;
- community facilities;
- Enhanced visitor facilities;
- Restaurant, leisure and boat uses;

I.2 Existing Conditions

I.2.1 Proposed Development Site

I.i Present and Previous Land Use

The region is predominantly rural with the small settlements of Lower and Upper Upnor along the shoreline. The two villages are mainly residential in nature with a few leisure facilities plus a degree of marine industry. Within Upper Upnor there sits Upnor Castle, a site of historical interest. Its location is backing onto the waterfront in the northern part of Upper Upnor.

I.ii Topography

Dominated by high ground, which, at its highest point, reaches 28m AoD, the majority of the Upnors area is at no risk of inundation. However the only settlement within the area, owing to the industrial opportunities offered by the river, is bank side. As such the villages of Lower and Upper Upnor are in fact situated on low lying land at around 4m AoD.

I.iii Geology

The underlying geology of The Upnors has a mixture of initial layers, Alluvium, Thanet Bed sands, and river gravels, underlain by chalk and Gault. Of the initial layers, Thanet Beds are of some 23 m thick in the area and consist mainly of sands. The River Gravel and Alluvium is generally made up of flints and slits and are found in and adjoining the flood plains of the Medway. The layer can be of anything in the region of 12 m in depth.

Below this lies three layers of Chalk, Upper, Middle and Lower. The Upper chalk is mainly soft, white limestone but nodular beds. At around 90m thick, flint is present as layers or nodules. The Middle Chalk is also mainly soft but flint is rare in the lower half. This occurs for a thickness of 60 m – 75 m Lower Chalk is capped by a thin bed of dark grey-green marl and consists primarily of blocky, light to dark grey chalk. It generally occurs with a thickness of between 55 m – 80 mThe Gault is a thin layer of dark, blue-grey clay at the foot of the chalk escarpment.

I.2.2 Existing drainage

The man-made drainage is fairly limited owing to the small degree of development in the area. From Southern Water records it can be seen that the existing drainage consists of:

- Surface runoff drainage with on outlet into the Medway for Lower Upnor;
- Foul sewer system for Lower Upnor draining out to the south west corner via a rising main;
- Surface runoff drainage with on outlet into the Medway for Upper Upnor;
- Foul sewer system for Upper Upnor draining out to the south east corner;
- Natural drainage is purely surface runoff draining directly into the Medway or into a local stream;

The surface drainage network is managed by Southern Water Plc and it is understood that the existing system is gravity fed with the assumption that, due to the tidal nature of the downstream environment, all outfalls are likely to have flapped gated outfalls. The existing surface water drainage system should be designed to a 1 in 30 year level.

I.2.3 Flood Defences

Owing to the nature of the topography of the area there is little in the way of official defence for the villages of Lower and Upper Upnor. Owing to high shoreline. Upper Upnor has no official defence, however in Lower Upnor there is a short section of low concrete wall at around 4.8m AoD which protects residences on low lying areas from potential inundation. The wall pre-dates 1978 since when no works have been undertaken.

The Medway Tunnel has been assessed to have a standard of protection of 1 in 1000 years along the approach roads which were constructed in mid 1990.

I.2.4 Historic Flooding

Information obtained from recorded water levels at Thunderbolt Pier indicate that flooding events occurred in 1927 (3.73m AoD), 1949 (4.45m AoD), 1953 (4.79m AoD), 1960 (3.66m AoD), 1965 (4.48m AoD) and 1978 (4.43m AoD).

I.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak levels of these tidal cycles for The Upnors are shown in Table I.1 below.

Table I.1: Expected Maximum Tidal Levels at Rochester Riverside

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.7 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	6.0 m AoD

The modelling indicates that for the 1000-2100 scenario, peak tidal levels at this site are increased by up to 0.1m if proposed land raising to 5.8 m AoD at Strood Riverside, Temple Marsh and Rochester Riverside go ahead. This increase is accounted for in Table I.1 above.

I.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the The Upnors site being tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two.

I.4.1 Surface Water Flooding

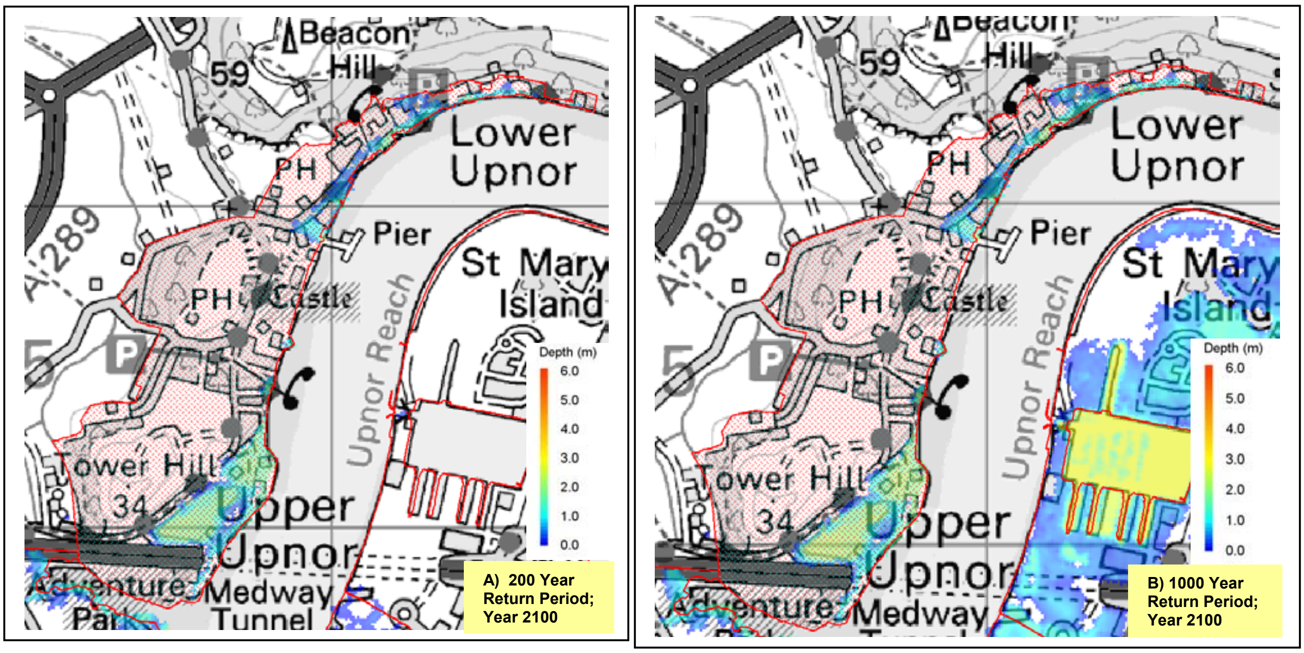
The main source of surface water flooding is as a result of backing up within the surface water drainage system as a result of insufficient storage capacity during the high tide, i.e. when the outlet flat valves are closed. However a significant area is not covered by surface water drainage and thus surface runoff would be the most likely source of surface water runoff. Anything considered above a 1 in 30 year event would probably result in event dependent flooding.

I.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

Initial overtopping occurs on the bank east of Tower Hill, at the pier and on the bank opposite Margetts Place. Flooding extends inland to the base of Tower Hill but is contained near the bank at Lower Upnor, reaching a maximum extent some 3 hours after initial inundation. Flood waters begin to recede after 3.5 hours, but some isolated areas remain at Upper Upnor south of Tower Hill.

Figure I.2 show the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure I.2: Extent of Flooding The Upnors (200_2100 & 1000_2100 events)



The key flooding characteristics for The Upnors are summarised in Table I.2.

Table I.2: Summary of The Upnors Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.7	2.2	1.4	4	2.1	0.135	0.2
1000	2100	6.0	2.4	1.4	5	2.3	0.135	0.2

Note:

Typical existing flood defence levels = 3.5 to 5 m AoD

Length of river frontage = 2.7 km

I.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- Over half of the river frontage would be overtopped during a 200 year and a 1000 year tide under 2100 climate conditions;
- The areas at risk are primarily adjacent to the river frontage, and they are limited a 0 to 200 m wide strip parallel to the river frontage;
- The maximum inundation depth could reach over 2m in the southwest corner of the site, adjacent to the Medway Tunnel.

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. Upstream of Upnor pier the defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table I.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Downstream of Upnor Pier the defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table G.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.85m
Minimum defence crest height:	6.15 m

Note that if an embankment defence is considered then an additional freeboard of 0.3 m is required at either location.

I.6 Photographs of the development site and area

Plate I.1: Lower Upnor Tidal Flooding Defence

Plate I.2: Upper Upnor Shoreline

J-1

Appendix J Strood Riverside

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

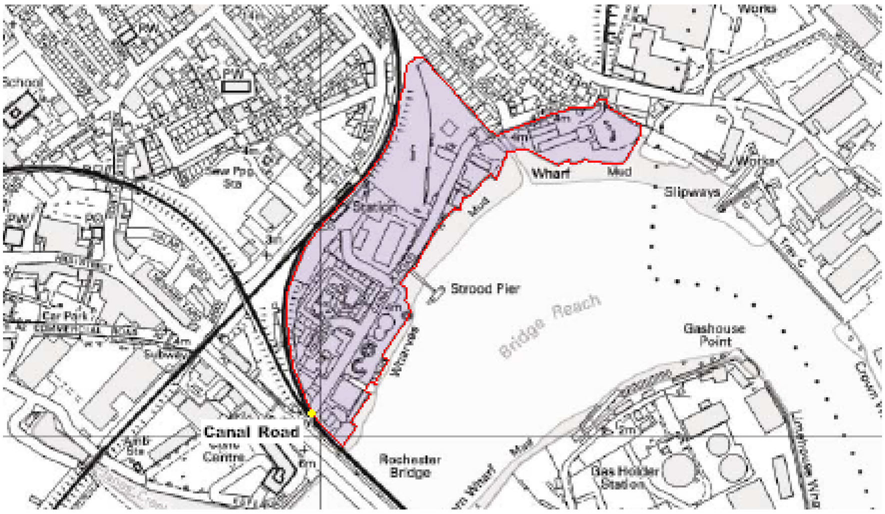
List of Plates

J.1 Introduction

J.1.1 Study Area

The Strood Riverside site is located on the River Medway along a stretch known as Bridge Reach. The site is approximately 10 hectares with a river frontage of around 0.8 km in length (See Figure J.1: Strood Riverside Site Location Plan). Located in the central area of the Medway Development Strategy, the site lies on the northern bank of the River Medway and is bounded to the North and West by the London Victoria and Canterbury Rail track. To the North are mainly residential areas plus the Medway Estate. Access to site is under the railway bridge along Canal Road only.

Figure J.1: Strood Riverside Site Location Plan



Rochester Riverside, Development Brief, Medway Council, 2004

J.1.2 The Development

The development site, which is owned by Medway Council, will include:

- around 500 new homes;
- riverside walk and cycle path;
- improve access and enhancement of the entrance to the railway station;
- improvement of highway network that serves the area;
- provision of community facilities to serve existing and future communities;
- preserve and improve riverside views;
- achieve flood protection along a large proportion of the riverside;

J.2 Existing Conditions

J.2.1 Proposed Development Site

J.i Location

The site is approximately 30 hectares in size with a water frontage onto the River Medway of approximately 1.6km. It is enclosed on its western and southern boundaries by the rail line and embankment with the aforementioned frontage to the north of the site.

J.ii Present and Previous Land Use

The area is predominantly residential with a small park lying at the South-Eastern corner on the waterfront. A number of dwellings are of a redundant nature and Strood Railway Station is included within the boundaries.

J.iii Topography

The whole area is low lying land at around 5m AoD.

J.iv Geology

The underlying geology of Strood Waterfront is initially Alluvium underlain by chalk and Gault. The Alluvium is generally made up of flints and slits and is found in and adjoining the flood plains of the Medway. The layer can be of anything in the region of 12 m in depth.

Below this lies three layers of Chalk, Upper, Middle and Lower. The Upper chalk is mainly soft, white limestone but nodular beds. At around 30 m thick, flint is present as layers or nodules. The Middle Chalk is also mainly soft but flint is rare in the lower half. This occurs for a thickness of 60 m – 75 m Lower Chalk is capped by a thin bed of dark grey-green marl and consists primarily of blocky, light to dark grey chalk. It generally occurs with a thickness of between 55 m – 80 m. The Gault is a thin layer of dark, blue-grey clay at the foot of the chalk escarpment.

J.2.2 Existing drainage

There are no details as to the current extent of surface or foul water drainage in Strood Riverside except for the rising surface water pipes from Vicarage Road.

J.2.3 Flood Defences

There is no official flood defence along the waterfront in Strood Riverside. There is foreshore protection which consists of sheet piling which leaves the foreshore at a height of 4.3m AoD along the front of the park and further foreshore in the northern reaches which is at around 3.5m AoD. These are fairly modern improvements dating to 1998.

J.2.4 Historic Flooding

The nearest point where records are available for Strood Riverside is at the A2 Rochester Bridge. Information obtained from recorded water levels indicates that flooding events occurred in 1927 (3.92m AoD), 1949 (4.54m AoD), 1960 (3.80m AoD), 1965 (4.60m AoD) and 1978 (4.51m AoD).

J.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak level of these tidal cycles for Strood Riverside are shown in Table J.1 below.

Table J.1: Expected Maximum Tidal Levels at Strood Riverside

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.7 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	5.9 m AoD

J.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for Strood Riverside site, tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two.

J.4.1 Surface Water Flooding

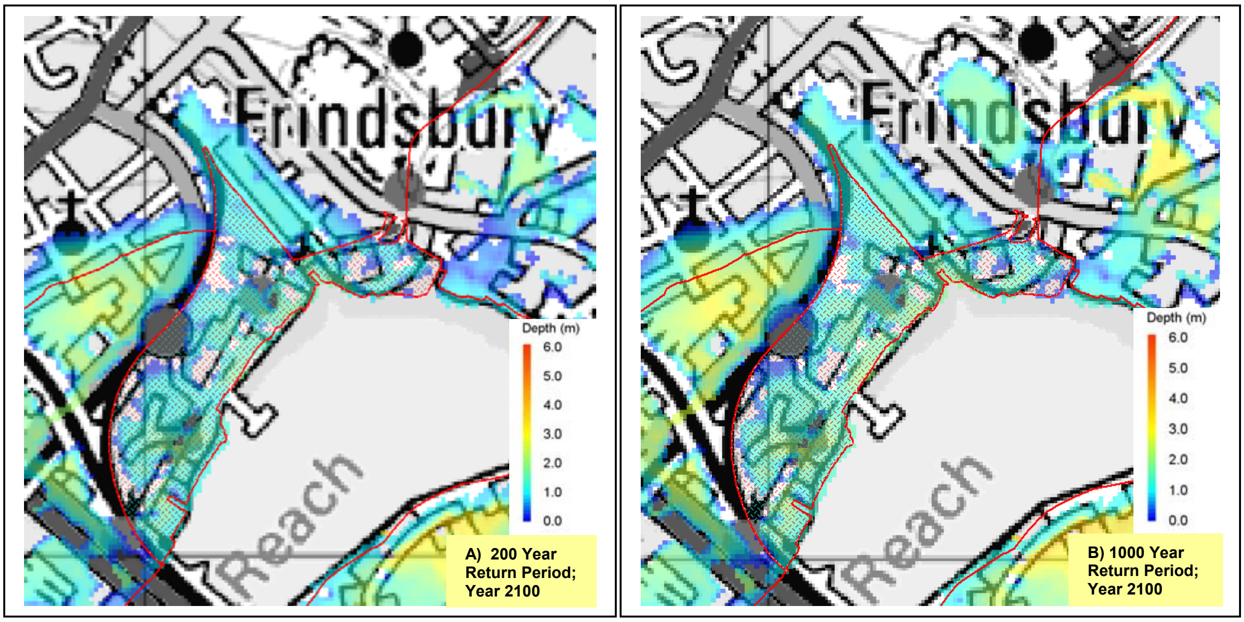
The main source of surface water flooding is as a result of backing up within the surface water drainage system as a result of insufficient storage capacity during the high tide, i.e. when the outlet flat valves are closed. However a significant area is not covered by surface water drainage and thus surface runoff would be the most likely source of surface water runoff. Anything considered above a 1 in 30 year event would probably result in event dependent flooding.

J.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

Initial overtopping occurs at Wingrove Drive and along the northern half of Canal Road. Within half an hour overtopping occurs along the whole length of Canal Road extending as far as Strood Station. Within 1.5 hours of initial overtopping , flooding has extended over the majority of the area. The flood extent begins to recede some 3.5 hours after initial overtopping and flood waters remain trapped in isolated patches across the area.

Figure J.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure J.2: Extent of Flooding Strood Riverside (200_2100 & 1000_2100 events)



The key flooding characteristics for Strood Riverside are summarised in Table J.2.

Table J.2: Summary of Strood Riverside Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.7	1.9	0.88	4.5	1.9	0.1	0.3
1000	2100	5.9	2.1	0.88	5.0	2.0	0.1	0.3

Note:

Typical existing flood defence levels = 3.5 to 5.8 m AoD

Length of river frontage = 0.88 km

J.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- The entire river frontage would be overtopped during a 200 year and a 1000 year tide under 2100 climate conditions;
- Almost the entire Strood Riverside area is subject to flooding, with a maximum inundation depth of 2 m;
- The flood water could spread further inland, even beyond the Strood Riverside site and develop further to the north, i.e. as far as 400 m from the river bank.

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. There appear to be two alternatives:

- Construct a new flood defence along the River Medway site frontage.
- Land raising throughout the site.

In terms of the former, such flood defences would require a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table J.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Note that if an embankment defence is considered then a freeboard of 0.6 m is required and the minimum defence crest level should be 5.9m.

For the land raising option it is suggested that the land would need to be raised as follows:

Flood level for 200 year 2060 situation (refer to Table J.1 above)	5.3m
Freeboard to account for uncertainty in the prediction of flood levels (refer to Table 4.5 above)	0.3m
Minimum level of raised ground:	5.6 m

J.6 Photographs of the development site and area

Plate J.1: Strood Riverside Foreshore

Appendix K Strood Centre

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

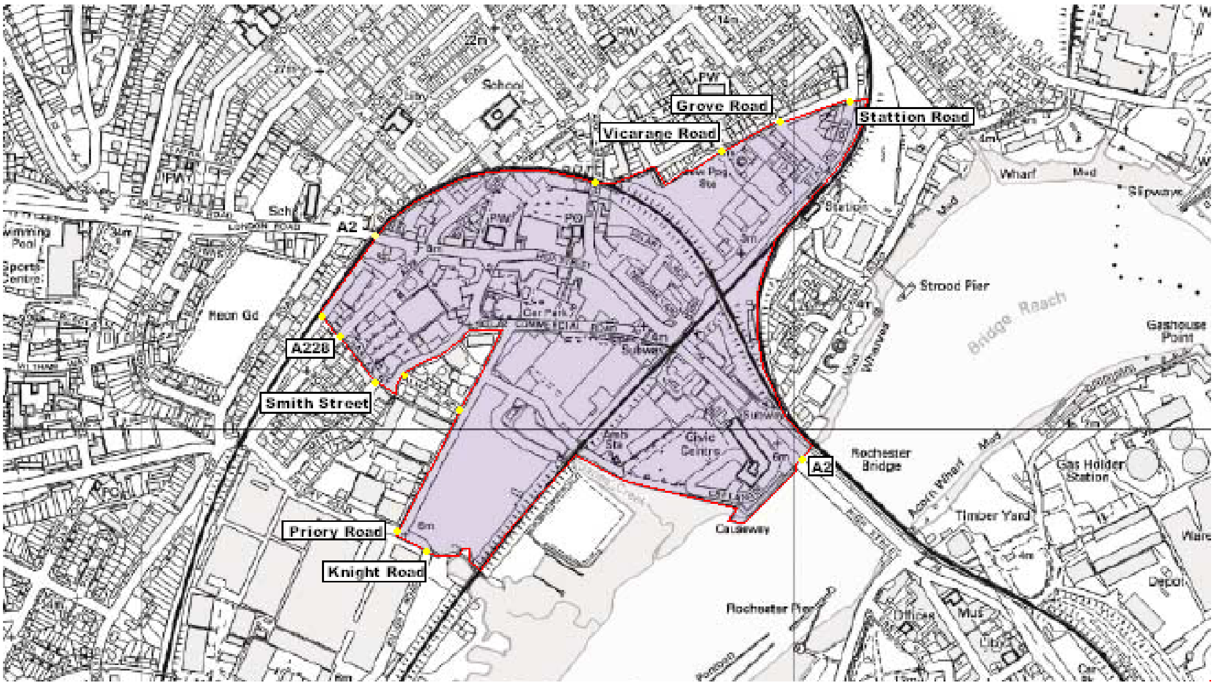
K.1 Introduction

K.1.1 Study Area

The Strood Centre site is located on the River Medway along a stretch known as Bridge Reach. The site is approximately 30 hectares although it has a river frontage of only 1.0 km (See Figure K.1: Stood Centre - Site Location Plan). Located in the central area of the Medway Development Strategy, the site lies on the northern bank of the River Medway and is bounded on three sides by railway lines, although two regions lie externally to this natural boundary, the Civic Centre and the area directly opposite Strood Centre.

The main access points to the site are the A2, A207, Knight Road, Priory Road and Station Road of which the A2 is the largest.

Figure K.1: Stood Centre - Site Location Plan



Medway Waterfront, Development Brief, Medway Council, 2004

K.1.2 The Development

The development site, which is owned by Medway Council, will include:

- potential for 100 – 200 new homes;
- highways improvements to reduce congestion;
- significant upgrade to the environment;
- enhancement of shopping areas;
- framework for redevelopment sites to achieve a comprehensive integration of uses and quality streetscapes;

- increased access to the river utilising Civic Centre area;
- Possible creation of 100-200 jobs;

K.2 Existing Conditions

K.2.1 Proposed Development Site

K.i Present and Previous Land Use

Current land use within Strood Centre consists mainly of commercial practices. Many main high street retailers along with independent traders share the central commercial area. Of particular interest is the large new Morrisons located on Commercial Road. In addition to this, and at particular risk due to their riverside location, reside a number of civic buildings on the Eastern fringe of the area including Medway Council offices.

K.ii Topography

The overall topography is characterised by low lying and flat land at a level of around 4 m AoD.

K.iii Geology

The underlying geology of Strood Centre is initially Alluvium underlain by chalk and Gault. The Alluvium is generally made up of flints and slits and is found in and adjoining the flood plains of the Medway. The layer can be of anything in the region of 12 m in depth. Below this lies three layers of Chalk, Upper, Middle and Lower. The Upper chalk is mainly soft, white limestone but nodular beds with flint present as layers and nodules and is of around 30 m thick. The Middle Chalk is also mainly soft but flint is rare in the lower half. Lower Chalk is capped by a thin bed of dark grey-green marl and consists primarily of blocky, light to dark grey chalk. The Gault is a thin layer of dark, blue-grey clay at the foot of the chalk escarpment.

Below this lies three layers of Chalk, Upper, Middle and Lower. The Upper chalk is mainly soft, white limestone but nodular beds. At around 30 m thick, flint is present as layers or nodules. The Middle Chalk is also mainly soft but flint is rare in the lower half. This occurs for a thickness of 60 m – 75 m Lower Chalk is capped by a thin bed of dark grey-green marl and consists primarily of blocky, light to dark grey chalk. It generally occurs with a thickness of between 55 m – 80 m. The Gault is a thin layer of dark, blue-grey clay at the foot of the chalk escarpment.

K.2.2 Existing drainage

The current drainage system is made up of the following systems:

- Surface water runoff system draining into Jane's Creek via four separate outlets;
- Surface water runoff system draining directly into the Medway;
- Surface water runoff draining to a pumping station situated on Vicarage Road and thus pumped via a rising main to the Medway;

- Foul water system which drains to the same Vicarage Road Pump Station where it is pumped via a rising main and Medway Bridge out of the area;

The surface drainage network is managed by Southern Water Plc and it is understood that the existing system is gravity fed with the assumption that, due to the tidal nature of the downstream environment, all outfalls are likely to have flapped gated outfalls. The existing surface water drainage system should be designed to a 1 in 30 year level.

K.2.3 Flood Defences

There are little in the way of official flood defences along the Strood Centre frontage. With shoreline protection using sheet piling any existing flood defences are limited to low level walls which have a level of around 4.3 m AoD. In addition to this some protection could be afforded by the railway embankments which run south-west to north-east

K.2.4 Historic Flooding

Information obtained from recorded water levels at the A2 Rochester Bridge indicate that flooding events occurred in 1927 (3.92m AoD), 1949 (4.54m AoD), 1960 (3.80m AoD), 1965 (4.60m AoD) and 1978 (4.51m AoD).

K.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak level of these tidal cycles for Strood Centre are shown in Table K.1 below.

Table K.1: Expected Maximum Tidal Levels at Strood Centre

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.8 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	6.0 m AoD

The modelling indicates that for the 1000-2060 and 1000-2100 scenarios, peak tidal levels at this site are increased by up to 0.1m if proposed land raising to 5.8 m AoD at Strood Riverside, Temple Marsh and Rochester Riverside go ahead. This increase is accounted for in Table K.1 above.

K.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the Strood Centre site being tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two.

K.4.1 Surface Water Flooding

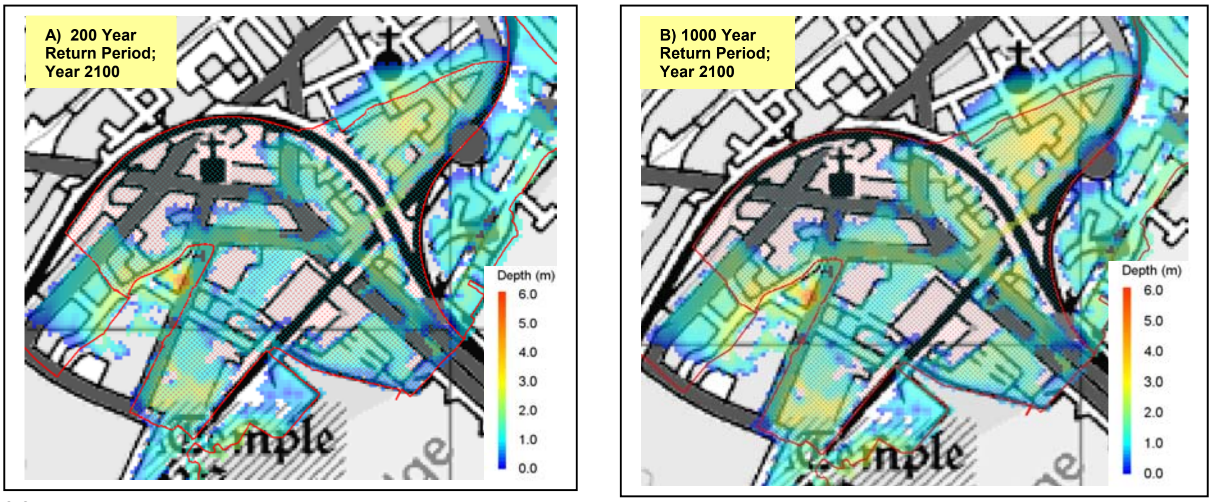
The main source of surface water flooding is as a result of backing up within the surface water drainage system as a result of insufficient storage capacity during the high tide, i.e. when the outlet flat valves are closed. However a significant area is not covered by surface water drainage and thus surface runoff would be the most likely source of surface water runoff. Anything considered above a 1 in 30 year event would probably result in event dependent flooding.

K.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

Initial flooding occurs from the creek flowing through the railway culvert at the corner of Knight Road and subsequently flowing north extending half way across the Morrison site area. After half an hour, the flooding extent covers the majority of the Morrison site area and begins to flow north-west into the Deacon Trading Centre between Priory Road and Alma Place. Approximately one and a half hours after initial overtopping, flood waters from both creeks flood the area to the north east of Alma Place and flow through the Retail Park to Commercial Road. From here, flood waters flow east extending to Friary Place and west to the car park. After two hours, flooding covers the majority of the area with the exception of the area around the western half of the High Street, to the north of the Strood Centre area. Flood waters recede some 3.6 hours after initial overtopping and isolated patches remain.

Figure K.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure K.2: Extent of Flooding Strood Centre (200_2100 & 1000_2100 events)



The key flooding characteristics for Stood Centre are summarised in Table K.2.

Table K.2: Summary of Strood Centre Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.7	1.7	1.1	4	2.7	0.27	0.6
1000	2100	6.0	1.9	1.1	5	3	0.27	0.6

Note:

Typical existing flood defence levels = 4 to 5.3 m AoD

Length of river frontage = 1.1 km

K.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- The entire river frontage would be overtopped during a 200 year and a 1000 year tide under 2100 climate conditions;
- The majority of the Strood Centre area is subject to flooding, with a maximum inundation depth of 3 m;
- The flood water could spread further inland, even beyond the Strood Centre and could spread as far as the A228 in places, which is 500 m away from the river bank.

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. These defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table K.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Note that if an embankment defence is considered then a freeboard of 0.6 m is required and the minimum defence crest level should be 5.9m.

K.6 Photographs of the development site and area

Plate K.1: Strood Centre Waterfront

Appendix L Strood Waterfront

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

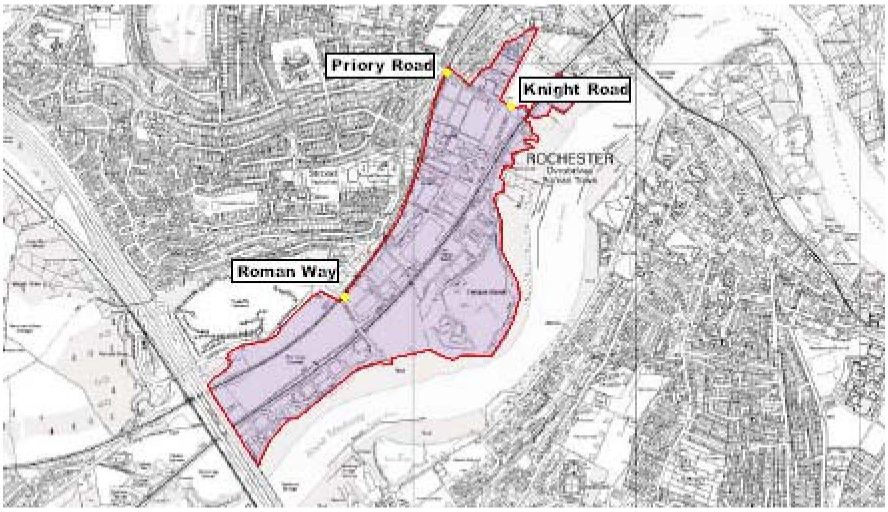
List of Plates

L.1 Introduction

L.1.1 Study Area

The Strood Riverside site is located on the River Medway along both Wickham and Tower Reach. The site is approximately 98 hectares with a river frontage around 2.9 km in length (See Figure L.1: Strood Waterfront Site Location Plan). Located in the south-western area of the Medway Development Strategy, the site lies on the northern bank of the River Medway and is bounded to the West by the Medway Valley Rail track as well as the M2 Bridge to the South and Priory Road to the North. Access is either from Priory Road, Roman Way or Knight Road.

Figure L.1: Strood Waterfront Site Location Plan



Rochester Riverside, Development Brief, Medway Council, 2004

L.1.2 The Development

The development site, which is owned by Medway Council, will include:

- between 100 and 500 new homes including new affordable accommodation;
- 150-250 new jobs;
- riverside walk;
- improved vehicular circulation south of Strood Centre;
- establish a station on the Medway Valley line;
- improve the setting of Temple Manor and improve access to Temple Marsh public open space;
- construct appropriate community facilities;
- encourage office light and general industrial and warehouse developments;
- new, appropriate sport facilities;
- development of community facilities;

L.2 Existing Conditions

L.2.1 Proposed Development Site

L.i Present and Previous Land Use

It is understood that this land has been used historically for tipping waste.

The area is predominantly industrial with warehouses and other mixed industrial users. Along the eastern fringe, immediately adjacent to the river is a large area of open public space known as Temple Marshes which affords views of Historic Rochester, and in particular the castle and the cathedral.

L.ii Topography

The Strood Waterfront Flood Extents Map shows contour lines for the site. For the most part Strood Waterfront is fairly high. Temple Marsh represents, at 6m AoD, the single largest area of low lying land for the area and it is only around the fringes that there is any land below this level.

L.iii Geology

The underlying geology of Strood Waterfront is initially Alluvium underlain by chalk and Gault. The Alluvium is generally made up of flints and slits and is found in and adjoining the flood plains of the Medway. The layer can be of anything in the region of 12 m in depth.

Below this lies three layers of Chalk, Upper, Middle and Lower. The Upper chalk is mainly soft, white limestone but nodular beds. At around 30 m thick, flint is present as layers or nodules. The Middle Chalk is also mainly soft but flint is rare in the lower half. This occurs for a thickness of 60 m – 75 m Lower Chalk is capped by a thin bed of dark grey-green marl and consists primarily of blocky, light to dark grey chalk. It generally occurs with a thickness of between 55 m – 80 m. The Gault is a thin layer of dark, blue-grey clay at the foot of the chalk escarpment.

L.2.2 Existing drainage

The existing drainage system is comprises of:

- Surface runoff drainage with outlets by Strood Yacht Club and Jane's Creek;
- Foul water system draining to Vicarage Road Pump Station. Via Strood Centre;

The surface drainage network is managed by Southern Water Plc and it is understood that the existing system is gravity fed with the assumption that, due to the tidal nature of the downstream environment, all outfalls are likely to have flapped gated outfalls. The existing surface water drainage system should be designed to a 1 in 30 year level.

L.2.3 Flood Defences

Owing to the largely rural nature of the waterfront along Strood Waterfront there is little in the way of official defence. However this is also the case where industry backs directly on to the river. Temple Marsh consists of fairly high ground and in places is above a 1 in 200 year level. Land was also been raised in the southern region between 1993 and 1995 to allow development. This is possibly to a 1 in 100 year level.

L.2.4 Historic Flooding

Information obtained from recorded water levels at the M2 Bridge indicate that flooding events occurred in 1927 (3.98m AoD), 1949 (4.50m AoD), 1953 (4.78m AoD), 1960 (3.85m AoD), 1965 (4.59m AoD) and 1978 (4.55m AoD).

L.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak levels of these tidal cycles for Strood Waterfront are shown in Table L.1.

Table L.1: Expected Maximum Tidal Levels at Strood Waterfront

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.7 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	5.9 m AoD

L.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the Strood Waterfront site being tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two.

L.4.1 Surface Water Flooding

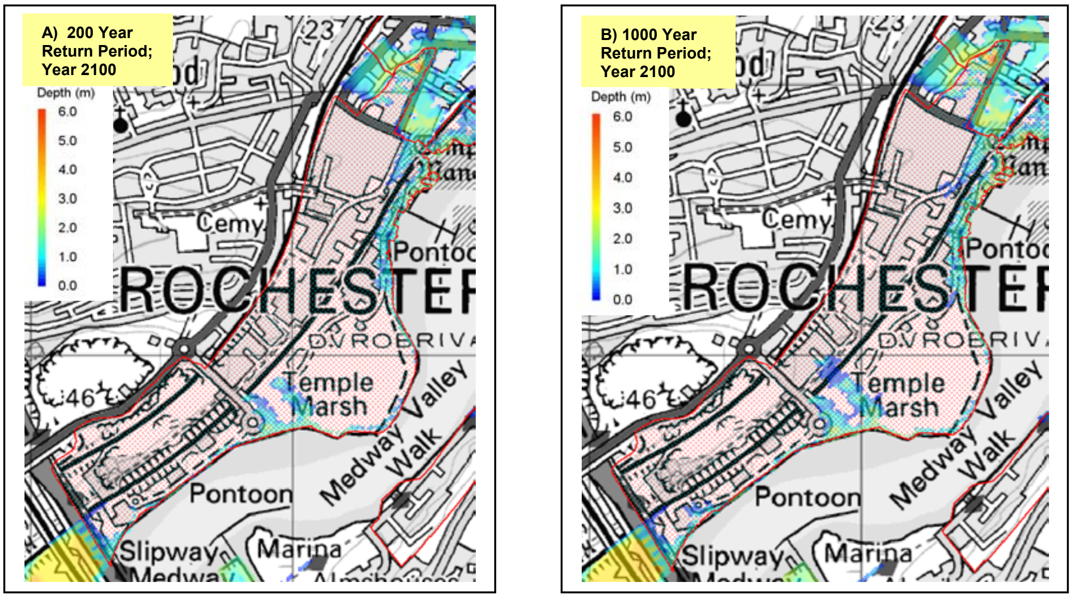
The main source of surface water flooding is as a result of backing up within the surface water drainage system as a result of insufficient storage capacity during the high tide, i.e. when the outlet flat valves are closed. However a significant area is not covered by surface water drainage and thus surface runoff would be the most likely source of surface water runoff. Anything considered above a 1 in 30 year event would probably result in event dependent flooding.

L.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

Initial overtopping occurs north of Strood Yacht Club and near Temple Marsh just east of Chariot Way. Subsequently, slight flooding occurs inland north of Strood Yacht Club and to the south of Temple Marsh. Approximately an hour after initial overtopping, flooding north of Strood Yacht Club flows south along the river bank and the flood depth in the low areas of Temple Marsh increases, reaching a maximum after three hours. Flooding begins to recede some 3.5 hours after initial overtopping and flood waters remain trapped in some isolated low lying areas.

Figure L.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure L.2: Extent of Flooding Strood Waterfront (200_2100 & 1000_2100 events)



The key flooding characteristics for Strood Waterfront are summarised in Table L.2.

Table L.2: Summary of Strood Waterfront Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.7	2.1	1.0	4	1.7	0.09	0.2
1000	2100	5.9	2.3	2.4	5	2.6	0.14	0.4

Note:

Typical existing flood defence levels = 3.6 to 6.3 m AoD

Length of river frontage = 2.6 km

L.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- Part of the river bank and flood defences would be overtopped during a 200 year and a 1000 year tide under 2100 climate conditions;
- The areas at risk are mainly adjacent to the water frontage and primarily limited to a 200 m wide strip parallel to the river frontage, with the exception of the southeast part of the site. Some of the flooding in this part is caused by the spreading of the flood water from the Strood Centre area;

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. These defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table L.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Note that if an embankment defence is considered then a freeboard of 0.6 m is required and the minimum defence crest level should be 5.9m.

L.6 Photographs of the development site and area

Plate L.1: Strood Waterfront Waterfront

Appendix M The Esplanade

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

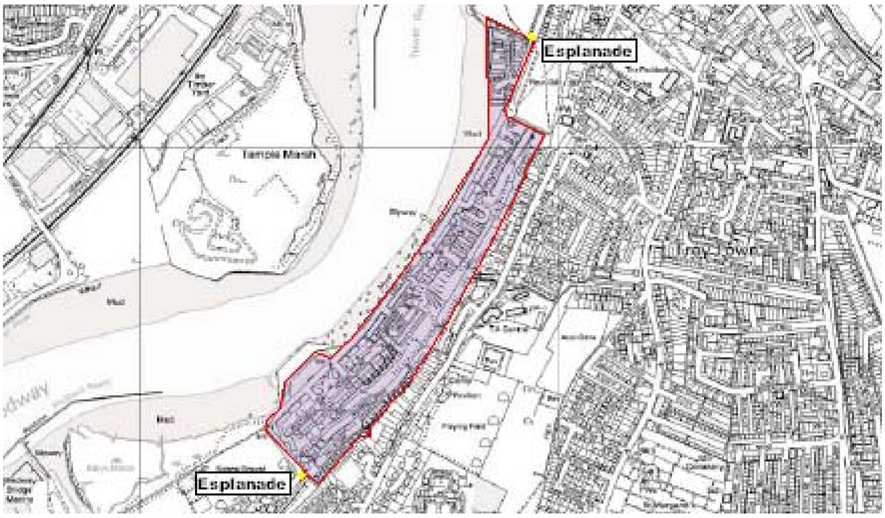
List of Plates

M.1 Introduction

M.1.1 Study Area

The Esplanade site is located on the River Medway straddles both Tower and Wickham Reach. The actual site is approximately 17 hectares with a river frontage around 0.8 km in length (See Figure M.1: Esplanade Site Location Plan). Located in the southern area of the Medway Development Strategy, the site lies on the southern bank of the River. Access to the site is by one route only, the Esplanade.

Figure M.1: Esplanade Site Location Plan



Rochester Riverside, Development Brief, Medway Council, 2004

M.1.2 The Development

The development site, which is owned by Medway Council, will include:

- Improvements to the school.

M.2 Existing Conditions

M.2.1 Proposed Development Site

M.i Present and Previous Land Use

The esplanade is almost whole residential with a number of new developments along the riverfront with a number of open public spaces.

M.ii Topography

The Esplanade is predominantly high ground with the shoreline level rising from north to south. The only significant area of low lying ground is along the northern waterfront where certain new residential properties have recently been constructed.

M.iii Geology

The underlying geology of Esplanade is initially Head underlain by chalk and Gault. Derived from pre-existing formations under near-glacial conditions Head is made of constituents which vary according to the location and the nature of the original strata.

Below this lies three layers of Chalk, Upper, Middle and Lower. The Upper chalk is mainly soft, white limestone but nodular beds. At around 30 m thick, flint is present as layers or nodules. The Middle Chalk is also mainly soft but flint is rare in the lower half. This occurs for a thickness of 60 m – 75 m Lower Chalk is capped by a thin bed of dark grey-green marl and consists primarily of blocky, light to dark grey chalk. It generally occurs with a thickness of between 55 m – 80 m. The Gault is a thin layer of dark, blue-grey clay at the foot of the chalk escarpment.

M.2.2 Existing drainage

The Esplanade drainage system comprises of:

- Surface water drainage with three outlets into the Medway purely for the most northerly development within the area;.
- Foul water drainage for the northern development which drains out north of region;
- Surface water drainage from more southerly developments with two outlets into the Medway;

There are no details concerning the southern half of the area.

The surface drainage network is managed by Southern Water Plc and it is understood that the existing system is gravity fed with the assumption that, due to the tidal nature of the downstream environment, all outfalls are likely to have flapped gated outfalls. The existing surface water drainage system should be designed to a 1 in 30 year level.

M.2.3 Flood Defences

The frontage along Esplanade has little in the way of official flood defence. In the southern half the shoreline rises in three distinct 'steps' which would certain help attenuate the risk of flooding. The respective heights along the waterfront are around 4.5m AoD, 5.5m AoD, 6.3m AoD and 8.2m AoD going in a north-south direction. Along the most northerly section a low toe board offers some limited protection as would the garden walls constructed for the riverside properties. However it must be stressed that this is a cosmetic wall rather than one designed with flood defence in mind.

M.2.4 Historic Flooding

The nearest point where measurements have been taken is at the A2 Rochester Bridge. Information obtained from recorded water levels indicate that flooding events occurred in 1927 (3.92m AoD), 1949 (4.54m AoD), 1960 (3.80m AoD), 1965 (4.60m AoD) and 1978 (4.51m AoD).

M.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak levels of these tidal cycles for The Esplanade are shown in Table M.1.

Table M.1: Expected Maximum Tidal Levels at The Esplanade

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.7 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	5.9 m AoD

M.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the Rochester Riverside site being tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two.

M.4.1 Surface Water Flooding

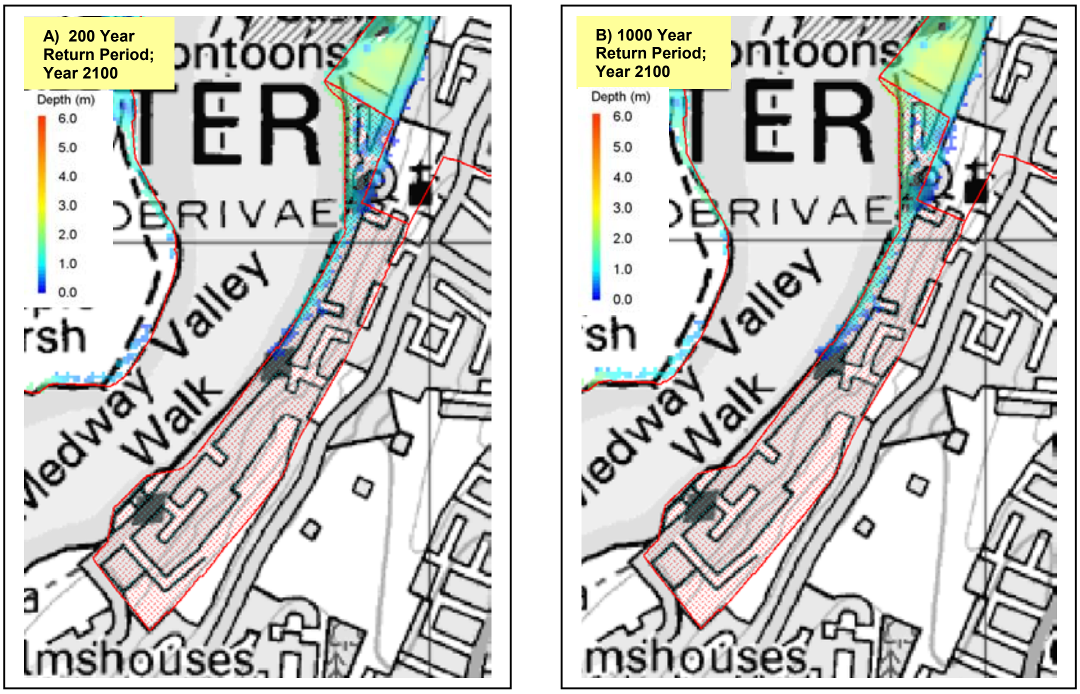
The main source of surface water flooding is as a result of backing up within the surface water drainage system as a result of insufficient storage capacity during the high tide, i.e. when the outlet flat valves are closed. However a significant area is not covered by surface water drainage and thus surface runoff would be the most likely source of surface water runoff. Anything considered above a 1 in 30 year event would probably result in event dependent flooding.

M.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

Very minor initial overtopping occurs to the north of the Esplanade area, west of Hathaway Court. Further south, along Centenary Walk, flooding is restricted to the very edge of the bank and does not inundate further inland. Flooding begins to recede 3.5 hours after initial overtopping

Figure M.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure M.2: Extent of Flooding Esplanade (200_2100 & 1000_2100 events)



The key flooding characteristics for the Esplanade are summarised in Table M.2.

Table M.2: Summary of Esplanade Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.7	2.1	0.63	4	2	0.03	0.15
1000	2100	5.95	2.35	0.63	5	2.3	0.03	0.15

Note:

Typical existing flood defence levels = 3.6 to 8.4 m AoD

Length of river frontage = 1.2 km

M.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- About 50% of the river bank and flood defences would be overtopped during a 200 year and a 1000 year tide under 2100 climate conditions;
- The areas at risk are mainly adjacent to the water frontage and limited to a relatively narrow strip (30 - 200 m wide);

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. These defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table M.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.3m
Minimum defence crest height:	5.6 m

Note that if an embankment defence is considered then a freeboard of 0.6 m is required and the minimum defence crest level should be 5.9m.

M.6 Photographs of the development site and area

Plate M.1: Middle Northern Section of Esplanade

Plate M.2: Upper Northern Section of Esplanade

Plate M.3: View of Far Northern Shoreline

Appendix N Gillingham Waterfront

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

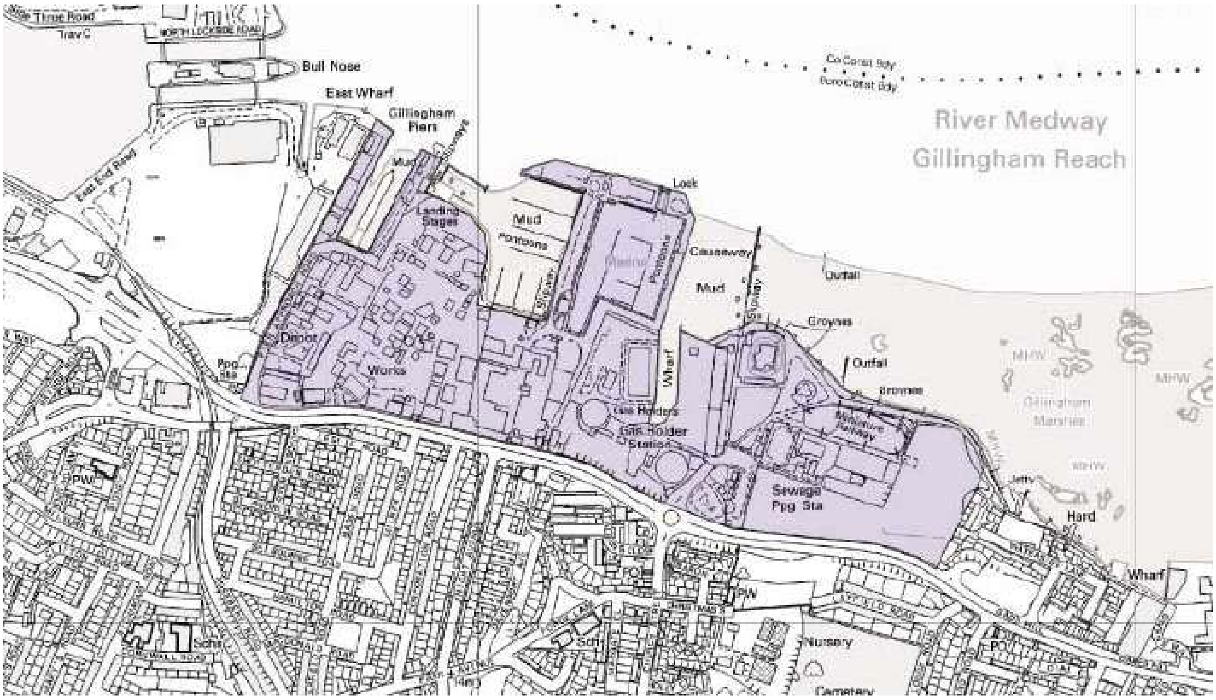
N.1 Introduction

N.1.1 Study Area

Gillingham Waterfront is located on the Gillingham Reach of the River Medway. The site stretches from of Chatham Port in the east to Danes Hill in the West. The total site area is 32 Hectares comprising public and private water based leisure activities, some housing and commercial facilities and vacant industrial sites. The site has a total river frontage of approximately 3.2 km in length. To the south the site is bordered by the Gillingham North Relief Road which divides the Waterfront area from the densely populated residential area known as North Gillingham.

The Waterfront area is represented by four distinct areas, namely Gillingham Waterfront Site, Gillingham Mariana, the Gas Holder Station and the Strand Leisure Park. The majority of the site is low lying with the ground rising to the south of the site. The foreshore consists primarily of mudflats with several groynes providing protection from coastal erosion. Access to the Marina is controlled by a lock.

Figure N.1: Gillingham Waterfront Site Location Plan



Development Brief, Medway Council, 2004

N.1.2 The Development

The development site, which is owned in part by Medway Council will provide mixed use developments, including marine activities and improved public access to the river, in particular for the existing and proposed residential developments which surround this area. The proposed development is as follows:

- Housing

- Light industrial and warehousing
- Marine activities (business and leisure)
- Community facilities
- Commercial
- Riverside walks / open access

N.2 Existing Conditions

N.2.1 Proposed Development Site

N.i Present and Previous Land Use

The current site incorporates derelict former industrial sites with a small amount of housing to west; a private marina and two gas holders to the middle of the site; and to the east of the site there are several leisure facilities, including open space, a swimming pool and a miniature railway.

N.ii Topography

The Gillingham Waterfront Flood Extents Map shows contour lines for the site as well as the expected extents of flooding to the area.

The site is fairly flat with levels generally between 4 and 6m AoD. Small areas of high ground are evident, but in general the levels only rise towards the south of the site towards the road embankment. The current sea defences are almost entirely less than 5m AoD.

N.iii Geology

The underlying geology of Gillingham Waterfront has a mixture of initial layers; Alluvium and River Gravels, and Thanet Bed sands. Of the initial layers, the Thanet Beds are approximately 30m thick. The River Gravels and Alluvium are generally made up of flints and slits and are found in the floodplains of the Medway; this layer may be in the region of 11m in depth.

Below the initial layers lies the Upper, Middle and Lower layers of Chalk. The Upper chalk is mainly soft, white limestone but nodular beds. At around 90m thick, flint is present as layers or nodules. The Middle Chalk is also mainly soft but flint is rare in the lower half. This occurs for a thickness of 60m - 75m Lower Chalk is capped by a thin bed of dark grey-green marl and consists primarily of blocky, light to dark grey chalk. It generally occurs with a thickness of between 58m – 77m. The underlying Gault is a thin layer of dark, blue-grey clay.

N.2.2 Existing drainage

Over years the site has been developed in the normal adhoc manner with the system of natural creeks being infilled or culverted and a system of pipes being used to carry surface water out to the River Medway. The public sewer network is managed by Southern Water Plc. and comprises separate foul and surface water sewers and combined surface and foul sewers. The foul and combined sewers are pumped from three positions into the foul sewer rising mains on Pier Road. Surface water discharges into the River Medway via a four know outfalls of 600mm, 800mm and two at 900mm diameter, these outfalls are understood to drain the site itself and extensive paved areas to the south of the site at Gillingham. The outfalls are presumed to be fitted with flap valves.

N.2.3 Flood Defences

It is understood that the existing frontage along the River Medway has been constructed over time to provide docks for the various industries that have grown up in the vicinity. The River Medway frontage is approximately 3.2 km long as indicated above and consists of a number of different structures; due to restricted access these are presumed to include:

- r reinforced concrete walls;
- concrete walls infilled with pre-cast panels;
- earth retaining timber crib walls;
- and concrete capped steel sheet piles.

The reinforced concrete walls can be seen in the photograph in section N.6

The Environment Agency confirms that this private frontage is believed to provide protection from flood events ranging from a 1 in 20 year to a 1 in 100 year annual return period. From the LiDAR survey data it appears the flood defences have a crest ranging from 3.1m – 5.5m AoD.

In principal the control of flooding along the River Medway is the responsibility of the Environment Agency however the Medway Ports Authority was assigned statutory responsibility for this section of the river as part of the Medway Ports Authority Act 1973. The riparian owner of the Historic Dockyard holds the responsibility for the maintenance of the frontage to the River.

N.2.4 Historic Flooding

Information obtained from recorded water levels at Gillingham Pier indicate that flood events occurred in 1927 (3.73m AoD), 1949 (4.45m AoD), 1953 (4.79m AoD), 1960 (3.66m AoD), 1965 (4.48m AoD) and 1978 (4.43m AoD). The mean high water level at this location is 3.16m AoD.

N.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak levels of these tidal cycles for Gillingham Waterfront are shown in Table N.1 below.

Table N.1: Expected Maximum Tidal Levels at Gillingham Waterfront

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.7 m AoD
200 (0.5%)	2100	5.6 m AoD
1000 (0.1%)	2100	5.9 m AoD

N.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the Gillingham Waterfront site being tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two, although due to the design of the outfalls it is important to consider the risk of surface water flooding.

N.4.1 Surface Water Flooding

Where the outfall from a surface water gravity sewer is closed due to tide locked conditions, it is possible that the sewer may become surcharged and cause localised flooding. Sewer systems may be designed to overcome this by either pumping surface water into the River Medway or by providing storage within the sewer system with which surface water can be attenuated until tide-locked conditions subside. Some surface water flooding would occur during extreme flood events above a 1 in 30 year return period since the public sewer network would not normally be designed to convey flows of this magnitude.

The existing surface water drainage system will not have sufficient capacity to cater for the scale of the proposed developments. Applications for any new connections must be made to Southern Water in the usual manner so that they can arrange for new works where required.

All surface water sewers are understood to flow by gravity and their outfalls will presumably be closed during tide-locked conditions to prevent tidal water backing up inside the surface water sewers. The spare capacity in these sewers is not known, but it is likely that some localised surface water flooding may occur during a rainfall event if the outfalls closed for extended periods, whereupon the surface water sewer will become surcharged.

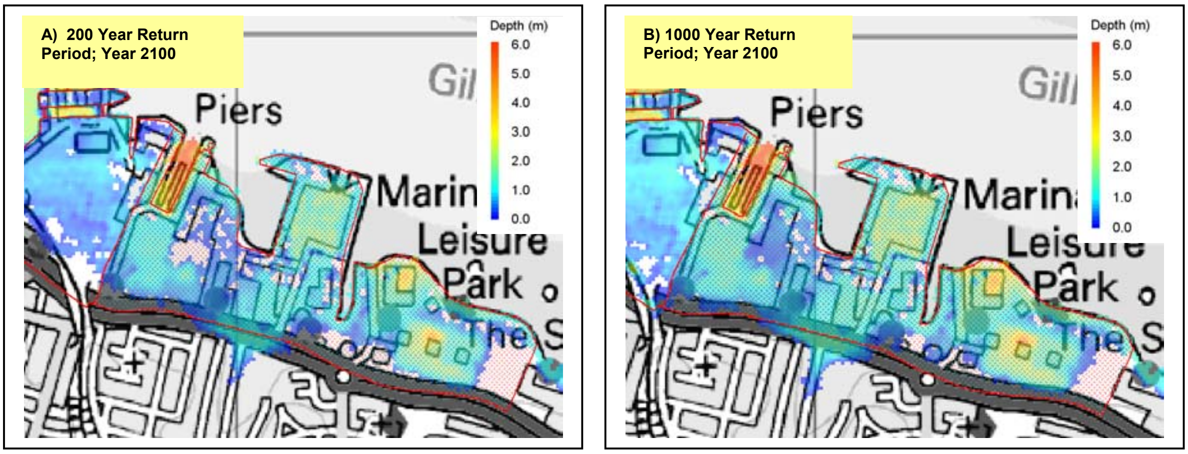
While it is understood that there are separate foul and surface water sewers on this site, there is a possibility that surface water drains may connect into the foul sewer. If surface water connections are widespread there may be a risk of foul water sewer flooding due to insufficient capacity.

N.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

A small amount of initial overtopping occurs around the piers and Leisure Park. Half an hour later flood waters begin to move inland and within an hour the majority of the area south of the pier, Marina and Leisure Park is flooded. Flood waters recede some 2.5 hours after initial overtopping and some flood waters remain trapped in a few isolated areas.

Figure N.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure N.2: Extent of Flooding Gillingham Waterfront (200_2100 & 1000_2100 events)



The key flooding characteristics for Gillingham Waterfront are summarised in Table N.2.

Table N.2: Summary of Gillingham Waterfront Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.6	5.6	2.4	4	1.8	0.27	0.4
1000	2100	5.9	5.9	2.4	5	2	0.32	0.4

Note:

Typical existing flood defence levels = 0 to 5 m AoD

Length of river frontage = 2.5 km

N.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- The entire river bank and flood defences would be overtopped during a 200 year and a 1000 year tide under 2100 climate conditions;
- Extensive flooding of the entire site would be expected;
- The flood water could spread further inland, even beyond the Gillingham Waterfront area to the north of the Gillingham North Relief Road;
- The maximum flood depth would be approximately 2 m.

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. These defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table N.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.85
Minimum defence crest height:	6.15 m

Note that if an embankment defence is considered then a freeboard of 1.15 m is required and the minimum defence crest level should be 6.45m.

N.6 Photographs of the development site and area

Plate N.1: Leisure Area with Marina and Gas Holder behind

Plate N.2: Waterfront at East of Site

Appendix O Chatham Port

List of Contents

Page

Chapters and Appendices

List of Figures

List of Tables

List of Plates

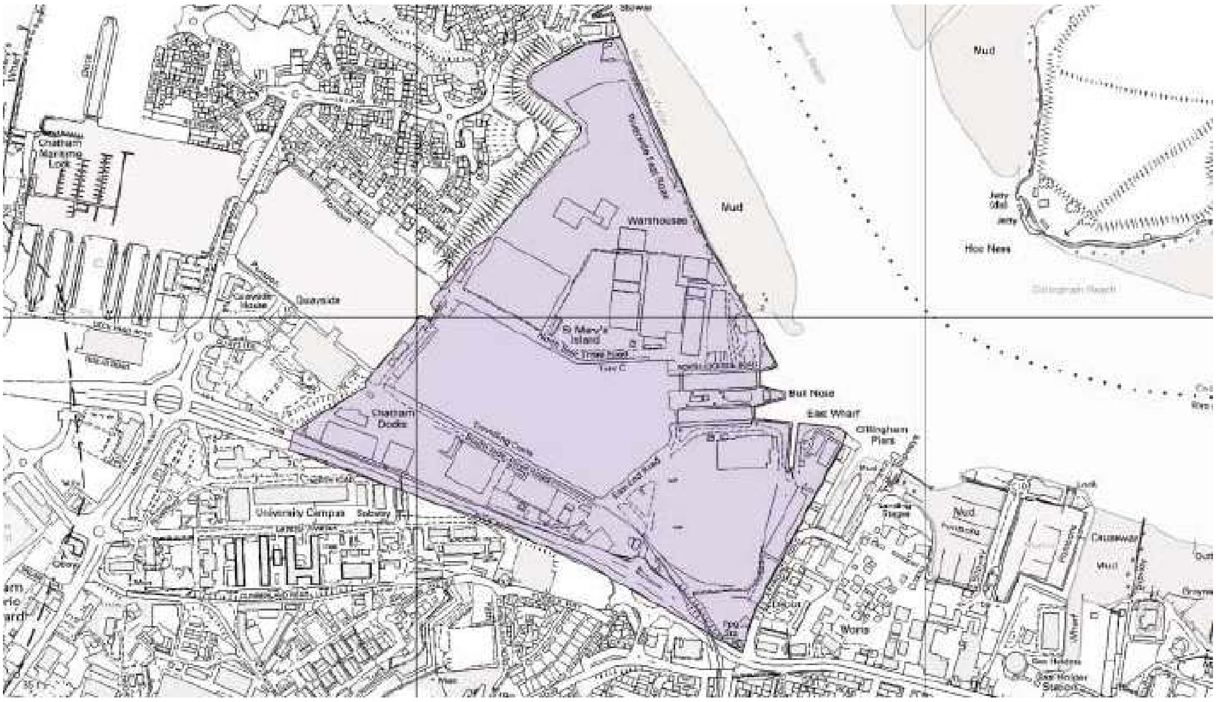
O.1 Introduction

O.1.1 Study Area

Chatham Port is located on the Short Reach of the River Medway. The site links St Mary's Island in the west and Gillingham Waterfront in the east. The total site area is 57 Hectares comprising a commercial port. The site has a total river frontage of approximately 1.2 km in length. To the south the site is bordered by the Gillingham North Relief Road which divides the Waterfront area from the densely populated residential area known as North Gillingham and the University campus.

The majority of the site is low lying with the ground rising to the south of the site. The foreshore consists primarily of mudflats with several groynes providing protection from coastal erosion. Access to the Marina is controlled by a lock.

Figure O.1: Chatham Port Site Location Plan



Development Brief, Medway Council, 2004

O.1.2 The Development

The development site is owned by the Mersey Docks and Harbour Company covers part of the former Chatham Naval Dockyard. The proposed development will be water related commercial and industrial, in particular expanding the cargo handling and marine industries.

O.2 Existing Conditions

O.2.1 Proposed Development Site

O.i Present and Previous Land Use

Formally part of the Chatham Naval Dockyard, Chatham Port is currently owned by the Mersey Docks and Harbour Company and is operated as an active commercial port handling timber and paper related products and offering ship-repairing facilities.

O.ii Topography

The Chatham Port Flood Extents Map shows contour lines for the site as well as the expected extents of flooding to the area.

The site is very flat with levels generally between 4m and 5 m AoD. There is a small area of high ground to the north of the site where levels rise to 8m AoD. The current sea defences are generally between 5.0m-5.6 m AoD.

O.iii Geology

The underlying geology of Chatham Port is Alluvium, which is generally made up of flints and slits and are found in the floodplains of the Medway; this layer may be in the region of 11m in depth. The Alluvium is underlain by the Thanet Beds which are approximately 30m thick

Below the initial layers lies the Upper, Middle and Lower layers of Chalk. The Upper chalk is mainly soft, white limestone but nodular beds. At around 90m thick, flint is present as layers or nodules. The Middle Chalk is also mainly soft but flint is rare in the lower half. This occurs for a thickness of 60m - 75m Lower Chalk is capped by a thin bed of dark grey-green marl and consists primarily of blocky, light to dark grey chalk. It generally occurs with a thickness of between 58m – 77m. The underlying Gault is a thin layer of dark, blue-grey clay.

O.2.2 Existing Drainage

The site has long served as a maritime port and it is presumed that all surface water from the site outfalls into the River Medway. The Southern Water Sewer Records indicate that the site les outside of their current management responsibility and consequently no information on the sewers for the site has been obtained. The Maritime site is privately maintained, however the flood attenuation pond at St Mary’s island is understood to discharge into the River Medway via the pond within this site.

It is probable that the pond within this port will provide surface water attenuation during tide locked conditions, although without additional knowledge of structures at the ports mouth and the position of surface water outfalls it is not possible to confirm this.

O.2.3 Flood Defences

It is understood that the existing frontage along the River Medway has been constructed over time to provide docks for the various industries that have been there over time. The River Medway frontage is approximately 1.2 km long as indicated above and consists of a number of different structures; due to restricted access these are presumed to include:

- reinforced concrete walls;
- concrete capped steel sheet piles.

The reinforced concrete walls can be seen in the photograph in section O.6

The Environment Agency has no knowledge of the defences at this location. From the LiDAR data it appears that there is a 500m span of defences at 5.6 m AoD; the remainder of the defences are as low as 4.4m AoD and are considered to be no greater than ground levels. It is therefore expected that the flood defences to this site will only be as good as the lower level defence on this site or the neighbouring Gillingham Waterfront site which is 4.0 m AoD. The higher level defences will provide some protection from overtopping to the northern part of the site, but will not protect the site from inundation which may occur due to flood levels exceeding the level of the defences to the south of the site.

In principal the control of flooding along the River Medway is the responsibility of the Environment Agency however the Medway Ports Authority was assigned statutory responsibility for this section of the river as part of the Medway Ports Authority Act 1973. The Mersey Docks and Harbour Company, as the riparian owner of the Port hold the responsibility for the maintenance of the frontage to the River.

O.2.4 Historic Flooding

Information obtained from recorded water levels at Gillingham Pier indicate that flood events occurred in 1927 (3.73m AoD), 1949 (4.45m AoD), 1953 (4.79m AoD), 1960 (3.66m AoD), 1965 (4.48m AoD) and 1978 (4.43m AoD). The mean high water level at this location is 3.16m AoD.

O.3 Tidal Flows and Levels

Tide profiles have been developed for the River Medway using 2-dimensional mathematical hydraulic modelling. The peak levels of these tidal cycles for Chatham Port are shown in Table O.1 below.

Table O.1: Expected Maximum Tidal Levels at Chatham Port

Return period event (years)	Year of occurrence	Expected tidal level at river centreline
200 (0.5%)	2060	5.3 m AoD
1000 (0.1%)	2060	5.6 m AoD
200 (0.5%)	2100	5.7 m AoD
1000 (0.1%)	2100	6.0 m AoD

The modelling indicates that for the 1000-2100 scenario, peak tidal levels at this site are increased by up to 0.1m if proposed land raising to 5.8 m AoD at Strood Riverside, Temple Marsh and Rochester Riverside go ahead. This increase is accounted for in Table O.1 above.

O.4 Flood Risk under Existing Conditions

There are two main sources of flooding applicable to any development proposed for the Chatham Port site being tidal and surface water. It is anticipated that tidal flooding will be the more critical of the two.

O.4.1 Surface Water Flooding

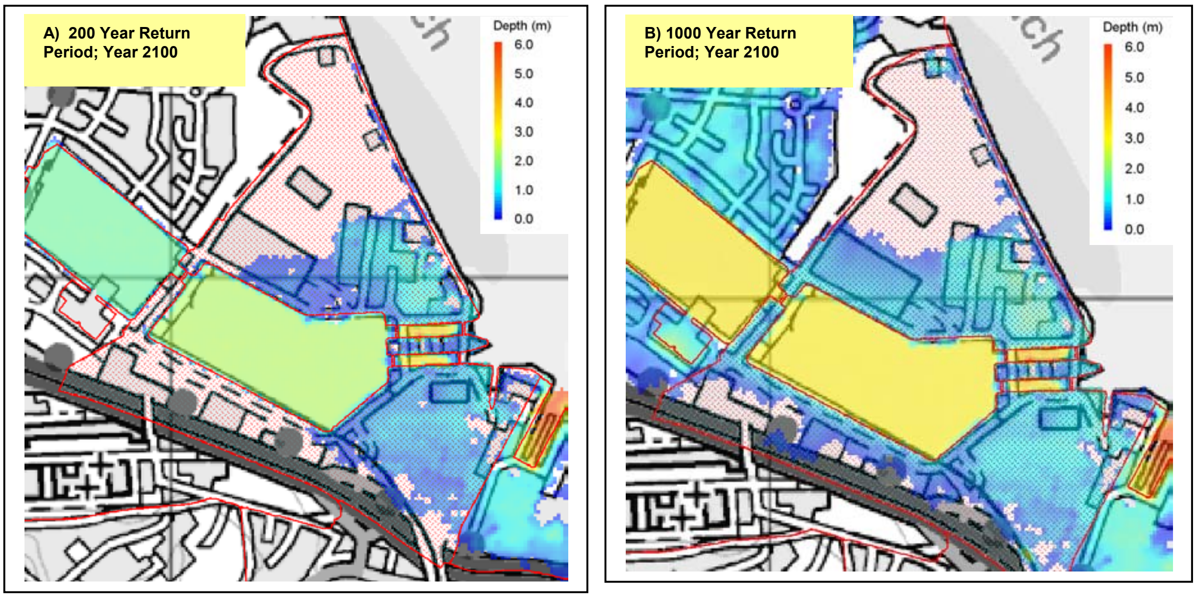
Where the outfall from a surface water gravity sewer is closed due to tide locked conditions, it is possible that the sewer may become surcharged and cause localised flooding. Sewer systems may be designed to overcome this by either pumping surface water into the River Medway or by providing storage within the sewer system with which surface water can be attenuated until tide-locked conditions subside. Since the sewers on this site are currently managed privately it is not possible to assess the full impact of surface water flooding. It is expected that some surface water flooding would occur during extreme rainfall events since the sewer network would not normally be designed to convey flood flows. Since there is very limited information regarding surface water drainage it is not possible to assess the capacity of the existing sewers to convey additional flows from the new development.

O.4.2 Location and Extent of Tidal Flooding for 2100 Climate Case

Initially there is slight overtopping either side of the locks to the eastern basin. Within half an hour extensive flooding occurs either side of the locks and flood water begins to flow into the basin. Extensive flooding of the basin occurs within 1.5 hours after initial overtopping reaching a maximum extent after 2.5 hours. Flooding recedes some 3 hours after overtopping and some flood waters remain trapped across the area.

Figure O.2 shows the model predicted flooding extents for a 200 year and a 1000 year tide under 2100 climate conditions respectively.

Figure O.2: Extent of Flooding Chatham Port (200_2100 & 1000_2100 events)



The key flooding characteristics for Chatham Port are summarised in Table O.2.

Table O.2: Summary of Chatham Port Flooding Characteristics

Return period (yr)	Climate condition	Max flood level (m AoD)	Max WL above defences (m)	Length of overtopping (km)	Duration of overtopping (hrs)	Max flood depth (m)	Area of flooding (km^2)	Flooding distance from river bank (km)
200	2100	5.6	1.3	0.75	3	1.3	0.21	0.5
1000	2100	6.0	1.6	0.75	3.5	1.6	0.4	0.7

Note:

Typical existing flood defence levels = 4.3 to 5.5 m AoD

Length of river frontage = 1.3 km

O.5 Guidelines for Development

The following key observations can be made from the analysis of the model results:

- The entire river bank and flood defences would be overtopped during a 200 year and a 1000 year tide under 2100 climate conditions;
- Extensive flooding would be expected for majority of this site;
- This site also acts as a pathway of the flood water spreading into its adjacent site to the west, i.e. Chatham Maritime and St Mary's Island;
- The maximum flood depth would be around 1.6m.

From the above it can be concluded that further development within the areas identified as liable to flooding will require enhanced river defences. These defences should have a minimum crest level as follows:

Flood level for 200 year 2060 situation (refer to Table O.1 above)	5.3m
Freeboard for concrete defences (refer to Table 4.5 above)	0.85
Minimum defence crest height:	6.15 m

Note that if an embankment defence is considered then a freeboard of 1.15 m is required and the minimum defence crest level should be 6.45m.

O.6 Photographs of the development site and area

Plate O.1: Flood Defences at the west of Chatham Port

Appendix P Chattenden

List of Contents

Page

Chapters and Appendices

List of Figures

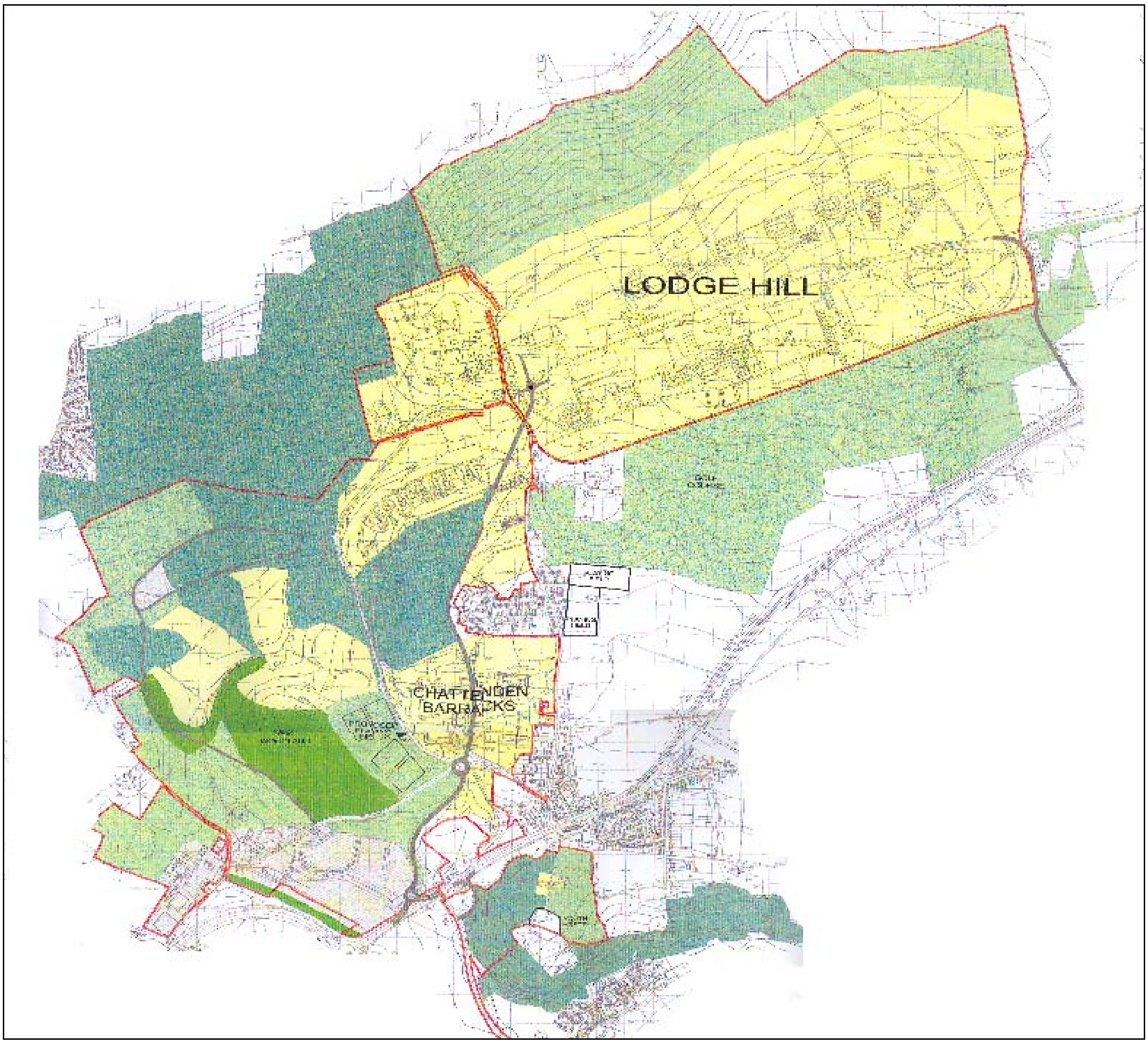
List of Plates

P.1 Introduction

P.1.1 Study Area

The Chattenden site is located to the north of Lower Upnor. The actual site is approximately 23.5 hectares but with no frontage along the Medway (See Figure P.1: Chattenden Site Location Plan). Located in the northern extreme of the Medway Development Strategy the site is currently Ministry of Defence property.

Figure P.1: Chattenden Site Location Plan



P.1.2 The Development

The development site will include:

- Property development – 5,000 new homes;

- Environmental development with new forest.

P.2 Existing Conditions

P.2.1 Proposed Development Site

P.i Present Land Use

Chattenden is currently a Ministry of Defence (MOD) site which is largely residential with other MOD infrastructure included. The Royal School of Military Engineering currently was a training area located at Lodge Hill.

P.ii Topography

The topographic characteristics of the area are of land at significant height above sea leave with the highest point at around 70 m AoD and the lowest at around 30 m AoD.. To the north, at Lodge Hill, a small valley is situated which drains into an east-west running water course. At the eastern extreme of the site, this watercourse joins a southerly running stream which eventually discharges into the River Medway.

P.iii Geology

The underlying geology of Chattenden is initially London Clays underlain by Thanet Beds succeeded by chalk and Gault.

Although up to 150m thick in some areas it is likely that the London Clays are significantly thinner in Chattenden. The Thanet Beds are of some 23 m thick in the area and consist mainly of sands. Below the initial layers lies the Upper, Middle and Lower layers of Chalk. The Upper chalk is mainly soft, white limestone but nodular beds. At around 90m thick, flint is present as layers or nodules. The Middle Chalk is also mainly soft but flint is rare in the lower half. This occurs for a thickness of 60m - 75m Lower Chalk is capped by a thin bed of dark grey-green marl and consists primarily of blocky, light to dark grey chalk. It generally occurs with a thickness of between 58m – 77m. The underlying Gault is a thin layer of dark, blue-grey clay.

P.2.2 Existing drainage

A large part of the area does not have a formally adopted drainage system and as such no records are freely available. Any proposed development must take steps in order to ascertain the extent of surface and foul water drainage at the proposed site.

A small degree of information was available for some housing near Round Top Wood where there exists a separated system with surface water draining to the east and foul water draining to the south west toward Strood and Rochester.

P.2.3 Flood Defences

With no frontage along the Medway there is and is no need of any tidal flood defence for Chattenden. Historic Flooding

There are no records of historic flooding.

P.3 Tidal Flows and Levels

Not situated on the Medway there are no tidal flows or levels

P.4 Flood Risk under Existing Conditions

Situated away from the Medway there is only the risk from surface water flooding.

P.4.1 Surface Water Flooding

Surface water flooding would occur as a result of insufficient capacity to drain runoff from the development site. This could be either:

- Insufficient capacity of the surface water drainage system
- Insufficient capacity of the natural drainage paths

As the site includes an un-adopted surface water drainage system, any proposed development would have to consider the capacity of the current drainage system carefully to ensure that it could meet any post-development requirements.

In terms of the capacity of the natural drainage paths, the principal carrier of water off site would appear to be the west-east running watercourse at Lodge Hill. Although this watercourse largely runs through a rural area, there will be a requirement to ensure that the railway line and station, situated immediately east of the Chattenden site, is not impacted by any increased site runoff.

If post-development site runoff is to be limited to the existing "greenfield" runoff then an attenuation pond is likely to be required. There are no obvious constraints on the size or location of such a pond and it would appear that it could be readily included in any development proposal for the area.

P.4.2 Tidal flooding

Situated away from the Medway there is no risk from tidal flooding.

P.5 Photographs of the development site and area

Plate P.1: Chattenden Barracks Site