APPENDIX 1

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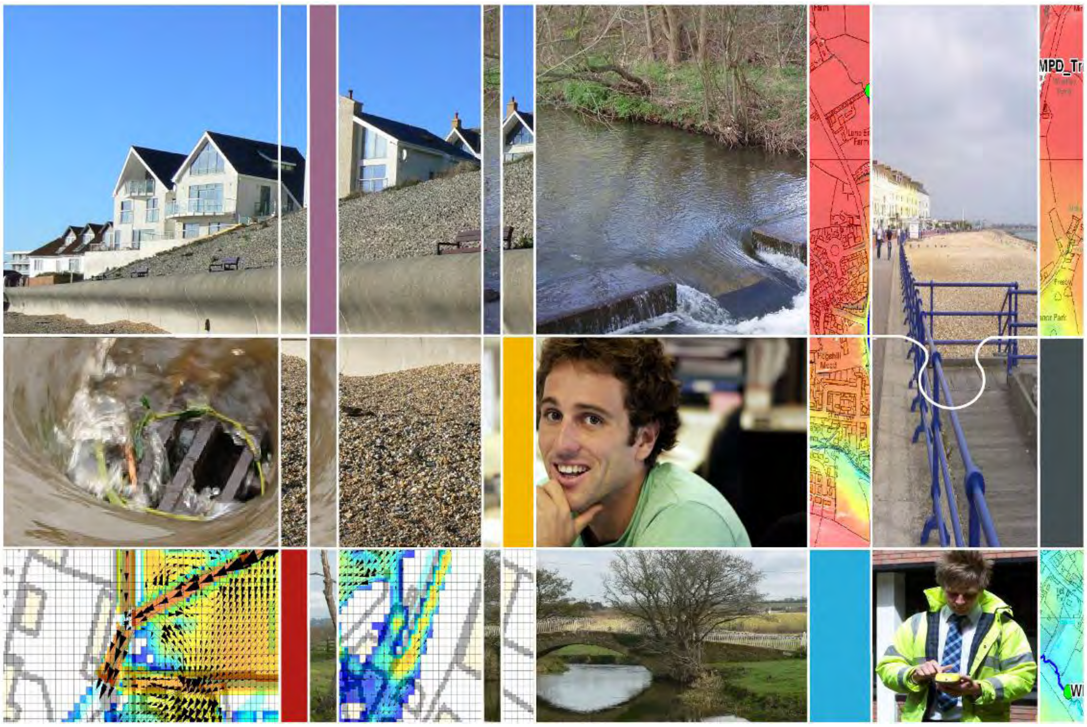

Medway Council Local Flood Risk Management Strategy

Final report

July 2014

CAPITA SYMONDS | URS
Flood Risk Management

Document overview

Capita Symonds with URS Infrastructure and Environment UK Ltd was commissioned by Medway Council in the preparation of their Local Flood Risk Management Strategy as required under the Flood and Water Management Act 2010.

Commission reference: LA020

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Forward

Medway Council was recently made Lead Local Flood Authority with a responsibility to oversee local flood risk. Local flood risk is associated with flooding caused by surface runoff, groundwater and small ditches and streams.

Flooding has a devastating impact on people and communities. Surface water flooding in particular was one of the major causes of widespread flooding experienced across England in 2007 and the events resulted in one of the widest ranging policy reviews of flood risk management.

We know that some of our areas are at risk to local flooding and do suffer from flooding from time to time. The likelihood of similar events to those witnessed across England in 2007 happening is set to increase because of more extreme weather. This also means that some areas are at risk of flooding which may have never flooded previously are now considered to be at risk.

The Governments response to the review resulted in legislation that required all County and Unitary Authorities to take on a role as a ‘Lead Local Flood Authority’. Part of that role is to produce a strategy to ensure local flood risk is managed in a more coordinated way, enabling organisations to work better with each other and the public.

Assessing the risk from flooding can be a difficult task. The main focus of this strategy, to set a framework around what needs to be done to manage the flood risk in Medway and reduce the consequences of flooding, where we can, in areas which do suffer flooding and where there is a known risk of flooding.

We’re keen to hear your views and would gratefully receive any further information you may have on flood risk in your area.

Councillor Phil Filmer
Portfolio Holder, Front Line Services.

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Executive Summary

Medway Council as a Lead Local Flood Authority is responsible for local flood risk management (defined as flood risk associated with surface water, ground water and ditches/streams). This Local Flood Risk Management Strategy ('the strategy') is a statutory document required by County and Unitary authorities under the Flood and Water Management Act 2010 (FWMA 2010).

The content under the following headings summarises the detail from each of the sections listed within the main report.

Section 1: Introduction

This section outlines why a strategy is required, and summarises the aim and objectives of the strategy.

Section 2: Overview of flooding in Medway

This section provides an overview of the risks associated with surface water, groundwater and watercourses within Medway. Detailed information regarding the surface water (pluvial) modelling and the high level assessment of groundwater modelling are presented in Technical Appendices 1 and 2 respectively.

Section 3: Managing flood risk in Medway

Authorities, organisations and individuals with responsibility for, and interest in, the management of local flood risk are identified in this section. It includes specific reference to the Risk Management Authorities (RMA's) defined in the FWMA 2010 and provides clarity on their roles and responsibilities.

Section 4: Local flood risk management objectives

This section summarises the development of local flood risk management objectives. The objectives, listed overleaf, have been developed to be consistent with the Environment Agency's National Flood and Coastal Erosion Risk Management Strategy.

- Work with stakeholders to develop a collective understanding of local flood risk to enable successful local flood risk management.
- Monitor flood risk.
- Ensure local policy is consistent with wider flood risk management policies and legislation. Promote the use of SuDS in accordance with the forthcoming role as SuDS Advisory Body.
- Take account of the cumulative effect of development and climate change on the risk of flooding throughout Medway.
- Ensure that all development has a positive or nil effect on the risk of flooding to and arising from proposed development.

- Use flood risk information to implement a risk based approach to capital investment decisions and maintenance programmes and activities.
- Consider how future infrastructure improvements (e.g. highways/rail/public realm works) and/or changes could be used to deliver local flood risk benefits.
- Share flood risk information in Medway with all Risk Management Authorities and the public.
- Increase public awareness with respect to flood risk and responsibility for flood risk management.
- Use information on flood risk as a tool for flood prediction and warning.

Section 5: Measures for managing flood risk

This section defines specific measures to achieve the objectives listed above. Due to the lack of good quality datasets, the strategy has focused on non-structural measures to increase understanding of local flood risks in Medway. This information will then be used to inform structural options / measures and to prioritise flood risk management in the future.

Section 6: Funding options

This section identifies available forms of funding. An overview of the following funding sources is provided including Area Based Grants, public funding from Flood Defence Grant in Aid (FDGiA), funding through Section 106 agreements, local levy, local fundraising and other sources.

Section 7: Wider environmental objectives

This section presents the assessment undertaken to consider how the strategy contributes to the achievement of wider environmental objectives in Medway. This has included a review of the environmental objectives contained within policy documents specific to the area. It also appraises the need for a Strategic Environmental Assessment (SEA) under the European Directive 2001/42/EC and associated Environmental Assessment of Plans and Programmes Regulations 2004.

Section 8: Review and update

This section considers the requirement to review and update the strategy, and summarises the democratic committees whom will be involved with that process.

1. Introduction

1.1 Why has a strategy been produced?

1.1.1 In 2008, Sir Michael Pitt published a report entitled 'Learning Lessons from the 2007 Floods'[1]. This report outlined the need for changes in the way the UK is adapting to the increased risk of flooding.

1.1.2 The Flood and Water Management Act[2] (FWMA) 2010, is an important part of the Government's response to Sir Michael Pitt's report. Through the FWMA, local authorities have a duty to take the lead in the management of local flood risk. Medway Council, as a designated Lead Local Flood Authority (LLFA), must 'develop, maintain and apply a Local Flood Risk Management Strategy which will clarify who is responsible for local flood risk management and enable effective partnerships to be formed between relevant Risk Management Authorities (RMAs).

1.1.3 It is not possible to prevent all flooding; however, over time, Medway Council will use the strategy to increase the level of understanding of local flood risk posed to the community and take the lead in effectively implementing measures to manage the risk where appropriate.

1.2 Aim

1.2.1 The aim of this strategy is to outline the approach Medway Council, as LLFA will take to manage local flood risk (which is defined as the risk of flooding from surface water runoff, groundwater and ordinary watercourses[3]). The strategy will be used to influence future capital investment, maintenance, public engagement and understanding, land-use planning, emergency planning and future developments across Medway.

1.3 Objectives

1.3.1 The objectives of the strategy are informed by Part 1, Article 2, Section 9 Sub-section 1 of the Flood Water Management Act which states that a strategy must specify:

a) The Risk Management Authorities in the authority's area.
b) The flood and coastal erosion risk management functions that may be exercised by those authorities in relation to the area.

[1] Cabinet Office (2008) Pitt Review – Learning Lessons from the 2007 Floods
[2] HMSO and the Queen's Printer of Acts of Parliament (2010) Flood and Water Management Act
[3] Strategies for the management of flood risk from main rivers and tidal flooding are managed by the Environment Agency (EA) communicated in their National Strategy, Catchment Flood Management Plans (CFMP) and Shoreline Management Plans (SMP).

c) The objectives for managing local flood risk.
d) The measures proposed to achieve those objectives.
e) How and when the measures will be implemented.
f) The costs and benefits of those measures, and how they are to be paid for.
g) The assessment of local flood risk for the purpose of the strategy.
h) How and when the strategy will be reviewed.
i) How the strategy contributes to the achievement of wider environmental objectives.

1.3.2 The FWMA must also be considered in the context of the EU Floods Directive 2007/60/EC, which was transposed into UK law by the Flood Risk Regulations 2009. The regulations required Lead Local Flood Authorities to undertake a Preliminary Flood Risk Assessment (PRFA).

1.3.3 PRFA's are the first of four stages in a six-year planning cycle to manage flood risk and provide an assessment of floods that have taken place in the past, and floods that could take place in the future. It considers flooding from surface water runoff, groundwater and ordinary watercourses and used to identify areas that are at risk of significant flooding (known as Flood Risk Areas). Medway Council completed a PFRA[4] report in 2011 which identified one of ten national Flood Risk Areas.

1.3.4 Lead Local Flood Authorities are required to produce Flood Risk Management Plans for Flood Risk Areas identified in the PFRA process. This strategy will assist in the development of a Flood Risk Management Plan.

[4] Medway Council (2011) Preliminary Flood Risk Assessment Report

2. Overview of local flood risk in Medway

2.1 Overview

2.1.2 This section provides an overview of local flood risk across Medway based upon previously completed studies and new flood risk information generated specifically to inform the strategy.

2.2 Surface water flooding

2.2.2 Detailed surface water modelling was undertaken to inform this strategy to provide a greater understanding of the risk of surface water flooding in Medway. The full methodology and outputs for the pluvial modelling are presented in Technical Appendix 1: Pluvial Modelling Methodology. Maximum flood depth mapping from the modelling is presented in Figures 3.1 to 3.3.

2.2.3 The analysis of the 0.5% Annual Exceedance Probability (AEP) event illustrated in Figure 3.3 represents a worst case scenario to enable the council to ensure preparedness should such an event occur and to better understand the extent of those risks across the administrative area.

2.2.4 The Preliminary Flood Risk Assessment undertaken in 2011 estimated that 41,000 properties (of which approximately 35,700 are residential properties) would be at risk of surface water flooding. The pluvial modelling undertaken estimated that 24,300 properties are at risk (of which 14,200 are residential), representing a significant reduction due to the model refinements. Both of these estimates are based on the 0.5 % AEP worst-case scenario.

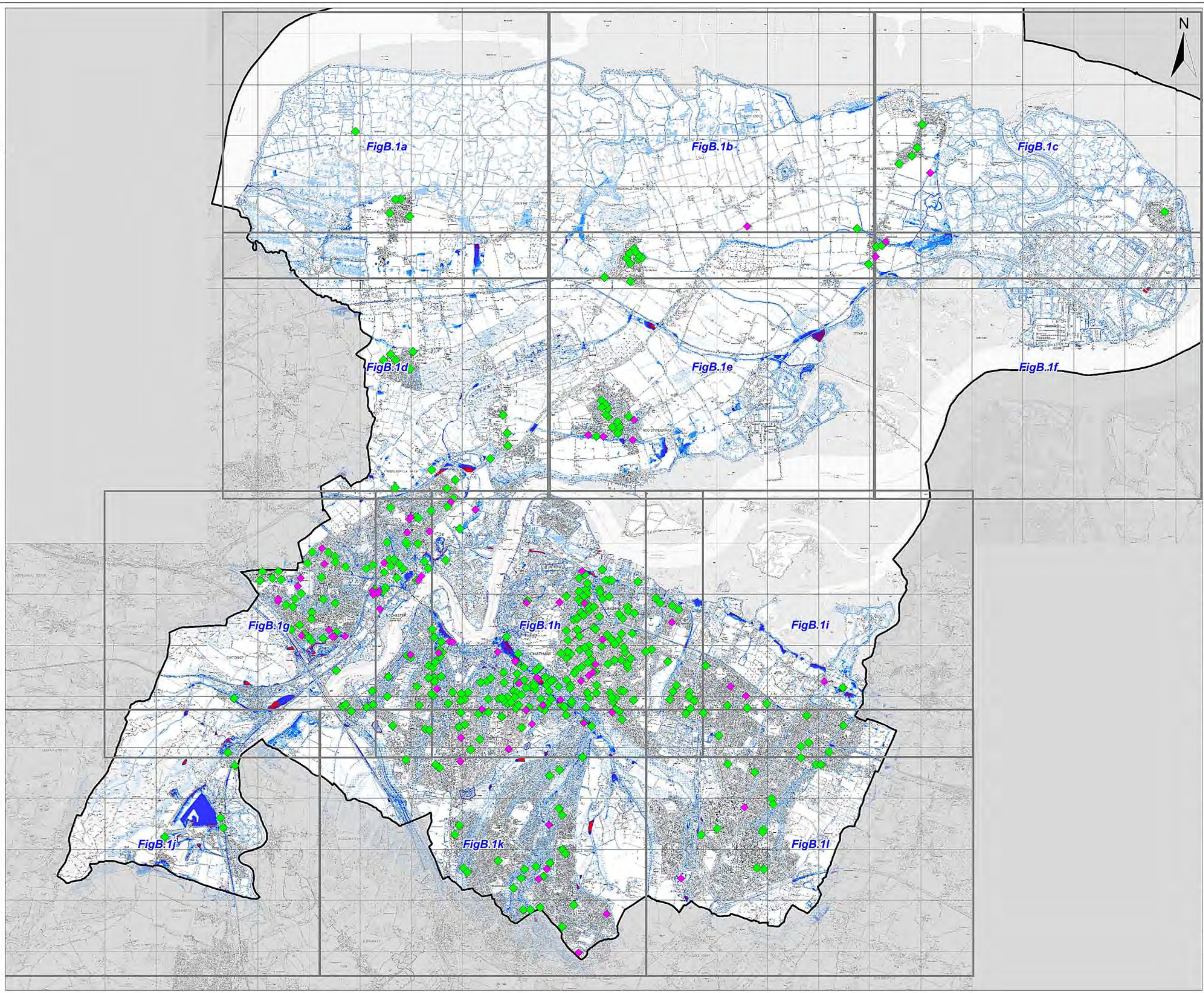
2.2.5 Prior to approving the outputs of the hydraulic modelling, the results were verified against historic records of flooding. These provided a good correlation and a useful comparison from which to measure surface water flood risk in Medway. The historic records indicate that on average there have been three counts of internal flooding affecting separate properties per year in Medway.

2.2.6 It is recognised that there is uncertainty associated with the derivation of the estimates. To improve our understanding of surface water flood risks (and other sources of flooding), a Surface Water Management Plan (SWMP) will be undertaken in those areas in order to establish more accurate estimates and to identify Critical Drainage Areas. This is included as one of the objectives to deliver the strategy.

2.2.7 Areas for inclusion within the SWMP will include those identified as high risk by the modelling and areas where there are records of historic flooding. This includes but is not necessarily limited to the urban centres of Chatham, Rochester and Strood, as well as rural areas such as Stoke where there is a known problem associated with surface water flooding.

Figure 2.1 Pluvial Flooding Maximum Flood Depth 3.3% AEP (extract from Technical Appendix 1)

(This figure has been provided as a separate file:
Medway Council LocalFloodRiskManagementStrategy_Fig3.1_DepthMap_0030yr_001.pdf)



KEY

Medway Council Boundary

Maximum Flood Depth (m)

- < 0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- > 1.5m

Flood Incidents

- Medway Council Recorded Flood Incidents
- Southern Water Recorded Flood Incidents

NOTES

1. Mapping of maximum flood depth and hazard rating categories has been generated from TuFLOW pluvial modelling results. Users of this map should refer to the Local Flood Risk Management Strategy Technical Appendix 1 Pluvial Modelling Methodology for a complete description of the limitations and accuracy of the maximum flood depth and hazard ratings shown.

2. This map only shows the predicted likelihood of pluvial flooding (this includes flooding from overland flow, small watercourses and ditches, that occurs during heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.

3. This map provides a strategic overview of pluvial flood risk and may be subject to further analysis in the future.

4. It should be noted that certain locations not shown may be at risk of flooding from other sources. For example, land adjacent to watercourses not included within this study; areas susceptible to drainage system inadequacies or localised ponding; areas flooded due to debris blockage.

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SJL	EC	SPR	OCT 2013

SCALES @ A3	ISSUING OFFICE
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MEDWAY COUNCIL LFRMS
MAIN REPORT

MAXIMUM FLOOD DEPTH (m)

3.3% ANNUAL EXCEEDANCE PROBABILITY (AEP) EVENT AND RECORDED FLOOD INCIDENTS

Medway
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CAPITA SYMONDS URS
Flood Risk Management

DRAWING NUMBER	REV
Figure 3.1	02

DRAWING NUMBER	REV
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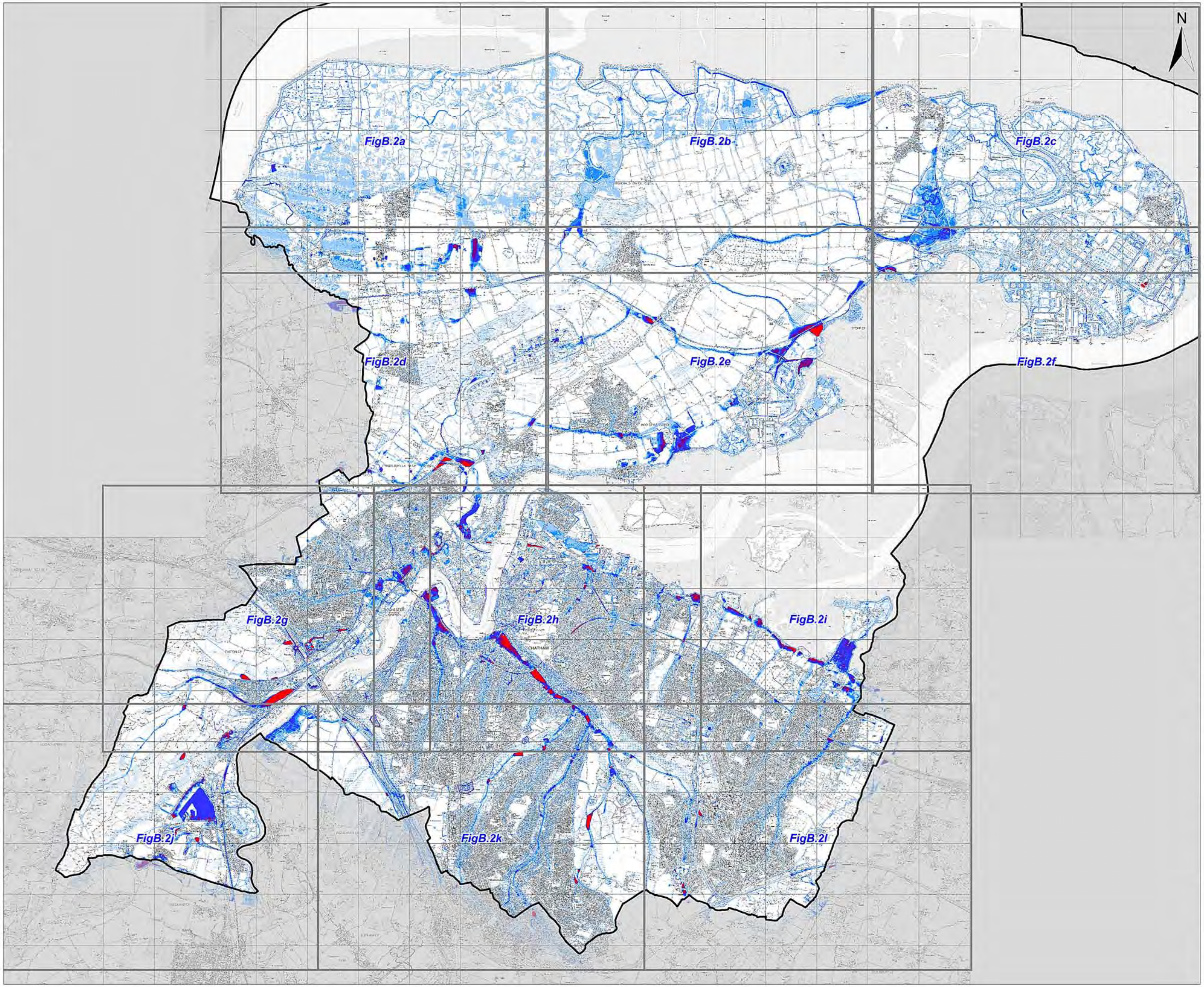
LAYOUT FILE NAME: MedwayCouncil-LocalFloodRisk ManagementStrategy_Fig3.1_DepthMap_0030yr_002.WOR

Figure 2.2 Pluvial Flooding Maximum Flood Depth 1% AEP including climate change (extract from Technical Appendix 1)

(This figure has been provided as a separate file:

MedwayCouncil-LocalFloodRiskManagementStrategy_Fig3.2_DepthMap_0100yrCC_001.pdf)



NOTES

KEY

Medway Council Boundary

Maximum Flood Depth (m)

- < 0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- > 1.5m

NOTES

1. Mapping of maximum flood depth and hazard rating categories has been generated from TuFLOW pluvial modelling results. Users of this map should refer to the Local Flood Risk Management Strategy Technical Appendix 1 Pluvial Modelling Methodology for a complete description of the limitations and accuracy of the maximum flood depth and hazard ratings shown.

2. This map only shows the predicted likelihood of pluvial flooding (this includes flooding from overland flow, small watercourses and ditches, that occurs during heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.

3. This map provides a strategic overview of pluvial flood risk and may be subject to further analysis in the future.

4. It should be noted that certain locations not shown may be at risk of flooding from other sources. For example, land adjacent to watercourses not included within this study; areas susceptible to drainage system inadequacies or localised ponding; areas flooded due to debris blockage

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MEDWAY COUNCIL LFRMS
MAIN REPORT

MAXIMUM FLOOD DEPTH (m)

1.0% ANNUAL EXCEEDANCE PROBABILITY (AEP) EVENT PLUS 30% CLIMATE CHANGE

Medway
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CAPITA SYMONDS URS
Flood Risk Management

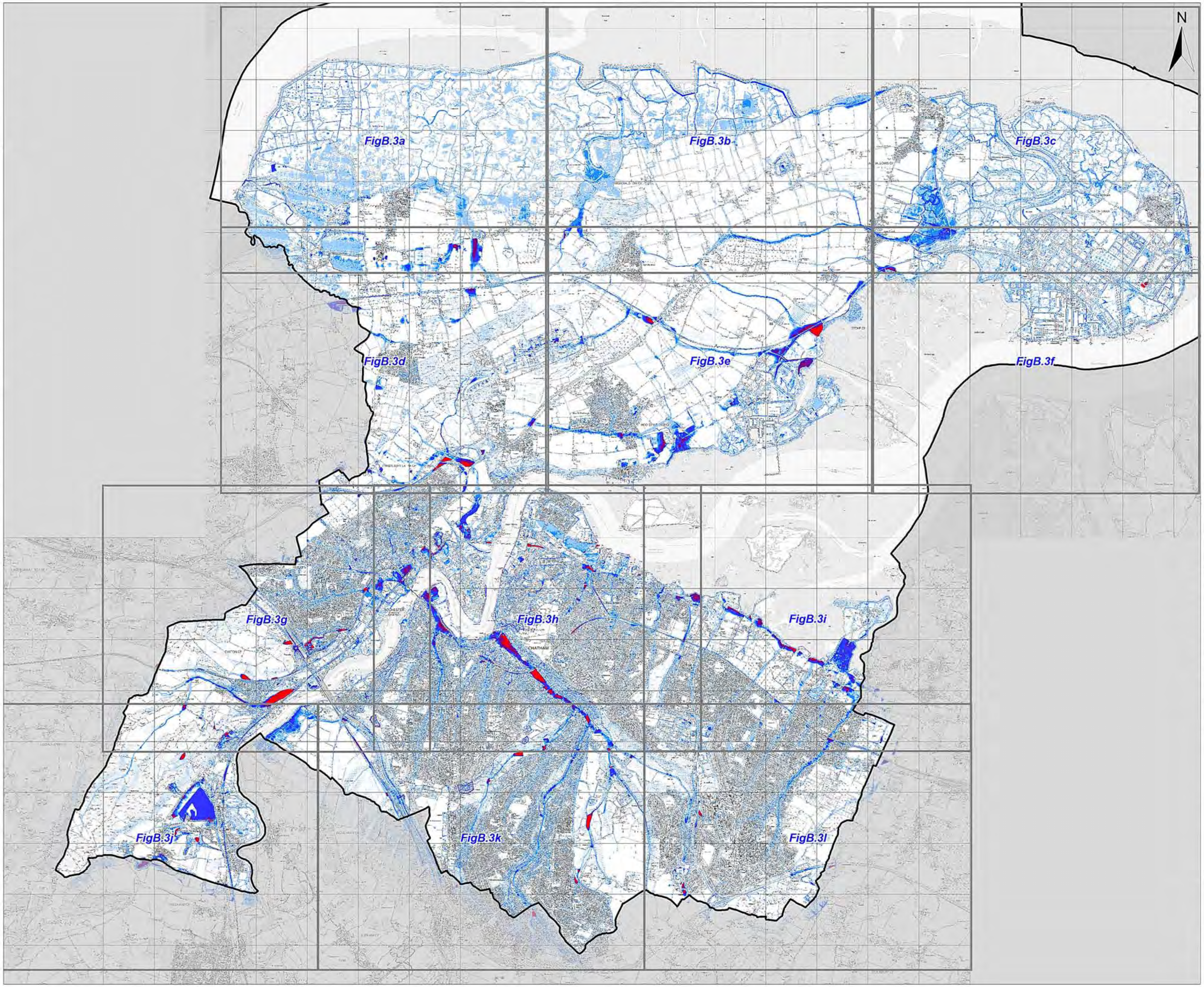
DRAWING NUMBER	REV
Figure 3.2	02

DRAWING NUMBER 47061941\Figure3.2 | REV 2

LAYOUT FILE NAME: MedwayCouncil-LocalFloodRisk ManagementStrategy_Fig3.2_DepthMap_0100yrCC_002.WOR

Figure 2.3 Pluvial Flooding Maximum Flood Depth 0.5% AEP (extract from Technical Appendix 1)

(This figure has been provided as a separate file:
MedwayCouncil-LocalFloodRiskManagementStrategy_Fig3.3_DepthMap_0200yr_001.pdf)



KEY

Medway Council Boundary

Maximum Flood Depth (m)

- < 0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- > 1.5m

NOTES

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3. This map provides a strategic overview of pluvial flood risk and may be subject to further analysis in the future.

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MEDWAY COUNCIL LFRMS
MAIN REPORT

MAXIMUM FLOOD DEPTH (m)

0.5% ANNUAL EXCEEDANCE PROBABILITY (AEP) EVENT

Medway
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CAPITA SYMONDS | URS
Flood Risk Management

DRAWING NUMBER	REV
Figure 3.3	02

DRAWING NUMBER	REV
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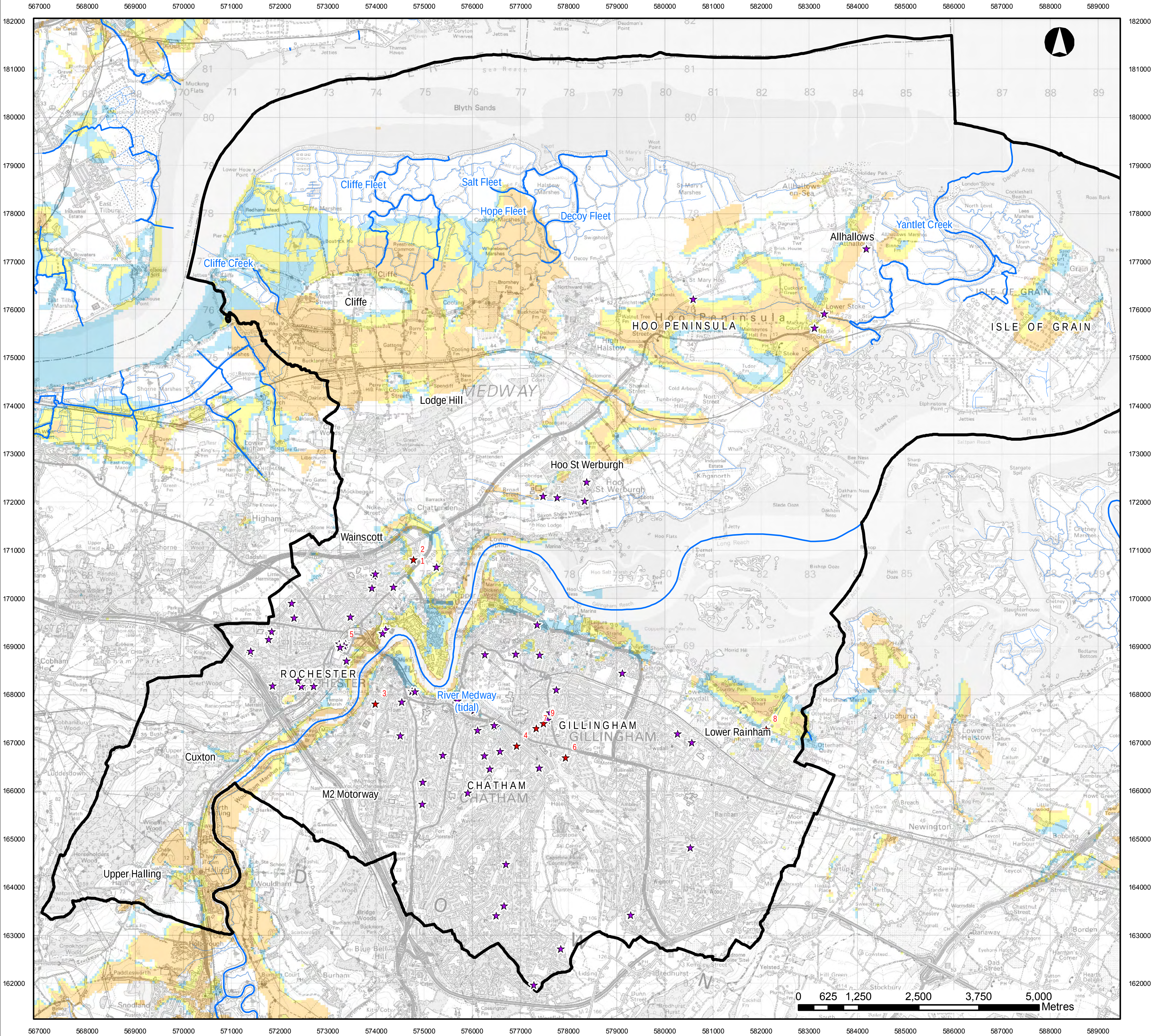
LAYOUT FILE NAME: MedwayCouncil-LocalFloodRisk ManagementStrategy_Fig3.3_DepthMap_0200yr_002.WOR

Figure 2.4 Areas susceptible to groundwater flooding (extract from Technical Appendix 2)

(This figure has been provided as a separate file:
MedwayCouncil-LocalFloodRiskManagementStrategy_Fig3.4_GroundwaterFlooding_001.pdf)



KEY

- Medway Council Administrative Area
- Rivers
- Historic Flooding Event (all events)
- Historic Flooding Event (basements / cellars)

BGS Groundwater Flooding Susceptibility

- Very High
- High
- Moderate

TECHNICAL NOTE
This map shows an approximate guide to areas that may be susceptible to groundwater flooding. However, for all new developments, site investigation is required to confirm local groundwater levels and therefore risk of groundwater flooding

USER NOTE
This plan has been produced in accordance with Planning Policy Statement 25 – development and flood risk. Because the information is indicative rather than specific, local planning authorities will nevertheless need to consult the Environment Agency on individual applications.

FLOODABLE AREAS NOT SHOWN
This study does not consider those areas susceptible to tidal, fluvial, surface water or pluvial flooding.

CAPITA SYMONDS | URS
Flood Risk Management

STRATEGIC FLOOD RISK MAPPING

PROJECT TITLE

MEDWAY COUNCIL LFRMS
TECHNICAL APPENDIX 2
GROUNDWATER ASSESMENT

DRAWING TITLE

FIGURE 3.4
BGS GROUNDWATER FLOODING
SUSCEPTIBILITY MAP

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BTV	BTV	SC	SC	Scale @ A3 1:80,000	FINAL
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08/06/2012	08/06/2012	08/06/2012	08/06/2012	47061941_GW_DRW001	2

3.3 Groundwater flooding

3.3.1 Groundwater flooding occurs as a result of water rising up from an underlying aquifer. This tends to occur after much longer periods of sustained rainfall, and the areas at most risk are often low-lying where the water table is likely to be at shallow depth.

3.3.2 It is also important to consider the impact of groundwater level conditions on other types of flooding e.g. fluvial, surface water and sewer. High groundwater level conditions may not lead to widespread groundwater flooding. However, they have the potential to exacerbate the risk of surface water and fluvial (river) flooding by reducing rainfall infiltration capacity, and to increase the risk of sewer flooding through sewer / groundwater interactions.

3.3.3 The need to improve the management of groundwater flood risk in the UK was identified through Defra's Making Space for Water strategy[5]. In order to develop local understanding of the nature of flood risk across the study area an assessment of the susceptibility of the area to groundwater flooding was undertaken[6]. This was a desk study based assessment using widely available sources of information as outlined in Technical Appendix 2 Groundwater Assessment.

3.3.4 This process, in tandem with a review of British Geological Survey mapping on groundwater flooding susceptibility enabled identification of those areas within Medway susceptible to groundwater flooding.

3.3.5 The conclusion of the assessment is the identification of the southern half of Medway's administrative area as having a degree of susceptibility to groundwater flooding due to the presence of the Chalk and Thanet Sands formations. This is illustrated in Figure 3.4. The assessment also concludes that areas of Hoo St Werburgh and Allhallows may also be at risk.

3.4 Ordinary watercourse flooding

3.4.1 Rivers are divided into two categories known as 'main rivers' and 'ordinary watercourses'. The Environment Agency has permissive powers to manage flood risk from main rivers, which are defined as rivers that can cause significant disruption if they flood and need special management to reduce the risks of flooding.

3.4.2 Ordinary watercourse flood risk is associated with very localised flooding from small open channels, ditches, streams, brooks and culverted watercourses. In the southern half of Medway, there are few known ordinary watercourses; it is likely that some previously open channel watercourses have been entirely culverted (i.e piped) and are now incorporated into the Southern Water sewer network as storm relief sewers. However, in the northern portion of the

[5] Defra (February 2005) Making Space for Water
[6] Capita Symonds / URS (August 2012) Medway Council Technical Appendix 2 Assessment of Susceptibility to Groundwater Flooding.

borough, there are extensive networks of small channels and ditches that cover the low-lying areas and drain to the tidal estuary.

3.4.3 The capacity and condition of ordinary watercourses is essential to the operation of the local drainage system and culverted watercourses are especially vulnerable to future flood risk. The responsibility for maintenance of ordinary watercourses rests with Medway Internal Drainage Board (where they operate) and riparian owners who own land where a watercourse flows through or adjacent to.

3.4.4 Changes to ordinary watercourse consenting have been made by the FWMA. In particular paragraph 32 (principally) of Schedule 2 of the FWMA amends section 23 of the Land Drainage Act 1991[7] to transfer some powers from the Environment Agency. Local Authorities will now lead on ordinary watercourse consenting and enforcement unless it is in an Internal Drainage District where Internal Drainage Boards (IDBs) will retain their existing powers.

3.5 Climate Change

3.5.1 The latest UK climate projections (UKCP09) suggest a shift towards generally wetter winters and increase in intense summer rainfall events. The UK has a long-term framework for building the UK's ability to adapt to a changing climate as outlined in the Climate Change Act 2008.

3.5.2 New development and the increasing density of our settlements could increase flooding, as there may be fewer areas available to absorb rainfall and store flood water. These factors are particularly important for local flooding. Planning policies already require new development to manage runoff sustainably. However, this does not mitigate all the effects of new development on runoff and they do not necessarily apply to permitted developments, which can increase the density of existing urban areas and increase the burden on local drainage infrastructure.

3.5.3 In order to provide a robust evidence base, an allowance for climate change over the next 100 years has been added to rainfall boundaries included in the surface water modelling. This is based on the guidance contained within National Planning Policy Guidance (an increase of 30%). These projections need to be taken into account when designing surface water infrastructure on new developments and flood infrastructure.

[7] HMSO and the Queen's Printer of Acts of Parliament (1991) Land Drainage Act

3.6 Flood incident reporting

3.6.1 Over the last few years, Medway Council has maintained records of flooding events that have occurred within their administrative area. The FWMA places a duty on LLFAs to investigate and record significant flood events.

3.6.2 The FWMA places a duty on LLFAs to investigate flood incidents from surface water, groundwater and ordinary watercourses, where it considers it 'necessary and appropriate'. The purpose of the investigation is to determine which Risk Management Authorities have relevant flood risk management functions and whether those Risk Management Authorities have exercised those functions in response to a flood. Having carried out an investigation Medway Council must publish the results and notify the relevant Risk Management Authorities.

3.6.3 A flood incident does not always necessitate a thorough investigation of the flood and its mechanisms, however, there may be instances where a more detailed investigation is undertaken in order to better deliver the objectives of this strategy, for instance to improve the understanding of flood risk.

3.6.4 Medway Council will establish a formal method of flood incident recording and make arrangements for the records to be captured and reviewed to enable identification of significant flood events.

4 Managing flood risk in Medway

4.1 Risk Management Authorities (RMAs)

4.1.1 In accordance with the Flood and Water Management Act, a RMA may include the Environment Agency, LLFA, District Council for an area for which there is no Unitary Authority, an internal drainage board, a water company and a highway authority. The following RMAs have therefore been identified across Medway Council's administrative area:

- Medway Council (LLFA)
- Environment Agency
- Medway Council as the Highways Authority
- Lower Medway Internal Drainage Board (IDB)
- Southern Water

4.1.2 Though not formally designated as RMAs by the FWMA, the following groups or organisations have roles and functions in flood risk management and have therefore been identified within the strategy:

- Regional Flood and Coastal Committee (RFCC)
- SE7 Regional Consortium
- 11 Parish Councils
- Network Rail
- Kent Resilience Forum
- Kent Fire and Rescue Service
- Land owners and land managers
- South East Water
- Rochester Bridge Trust
- The public

4.2 Roles and responsibilities

4.2.1 Information included in Appendix 3 sets out some of the key duties, powers, roles and responsibilities of each of the RMAs. It should be noted that these tables are not exhaustive, and the source documents and legislation should always be referred back to for further information and clarification.

4.3 Information and skill sharing

4.3.1 It is essential that RMAs work together to achieve the functions set out in recent legislation. Effective sharing of information between RMAs can go a long way towards this aim. Section 14 of the FWMA gives Medway Council, as the LLFA, the power to request information in connection with its flood risk management functions. It also states that information requested must be provided in the manner and within the period specified in the request.

4.3.2 'Information' can cover any data, documents or facts recorded in any form and includes paper files, notes, reports, databases, spreadsheets, drawings and plans, photographs and videos, electronic documents, emails, etc. There is a vast amount of data, in these different forms, held by a number of different RMAs; the challenge will be identifying what information exists and where it is held. This process was initiated during the preparation of the Preliminary Flood Risk Assessment when data was collected from different RMAs. This data has provided the overall evidence base of flood risk information which will inform future flood risk management work.

4.4 Role of the public and businesses

4.4.1 Members of the public have an important role to play in the context of local flood risk management. In many cases, the council and other Risk Management Authorities will be reliant on information from local residents and business owners in order to be able identify the mechanisms and impacts of flood events. It is important that this information is directed to the council and acted upon where appropriate to fulfil the requirements of the Flood Water Management Act and thereby continue to assist in the management of local flood risk.

4.4.2 As well as informing the council of areas experiencing flooding, the public also have a role to play in finding out whether they are at risk, and if so, implementing flood risk management measures where they are responsible for protecting their properties. These may include good housekeeping measures such as the careful management of surface water from their gardens and hard standing surfaces, the maintenance of open watercourses and ditches associated with their properties or the installation of flood protection measures during flood warnings. The Environment Agency's website (https://www.gov.uk/government/organisations/environment-agency) provides a comprehensive resource on preparing for flooding.

4.4.3 In order for local residents to fulfil their responsibilities of reporting flood incidents to the council and undertaking management measures for their own properties and local areas, local groups of residents or property owners may consider establishing local partnerships or flood working groups to tackle flood risk issues together.

4.5 Role of developers

4.5.1 Developers have a vital role to play in delivering the outcomes of the strategy, particularly with regards to the provision of sustainable drainage infrastructure within new developments. Developers should take note of the information contained within the strategy and work collaboratively with other Risk Management Authorities in Medway to assist the delivery of local flood risk management for the benefit of all who live or work in Medway.

4.6 Role of the Local Planning Authority

4.6.1 The National Planning Policy Framework[8] (NPPF) sets out the Government's planning policies for England and how these will be applied. Section 10 of the NPPF sets out the approach for meeting the challenge of climate change, flooding and coastal change and highlights the role that Local Planning Authorities have to ensure that inappropriate development in areas at risk of flooding is avoided by directing development away from areas at highest risk.

4.6.2 National Planning Policy Guidance (NPPG) accompanies NPPF. The chapter 'Flood Risk and Coastal Change' advises on how planning can specifically take account of the risks associated with flooding and coastal change in plan making and the application process.

4.6.3 Any future local policies should be developed in consultation with the Environment Agency, Lead Local Flood Authority, emergency responders and internal drainage boards where appropriate.

[8] CLG (March 2012) National Planning Policy Framework

5 Local flood risk management objectives

5.1 National flood and coastal erosion risk management strategy

5.1.1 The FWMA states that the Environment Agency must 'develop, maintain, apply and monitor a strategy for flood and coastal erosion risk management in England' as part of its strategic overview role for flood and coastal erosion risk management. In response to this, the Environment Agency has developed the National Strategy jointly with Defra to ensure that it reflects government policy.

5.1.2 The National Strategy[9] was published in 2011 and sets out strategic aims and objectives for managing flood and coastal erosion risks and the measures proposed to achieve them. As required by the FWMA, Medway Council has sought to ensure that this strategy is consistent with the approach and guiding principles that have been set out in the National Strategy.

5.2 Flood risk management objectives

5.2.1 A review of the objectives set out in the overarching National Strategy for flood and coastal erosion risk management for the whole of England (Defra, Environment Agency 2011) has been undertaken. In addition to the national objectives, the National Strategy also sets out six high-level principles by which it suggests that decisions relating to flood risk management and the processes by which they are taken should be guided. These guiding principles are as follows:

- Community focus and partnership working
- A catchment and coastal "cell" based approach
- Sustainability
- Proportionate, risk-based approaches
- Multiple benefits
- Beneficiaries should be encouraged to invest in risk management

5.2.2 The objectives for the strategy have been developed in line with the five strategic objectives and the six guiding principles set out in the National Strategy. This is illustrated alongside the objectives in Table 5.1.

[9] Environment Agency, Defra (2011) Understanding the risks, empowering communities, building resilience. The national flood and coastal erosion risk management strategy for England.

5.3 Medway Council Plan

Medway Council Plan (2013-2015)

5.3.1 The Medway Council Plan is a business plan which sets out how the council will ensure they the best possible services are provided to residents. Implementation of the objectives and measures within this strategy will directly contribute to three of the five priority areas including:

- Safe, clean and green Medway.
- Everybody travelling easily around Medway.
- Everyone benefiting from the area's regeneration.

5.3.2 Two core values set out the principles of how Medway will work to deliver these priorities:

Putting customers at the centre of everything we do.

5.3.3 Providing a clear plan for managing local flood risk helps residents within Medway to understand what is happening within the community to manage flooding and how to identify who can help them tackle flood risk issues.

Giving value for money.

5.3.4 The disruption and damage caused by local flooding can affect residents, businesses, and the economy. Reducing the risk of local flooding via implementation of this strategy reduces this impact and ensures that there is appropriate scrutiny of flood risk management expenditure. It also allows the appraisal of wider benefits that can be delivered which also contribute towards the objectives within the Council Plan, thereby representing further value for money.

Table 5.1 Flood risk management objectives

Adherence of objectives to the National Strategy Guiding Principles

GP1 Community focus and partnership working
GP2 A catchment and coastal "cell" based approach
GP3 Sustainability
GP4 Proportionate, risk-based approaches
GP5 Multiple benefits
GP6 Beneficiaries should be encouraged to invest in risk management

		1	2	3	4	5	6
National Strategy Objective 1: Understand the risks *Understanding the risks of flooding and coastal erosion, working together to put in place long-term plans to manage these risks and making sure that other plans take account of them.*							
1a	Medway Council will work with stakeholders to develop a collective understanding of local flood risk.	■					
1b	Medway Council will monitor flood risk.		■				
National Strategy Objective 2: Prevent inappropriate development *Avoiding inappropriate development in areas of flood and coastal erosion risk and being careful to manage land elsewhere to avoid increasing risks.*							
2a	Medway Council will ensure local policy is consistent with wider flood risk management policies and legislation and provide clear advice on how to achieve those policies within Medway.			■			
2b	Medway Council will promote the use of SuDS in accordance with its forthcoming role as SuDS Advisory Body.			■		■	
2c	Medway Council will take account of the cumulative effect of developments and climate change on the risk of flooding throughout Medway.			■			

Adherence of objectives to the National Strategy Guiding Principles

GP1 Community focus and partnership working
GP2 A catchment and coastal "cell" based approach
GP3 Sustainability
GP4 Proportionate, risk-based approaches
GP5 Multiple benefits
GP6 Beneficiaries should be encouraged to invest in risk management

		1	2	3	4	5	6
2d	Medway Council will seek to ensure that all development has a positive or nil effect on the risk of flooding to and arising from proposed development.						
National Strategy Objective 3: Manage the likelihood of flooding *Building, maintaining and improving flood and coastal erosion management infrastructure and systems to reduce the likelihood of harm to people and damage to the economy, environment and society.*							
3a	Medway Council will consider how future infrastructure improvements (e.g. highways, rail, public realm works) and/or changes could be used to deliver local flood risk reduction/benefits.						
3b	Medway Council will use flood risk information to implement a risk-based approach to capital investment decisions and maintenance programmes and activities.						

Adherence of objectives to the National Strategy Guiding Principles

GP1 Community focus and partnership working
GP2 A catchment and coastal "cell" based approach
GP3 Sustainability
GP4 Proportionate, risk-based approaches
GP5 Multiple benefits
GP6 Beneficiaries should be encouraged to invest in risk management

		1	2	3	4	5	6
National Strategy Objective 4: Help people manage their own risk *Increasing public awareness of the risk that remains and engaging with people at risk to encourage them to take action to manage the risks that they face and to make their property more resilient.*							
4a	Medway Council will share information with respect to flood risk across Medway with all Risk Management Authorities and the public.						
4b	Medway Council will increase public awareness (property owners, developers) with respect to flood risk and responsibility for flood risk management.						
National Strategy Objective 5: Improve flood prediction, warning and post-flood recovery *Improving the detection, forecasting and issue of warnings of flooding, planning for and co-ordinating a rapid response to flood emergencies and promoting faster recovery from flooding.*							
5a	Medway Council will use information on flood risk as a tool for flood prediction and warning.						

6 Measures for managing flood risk

6.1 Flood risk management measures

6.1.1 Medway Council are not yet in a position to confidently identify significant flood risk/Critical Drainage Areas within the administrative area due to the quality of their flood record datasets. As a result, it is considered that identification of structural measures for flood risk areas would be inappropriate at this stage. An assessment of structural measures will be included at a later date in the proposed Surface Water Management Plan. The strategy instead focuses on non-structural measures that can be implemented, which can help to build upon the understanding of flood risk in the area.

6.1.2 Table 6.1 provides an overview of the flood risk management measures that have been identified by Medway Council and includes an indication of the timeframe by which the measures are will be carried out and/or reviewed. These have been defined as:

- Short (1-2 years).
- Medium (2-5 years), i.e. within the lifetime of the strategy, and
- Long term (>5 years, to be carried forward for review in the next iteration of the strategy.

Table 6.1 Flood risk management measures

National objectives	Local objectives	Measures	Responsibility authority	Supporting authorities	Funding	Timeframe for implementation
1. Understand the risks.	A. Medway Council will work with stakeholders to develop a collective understanding of local flood risk.	• Establish an internal flood group. • Establish an external flood group. • Provide internal training to teams and individuals who can contribute towards flood risk management. • Undertake a Surface Water Management Plan.	MC	EA, IDB, Southern Water	Defra	Short term (<2 years)
	B. Medway Council will monitor flood risk.	• Improved flood incident record collection to establish a record of flood incidents. • Establish a record of structures and features.				
2. Prevent inappropriate development.	A. Medway Council will ensure local planning policy is consistent with wider flood risk management policies and legislation and provide clear advice on how to achieve those policies within Medway.	• Undertake a review of current council planning policies relevant to local flood risk management to ensure consistency with national policy and legislation.	MC	EA, IDB, Southern Water	Defra	Short term (<2 years)
	B. Medway Council will promote the use of SuDs in accordance with the forthcoming role as SuDs Advisory Body	• Establish a SuDS Approval Body within the council. • Develop local guidance and standards for the adoption of SuDS within the Medway area to prepare for the forthcoming enactment of the SAB. • Identify opportunities to retrofit SuDS into existing developments.	Defra, MC	Defra, EA	Defra	Short to medium term (<2 years up to < 5 years)

	C. Medway Council will take account of the cumulative effects of developments and climate change on the risk of flooding throughout Medway.	• Work with other Risk Management Authorities via the planning process to achieve common goals to reduce flood risk.	MC	EA	Defra	Short term (<2 years)
3. Manage the likelihood of flooding.	A. Medway Council will require that all development has positive or nil effect on risk of local flooding to and arising from new development.	• Development of processes to enable a risk based review drainage proposals by the Lead Local Flood Authority for planning applications within areas with a known risk of local flooding.	MC	EA, IDB, Southern Water	Defra	Short term (<2 years)
	B. Medway Council will consider how future infrastructure improvements (e.g. highways, rail, public realm) could be used to deliver local flood risk reduction/benefits.	• Development of processes to enable review, by the Lead Local Flood Authority of infrastructure proposals.	MC	EA	Defra	Short term (<2 years).
	C. Medway Council will use flood risk information to implement a risk-based approach to capital investment decisions and maintenance programmes and activities.	• Use an Asset Register Management Database as a basis for informing a risk based approach to capital investment decisions and maintenance programmes and activities led risk/conditions surveys against asset valuation.	MC		Defra	Short term (<2 years)
4. Help people to manage their own risk.	A. Medway Council will share flood risk information with Risk Management Authorities and the public.	• Web development to improve accessibility to flood risk information. • Consultation and engagement with external flood group.	MC	EA, IDB, Southern Water	Defra	Short term (<2 years)

	B. Medway will seek increase public awareness with respect to flood risk and responsibility for flood risk management.	• Engage with local communities regarding responsibilities for flood risk management (particularly land drainage consenting).				
5. Improve flood prediction warning and post flood recovery.	A. Medway Council will use information on local flood risk as a tool for flood prediction and warning.	• Maintain / improve local risk mapping using outputs from SWMP.	MC	EA, IDB, Southern Water	Defra	Short term (<2 years)

7 Funding Options

7.1 Funding

7.1.1 The effective practical implementation of flood risk management measures requires adequate resources both for the management and response activities of the LLFA as well as for capital projects. This section provides a summary of available forms of funding and seeks to assist with identifying any further actions that will be needed to ensure that particular funding alternatives are feasible.

7.1.2 Figure 7.1 illustrates the various streams of funding open to Risk Management Authorities which are discussed in turn in the following sections.

Funding to LLFAs through Area Based Grants

7.1.3 Funding for LLFAs to meet their new responsibilities has been allocated through Area Based Grants or local services support grants. The money is not ring fenced so individual LLFAs must decide how much of this grant to spend, subject to limits on overall budgets and the need for investment on other priorities.

7.1.4 The amount of money allocated to individual LLFAs varies based on the overall risk within the relevant area. This money has been made available to support Medway Council with its ongoing local flood risk management activities.

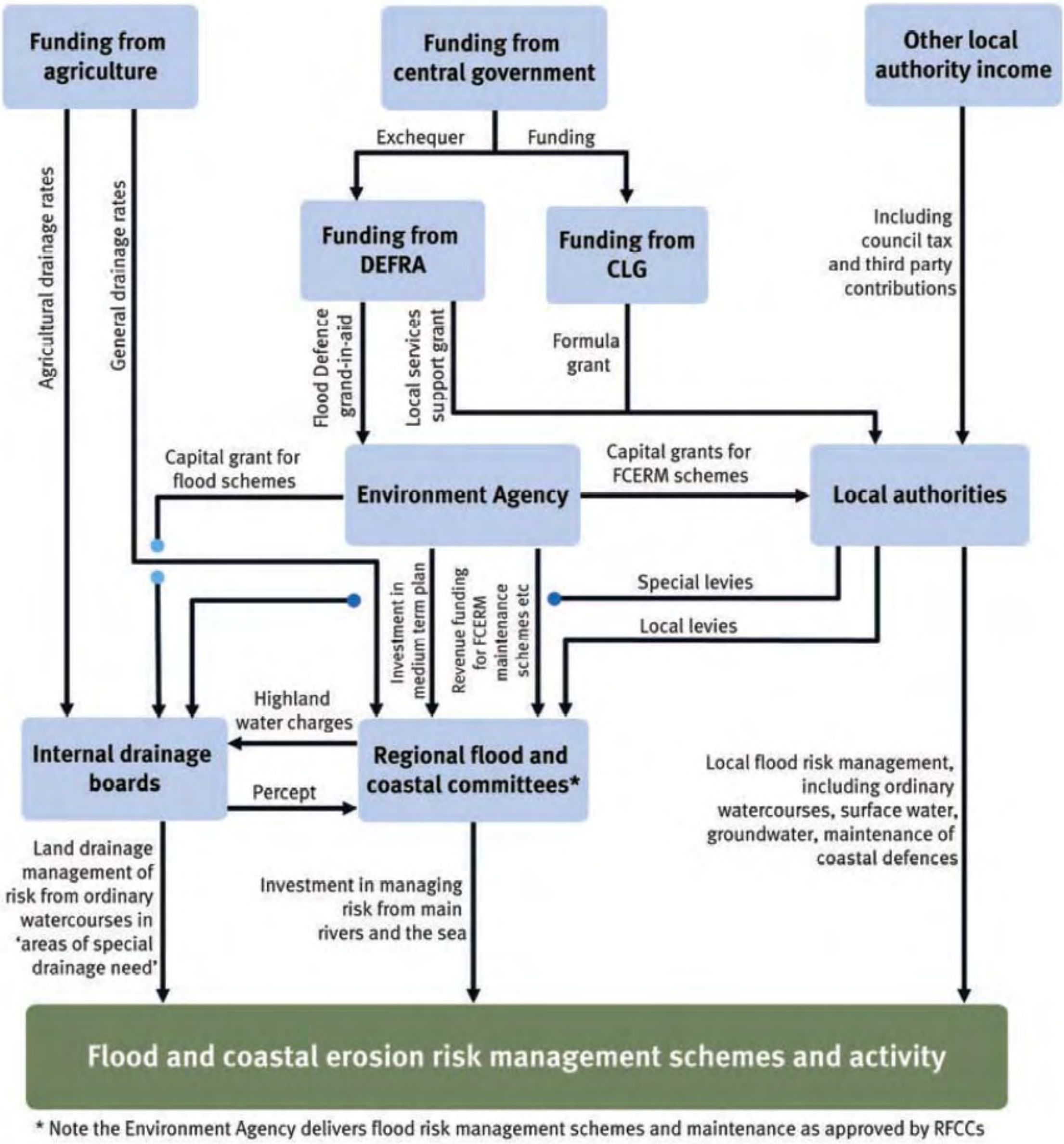

Figure 7.1 Funding for Risk Management Authorities (Environment Agency, 2011)

Public funding through 'Payment for Outcomes' and 'Flood Defence Grant in Aid' Schemes

7.1.5 Recommendation 24 of the Pitt Review stated that the "Government should develop a scheme that allows and encourages local communities to invest in flood risk management measures". This recommendation is delivered by using the new 'Payment for Outcomes' approach which came into force in April 2012. All schemes are now offered a fixed subsidy based on the benefits delivered when the outcomes are achieved with the aim to encourage communities to take more responsibility for the flood risk that they face.

7.1.6 The new approach will see funding levels for each scheme (provided by Defra through Flood Defence Grant in Aid) relating directly to benefits, in terms of the number of households protected, the damages being prevented plus other scheme benefits such as environmental benefits, amenity improvement, agricultural productivity and benefits to business. In addition to these elements, payment rates for protecting households in deprived areas will be higher so that schemes in these areas are more likely to be fully funded by the Government[10].

7.1.7 Under this system some schemes will receive complete funding if the benefits significantly outweigh the costs. For other schemes partial funding would be available. It is hoped that this approach would encourage people to find cheaper ways to achieve positive outcomes and/or find other funding mechanisms to pay the remaining cost of the scheme. Any shortfall in the amount of grant in aid required to construct the scheme will need to be found from elsewhere. This could be from local levy funding from the local levy, from local businesses or other parties who will benefit from the scheme.

Local levy

7.1.8 The local levy is administered by the Southern Region Regional Flood and Coastal Committee (RFCC). The local levy can be distributed to flood defence schemes at the discretion of the RFCC. It is often used to fund locally important schemes which would otherwise not receive funding or to provide partnership contributions for grant in aid funding. Figure 7.2 illustrates the 'Payment for Outcomes' approach and the importance of the local levy in fully funding flood defence and maintenance schemes.

[10] For further information on how levels of depravation will be assessed, refer to the Index of Multiple Deprivation commissioned by the Department for Communities and Local Government (www.imd.communities.gov.uk)

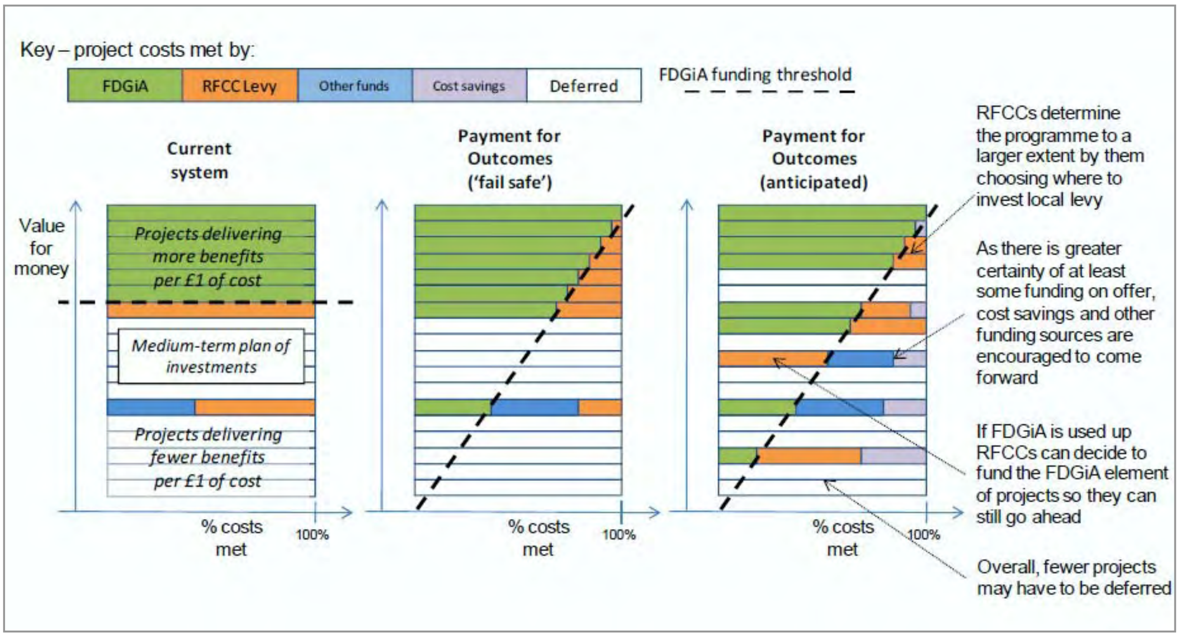

Figure 7.2 The Payment for Outcomes Approach
Source: Defra Consultation Document (page 19)

Funding through the European Union

7.1.9 European Union funding is available through the European Regional Development Fund (ERDF).

Developer Contributions

7.1.10 Section 106 of the Town and Country Planning Act 1990 allows a Local Planning Authority to enter into an agreement with a landowner or developer in association with the granting of planning permission. A Section 106 agreement is used to address issues that are necessary to make a development acceptable, such as supporting the provision of services and infrastructure.

7.1.11 One of the recommendations of 'Making Space for Water' was that LPAs should make more use of Section 106 agreements to ensure that there is a strong planning policy to manage flood risk. This means that any flood risk, which is caused by, or increased by, new development, should be resolved and funded by the developer. Medway Council will review the consideration of flood risk within Section 106 agreements during further iterations of the Guide to Developer Contributions.

Local Fundraising

7.1.12 In addition to contributions from developers, another important funding mechanism will come from local fundraising from the local communities and businesses that stand to benefit from the proposed flood defence schemes.

Other sources of funding

7.1.13 Defra is currently producing a good practice guide to support LPAs called 'Solutions for Joint Funding of Surface Water Schemes'. This project will explain the funding mechanisms and time cycles, approval processes of key partners and benefits of joint funding of local flood risk management.

8 Wider environmental objectives

8.1 Overview

8.1.1 In order to address this requirement, a review of relevant policy documents has been undertaken to identify environmental objectives of relevance to the study area. Subsequently, an assessment of which of Medway Council's flood risk management objectives (if any) contribute to each of these environmental objectives has been undertaken and justification provided. This process is presented in Table 8.1.

8.1.2 The European Directive 2001/42/EC was adopted in 2001 and transposed into English legislation by the Environment Assessment of Plans and Programmes Regulations in 2004. The purpose of the Directive is to increase the level of protection for the environment. It integrates environmental considerations into the preparation and adoption of plans and programmes with the view of promoting sustainable development.

8.1.3 The Directive requires a Strategic Environmental Assessment (SEA) to be carried out for all plans and programmes, which are subject to preparation and/or adoption, by an authority at national level, regional or local level. A SEA screening report concluded that is it is unlikely that there will be any significant environmental effects arising from the objectives and measures included within the strategy and as such does not require a full SEA to be undertaken.

Table 8.1 Contribution of objectives to the achievement of wider environmental objectives

Source Document	Wider Environmental Objectives		Flood Risk Management Objectives												Comments
			1a	1b	2a	2b	2c	3a	3b	3c	4a	4b	5a	5b	
Regeneration, Communities and Culture Overview and Scrutiny Committee	1	Manage, protect, conserve and invest in our open spaces to create parks that can be enjoyed by all													2c. Ensuring that new development does not increase current flood risk will help to protect open spaces from flood damage in the future; 3b. The use of non structural methods and/or SUDS can reduce the environmental impacts of flood risk measures, helping to conserve existing open spaces
	2	Reduce the carbon footprint and foster sustainable development in Medway													2a. The implementation of sustainable drainage techniques is a large part of wider policies such as the WFD and the FWMA and will help towards fostering sustainability in Medway; 3b. Sustainability goals could be reached by the use of SUDS that have both environmental and social benefits (e.g. Improved biodiversity and increased amenity etc) and also potential economic benefits (e.g. tourism)
Southern Water: Final Water Resources Management Plan	3	To protect and enhance terrestrial biodiversity including designated and other important habitats and species													2c. Ensuring that new development does not increase current flood risk will help to protect important habitats from flood damage in the future; 3b. Flood risk management measures could both benefit and damage habitats/ecosystems. It is important that these factors are weighed up against each other to ensure the overall protection of the environment
	4	To protect and enhance aquatic biodiversity including designated and important habitats and species													2c. Ensuring that new development does not increase current flood risk will help to protect important habitats from flood damage in the future; 3b. Flood risk management measures could both benefit and damage habitats/ecosystems. It is important that these factors are weighed up against each other to ensure the overall protection of the environment
	5	To minimise negative effects on local communities resulting from construction and operation of options													2c. Ensuring that new development does not increase current flood risk will help to protect local communities from flood damage in the future; 3b. Detrimental social effects of a flood management strategy should be considered before any development is implemented. It should be noted that economic and environmental impacts are likely to have social impacts on the community as well
	6	To protect and enhance geological and geomorphological diversity													3b. Flood risk management measures could both benefit and damage habitats/ecosystems. It is important that these factors are weighed up against each other to ensure the overall protection of the environment
	7	To maintain and enhance landscape character													2c. Ensuring that new development does not increase current flood risk will help to protect landscape character from flood damage in the future; 3b. Flood risk management measures could both benefit and damage landscape character. It is important that these factors are weighed up against each other to ensure the overall protection of the environment
	8	To maintain and enhance salmonid and freshwater fisheries													2c. Ensuring that new development does not increase current flood risk will help to protect fisheries from flood damage in the future; 3b. The safeguarding of fisheries through flood management is important to maintain local economic activity as well as reducing environmental impacts related to over fishing of other areas. Damage to fisheries resulting in economic losses would also have a social impact
	9	To reduce contamination and safeguard soil quality and quantity													3b. Consideration must be given to the environmental (and economic in agricultural areas) impacts on soil quality to ensure any proposed flood mitigation measures do not contribute to contamination or other negative soil properties.
	10	To protect and enhance groundwater quantity and quality													3b. Consideration must be given to the environmental and economic impacts on groundwater sources to ensure any proposed flood mitigation measures do not contribute negatively to water quality and quantity.
	11	To protect and enhance coastal water quality													3b. Consideration must be given to the environmental, social and economic impacts on coastal waters to ensure any proposed flood mitigation measures do not contribute negatively to water quality.
	12	To protect and enhance transitional surface water flows and quality													3b. Consideration must be given to the environmental, social and economic impacts on transitional surface waters to ensure any proposed flood mitigation measures do not contribute negatively to water quality.
	13	To protect and enhance surface water flows and quality													3b. Consideration must be given to the environmental, social and economic impacts on surface waters to ensure any proposed flood mitigation measures do not contribute negatively to water quality.

Source Document	Wider Environmental Objectives		Flood Risk Management Objectives												Comments
			1a	1b	2a	2b	2c	3a	3b	3c	4a	4b	5a	5b	
	14	To minimise the risk of flooding taking account of climate change	■	■	■		■		■	■					1a. To be able to minimise the risk of flooding, it is first necessary to fully understand this risk so that it can be planned for and managed effectively; 1b. Climate change will increase the likelihood of flood events and must be considered when devising management strategies; 2a. A reduction in flood risk is a part of a number of wider policies (RBMPs, SMPs, RFRAs etc). Flood risk strategies should be consistent across all policies to ensure efficient risk management; 2c. Any development must not increase flood risk. In the case of flood risk management developments, they must not just simply transfer risk to other areas; 3b. The council must consider the environmental impacts of any flood risk measures and also any economic losses related to flooding if no management strategy is implemented; 3c. Development of infrastructure to double up as flood management features could mean reduction in flood risk could be achieved efficiently
	15	To maintain and enhance local air quality							■						3b. Flood mitigation measures that enhance green areas such as SUDS could help to maintain local air quality as a by-product
	16	To reduce greenhouse gas emissions							■						3b. Flood mitigation measures that enhance green areas such as SUDS could help to reduce or offset greenhouse gas emissions in Medway
	17	To reduce the generation of waste and encourage re-use and recycling of waste and use sustainably produced and local products							■						3b. Efficient use of raw materials in the implementation of flood management measures will have environmental benefits by reducing waste going to landfill. There is also potential for using recycled and/or locally sourced materials
	18	To protect and enhance sites and features of archaeological, historical and architectural interest					■		■						2c. Ensuring that new development does not increase current flood risk will help to protect archaeological and historic features from flood damage in the future; 3b. Consideration must be given to the social and economic impacts on archaeological or historic features to ensure any proposed flood mitigation measures do not contribute negatively towards their preservation.
	19	To minimise adverse effects to other abstractors, rights of navigation and other commercial users of water bodies	■				■		■						1a. Cooperation with all stakeholders on flood risk management will help to minimise negative impacts upon all relevant parties 2c. Ensuring that new development does not increase current flood risk will help to minimise effects to other water users from flood damage in the future; 3b. Consideration should be given to the social and economic impacts that flood mitigation measures may have on other water users.
Medway Strategic Flood Risk Assessment	20	Quantity: minimise impermeable surfaces by good planning of development layout					■		■	■					2c. Positive effects on flooding can be achieved by reducing areas of impermeable surfaces to minimise runoff; 3b. Permeable surfaces allow for increased groundwater recharge and improve water quality by filtration resulting in reduced treatment costs. Permeable surfaces also reduce runoff that can wash pollutants from urban surfaces into watercourses; 3c. Future infrastructure improvements could be designed to incorporate permeable surfaces that can be used in place of non permeable materials such as paving in car parks etc to improve infiltration capacity and thus improve flood attenuation capabilities
	21	Quantity: control at source to reduce extra runoff					■		■	■					2c. New or re-developments can be designed to have more control over excess runoff so that overall flood risk decreases (or at least does not increase); 3b. Environmental benefits are offered by reduced runoff such as decreased erosion as well as less potential for pollutants to be washed into watercourses; 3c. infrastructure can be designed specifically to incorporate ways of attenuating flows such as increasing infiltration or temporary storage
	22	Quantity: limit peak discharge to an agreed allowable runoff rate					■		■	■					2c. New or re-developments can be designed to have more control over excess runoff so that overall flood risk decreases (or at least does not increase); 3b. Environmental benefits are offered by reduced runoff such as decreased erosion as well as less potential for pollutants to be washed into watercourses; 3c. infrastructure can be designed specifically to incorporate ways of attenuating flows such as increasing infiltration or temporary storage
	23	Quantity: attenuate excess water to an agreed storm return period (normally 1 in 100 year with allowances for climate change)		■			■		■	■					1b. Allowing for climate change ensures that any flood mitigation measures are sufficient for predicted future scenarios; 2c. New or re-developments can be designed to have more control over excess runoff so that overall flood risk decreases (or at least does not increase); 3b. Environmental benefits are offered by reduced runoff such as decreased erosion as well as less potential for pollutants to be washed into watercourses; 3c. infrastructure can be designed specifically to incorporate ways of attenuating flows such as increasing infiltration or temporary storage

Source Document	Wider Environmental Objectives		Flood Risk Management Objectives												Comments
			1a	1b	2a	2b	2c	3a	3b	3c	4a	4b	5a	5b	
	24	Quantity: low flow routes for frequent storms and first part of volume of rare storms through treatment stage				■	■		■	■					2b. Flow routes are rarely confined to a single development site and therefore need to be examined across a larger area; 2c. New or re-developments can be designed to have more control over runoff so that overall flood risk decreases (or at least does not increase); 3b. Environmental benefits are offered by reduced runoff such as decreased erosion as well as less potential for pollutants to be washed into watercourses; 3c. infrastructure can be designed specifically to incorporate ways of routing flows away from important areas or features
	25	Quantity: high flow routes for extreme events with overland flood routes				■	■		■	■					2b. Flow routes are rarely confined to a single development site and therefore need to be examined across a larger area; 2c. New or re-developments can be designed to have more control over excess runoff so that overall flood risk decreases (or at least does not increase); 3b. Environmental benefits are offered by reduced runoff such as decreased erosion as well as less potential for pollutants to be washed into watercourses; 3c. infrastructure can be designed specifically to incorporate ways of routing flows away from important areas or features
	26	Quality: prevent pollution by good planning of development layout and site management							■						3b. Flood mitigation measures that reduce pollution (such as SUDS) will have obvious environmental benefits. There is also potential for economic gains as water treatment does not need to be as rigorous
	27	Quality: treatment stages, usually a minimum of one for housing													
	28	Quality: appropriate technique to treat runoff from roads and pavements							■						3b. Flood mitigation measures such as SUDS that can be used to treat runoff will have obvious environmental benefits. There is also potential for economic gains as water treatment does not need to be as rigorous
	29	Quality: 'source control' preferred to control silt and pollution							■						3b. Consideration should be given to certain flood mitigation measures that are designed to offer environmental benefits by filtering the water of silt and pollutants to improve water quality. There is also potential for economic gains as water treatment does not need to be as rigorous
	30	Quality: 'first flush' treatment for all roads and pavements							■						3b. Consideration should be given to flood mitigation measures that are designed to offer environmental benefits by isolating the first flush from cleaner runoff which will help to reduce the majority of pollutants reaching watercourses untreated
	31	Amenity: Techniques should maximise opportunities for amenity including environmental and bio-diversity where possible							■						3b. Flood mitigation measures can be used to increase the amenity value of land and thus have social and environmental benefits (as well as potential economic benefits)
	32	Amenity: Techniques should protect amenity							■						3b. Consideration should be given to those flood mitigation measures that can be used in tandem with existing amenity features without having to remove them, therefore avoiding a loss of amenity that could lead to social, environmental and economic losses
Sustainable Community Strategy 2010-26	33	Medway to have a safe and high quality environment by 2026							■						3b. Consideration should be given to those flood mitigation measures that can have beneficial environment and social impacts by increasing biodiversity and amenity
	34	Increase user access through promoting the Hoo Peninsula and North Kent Marshes as a sustainable tourism initiative							■						3b. Consideration should be given to those flood mitigation measures that are able to increase amenity and environmental value of the area. This will help to attract tourism which in turn, will have economic benefits
	35	Increase user access through promoting greater awareness of the Medway and Thames estuary resources							■						3b. Social benefits derived from flood risk managements schemes (e.g. Improved amenity) can help to improve user access which should in turn help to raise awareness of the area
Medway Estuary and Swale Shoreline Management Plan	36	Prevent degradation of landscape quality and visual amenity from flooding and flood risk management works					■		■						2c. Ensuring that new development does not increase current flood risk will help to protect landscapes from flood damage in the future; 3b. Consideration should be given to potential environmental and economic losses that could occur from degradation of the landscape as well as social impacts from a loss of amenity as a result of any proposed flood management strategies.
	37	Promote biodiversity opportunities and prevent loss/damage to habitats and associated species at various SSSIs, SNCIs, SPAs and UK BAP priority habitats from flooding and flood risk management works					■		■						2c. Ensuring that new development does not increase current flood risk will help to protect important habitats and conservation sites from flood damage in the future; 3b. Consideration should be given to those flood mitigation measures that can offer environmental benefits (e.g. enhanced biodiversity through improved water quality etc) while also protecting the fragile habitats from flood events. Any potential negative impacts of a flood mitigation scheme also need to be considered in the planning stages

Source Document		Wider Environmental Objectives	Flood Risk Management Objectives												Comments
			1a	1b	2a	2b	2c	3a	3b	3c	4a	4b	5a	5b	
	38	Promote biodiversity opportunities and avoid net loss of coastal grazing marshes and intertidal habitat and associated species from coastal squeeze and flood risk management works					■		■						2c. Ensuring that new development does not increase current flood risk will help to protect important habitats from flood damage in the future; 3b. Consideration should be given to those flood mitigation measures that can offer environmental benefits (e.g. enhanced biodiversity through improved water quality etc) while also protecting the fragile habitats from flood events. Any potential negative impacts of a flood mitigation scheme also need to be considered in the planning stages
	39	Prevent loss/damage to heritage from flooding and flood risk management works or implement appropriate mitigation measures, including preservation of evidence by record. Seek opportunities to enhance features where appropriate					■		■						2c. Ensuring that new development does not increase current flood risk will help to protect heritage sites and features from flood damage in the future; 3b. Consideration should be given to the social and economic impacts on heritage sites to ensure any proposed flood mitigation measures do not contribute negatively towards their preservation.
	40	Prevent loss/damage to Conservation Areas and SAMs from flooding and flood risk management works. Seek opportunities to enhance features where appropriate					■		■						2c. Ensuring that new development does not increase current flood risk will help to prevent damage to conservation areas and SAMs in the future; 3b. Consideration should be given to the environmental, social and economic impacts on conservation and SAM sites to ensure any proposed flood mitigation measures do not contribute negatively towards their preservation.
	41	Prevent loss/damage to shell fishery at Queensborough from flooding or flood risk management works					■		■						2c. Ensuring that new development does not increase current flood risk will help to prevent damage to the fishery in the future; 3b. Consideration should be given to the environmental, social and economic impacts of flood defences on the shell fishery. Negative impacts (e.g. cost to protect the fishery from floods) should be weighed up against positive impacts such as avoiding the need for over fishing in other areas and economic and social gains from employment opportunities
	42	Prevent loss/damage/disruption to recreation and associated business from flooding and flood risk management works					■		■						2c. Ensuring that new development does not increase current flood risk will help to prevent damage to recreation facilities in the future; 3b. Consideration should be given to the environmental, social and economic impacts of flood defences on recreation and associated businesses. Negative impacts (e.g. cost to protect recreation sites from floods) should be weighed up against positive impacts such as economic and social gains from maintaining access to recreation facilities
Medway Flood Defence Strategy: High Level Appraisal of Potential Solutions to Manage Flood Risk in the Urban Medway	43	To effectively realise Medway's role within the Thames Gateway and associated growth requirements primarily through effective physical regeneration, the reuse of previously developed land and the protection and enhancement of the area's many natural and heritage assets.				■			■						2b. Flood risk management strategies that are able to offer benefits across regeneration areas rather than just individual sites will help to achieve Medway's goal of effective physical regeneration; 3b. Consideration should be given to the use of brownfield sites for flood mitigation measures which will benefit the environment by reducing the need for development of greenfield sites as well as aiding the physical regeneration of the area. Flood risk management strategy may also make it possible to develop sites that were previously non viable development options due to flood risk, helping to meet growth requirements
	44	To develop Chatham as a city centre of regional significance with its role complemented by thriving and attractive traditional town centres in Strood, Rochester, Gillingham and Rainham together with a network of strong neighbourhood centres serving local communities							■						3b. Consideration should be given to those flood mitigation measures that have the potential to improve local amenity, resulting in both social and economic benefits and thus helping Chatham and surrounding towns to develop. There may also be opportunities for environmental benefits depending on measures implemented
	45	To radically improve the quality of the townscape and public realm within the central urban area and along the urban waterfront							■						3b. Consideration should be given to those flood mitigation measures that have the potential to improve local amenity, resulting in both social and economic benefits and thus helping to enhance the townscape. There may also be opportunities for environmental benefits depending on measures implemented
	46	To enhance the quality of life of local people through the promotion of healthier lifestyles and the provision of improved cultural, leisure and tourism facilities, including along the river Medway.							■						3b. Consideration should be given to the provision of green space by the use of SUDS as a flood mitigation measure which would benefit local amenity and the environment, making outdoor space more attractive and therefore helping to promote healthier, more active lifestyles. It could also attract economic benefits from increased tourism

Source Document		Wider Environmental Objectives	Flood Risk Management Objectives												Comments
			1a	1b	2a	2b	2c	3a	3b	3c	4a	4b	5a	5b	
Environment and Front Line Services Overview and Scrutiny Committee	47	To ensure prudent use of land and other resources							■						3b. Consideration should be given to the impacts of flood mitigation strategies upon land usage. Where possible, non-structural methods (e.g. improved planning and forecasting etc) should be implemented to reach flood management targets without the need for construction. Where structural measures are required, SUDS could be used to control flooding while maintaining the green nature of the land. They also require minimal raw materials in comparison to 'harder' more engineered techniques
	48	To reduce greenhouse gas emissions		■					■						1a. Certain flood mitigation measures will have varying effects on the volumes of greenhouse gases produced (mainly from the construction phase) and as such, varying contributions towards climate change. This should be considered when producing a flood management policy; 3b. Climate change has a marked effect on the environment and any contributions to greenhouse gases from flood management schemes should be considered before implementation
	49	To minimise air quality impacts							■						3b. The implementation of SUDS over 'harder' flood mitigation methods could help to maintain levels of green space in the area that would contribute towards improved air quality
	50	To conserve landscapes and townscapes					■		■						2c. Ensuring that new development does not increase current flood risk will ensure that land/townscapes will remain protected in the future; 3b. Flood management measures can help to protect town and landscapes from flood damage and at the same time add extra social and environmental benefits by improving amenity and green space. Non-structural methods that do not impact on the land/townscape should also be considered (however this maybe a missed opportunity to make improvements rather than just avoiding degradation).
	51	To protect local amenity	■				■		■						1a. Cooperation with all stakeholders will help to assess the views of what contributes to local amenity so that it can be effectively protected; 2c. Ensuring that new development does not increase current flood risk will ensure that amenity sites in Medway will remain protected in the future; 3b. Flood mitigation measures can be used to maintain the green nature of areas that add amenity value. Using the correct measures can not only protect local amenity but may also be able to improve it
	52	To minimise adverse effects on water quality							■						3b. The use of SUDS can lead to environmental benefits from improved water quality by acting as a filtration treatment stage. This also has an economic benefit as water will not require as much treatment by water companies
	53	To minimise local transport impacts							■	■					3b. Flood mitigation measures can be used to protect transport infrastructure leading to economic benefits derived from less damage and also from a reduction in loss of economic activity from people unable to travel due to flood waters; 3c. Reducing flood effects on transport networks could be realised by implementing flood measures as part of general infrastructure improvements works that could also benefit the wider area
	54	To provide employment opportunities							■						3b. Social benefits could be derived from the creation of employment opportunities in the process of designing, constructing and maintaining flood mitigation measures
	55	To provide opportunities for public involvement / education	■						■		■	■			1a. Engaging with all stakeholders including the public is key to ensuring the flood risk situation in the area is fully understood which is vital when designing a management strategy; 3b. During the planning stages, consultation with the public should be offered to help to assess the social impacts of flood management schemes on residents as well as any economic impacts to local businesses; 4a. Sharing of information between the council and the public is important for ensuring that the public feel involved and fully understand the proposals so that consultation is effective and efficient; 4b. Increasing public awareness of flood risk will help to educate the public so that they can take steps to better protect themselves in the event of a flood
	56	To minimise costs of waste management													
	57	To ensure reliability of delivery													
	58	To conform with waste policy													

9 Review and Update

9.1 Overview

9.1.1 It is proposed that at a minimum, a review of the strategy should take place every six years to coincide with the requirement under the Flood Risk Regulations 2009 to revise the Preliminary Flood Risk Assessment and flood risk and hazard maps.

9.1.2 As a result of recent legislation and new roles and responsibilities of LLFA's, there are likely to be many changes to the way flood risk is managed. The strategy should be viewed as a dynamic strategy and some updates may need to be produced to recognise those changes.

9.1.3 Potential triggers include:

- Occurrence of a significant and widespread surface water flood event.
- Additional data or modelling becoming available which may alter the understanding of risk within the study area.
- If the outcome of investment decisions by partners is different to the preferred option which may require a revision to the action plan.

9.1.4 To complement the strategy, annual action plans will be produced in conjunction with other Risk Management Authorities and will include;

- A report of any changes and amendments deemed necessary
- An overview of the newest information available about local flood risk.
- Actions required to satisfy legislation within the forthcoming year
- Actions from Surface Water Management Plans
- Other flood risk management activities, which will be undertaken by Medway Risk Management Authorities in the current year.

9.2 Democratic input

Regeneration, Community and Culture

9.2.1 The Regeneration, Community and Culture Overview and Scrutiny Committee are the relevant scrutiny committee for flood and coastal erosion risk management. The committee plays a key role in developing and reviewing policy and holding the cabinet to account through a facility to call-in cabinet decisions for review or undertaking pre-decision scrutiny. It represents one of the most important ways in which Councillors can influence council policy and champion their constituents.

9.2.2 The FWMA 2010 amends the Local Government Act 2000 to include arrangements to review and scrutinise the flood management and coastal erosion risk management functions of Risk Management Authorities which may affect the Local Authorities area. The strategy will therefore be reviewed via that democratic process.

Regional Flood and Coastal Committees (Southern Regional Flood and Coastal Committee)

9.2.3 Regional Flood and Coastal Committees scrutinise the Environment Agency's work. Medway is within the Southern Region Regional Flood and Coastal Committee and has one Member on the committee from a total membership of 14. The committee is also responsible for administering the local levy, which is a fund paid into each authority in the region according to the number of Band D properties in the authority. The local levy is described in 7.2.6.

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Glossary

Annual Exceedance Probability (AEP)

The average probability of a rainfall event occurring in any given year.

Catchment Flood Management Plan

A high-level planning strategy through which the EA works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.

Civil Contingencies Act

This Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums must put into place emergency plans for a range of circumstances including flooding.

Climate Change

When included as part of a flood event return period scenario, it means that that scenario includes the anticipated affects of climate change. For rainfall events, it incorporates a 30% increase. These climate change values are based upon information within the NPPF and PPS25 Practice Guide.

FCERM

Flood and Coastal Erosion Risk Management

Flood and Water Management Act (FWMA)

Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.

Flood Hazard

The derivation of flood hazard is based on the methodology in Flood Risks to people FD2320 using and is a function of flood depth, flow velocity and a debris factor.

Flood Map for Surface Water (FMfSW)

National surface water flood risk mapping published by the EA. This dataset provides an indication of the broad areas likely to be at risk of surface water flooding during the 0.5% and 3.3% AEP rainfall events.

Flood Risk Regulations 2009 (FRR 2009)

Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.

IDB

Internal Drainage Board

Lead Local Flood Authority (LLFA)

Lead Local Flood Authority in relation to an area in England means the unitary authority for the area, or if there is no unitary authority, the county council for the area (as defined by the FWMA).

LiDAR

Light Detection and Ranging data is obtained from an airborne survey technique that uses a laser to measure the distance between an aircraft and the ground surface.

Local Flood Risk Management Strategy (LFRMS)

A strategy for the management of local flood risk (that from surface water, groundwater and ordinary watercourses), to be developed, maintained, applied and monitored by the LLFA, as a duty under the FWMA.

Local Resilience Forum

A multi-agency forum, bringing together all the organisations that have a duty to cooperate under the Civil Contingencies Act, and those involved in responding to emergencies. They prepare emergency plans in a co-ordinated manner.

National Receptor Database (NRD)

A collection of risk receptors produced by the EA.

Ordinary Watercourse

All watercourses that are not designated Main River, and which are the responsibility of Local Authorities or, where they exist, IDBs

Ordnance Survey Master Map (OSMM)

OS Master Map is highly detailed mapping including individual buildings, roads and areas of land according to land use categories. The data is presented in GIS as polygon and line data.

Pitt Review

Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.

Pluvial modelling

Flooding from water flowing over the surface of the ground; often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow.

Preliminary Flood Risk Assessment (PFRA)

A report required under the FRR 2009 for each LLFA administrative area, detailing information on past and future (potential) floods, and identifying Flood Risk Areas. LLFAs are only required to undertake a PFRA for local sources of flooding, which principally includes surface water, groundwater and ordinary watercourses.

Risk Management Authority (RMA)

Organisation that has a key role in flood and coastal erosion risk management as defined by the Flood and Water Management Act 2010. These include the EA, lead local flood authorities, district councils where there is no unitary authority, internal drainage boards, water companies and highways authorities.

Regional Flood and Coastal Committee (RFCC)

Established by the EA under the FWMA and takes the place of the Southern Regional Flood Defence Committee (RFDC). It brings together members appointed by LLFAs and independent members with relevant experience for the purpose of effective flood risk management.

Risk

In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.

SEA

Strategic Environmental Assessment

Stakeholder

A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.

Surface Water

Rainwater (including snow and other precipitation) that is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.

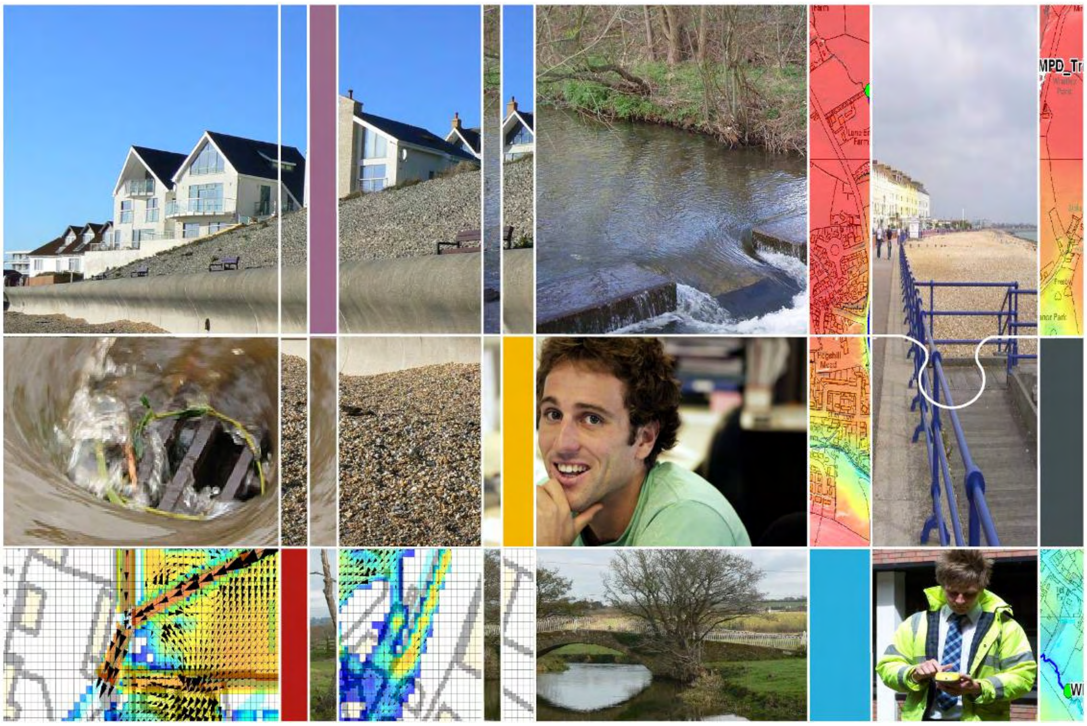
TuFLOW

TuFLOW is a modelling package for simulating depth averaged 2D free-surface flows and is in widespread use in the UK and elsewhere for 2D inundation modelling.

Appendix 1 – Pluvial Modelling Methodology

Medway Council
Serving You

Commission reference: LA020



Medway Council Local Flood Risk Management Strategy

Technical Appendix 1: Pluvial Modelling Methodology (Final Report)

October 2013

CAPITA SYMONDS | URS
Flood Risk Management

Document overview

Capita Symonds with URS Infrastructure and Environment UK Ltd was commissioned by Medway Council in the preparation of their Local Flood Risk Management Strategy as required under the Flood and Water Management Act 2010.
This report details the methodology for the pluvial modelling carried out as part of this study.

Document history

Version	Status	Issue date	Prepared by	Reviewed by	Approved by
1	Draft	Aug 2012	Edward Byers Graduate Consultant Sarah Littlewood Assistant Consultant	Stephen Riley Principal Consultant Jon Robinson Technical Director	Jon Robinson Technical Director Scott Ferguson Technical Director
2	Final Draft	October 2013	Emily Craven Principal Consultant Edward Byers Assistant Consultant	Tom Edward Senior Consultant	Jon Robinson Technical Director

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1. Introduction

1.1 Project background

1.1.1 The Flood and Water Management Act[1] (FWMA) designates Medway Council as a Lead Local Flood Authority (LLFA) and requires Medway Council to develop, maintain and apply a Local Flood Risk Management Strategy (LFRMS) ("the Strategy") for its administrative area. Over time, Medway Council will use this Strategy to increase their understanding of local flooding issues (from surface water, groundwater and ordinary watercourses), and improve the management of local flood risk. Therefore, in order to inform the Strategy, it is necessary for Medway Council to undertake an assessment of the level of flood risk across the Council's administrative area.

1.1.2 In addition to this duty under the FWMA, one of the requirements of the Flood Risk Regulations 20092 (FRR 2009) is the preparation of flood risk and flood hazard maps for relevant sources of flooding by December 2013.

1.1.3 In light of these two requirements, direct rainfall modelling using TuFLOW software has been undertaken across the Council's administrative area in order to gain an improved understanding of the risk of flooding resulting from heavy rainfall and overland flow. This is also referred to as pluvial flooding.

1.1.4 This document provides a record of the approach and methodology that has been adopted for the pluvial modelling across Medway Council's administrative area. As such it forms a supporting document to Medway Council's LFRMS[3].

1.2 Study objectives

1.2.1 The aim of pluvial modelling is to determine the risk of pluvial flooding across the Council's administrative area. This will be achieved through the following objectives:

1) Apply rainfall events of known probability directly to the ground surface to provide an indication of potential flow path directions and velocities and areas where surface water will pond;

2) Undertake verification of pluvial modelling results based on historic flood records held by the Council, site visits and local knowledge;

[1] HMSO and the Queen's Printer of Acts of Parliament (2010) Flood and Water Management Act
[2] HMSO and the Queen's Printer of Acts of Parliament (2009) Flood Risk Regulations
[3] Capita Symonds / URS (August 2012) Medway Council Local Flood Risk Management Strategy (DRAFT)

3) Undertake sensitivity analysis to provide an indication of the level of confidence that can be placed in the model results;

4) Prepare maps to show the maximum flood depths for each modelled return period;

5) Prepare maps to show the corresponding flood hazard ratings (a function of both the depth and velocity of floodwater) for each modelled return period.

1.3 Previous studies

Environment Agency Flood Map for Surface Water

1.3.1 The Environment Agency (EA) have undertaken national surface water flood risk mapping and prepared the Flood Map for Surface Water (FMfSW) dataset. This dataset provides an indication of the broad areas likely to be at risk of surface water flooding during the 0.5% Annual Exceedance Probability (AEP) event and the 3.3% AEP event. For each event, the FMfSW identifies those areas that experience flooding greater than 0.1m, and those areas modelled to experience flooding of greater than 0.3m.

1.3.2 The TuFLOW pluvial modelling undertaken to support the LFRMS for Medway Council will build upon this the FMfSW national modelling and seeks to provide a model with an improved level of accuracy with assumptions based on the local conditions rather than national assumptions.

Medway Council Preliminary Flood Risk Assessment

1.3.3 In accordance with the requirements of the FRR 2009, Medway Council prepared a Preliminary Flood Risk Assessment[4] (PFRA) for their administrative area in 2011. The PFRA contains information regarding past and future (potential) floods from local sources of flooding, which principally includes surface water, groundwater and ordinary watercourses. Historic flood records held by the Council as well as those included within the PFRA report will be used to verify the pluvial modelling results.

[4] Medway Council (2011) Preliminary Flood Risk Assessment Report

2. Model Build and Simulation

2.1 Modelling approach (choice of software)

2.1.1 TuFLOW software has been used to undertake the modelling assessment. TuFLOW is a modelling package for simulating depth averaged 2D free-surface flows and is in widespread use in the UK and elsewhere for direct rainfall modelling. All models have been run using TuFLOW build 2011-09-AF-iDP-w64.

2.1.2 Using this approach and software, rainfall events of known probability are applied directly to the ground surface and are routed overland to provide an indication of potential flow path directions and velocities and areas where surface water will pond.

2.2 Catchment characteristics and model extents

2.2.1 Medway is located in Kent, to the south of the Thames Estuary. The River Medway divides the administrative area in half, with the northern half comprising predominantly low lying rural marshland and scattered villages and the southern portion populated by the larger towns of Rochester, Chatham and Gillingham.

2.2.2 Due to the size of the study area (260km^2) it has not been possible to construct one model for the entire study area and retain a reasonable model resolution. As a result, five individual hydraulic models have been constructed to cover the administrative area of Medway Council. The extent of each of the models is based upon the natural catchments within Medway. Figure A.1 shows the boundaries of the models covering the Borough of Medway, along with the name of the model.

2.3 Model grid size

2.3.1 The five pluvial models have been constructed with a 5m grid size. This grid size was chosen as it represented a good balance between the degree of accuracy (i.e. ability to model overland flow paths along roads or around buildings) whilst maintaining reasonable model run ("simulation") times. For example, refining the grid size from a 5m grid to a 2m grid is likely to increase each model simulation time from 30 hours to approximately 11 days.

2.4 Topographic representation

2.4.1 Light Detecting and Ranging Data (LiDAR) was used as the base information for the model topography across the majority of the study area. LiDAR data is an airborne survey technique that uses a laser to measure the distance between an aircraft and the ground surface.

2.4.2 The EA LiDAR data covering the majority of the study area from their archive dataset that contains digital elevation data derived from surveys carried out since 1998. Some of the coverage has a resolution of 1m and the remainder, primarily to the north-west of the River Medway, 2m, and the vertical accuracy is typically +/-150mm. LiDAR data is provided in two formats:

- Digital Surface Model (DSM), which includes vegetation and buildings; and
- Digital Terrain Model (DTM), which is filtered to remove the majority of buildings, structures and vegetation.

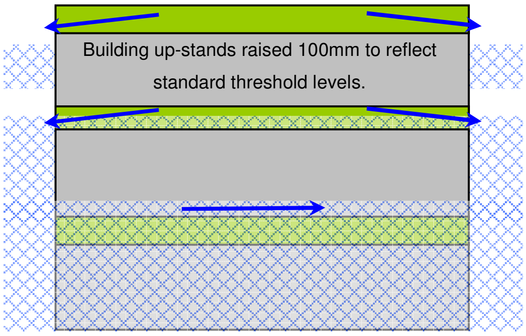
2.4.3 For the purpose of this study, the Digital Terrain Model (DTM) was used to represent the 'bare earth' elevation, with buildings, structures and vegetation removed. This is a conservative assumption as in reality these items would obstruct flood flows, thus potentially impacting on flood velocity and depth.

2.4.4 LiDAR data was not available for a small part of the study area. DTM data was purchased from GeoPerspectives for these areas which are identified on Figure A.1. This data has a resolution of 5m and the stated vertical accuracy is +/-1500mm.

2.4.5 Following initial model runs is was apparent that model instability occurred in a number of areas with sudden changes in topography such as the cliffs association with disused chalk pits in Frindsbury as well as Bores Hole near Cuxton, and the disused moat associated with Fort Amherst and Prince William's Bastion in Chatham. The ZSHP function in TuFLOW was used to smooth the changes in topography in these areas to improve the stability of the model. An example of the use of the ZSHP function for this purpose is shown in Figure A.2

2.5 Building representation

2.5.1 Building footprints have been represented in the model through the use of an 'up-stand' and higher roughness coefficients to mimic reduced conveyance through the footprints of the buildings. The 'up-stand' is derived based upon Ordnance Survey Master Mapping (OSMM) last revised in 2010, and is set at 100mm above the average ground level within each building footprint to represent the average threshold level of properties.



As the rainfall event begins, rainfall will fall onto the raised building pad and create flowpaths around the structure. The reduced Mannings (=0.015) is applied to the surface of the pad (only) to reduce any ponding occurring within the building pad itself and promote runoff from this area.

As the depth of flooding increased the Mannings of 0.015 is still being applied on the surface of the building pad until a depth of 30mm is attained.

As the depth of flooding increases, a high Manning's n value of 0.5 is then applied to the building to reflect the resistance to flow over the buildings pads surface (the low 0.015 is only applied the depths of flooding on the pad which are less than 30mm).

Building Pad Threshold = 100 mm
Area where variable Mannings roughness is applied = 30mm
Floodwater

Figure 2.1 Representation of buildings

2.6 Structures

2.6.1 In some parts of the model domain, it was necessary to modify the representation of the topography from that produced from the LiDAR data alone. Two approaches have been used to amend the topographic representation and to model structures in the model domain.

2.6.2 Structures within the study area which were modelled in the 2D domain include larger features such as rail or road overpasses, for example where roads pass underneath the rail line running from Chatham to Rochester, or where Claremont Way passes under New Road (A2) in Chatham. The structures were represented by using the ZLN or ZSHP function in TuFLOW which allows the user to specify the dimensions of the feature. Invert levels were determined by inspecting the LiDAR DTM. The widths of these features were either measured on site visits, from aerial photography, or from the LiDAR DTM.

2.6.3 The 2D domain has a grid size of 5m, and therefore it is not possible to accurately represent smaller structures and features using this approach. As a result, ESTRY has been used to represent these elements in a 1D domain linked to the 2D model domain. As opposed to a 2D representation of such structures, a 1D representation allows the width of the structure to be specified without being limited to grid size. Structures modelled in 1D using ESTRY include underpasses and culverts. For example in Gillingham, ESTRY was used to represent short sections of Pier Road and Medway Road where they pass under the rail line. ESTRY was also used for smaller structures, for example a pedestrian subway underneath Ito Way (A289), where it joins Sovereign Boulevard.

2.6.4 The dimensions of the structures were approximated from a review of aerial photography, observations made during the site walkover and interrogation of the DTM. Unlike structures modelled in 2D, rainfall is only allowed to enter the structure through the entrances of the structure and not from above.

2.6.5 Following the initial model simulations, a site walkover was undertaken for particular areas to verify the results. This identified further structures, such as culverts, that potentially have an influence on the propagation of surface water for inclusion within the models. The walkover informed the representation of structures already represented with the models.

2.7 Rainfall boundaries

2.7.1 The pluvial modelling is designed to analyse the impact of heavy rainfall events across Medway by assessing flow paths, velocities and catchment response.

2.7.2 In order to ensure that the worst case scenario is assessed and that the entire catchment is contributing to surface water runoff, the critical storm duration has been estimated.

2.7.3 In order to determine the rainfall profiles to be applied to the models, catchment descriptors for centre points of hydrological sub-catchments within each model area were exported from the Flood Estimation Handbook (FEH).

2.7.4 The Revitalised Flood Estimation Handbook (ReFH) method was used to carry out a high level investigation of critical storm duration for a number of distinct catchments within each model domain. Results indicated that critical storm duration varied greatly across model domains, even within a relatively small area. Ideally, model simulations would therefore be carried out applying a range of critical storm durations across the model domains.

2.7.5 However due to the large area to be modelled, approximately 267km^2, and the resultant long simulation times for 2D models, such an approach is not practical. Following the critical storm duration analysis, the decision was therefore taken to run all models with a single rainfall duration.

2.7.6 The range of critical storm durations for all models and sub-catchments was analysed and a single duration of 3 hours was selected, in order to represent a compromise between rainfall event duration and rainfall intensity across the modelled area.

2.7.7 The use of a 3 hour critical storm duration for all models also ensures consistency and comparability of model results across Medway District, and for practical purposes limits model run times to approximately 6 hours.

2.7.8 The Flood Map for Surface Water (FMfSW, 2010) and Areas Susceptible to Surface Water Flooding (SWtSWF, 2009) mapping applied critical storm durations of 1.1 hours and 6.5 hours respectively. The critical storm duration chosen for the Medway modelling therefore lies within the expected range for surface water modelling rainfall event durations, however it represents a different scenario to those modelled during previous studies.

2.7.9 Based on a critical storm duration of 3 hours (180 minutes), rainfall profiles (hyetographs) for the following rainfall events were generated:

- 3.3% AEP (1 in 30 year)
- 1% AEP (1 in 100 year) plus climate change (+30%)
- 0.5% AEP (1 in 200 year)

2.7.10 These were created by importing catchment descriptors and storm durations into the Rainfall Profile function of WinDes® software. The Rainfall Profile provides rainfall intensity (in mm/hr) for each minute of the storm. The Rainfall Profile function of WinDes® is unable to include an addition for climate change. Therefore, 30% (the figure provided within the Technical Guidance to the NPPF to account for climate change over the next 100 years) was added to the hyetograph.

2.7.11 Due to the decision to use a single critical storm duration across all model domains, sensitivity testing was carried out to provide an indication of the sensitivity of model output i.e. flood depths, to variation in the critical storm duration. This provides an indication of the influence of the choice of critical storm duration on model results. Further detail on the sensitivity testing carried out is provided in Section 2.12.

2.8 Runoff coefficients and drainage losses

2.8.1 Runoff coefficients have been applied to the rainfall profiles in order to represent the varying level of infiltration on different land use surfaces, therefore altering the input data directly. Table 2.1 shows the runoff coefficients that have been applied within the models based upon OSMM data land use categories.

2.8.2 In addition to variation in the rate of surface water runoff, the model also accounts for losses to the Southern Water surface water sewer network where it is present. Table 2.1 also includes details of the continuing losses to the drainage system, which is 12mm/hr based on best practice (EA FMfSW guidance doc).

Table 2.1 Runoff coefficients

OS Master Map Feature Code	Descriptive Group	Comment	Runoff Coefficient	Drainage - Continuous Loss (mm/hr)
10021	Building		0.9	12
10053	General Surface	Residential yards	0.5	12

OS Master Map Feature Code	Descriptive Group	Comment	Runoff Coefficient	Drainage - Continuous Loss (mm/hr)
10054	General Surface	Step	0.8	12
10056	General Surface	Grass, parkland	0.35	0
10062	Building	Glasshouse	0.95	12
10076	Land; Heritage And Antiquities		0.85	12
10089	Water	Inland	1	0
10111	Natural Environment (Coniferous/Non Coniferous Trees)	Heavy woodland and forest	0.2	0
10119	Roads Tracks And Paths	manmade	0.85	12
10123	Roads Tracks And Paths	tarmac or dirt tracks	0.75	12
10167	Rail		0.35	12
10172	Roads Tracks And Paths	Tarmac	0.85	12
10183	Roads Tracks And Paths (roadside)	Pavement	0.85	12
10185	Structures	Roadside structure	0.9	12
10187	Structures	Generally on top of buildings	0.9	12
10203	Water	foreshore	1	0
10210	Water	tidal water	1	0
10217	Land (unclassified)	Industrial Yards, Car Parks	0.85	12

2.9 Roughness coefficients

2.9.1 Given the shallow depths of flooding, in comparison to fluvial or tidal flooding, roughness values have an influence on the surface water flood flow paths and as such need to be represented accurately within pluvial models.

2.9.2 OSMM data has been used to specify varying Manning's roughness coefficients across the five models according to land use. The polygons contained in the Master Map dataset area were queried in MapInfo and the land uses have been split into groups, with a Manning's n roughness coefficient assigned to each land use category.

Table 2.2 Roughness coefficients

OS Master Map Feature Code	Descriptive Group	Comment	Manning's Roughness
10021	Building		0.015 (Depth <= 30mm) 0.500 (Depth > 30mm)
10053	General Surface	Residential yards	0.04
10054	General Surface	Step	0.025
10056	General Surface	Grass, parkland	0.03
10062	Building	Glasshouse	0.015 (Depth <= 30mm) 0.500 (Depth > 30mm)
10076	Land; Heritage And Antiquities		0.5
10089	Water	Inland	0.035
10111	Natural Environment (Coniferous/Non Coniferous Trees)	Heavy woodland and forest	0.1
10119	Roads Tracks And Paths	manmade	0.02
10123	Roads Tracks And Paths	tarmac or dirt tracks	0.025
10167	Rail		0.05
10172	Roads Tracks And Paths	Tarmac	0.02
10183	Roads Tracks And Paths (roadside)	Pavement	0.02
10185	Structures	Roadside structure	0.03
10187	Structures	Generally on top of buildings	0.5
10203	Water	foreshore	0.4
10210	Water	tidal water	0.035
10217	Land (unclassified)	Industrial Yards, Car Parks	0.035

2.10 Model scenarios and simulations

2.10.1 Table 2.3 sets out the model design runs that have been carried out for each of the five models as well as the suggested use for the outputs for each of the return periods. When considering climate change for rainfall events, a 30% increase has been applied. This is based upon information within the NPPF5 and PPS25 Practice Guide[6].

Table 2.3 Modelled scenarios and suggested use

Modelled Return Period	Suggested Use
3.3% AEP Probability of occurrence is 1 in 30 in any given year	Southern Water sewers are typically designed to accommodate rainfall event with a 3.3% AEP period or less. This GIS layer will help to identify areas that may be prone to regular flooding and could be used by highway teams to inform maintenance regimes.
1% AEP + climate change Probability of occurrence is 1 in 100 in any given year, plus a 30% allowance for climate change	The NPPF requires that the impact of climate change is fully assessed. Reference should be made to this flood outline by the spatial planning teams to assess the sustainability of future developments.
0.5% AEP Probability of occurrence is 1 in 200 in any given year	To be used by emergency planning teams when formulating emergency evacuation plans from areas at risk of flooding.

2.10.2 All models were initially run for six hours and then assessed to determine whether this duration was sufficient to allow full propagation of all surface water flow paths within each model. A six hour simulation time was considered appropriate for all five of the models.

2.11 Model stability

2.11.1 Assessing the stability of a model is a critical step in understanding the robustness of a model and its ability to simulate a flood event accurately. Stability in a TuFLOW model can be assessed by examining the cumulative error (or mass balance) of the model as well as the warnings outputted by the model during the simulation.

2.11.2 A review of the mass balance output files shows that the cumulative error of the models is largely within the recommended range of +/-5% for the majority of the simulation. High values

[5] CLG (March 2012) National Planning Policy Framework
[6] CLG (December 2009) Planning Policy Statement 25: Development and Flood Risk Practice Guide

are reported at the beginning of the rainfall event when the model cells first wet then settle down for the remainder of the simulation. The cause and location of the high cumulative errors was investigated by examining a number of other output files provided by TuFLOW. The high values were found to occur at isolated locations throughout the study area for a single timestep and were not found to persistently occur at a single cell. This suggests that the high cumulative error is a consequence of the initial wetting process at the start of the rainfall event. The high cumulative error values are therefore considered to have a negligible impact on the overall model results.

2.11.3 A number of warnings occur in all models. The warnings relate to areas of poor convergence, or in other words, where TuFLOW has had trouble finding a solution. The warnings were found to be spatially varied and non-persistent in time, which is a relatively common occurrence in these types of models. As the warnings were not found to repeatedly occur, these have a negligible impact on the overall model results and the model is considered fit for purpose.

2.12 Sensitivity analysis

2.12.1 Understanding the performance of a model is fundamental to the modelling process, as the fitness for purpose of a model must be demonstrated in order to apply confidence to the model results.

2.12.2 Calibration of the model is important to provide assurance that the model structure represents the study area appropriately. In the absence of suitable calibration data, greater emphasis should be placed on sensitivity testing of the model in order to gain understanding of the relationship between key input variables.

2.12.3 Uncertainties associated with numerical coefficients used to simulate 'real life' factors should be assessed in order to reinforce confidence in model outputs. If sensitivity testing shows that model outputs depend heavily on a particular factor, then further development of the model may be required to produce a more robust schematisation. Alternatively, the model outputs would require a caveat to make users of the results aware of the dependency on a particular factor.

2.12.4 In order to assess the magnitude of change arising from the sensitivity analysis, 30 points within the MED2 model domain have been selected and the change in depth arising from each test analysed. Placement of sensitivity testing points was based on location of flooding incidents recorded by Medway District Council between April 2001 and March 2011. Areas indicated as at risk from significant flooding by the baseline modelling were also deemed suitable testing points.

Storm Duration

2.12.5 Longer duration storms are generally characterised as featuring lower peak rainfall intensities in comparison to short duration storms within the same return period. Although a storm profile will feature a lower peak rainfall rate, sustained rainfall into a catchment area can highlight flooding mechanisms which would not come into force during a short duration event.

2.12.6 The variation of model outputs following changes to the critical storm duration, and therefore rainfall intensity, was examined. The 3 hour critical storm duration was chosen for the baseline modelling for all Medway models to ensure result consistency and comparability across the entire Medway district.

2.12.7 In order to determine the rainfall profile that should be applied to the MED2 model to test the sensitivity of the model outputs to critical storm duration, catchment descriptors for the centre point of the model area were exported from the Flood Estimation Handbook (FEH).

2.12.8 By importing the catchment descriptors into the Revitalised Flood Estimation Handbook (ReFH) a critical storm duration of 102 minutes (1.7 hours) was estimated for the MED2 model.

2.12.9 To examine the effect of storm duration on the model outputs sensitivity analysis was undertaken using the 1% AEP + CC storm event run with 3 and 1.7 hour rainfall profiles. The total rainfall depths applied for the 1.7hr and 3hr storm are 80.0mm and 88.9mm respectively. Figure 2.2 shows how the hyetograph for these different rainfall durations differs.

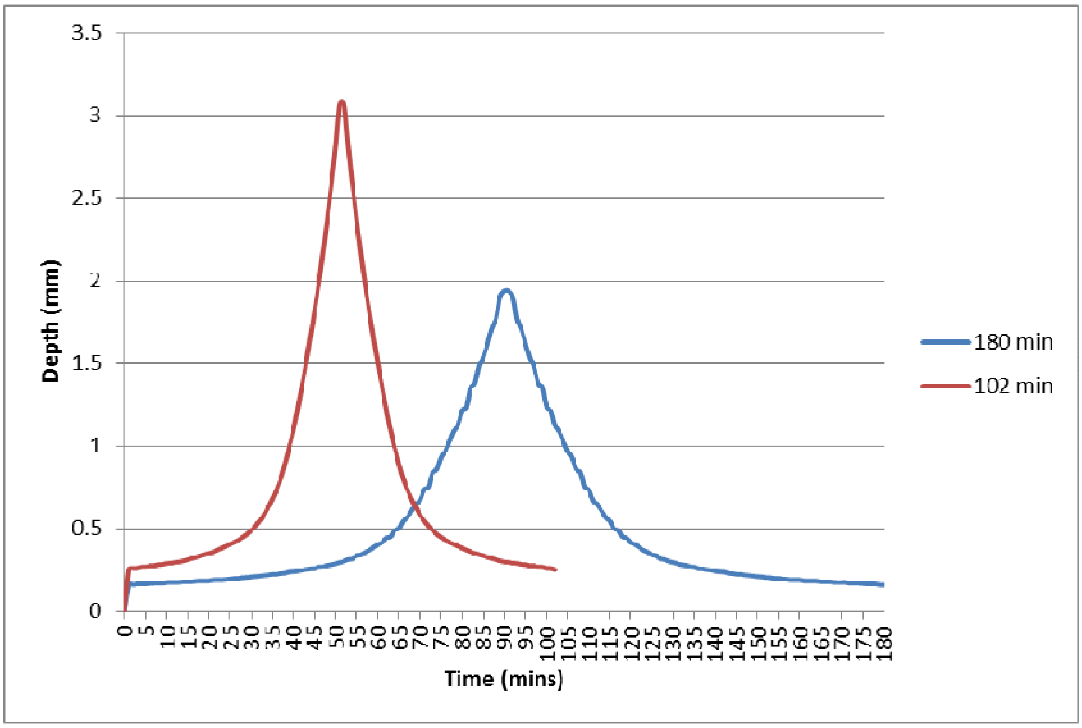


Figure 2.2: 100 year rainfall profiles (with an allowance for climate change) with varying storm duration

2.12.10 The flood extent and depth from the 1.7 hour rainfall event is generally greater than that of the 3 hour rainfall event. The assessment of the sensitivity testing locations shows a mean increase of peak flood depth of 0.03m (standard deviation 0.08). Of the 30 sensitivity testing locations, 5 experience a decrease in flood depths for the 1.7 hour rainfall event. Whilst the total rainfall depth applied to the model is greater for the 3 hour rainfall event, the rainfall intensity is far greater for the 1.7 hour event and therefore rainfall is input to the model more rapidly. The standard deviation of 0.08 indicates that the degree of change in flood depths does not vary significantly throughout the sensitivity testing locations.

Sensitivity Testing Conclusions

2.12.11 The sensitivity testing has highlighted that the model is relatively insensitive to changes in the critical storm duration. That is, changes in the rainfall profile result in minor variations in modelled flood depth. At 5 of the 30 sensitivity testing locations mean peak flood depth decreases for the shorter critical storm duration, indicating that the nature of changes in model outputs vary spatially throughout the model domain, though not to a great degree.

2.13 Calibration and verification data

2.13.1 The validity of each of the hydraulic models has been assessed using the following three sources of information:

- EA Flood Map for Surface Water Maps – A visual comparison of both data sets shows a good correlation between areas identified by the EA as being at greater risk of surface water flooding and pluvial modelling outputs
- Historic data provided by Medway Council representatives – Where available, historic flood records provided by the Councils have been plotted against pluvial modelling results
- Discussions with the Medway Council regarding pluvial modelling outputs

2.14 Model log

2.14.1 A completed Model Log and Quality Assurance form has been completed as part of the modelling process. The Model Log details the model build and the approach taken by the modeller, for example, details of the representation of specific structures and inclusion of specific boundaries within the models. The QA form documents URS' internal review of the models.

3. Model Results and Outputs

3.1 Maximum flood depth

3.1.1 The main output from the TuFLOW pluvial modelling is mapping of the maximum flood depth experienced across the study area. The maximum flood depth experienced at each cell across the model domain has been thematically mapped using the legend displayed in the following table. Maximum flood depth for the 3.3% AEP event has also been thematically mapped along with Medway District Council recorded flood incidents (Figure 3.1 of the main LFRMS report).

Table 3.1 Maximum Flood Depth Legend

	Maximum flood depth (m)
	< 0.1m
	0.1m to 0.25m
	0.25m to 0.5m
	0.5m to 1.0m
	1.0m to 1.5m
	> 1.5m

3.2 Flood hazard

3.2.1 Flood hazard is a function of both the flood depth and flow velocity at a particular location. The model outputs of flood depth and flow velocity (for each element in the model) were therefore used to determine flood hazard categories within the flood cell. Each grid cell within the TuFLOW model domain has been assigned one of four hazard categories: 'Extreme Hazard', 'Significant Hazard', 'Moderate Hazard', and 'Low Hazard'.

3.2.2 The derivation of these categories is based on Flood Risks to People FD2320[7], using the following equation:

$$\text{Flood Hazard Rating} = ((v+0.5)*D) + DF$$

(Where v = velocity (m/s), D = depth (m) and DF = debris factor)

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

[7] Defra, Environment Agency (2005) FD2320 Flood Risks to People

Table 3.2 Hazard categories based on FD2320, Defra & Environment Agency 2005

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

3.3 Flood risk to properties

3.3.1 A count of the indicative number of properties shown to be at risk from the pluvial modelling has been undertaken.

3.3.2 OSMM data was used to create a dataset of all the buildings with an area greater than 25m2 within the modelled study area. GIS analysis was undertaken to determine the average flood depth within each building footprint during each of the modelled return periods. The EA National Receptor Dataset (NRD) was then queried against the buildings layer to determine the number of address points within each building footprint as well as the classification of the property based on MCM Codes (MCM Codes can be found in Appendix 3.1 of the Multi-Coloured Manual8).

3.3.3 This information was then used to provide counts for the following criteria during the 0.5% AEP (1 in 200 year) modelled flood event:

- No. of residential properties at risk of flooding to a depth equal to or greater than 0.1m
- No. of non-residential properties at risk of flooding to a depth equal to or greater than 0.1m
- No. of residential properties at risk of flooding to a depth equal to or greater than 0.5m
- No. of non-residential properties at risk of flooding to a depth equal to or greater than 0.5m

3.3.4 The results are presented in the following table.

[8] Flood Hazard Research Centre (2010) Multi-Coloured Manual

Table 3.3 Property and infrastructure at risk of pluvial flooding

Receptor	At risk of flooding to a depth of ≥ 0.1m during the 0.5% AEP modelled rainfall event	At risk of flooding to a depth of ≥ 0.3m during the 0.5% AEP modelled rainfall event
Residential	14,200	2,200
Commercial / Industrial	700	300
Infrastructure	100	0
Other	0	0
Unclassified	9,300	2
Total	24,300	4,500

Notes:

1. The EA National Receptor Database (NRD) has been used to identify receptors at risk of flooding. The type of receptor has been identified based on definitions (MCM Codes) within Appendix 3.1 of the Multi-Coloured Manual and divided into sub-categories.
2. Building thresholds have been represented in the modelling as 'up-stands', raised 100mm above the average ground level within the building footprint. A depth of >0.1m will result in a flood level of 0.1m above the property threshold.

3.4 Model uncertainty

3.4.1 Model validation can provide an indication of the uncertainty associated with modelled flood depths through comparison with previous modelled data, recorded flood incidents, and discussion with local stakeholders. Details of information used in the validation process are provided in Section 2.13.

3.4.2 Sensitivity testing allows analysis of the influence of model parameters on outputs.

3.4.3 Uncertainty in model outputs arises through the use of numerical coefficients used to simulate 'real life' factors. The selection of model parameters to represent such factors is necessary in the absence of appropriate data to inform aspects of the model.

3.4.4 Model parameters can potentially have a large impact on the model outputs, thereby impacting on confidence in model results. Sensitivity testing allows analysis of the impact of such parameters, through identification of the variation of model outputs as model parameters are varied one at a time. This analysis has been discussed in Section 2.12.

4. Conclusions and Recommendations

4.1.1 The pluvial modelling undertaken to inform the LFRMS for Medway Council represents a strategic approach to identify areas at risk of pluvial flooding. It represents a significant refinement on the previously available information on surface water flooding across the Medway Council administrative area. The models and their mapped results should only be used in conjunction with the information set out in this technical appendix. Recommendations for future improvements to the models include (but are not limited to) the following:

- Explicitly model the existing drainage network in key areas of risk, as opposed to a study area - wide assumption on drainage capacity
- Inclusion of survey data for critical structures
- Inclusion of river flows and channel capacity (where applicable)
- Reduction in model grid size in key areas of risk
- Further testing of different storm durations
- Inclusion of defacto defences outside of the scope of the current project (e.g. assets identified through the Asset Register process)
- The use of better quality or more up to date topographic information particularly in areas of recent development and where the most accurate LiDAR was not available.

Glossary

Annual Exceedance Probability (AEP)

The average probability of a rainfall event occurring in any given year.

Above Ordnance Datum (AOD)

The standard datum which topographic levels are quoted relative to throughout the study area.

Climate Change

When included as part of a flood event return period scenario, it means that that scenario includes the anticipated affects of climate change. For rainfall events, it incorporates a 30% increase. These climate change values are based upon information within the NPPF and PPS25 Practice Guide.

Culvert

A channel or pipe that carries water below the level of the ground.

Digital Terrain Model (DTM)

Digital representation of ground surface topography

ESTRY

ESTRY, which is a part of the TUFLOW software, is a 1D network dynamic flow software suitable for mathematically modelling floods and tides (and/or surges).

Flood and Water Management Act (FWMA)

Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.

Flood Hazard

The derivation of flood hazard is based on the methodology in Flood Risks to people FD2320 using and is a function of flood depth, flow velocity and a debris factor.

Flood Map for Surface Water (FMfSW)

National surface water flood risk mapping published by the EA. This dataset provides an indication of the broad areas likely to be at risk of surface water flooding during the 0.5% and 3.3% AEP rainfall events.

Flood Risk Regulations 2009 (FRR 2009)

Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.

Lead Local Flood Authority (LLFA)

Lead Local Flood Authority in relation to an area in England means the unitary authority for the area, or if there is no unitary authority, the county council for the area (as defined by the FWMA).

LiDAR

Light Detection and Ranging data is obtained from an airborne survey technique that uses a laser to measure the distance between an aircraft and the ground surface.

Local Flood Risk Management Strategy (LFRMS)

A strategy for the management of local flood risk (that from surface water, groundwater and ordinarywatercourses), to be developed, maintained, applied and monitored by the LLFA, as a duty under the FWMA.

National Receptor Database (NRD)

A collection of risk receptors produced by the Environment Agency.

Ordnance Survey Master Map (OSMM)

OS Master Map is highly detailed mapping including individual buildings, roads and areas of land according to land use categories. The data is presented in GIS as polygon and line data.

Pluvial modelling

Flooding from water flowing over the surface of the ground; often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow.

Preliminary Flood Risk Assessment (PFRA)

A report required under the FRR 2009 for each LLFA administrative area, detailing information on past and future (potential) floods, and identifying Flood Risk Areas. LLFAs are only required to undertake a PFRA for local sources of flooding, which principally includes surface water, groundwater and ordinary watercourses.

TuFLOW

TuFLOW is a modelling package for simulating depth averaged 2D free-surface flows and is in widespread use in the UK and elsewhere for 2D inundation modelling.

A. Appendix A – Study Area Mapping

Figure A.1 Study Area, LiDAR Topographic Survey and Model Boundaries

Figure A.2 Example of topographic smoothing due to model instabilities

Figure A.3 OSMM Land Use Categories

Figure A.4 Losses to Southern Water drainage network based on OSMM land use categories

B. Appendix B – Maximum Flood Depth Mapping

Figure B.1 Maximum flood depth – 3.3% AEP event
(Figures B.1.a – B.1.l provide 1:20,000 scale coverage of the study area).

Figure B.2 Maximum flood depth – 1% AEP event including 30% climate change allowance
(Figures B.2.a – B.2.l provide 1:20,000 scale coverage of the study area).

Figure B.3 Maximum flood depth – 0.5% AEP event
(Figures B.3.a – B.3.l provide 1:20,000 scale coverage of the study area).

C. Appendix C – Flood Hazard Mapping

Figure C.1 Flood hazard rating – 3.3% AEP event
(Figures C.1.a – C.1.l provide 1:20,000 scale coverage of the study area).

Figure C.2 Flood hazard rating – 1% AEP event including 30% climate change allowance
(Figures C.2.a – C.2.l provide 1:20,000 scale coverage of the study area).

Figure C.3 Flood hazard rating – 0.5% AEP event
(Figures C.3.a – C.3.l provide 1:20,000 scale coverage of the study area).

D. Appendix D – Sensitivity Analysis

Table D.1 – Sensitivity Analysis - 1.7 hour Critical Storm Duration 1% AEP event including 30% climate change allowance

(Figures D.1.a – D.1.l provide 1:20,000 scale coverage of the study area).

Figure D.1 – Sensitivity Analysis - 1.7 hour Critical Storm Duration 1% AEP event including 30% climate change allowance

Table D.1 Sensitivity Analysis. Comparison of 3 hour (baseline) and 1.7 hour (sensitivity test) storm duration, 1% AEP event including 30% climate change allowance.

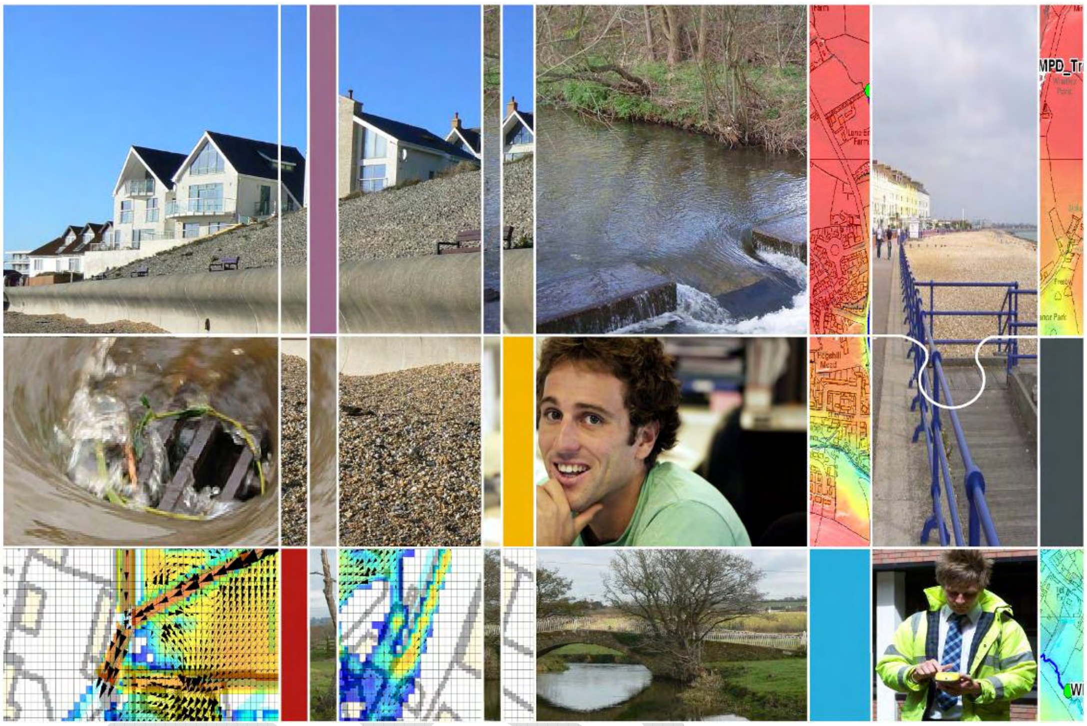
Sensitivity Test Point	Maximum flood depth (m)		Difference (sensitivity test - baseline)	
	3hr rainfall event (baseline)	1.7hr rainfall event (sensitivity test)	(m)	%
ST_Location_01	1.86	1.92	0.06	3.2
ST_Location_02	1.24	1.30	0.06	4.8
ST_Location_03	1.86	1.89	0.03	1.6
ST_Location_04	1.73	1.71	-0.02	-1.2
ST_Location_05	0.55	0.67	0.12	21.8
ST_Location_06	0.13	0.15	0.02	15.4
ST_Location_07	1.77	1.96	0.19	10.7
ST_Location_08	1.12	1.30	0.18	16.1
ST_Location_09	1.76	1.78	0.02	1.1
ST_Location_10	2.09	1.92	-0.17	-8.1
ST_Location_11	0.09	0.09	0.00	0.0
ST_Location_12	0.01	0.01	0.00	0.0
ST_Location_13	0.17	0.28	0.11	64.7
ST_Location_14	0.03	0.05	0.02	66.7
ST_Location_15	0.06	0.05	-0.01	-16.7
ST_Location_16	0.11	0.07	-0.04	-36.4
ST_Location_17	0.01	0.02	0.01	100.0*
ST_Location_18	0.00	0.02	0.02	100.0*
ST_Location_19	0.00	0.01	0.01	100.0*
ST_Location_20	0.01	0.03	0.02	200.0*
ST_Location_21	0.04	0.04	0.00	0.0
ST_Location_22	0.02	0.02	0.00	0.0
ST_Location_23	0.16	0.16	0.00	0.0
ST_Location_24	1.65	1.86	0.21	12.7
ST_Location_25	1.83	1.70	-0.13	-7.1
ST_Location_26	0.66	0.69	0.03	4.6
ST_Location_27	0.01	0.01	0.00	0.0
ST_Location_28	0.74	0.81	0.07	9.5
ST_Location_29	0.16	0.19	0.03	18.8
ST_Location_30	0.84	0.90	0.06	7.1
Mean			**0.03**	
Maximum			**0.21**	
Minimum			**-0.17**	
SD			**0.08**	

% difference values unrealistically highly due to the very shallow depth of flooding encountered.

Appendix 2 – Groundwater Assessment

Medway Council
Serving You

Commission reference: LA020



Medway Council Local Flood Risk Management Strategy

Technical Appendix 2:

High Level Assessment of Groundwater Flooding Susceptibility

Final Report

October 2013

CAPITA SYMONDS | URS
Flood Risk Management

Document overview

Capita Symonds with URS Infrastructure and Environment UK Ltd was commissioned by Medway Council in the preparation of their Local Flood Risk Management Strategy as required under the Flood and Water Management Act 2010.

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Document history

Version	Status	Issue date	Prepared by	Reviewed by	Approved by
1	Draft for client review	Jun 2012	Christopher Woolhouse Hydrogeologist	Stephen Cox Principal Consultant Stephen Riley Principal Consultant	Jon Robinson Technical Director Scott Ferguson Technical Director
2	Final	September 2013	Edward Byers Assistant Flood Risk Consultant	Emily Craven Principal Consultant	Jon Robinson Technical Director

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Glossary

TERM	DEFINITION
Aquiclude (or unproductive strata)	Formations that may be sufficiently porous to hold water, but do not allow water to move through them.
Aquifer (secondary and primary)	Layers of rock sufficiently porous to hold water and permeable enough to allow water to flow through them in quantities that are suitable for water supply. The Environment Agency has classified the bedrock and superficial geology aquifers as secondary or primary.
Aquitard	Formations that permit water to move through them, but at much lower rates than through the adjoining aquifers.
Climate Change	Long term variations in global temperature and weather patterns, caused by natural and human actions.
Flood defence	Infrastructure used to protect an area against floods, such as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floods and Water Management Act	Legislation constituting part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to help protect ourselves better from flooding, to manage water more sustainably and to improve services to the public.
Fluvial flooding	Flooding by a river or a watercourse.
Groundwater	Water that is underground. For the purposes of this study, it refers to water in the saturated zone below the water table.
Pluvial Flooding	Flooding as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity.
Risk	The product of the probability and consequence of the occurrence of an event.
Sewer flooding	Flooding caused by a blockage, undercapacity or overflowing of a sewer or urban drainage system.
Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques. The current study refers to the 'infiltration' category of sustainable drainage systems e.g. soakaways, permeable paving.

1. Introduction

1.1 Groundwater Flooding

1.1.1 Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from springs. This tends to occur after long periods of sustained rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by principal aquifers, although increasingly it is also being associated with more localised floodplain sands and gravels (secondary aquifers).

1.1.2 Groundwater flooding tends to occur sporadically in both location and time, and because of the more gradual movement and drainage of water, tends to last longer than fluvial, pluvial or sewer flooding. When groundwater flooding occurs, basements and tunnels can flood, buried services may be damaged, and storm sewers may become ineffective, exacerbating the risk of surface water flooding. Groundwater flooding can also lead to the inundation of farmland, roads, commercial, residential and amenity areas.

1.2 The Current Report

1.2.1 Medway Council is a designated Lead Local Flood Authority (LLFA) in accordance with the Flood and Management Act (FWMA) 2010. URS has been commissioned to prepare its Local Flood Risk Management Strategy (the 'strategy').

1.2.2 As part of the strategy this report provides a high level assessment of groundwater flooding susceptibility. The following sections outline the geology and hydrogeology in the Medway Council administrative area. From this analysis:

- Potential groundwater flooding mechanisms are identified;
- Evidence for groundwater flooding is discussed (if available);
- Areas susceptible to groundwater flooding are recognised; and
- Recommendations are provided for further investigation

2. Topography and Hydrology

2.1.1 The study area is defined by the administrative area of Medway Council, the Lead Local Flood Authority (LLFA), as shown in Figure 1.

2.1.2 The Hoo Peninsula forms the northern half of the administrative area (approximately 146 km2), largely comprising mud flats and marshlands that separate the Thames and Medway estuaries. The marshlands are close to sea level, although ground elevations are higher inland, reaching 74 maOD at Lodge Hill. A number of surface water courses drain the marshes including Cliffe Creek, Cliffe Fleet, Hope Fleet, Salt Fleet, Decoy Fleet and Yantlet Creek.

2.1.3 The Thames and Medway estuaries and the River Medway are the main surface water features in the administrative area. The tidal River Medway meanders southwest to northeast through the centre of the administrative area, with historic naval dockyards located at Rochester and Chatham.

2.1.4 The main towns of Rochester, Chatham and Gillingham form the southern half of the administrative area. The topographic highs approach 200 maOD and are located to the south near the M2 motorway, forming part of the North Downs. A dry chalk valley system runs northwest towards the tidal River Medway, with Chatham on the western slopes and Gillingham on the eastern slopes.

3. Geology

3.1.1 Figures 2 and 3 provide bedrock and superficial geological information for the administrative area of Medway Council and the surrounding area. Figure 4 presents a geological cross section that has been drawn as part of this study and is used to improve the hydrogeological conceptual understanding of the area.

3.2 Bedrock Geology

3.2.1 The bedrock geology in the study area is detailed in Table 3.1 in lithostratigraphical order, based on the BGS geological sheets 271 and 272. Where available, the regional thickness of the bedrock units is also presented based on the BGS Lexicon database (2012).

3.2.2 The main bedrock geology of the area comprises the Chalk Group of Cretaceous age, overlain by the Thanet Sand Formation (fine grained sand), Lambeth Group (clay mottled in part with beds of sand, pebbles and shells), Harwich Formation (sand with black flint pebbles) and London Clay Formation (clay, silty in part, sandy at the top and base).

3.2.3 The Chalk Group, which comprises several formations (Table 3.1), is found to outcrop at the surface across much of the southern half of the administrative area, along the North Downs. The largely undifferentiated Lewes Nodular Chalk, Seaford Chalk and Newhaven Chalk Formations (part of the White Chalk Subgroup) outcrop at Rochester, Gillingham and Chatham in the south, and also Cliffe on the Hoo Peninsula. Older Chalk formations, including the West Melbury Marly Chalk Formation, outcrop in the southwest corner of the administrative area near Upper Halling. In places the outcrop is obscured by superficial deposits (see Section 3.2).

3.2.4 The bedrock geology dips to the northeast, so that the younger Thanet Sand Formation and Lambeth Group outcrop in a northwest to southeast trending band across the centre of the administrative area, from Wainscott to Lower Rainham, respectively. A local syncline also causes these units to outcrop in the northwest of the administrative area around Cliffe. The outcrop is obscured in some areas by superficial deposits associated with the River Medway, Medway estuary and Thames estuary (see Section 3.2).

3.2.5 The London Clay Formation overlies the Lambeth Group and outcrops in the northern part of the administrative area on the Hoo Peninsula, including Chattenden and High Halstow, where superficial deposits are absent.

Table 3-1 – Bedrock Geology

Geological Units			Description	Regional Thickness
Eocene	London Clay Formation		Mixture of brown, grey, fine, sandy, silty clay and fine sand.	Up to 137m (up to 40m locally)
Paleocene to Eocene	Lambeth Group		Variable, component formations are Upnor Formation (glauconitic fine- to medium-grained sand with beds and stringers of well-rounded, black flint pebbles), Reading Formation (bluey, brown clay and sands) and Woolwich Formation (grey to grey-brown, interlaminated fine-grained sands, silts and clays).	Upnor Formation: 5 -6m Reading Formation: 12 - 16m Woolwich Formation: 11 – 12m Locally the Lambeth Group is up to 20m thick
Paleocene	Thanet Sand Formation		Fine grained sand, clayey and silty in the lower part, coarsening upwards.	21 – 40 m Approximately 37m locally
Cretaceous	White Chalk Subgroup	Newhaven Chalk	Soft to medium hard, smooth white chalks with marl seams and flint bands	45 – 75 m Not known locally
		Seaford Chalk	Firm white chalk with conspicuous semi-continuous nodular and tabular flint seams	55 – 60 m Not known locally
		Lewes Nodular Chalk	Hard, nodular, locally iron stained and flinty. Marl seams up to 0.1m are regular.	35 - 60m Not known locally
		New Pit Chalk Formation	Soft, smooth texture and massively bedded.	35 - 50 m Not known locally
		Holywell Nodular Chalk Formation	Nodular, gritty texture of broken shells. No flints	25 – 35 m Not known locally.
	Grey Chalk Subgroup	Zig Zag Chalk Formation	Marly, massively bedded chalk.	35 – 50 m Not known locally.
		West Melbury Marly Chalk Formation	Grey and off-white, soft, marly chalk and hard grey limestone	15 – 25 m Not known locally.

3.3 Superficial Deposits Geology

3.3.1 The superficial geology of the administrative area consists of Head, Alluvium, Beach and Tidal Flat Deposits, River Terrace Deposits and Clay with Flints Formation.

3.3.2 Head deposits form a significant outcrop in the study area, covering a large proportion of the Hoo Peninsula in the north, including the area of Cliffe, and from Allhallows to Hoo St Werburgh. There are exist ribbons of Head deposits associated with the Chalk valleys in the southern half of the study area. The geological map (Figure 3) for the area indicates that the deposits comprise clay, silt, sand and gravel. The thickness of the deposits is likely to be variable.

3.3.3 Significant Alluvium deposits occur at lower elevations on the Hoo Peninsula, associated with marshland. They also rest within the River Medway valley floor and form small islands within the Medway estuary. The deposits comprise mainly silty, peaty, sandy clay.

3.3.4 Beach and Tidal Flat Deposits are found along the northern coast of the Hoo Peninsula and within the Medway estuary. The deposits comprise mainly clay, silt and sand.

3.3.5 Patchy River Terrace Deposits formed of four terraces are located on the Hoo Peninsula in the area between Allhallows and Hoo St Weburgh, and on the Isle of Grain. Minor deposits can also be found near Wainscott and Gillingham. The River Terrace Deposits are predominantly sand and gravel, although near the edge of the Medway estuary at Hoo St Weburgh they comprise clay and silt.

3.3.6 On higher ground to the south of the study area around Chatham and Gillingham, the Clay with Flints Formation overlies the Chalk. The formation is described as, orange, brown sandy clay with abundant nodules and rounded pebbles of flint (BGS, 2012).

4. Hydrogeology

4.1.1 The hydrogeological significance of the various geological units within the study area is provided in Table 4.1. The range of permeability likely to be encountered for each geological unit is also incorporated in Table 4.1, based on BGS permeability data (BGS 2012b).

Table 4-1 – Geological Units in the Study Area and Hydrogeological Significance

Geological Unit	Table heading	Permeability (BGS)	Hydrogeological Significance (EA)
Superficial Deposits	Head	Very low – High	Secondary (Undifferentiated)
	Alluvium	Very low - Moderate	Secondary (Undifferentiated)
	Beach and Tidal Flat Deposits	Very low - Moderate	Secondary (Undifferentiated)
	River Terrace Deposits (sand and gravel)	High – Very High	Secondary (A) Aquifer
	River Terrace Deposits (clay and silt)	Very low – Low	Unproductive Strata
	Clay with Flints Formation	Very low – High	Unproductive Strata
Bedrock Geology	London Clay Formation	Very low – Low	Unproductive Strata
	Lambeth Group	Low – High	Secondary (A) Aquifer
	Thanet Sand Formation	Low – High	Principal Aquifer
	Chalk Group (except for West Melbury Chalk Formation and Zig Zag Chalk Formation)	Very High – Very High	Principal Aquifer
	Chalk Group (West Melbury Chalk Formation and Zig Zag Chalk Formation)	High – Very High	

The 'Hydrogeological Significance' is based on the Environment Agency (EA) classification:
'Principal Aquifer' - layers that have high permeability. They may support water supply and/or river base flow on a strategic scale.
'Secondary Aquifer (A)' - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.
'Secondary (Undifferentiated)' - Been assigned in cases where it has not been possible to attribute either category A or B to a rock type. Previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.
'Unproductive Strata' These are rock layers or superficial deposits with low permeability that have negligible significance for water supply or river base flow.

4.2 Bedrock Hydrogeology

Bedrock Hydrogeological Units

4.2.1 The Chalk Group is classified as a principal aquifer by the Environment Agency and permits groundwater flow. The aquifer underlies much of the southern half of the administrative area and forms an important groundwater resource, supporting a number of licensed groundwater abstractions and base flow to the River Medway. The Chalk Group is of significant interest to this current study.

4.2.2 The physical properties for minor aquifers in England and Wales (Jones et al., 2000) suggests the Thanet Sand Formation, Lambeth Group and the Harwich Formation are often considered as a single groundwater unit, which is in hydraulic continuity with the Chalk. The Environment Agency classifies the Thanet Sand Formation as a principal aquifer and the Lambeth Group as a secondary (A) aquifer; they are both of interest to this study.

4.2.3 The London Clay Formation, which underlies the majority of the Hoo Peninsula, is an aquiclude and does not permit groundwater flow. It is classed by the Environment Agency as unproductive strata.

Bedrock Groundwater Levels

4.2.4 Water level data have been provided by the Environment Agency for 13 observation boreholes within the study area, all of which monitor water levels in the Chalk Group. The observation borehole locations are shown on Figures 1, 2 and 3 and the water level plots are presented in Appendix A.

4.2.5 The longest monitoring record is for Ranscombe (EA Ref. 442141001), which dates back to August 1968. This indicates that the highest water levels were experienced in the winter of 2000/01, as demonstrated by many of the other local observation boreholes.

4.2.6 In the area of Cliffe on the Hoo Peninsula, the water table in the Chalk is close to sea level and influenced by local groundwater abstractions, reaching a maximum of around 2 to 3 maOD (see Appendix A for records at APCM Ltd, Simmonds Hole and Cooling Castle). Ground levels reach 13 maOD at Cliffe, although at the margins of the settlement they are close to, or at the same elevation as, the water table in the Chalk.

4.2.7 Within the tidal River Medway valley, water levels in the Chalk are also close to sea level as expected, reaching a maximum of around 3 maOD in the winter of 2000/01 (see Appendix A for records at Cuxton Meter House and Halling Sewage Works). Ground level at the observation boreholes was only around 0.5 to 1.5 m higher than the water table at that time.

4.2.8 The Dene Farm observation borehole monitors water levels within a dry tributary valley of the River Medway to the west of Cuxton, where ground levels are around 12 to 13 maOD. Although the water table is often at least 10 m below ground level and close to sea level, in the winter of 2000/01 it rose to within 2 or 3 m of ground level.

4.2.9 On higher ground within the southern half of the study area, the observation borehole records indicate that the water table is always at significant depth (see Appendix A for records at Brompton, Ranscombe, Sharstead and Wigmore Reservoir).

4.3 Superficial Deposits Hydrogeology

Superficial Deposits and Hydrogeological Units

4.3.1 The Head, Alluvium and Beach and Tidal Flat Deposits are expected to behave as aquitards, although sand and gravel horizons may locally form a perched aquifer depending on their lateral extent and thickness. The coastal and estuarine deposits are likely to be in some hydraulic continuity with the sea, and therefore groundwater levels are expected to demonstrate tidal fluctuations.

4.3.2 The River Terrace Deposits are expected to behave as a Secondary Aquifer (A) due to the dominance of sand and gravels; perched water tables will form within the deposits where they overlie the London Clay Formation aquiclude on the Hoo Peninsula.

Superficial Deposits and Water Levels

4.3.3 Medway Council and the Environment Agency do not monitor groundwater levels in the superficial deposits. However, borehole logs are available from the British Geological Survey and these often provide information on groundwater levels.

4.4 Groundwater / Surface Water Interactions

4.4.1 The published hydrogeological map (Figure 4) indicates that groundwater flow in the Chalk aquifer is towards the tidal River Medway and estuary systems. Therefore, the River Medway will receive significant base flow contributions from the Chalk aquifer.

4.4.2 The River Medway is tidal and much of the study area is estuarine or coastal. As sea and river levels rise and fall with the tides, this will have a local influence on the aquifers, and groundwater levels are expected to demonstrate a tidal response.

4.5 Groundwater Abstractions

4.5.1 The locations of licensed groundwater abstractions were requested from the Environment Agency and these are shown on Figures 1, 2 and 3. However, the larger public water supply abstractions are not shown for security reasons, although their source protection zones are provided on Figure 6.

4.5.2 The public water supply abstractions are located in the southern half of the study area. The smaller licensed abstractions are concentrated on the Hoo Peninsula, and provide irrigation water to farmland.

4.5.3 It is possible that in the future some of these abstractions may reduce or cease, either temporarily or for the longer term. If this occurs it is possible that water levels in the Chalk aquifer will increase, potentially increasing susceptibility to groundwater flooding in some areas.

4.6 Artificial Groundwater Recharge

4.6.1 Water mains leakage data for the Medway Council administrative area were not provided for this study. However it should be noted that recharge to groundwater by leaking mains could result in a local rise in groundwater levels. This rise might not prove significant under dry conditions, but could exacerbate the risk of groundwater flooding following and/or during periods of heavy rainfall.

4.6.2 The drainage/sewer network can act as a further source of artificial recharge. When pipes are installed within principal or secondary aquifers, the groundwater and drainage network may be in partial hydraulic connection. When pipes are empty, groundwater may leak into the drainage network with water flowing in through cracks and porous walls, draining the aquifer and reducing groundwater levels. During periods of heavy rainfall when pipes are full, leaking pipes can act as recharge points, artificially recharging the groundwater table and subsequently increasing groundwater levels with potential impacts on groundwater quality.

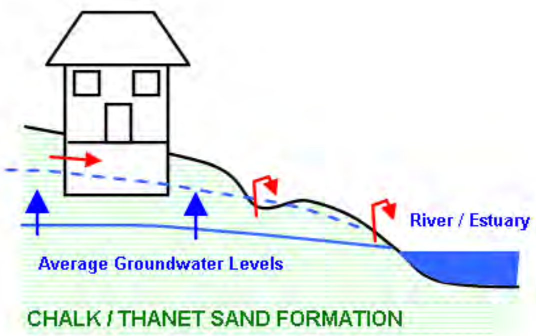
5. Assessment of Areas Susceptible to Groundwater Flooding

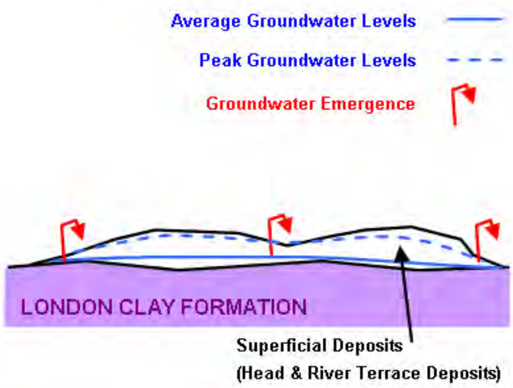
5.1 Groundwater Flooding Mechanisms

5.1.1 Based on the hydrogeological conceptual understanding of the study area, the key groundwater flooding mechanisms that may exist are:

- **Chalk Group and Thanet Sand Formation principal aquifers and Lambeth Group secondary A aquifer outcropping in the south of the study area at Rochester, Gillingham and Chatham, and on the Hoo Peninsula at Cliffe.** Environment Agency groundwater level data indicate a shallow water table in low lying areas, including the River Medway valley and its dry tributary valleys, and coastal / estuarine locations. Basements / cellars in these areas may be at risk from groundwater flooding after prolonged wet periods such as that experienced in the winter of 2000/01. In addition, groundwater springs could emerge within topographic depressions or near the base of tributary valleys that are usually dry (e.g. at Cuxton). Where superficial deposits such as Head and Alluvium overlie the bedrock aquifers (e.g. in the marshlands around Cliffe), these are likely to be in some hydraulic continuity with the bedrock aquifers so that groundwater flooding can still occur. However, the severity of the flooding is likely to be reduced.

- **Superficial deposits not in hydraulic continuity with bedrock aquifers, overlying the London Clay i.e. River Terrace Deposits and Head deposits on the Hoo Peninsula:** Perched water tables may develop within these deposits, through a combination of natural rainfall recharge and artificial recharge e.g. leaking water mains. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars following prolonged wet weather. Another potential impact is a temporary loss of agricultural land in low lying areas.





5.2 Evidence of Groundwater Flooding

5.2.1 No specific groundwater flooding incidents have been reported to Medway Council. However, the Environment Agency holds records for 83 generic flood incidents that occurred between 2001 and 2011. The cause of flooding is not identified, although 9 of the records are related to basement or cellar flooding and could therefore be associated with groundwater flooding. All of the recorded historic flood incidents are presented on Figures 2, 3 and 5 and those linked to basement or cellar flooding are numbered 1 to 9.

5.2.2 Flood Incidents 1 to 9 (basement / cellar flooding) are located over the Chalk Group or Thanet Sand Formation aquifers where superficial deposits are sparse. However, only flood incidents 1, 2, 5 and 8 are located in low lying areas where water levels are likely to be close to ground level. Therefore, it is believed that these have the greatest potential to be groundwater flooding events.

5.3 Areas Susceptible to Groundwater Flooding

BGS Groundwater Flooding Susceptibility Maps

5.3.1 The BGS has produced a dataset showing areas susceptible to groundwater flooding based on topography, geological and hydrogeological conditions (see Figure 5).

5.3.2 The main areas within the study area identified as having a 'very high' or 'high' susceptibility to groundwater flooding are the Hoo Peninsula (including Cliffe and the Isle of Grain), the River Medway valley, and the southern margins of the Medway estuary.

5.3.3 None of the historic basement or cellar flood events (labelled 1 to 9) are encompassed by zones of higher susceptibility to groundwater flooding. However, flood events 1, 2, 5 and 8 are close to these zones. This indicates that either the BGS groundwater flooding susceptibility zones may need to be revised, or that these flood events are not associated with groundwater flooding.

5.3.4 In general, based on the available data, it is thought that the approximate areas identified by the BGS as being susceptible to groundwater flooding are as expected. There is lower confidence in the dataset where the London Clay Formation is overlain by Head and River Terrace Deposits on the Hoo Peninsula, as the Environment Agency does not monitor groundwater levels in these superficial deposits.

5.3.5 It is also worth noting that the BGS dataset does not take into account rebound of groundwater levels. There exist a number of groundwater abstractors across the study area. It is possible that if certain key abstractions were reduced or switched off, the areas susceptible to groundwater flooding may increase.

6. Assessment of Areas Suitable for Infiltration SuDS

6.1 Definition of SuDS, Environment Agency Guidance and the Water Framework Directive

6.1.1 In recent times, the installation of sustainable drainage systems (SuDS) has been encouraged for new and existing developments with the aim of reducing overall flood risk. The Flood and Water Management Act 2010 provides a definition of sustainable drainage:

"Sustainable drainage" means managing rainwater (including snow and other precipitation) with the aim of –

- *reducing damage from flooding,*
- *improving water quality,*
- *protecting and improving the environment,*
- *protecting health and safety, and*
- *ensuring the stability and durability of drainage systems.*

6.1.2 Infiltration SuDS rely on infiltration of runoff (from a developed site) into the soil and underlying aquifer e.g. soakaways and permeable paving. They have the potential to impact water levels and water quality in the aquifer, and so the Water Framework Directive (WFD) must be considered.

6.1.3 The European WFD is implemented in England by the Environment Agency through River Basin Management Plans (RBMP). These documents were published by the Environment Agency in December 2009 and they outline measures that are required by all sectors impacting the water environment. They also identify water bodies across England and their current status.

6.1.4 The key RBMP groundwater body within the study area is the North Kent Medway Chalk (GB40601G500300). This is currently in poor status with respect to both chemical (owing to general chemical assessment and drinking water protected area status) and quantitative status (owing to impact on surface waters and resource balance).

6.1.5 Improper use of infiltration SuDS could lead to flooding / drainage issues and also contamination of the underlying superficial deposit or bedrock aquifers; the latter adding to the poor status of the North Kent Medway Chalk water body. However, correct use of infiltration SuDS is likely to help improve the chemical and quantitative status of the water body and reduce overall flood risk.

6.1.6 Environment Agency guidance on the appropriate design of infiltration SuDS is available on their website at: http://www.environment-agency.gov.uk/business/sectors/39909.aspx**.** This should be considered by developers and their contractors, and by Medway Council when approving or rejecting planning applications.

6.1.7 The following Sections provide an overview of the suitability for infiltrations SuDS within the Medway Council administrative area.

6.2 Infiltration SuDS Suitability Map

BGS Infiltration SuDS Suitability

6.2.1 The infiltration SuDS suitability map shown on Figure 6 is largely based on the BGS infiltration SuDS suitability dataset (BGS 2012c). It is understood from the BGS guidance notes that the dataset is derived from the following data:

- Infiltration constraints summary layer
- Superficial deposits permeability
- Superficial deposits thickness
- Bedrock permeability
- Depth to water level
- Geological indicators of flooding

6.2.2 Four score categories have been identified by the BGS for suitability for Infiltration SuDS:

1) **Highly compatible for Infiltration SuDS:** The subsurface is likely to be suitable for free-draining infiltration SuDS
2) **Probably compatible for Infiltration SuDS:** The subsurface is probably suitable for infiltration SuDS although the design may be influenced by the ground conditions
3) **Opportunities for bespoke infiltration SuDS:** The subsurface is potentially suitable for infiltration SuDS although the design will be influenced by the ground conditions
4) **Very significant constraints are indicated:** There is a very significant potential for one or more geohazards associated with infiltration

6.2.3 The areas delineated as 'Highly compatible for Infiltration SuDS' and 'Probably compatible for Infiltration SuDS' on Figure 6 are located over the Chalk Group and Thanet Sand Formation at Cliffe (on the Hoo Peninsula) and in the southern half of the study area. They are also associated with thick and permeable Head and River Terrace Deposits on the Hoo Peninsula.

6.2.4 It is noted that this is a high level assessment and only forms an approximate guide to infiltration SuDS suitability; a site investigation is required in all cases to confirm local conditions. The maximum likely groundwater levels should be assessed, to confirm that soakaways will continue to function even during prolonged wet conditions.

Historic Landfill Sites and Contaminated Land

6.2.5 Where possible, infiltration SuDS should be located away from areas of historic landfill (shown on Figure 6) and areas of known contamination or risk of contamination. This is to ensure that the drainage does not re-mobilise latent contamination and exacerbate the risk to groundwater quality and down gradient receptors, such as abstractors, springs and rivers. A preliminary groundwater risk assessment should be included with the planning application.

Source Protection Zones

6.2.6 Restrictions on the use of infiltration SuDS apply to those areas within Source Protection Zones (SPZ). Developers must ensure that their proposed drainage designs comply with the available Environment Agency guidance. The BGS infiltration SuDS suitability dataset does not consider SPZs and so these are shown on Figure 6.

7. Conclusions and Recommendations

7.1 Conclusions

7.1.1 The following conclusions can be drawn from the current study:

- The bedrock geology underlying the southern half and northwest corner of the study area comprises the Chalk Group and Thanet Sand Formation. Both are classified by the Environment Agency as principal aquifers and are therefore a potential source of groundwater flooding;
- The bedrock geology across much of the northern half of the study area comprises the London Clay Formation, which is unproductive strata with little potential for groundwater flooding. However, between Hoo St Werburgh and Allhallows the superficial geology, which overlies the London Clay Formation, includes Head and River Terrace Deposits. There is potential for a perched water table to develop within these and therefore potential for groundwater flooding.
- Groundwater level monitoring data have been provided by the Environment Agency for the Chalk Group principal aquifer. These indicate that groundwater levels are close to sea level, and at a shallow depth below ground level adjacent to the tidal River Medway, the Medway estuary and on the Hoo Peninsula at Cliffe;
- There are no groundwater level monitoring data available for the superficial deposits, including the Head and River Terrace Deposits on the Hoo Peninsula;
- Flood events data have been collated by the Environment Agency. Unfortunately the type of flooding is not identified, although a number of records are associated with flooding of basements / cellars and could be groundwater related, particularly those in low lying areas;
- Areas susceptible to groundwater flooding have been identified using the BGS groundwater flooding susceptibility dataset. The data indicate a ‘high’ or ‘very high’ susceptibility to groundwater flooding on the Hoo Peninsula (including Cliffe and the Isle of Grain), the River Medway valley, and the southern margins of the Medway estuary. There is a poor correlation between the BGS dataset and those flood events data associated with basement flooding. This indicates that either the BGS dataset needs to be refined, or the basement flood events were not caused by groundwater flooding;
- The BGS groundwater flooding susceptibility dataset does not take into account rebound of groundwater levels. It is possible that if certain key groundwater abstractions were reduced or switched off, the areas susceptible to groundwater flooding may increase;
- In recent times, the installation of sustainable drainage systems (SuDS) has been encouraged for new and existing developments with the aim of reducing overall flood risk. The BGS infiltration SuDS suitability dataset indicates that the areas ‘Highly compatible for Infiltration SuDS’ and ‘Probably compatible for Infiltration SuDS’ are located over the Chalk Group and Thanet Sand Formation aquifers at Cliffe (on the Hoo Peninsula) and in the southern half of

the study area. They are also associated with thick and permeable Head and River Terrace Deposits on the Hoo Peninsula;

- The BGS infiltration SuDS suitability dataset does not consider source protection zones associated with large public water supply abstractions. These are an additional constraint on the use of infiltration SuDS and have been identified as part of this study.

7.2 Recommendations

7.2.1 The following recommendations are made based on the current study:

- The areas identified as having a high susceptibility to groundwater flooding should be compared with those areas identified as being susceptible to other sources of flooding e.g. fluvial, pluvial and sewer. An integrated understanding of flood risk will be gained through this exercise
- Data identifying properties with basements / cellars should be used to improve the understanding of susceptibility to groundwater flooding, if available
- Records of possible groundwater flooding should be corroborated by Medway Council using current data on local groundwater levels and antecedent condition local to potential groundwater flooding events at the time of the event

8. References

Ref 1 - British Geological Survey. 1:50,000 Scale Geology Series [Geological Map] Sheet 271 Morpeth: Bedrock and Superficial Deposits.

Ref 2 - British Geological Survey. 1:50,000 Scale Geology Series [Geological Map] Sheet 272 Tynemouth: Bedrock and Superficial Deposits.

Ref 3 - BGS Lexicon. May 2012. www.bgs.ac.uk.

Ref 4 - DEFRA, March 2010. Surface Water Management Plan Technical Guidance.

Ref 5 - Environment Agency, 2010. Areas Susceptible to Groundwater Flooding. Guidance Document

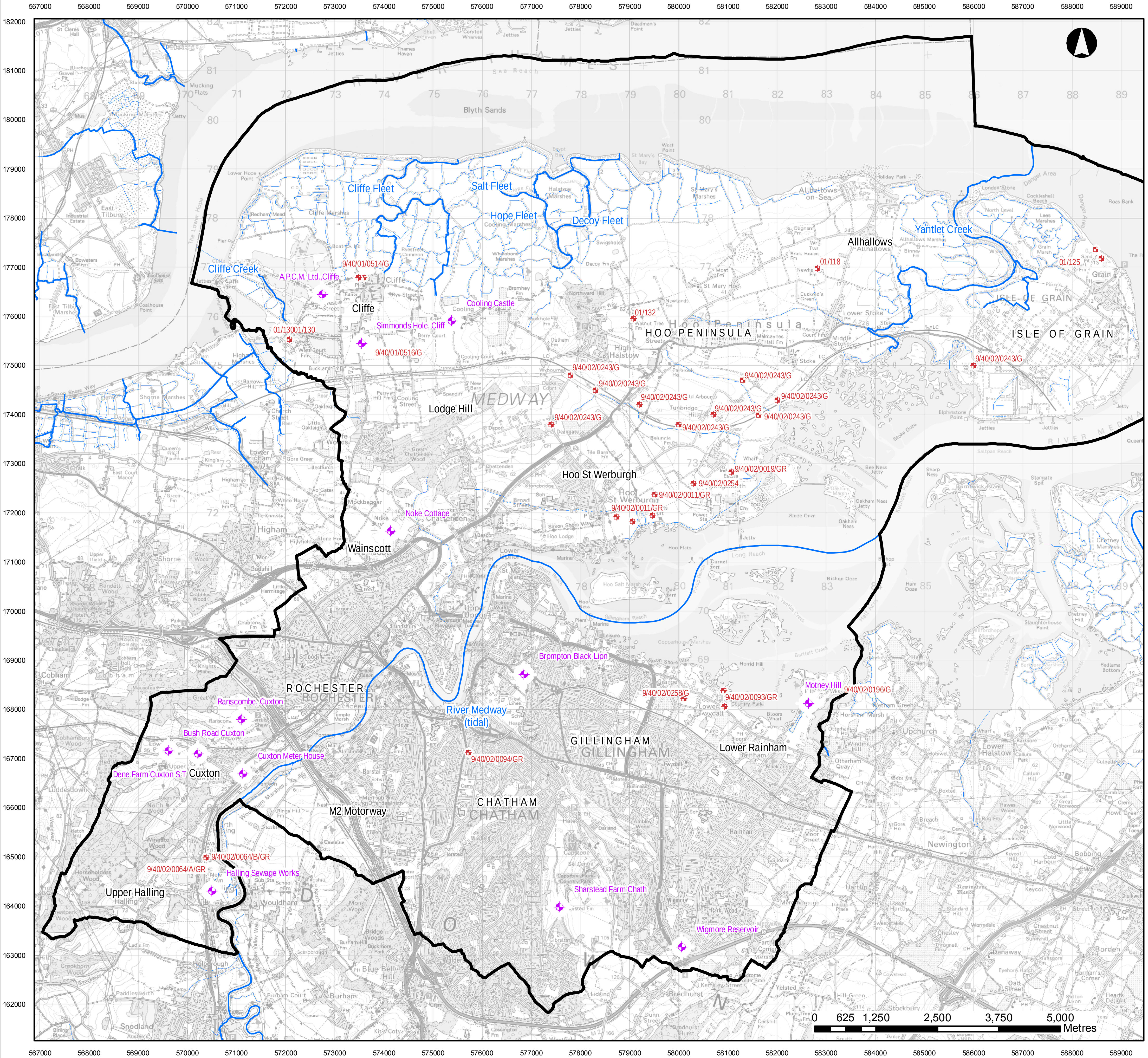
Ref 6 – BGS Permeability Data. 2012. http://www.bgs.ac.uk/products/hydrogeology/permeability.html

Ref 7 - BGS SuDS Suitability Data. 2012. http://www.bgs.ac.uk/products/hydrogeology/infiltration Suds.html

Ref 8 - Jones, H K, Morris, B L, Cheney, C S, Brewerton, L J, Merrin, P D, Lewis, M A, MacDonald, A M, Coleby, L M, Talbot, J C, McKenzie, A A, Bird, M J, Cunningham, J, and Robinson, V K.. 2000. The physical properties of minor aquifers in England and Wales. British Geological Survey Technical Report, WD/00/4. 234pp. Environment Agency R&D Publication 68.

Appendix A – Environment Agency Observation Borehole Water Level Plots

Appendix B – Figures



KEY

- Medway Council Administrative Area
- Environment Agency Observation Boreholes
- Licensed Groundwater Abstractions
- Rivers

USER NOTE
This plan has been produced in accordance with Planning Policy Statement 25 – development and flood risk. Because the information is indicative rather than specific, local planning authorities will nevertheless need to consult the Environment Agency on individual applications.

FLOODABLE AREAS NOT SHOWN
This study does not consider those areas susceptible to tidal, fluvial, surface water or pluvial flooding.

Medway COUNCIL

CAPITA SYMONDS | URS
Flood Risk Management

STRATEGIC FLOOD RISK MAPPING

PROJECT TITLE

MEDWAY COUNCIL LFRMS
TECHNICAL APPENDIX 2
GROUNDWATER ASSESMENT

DRAWING TITLE

FIGURE 1
LOCATION MAP

ORIGINATED BY	DRAWN BY	CHECKED BY	APPROVED BY	SCALE	STATUS
SJC	SJC	PJS	PJS	Scale @ A3 1:80,000	FINAL
DATE	DATE	DATE	DATE	DRAWING NUMBER	REVISION
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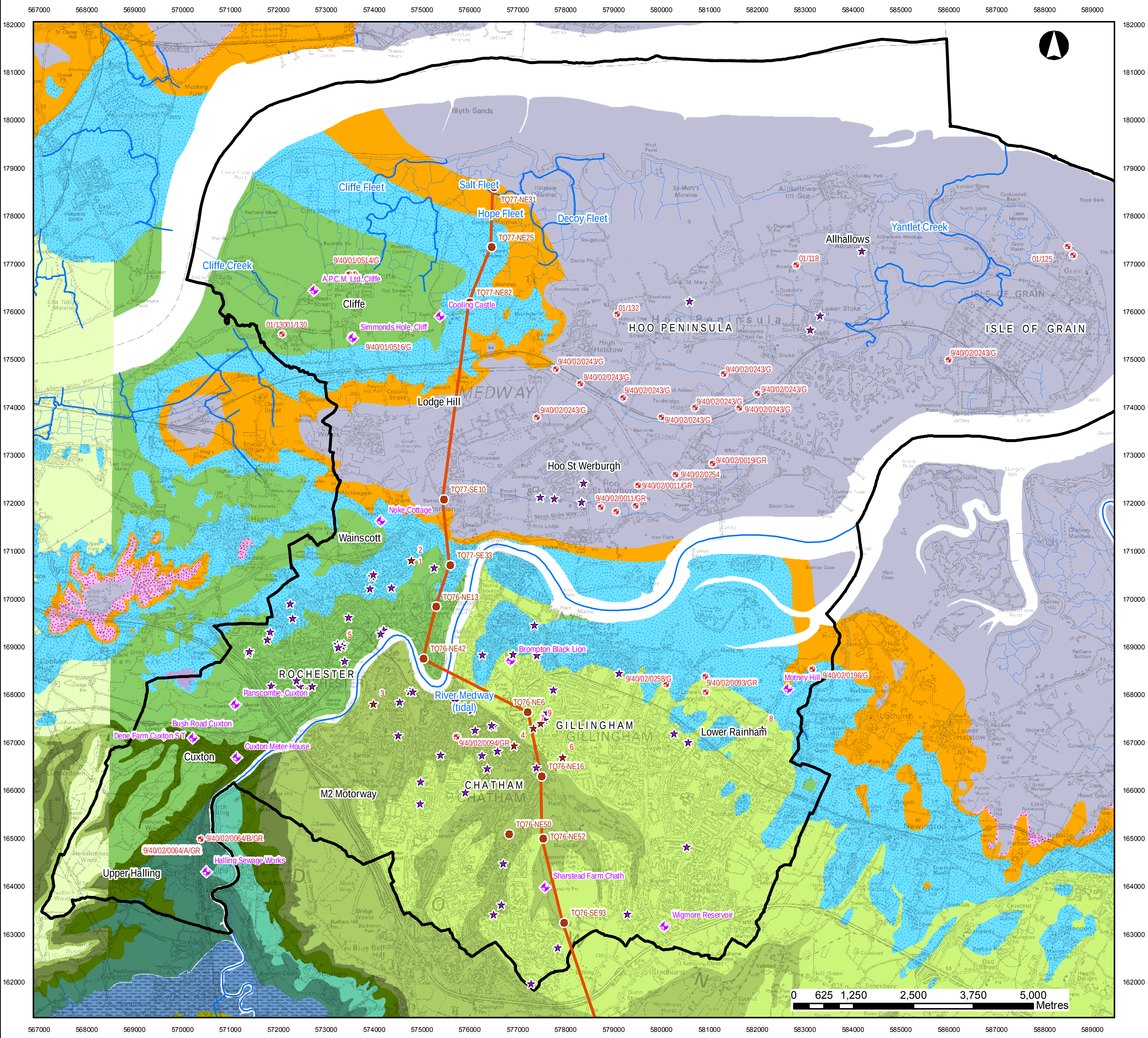

KEY

- Medway Council Administrative Area
- Rivers
- Historic Flooding Event (all events)
- Historic Flooding Event (basements / cellars)
- Environment Agency Observation Borehole
- Licensed Groundwater Abstraction
- BGS Borehole Log
- Geological Cross Section

Bedrock Geology

- Lenham Formation
- London Clay Formation
- Harwich Formation
- Lambeth Group
- Thanet Sand Formation
- Seaford Chalk Formation & Newhaven Chalk
- Seaford Chalk Formation
- Lewes Nodular Chalk Formation
- Lewes Nodular Chalk, Seaford Chalk and Newhaven Chalk Fm (Undiff)
- New Pit Chalk Formation
- Holywell Nodular Chalk Formation
- Zig Zag Chalk Formation
- West Melbury Marly Chalk Formation
- Gault Formation
- Folkestone Formation

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CAPITA SYMONDS | URS
Flood Risk Management

STRATEGIC FLOOD RISK MAPPING

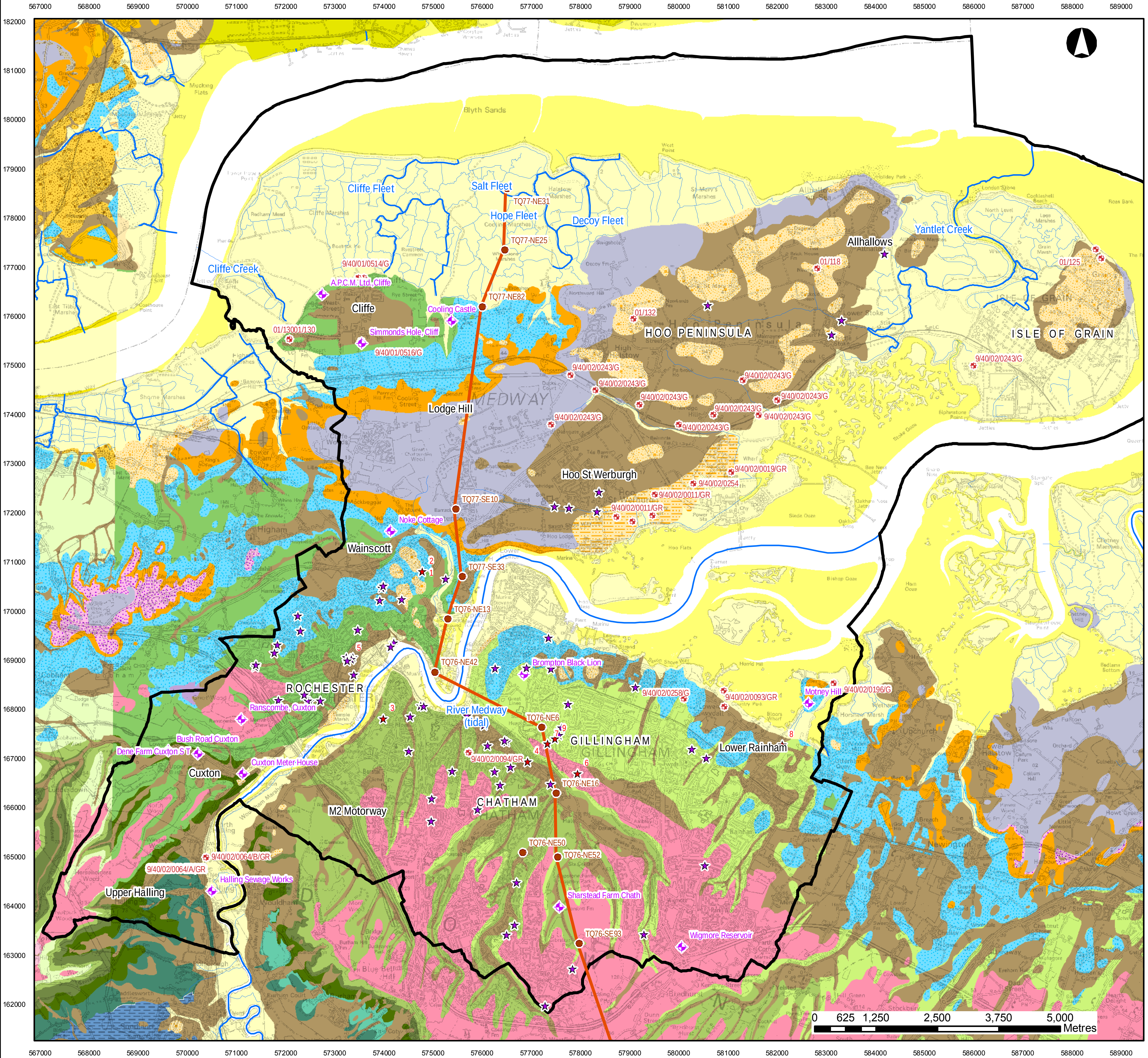
PROJECT TITLE

MEDWAY COUNCIL LFRMS
TECHNICAL APPENDIX 2
GROUNDWATER ASSESMENT

DRAWING TITLE

FIGURE 2
BEDROCK GEOLOGY MAP

ORIGINATED BY	DRAWN BY	CHECKED BY	APPROVED BY	SCALE	STATUS
BTV	BTV	SC	SC	Scale @ A3 1:80,000	FINAL
DATE	DATE	DATE	DATE	DRAWING NUMBER	REVISION
08/06/2012	08/06/2012	08/06/2012	08/06/2012	47061941_GW_DRW002	2



KEY

- Medway Council Administrative Area
- Rivers
- Historic Flooding Event (all events)
- Historic Flooding Event (basements / cellars)
- Environment Agency Observation Boreholes
- Licensed Groundwater Abstractions
- BGS Borehole Logs
- Geological Cross Section

Superficial Geology

- Head (Clay, Silt, Sand and Gravel)
- Alluvium (Clay, Silt, Sand & Gravel)
- Peat
- Beach & Tidal Flat Deposits (Undiff)
- Tidal Flat Deposits
- Tidal River Or Creek Deposits
- River Terrace Deposits - Sand_Gravel
- River Terrace Deposits - Clay_Silt
- River Terrace Deposits (Undiff)
- Kempton Park Gravel Formation
- Taplow Gravel Formation
- Lynch Hill Gravel Member
- Boyn Hill Gravel Member
- Black Park Gravel Member - Sand Gravel
- Chelsfield Gravel Formation
- Clay with Flints Formation - Clay Silt Sand Gravel

Bedrock Geology

- Lenham Formation
- London Clay Formation
- Harwich Formation
- Lambeth Group
- Thanet Sand Formation
- Seaford Chalk Formation & Newhaven Chalk
- Seaford Chalk Formation
- Lewes Nodular Chalk Formation
- Lewes Nodular Chalk, Seaford Chalk & Newhaven Chalk Fm (Undiff)
- New Pit Chalk Formation
- Holywell Nodular Chalk Formation
- Zig Zag Chalk Formation
- West Melbury Marly Chalk Formation
- Gault Formation
- Folkestone Formation

USER NOTE
This plan has been produced in accordance with Planning Policy Statement 25 – development and flood risk. Because the information is indicative rather than specific, local planning authorities will nevertheless need to consult the Environment Agency on individual applications.

FLOODABLE AREAS NOT SHOWN
This study does not consider those areas susceptible to tidal, fluvial, surface water or pluvial flooding.

Medway COUNCIL

CAPITA SYMONDS | URS
Flood Risk Management

STRATEGIC FLOOD RISK MAPPING

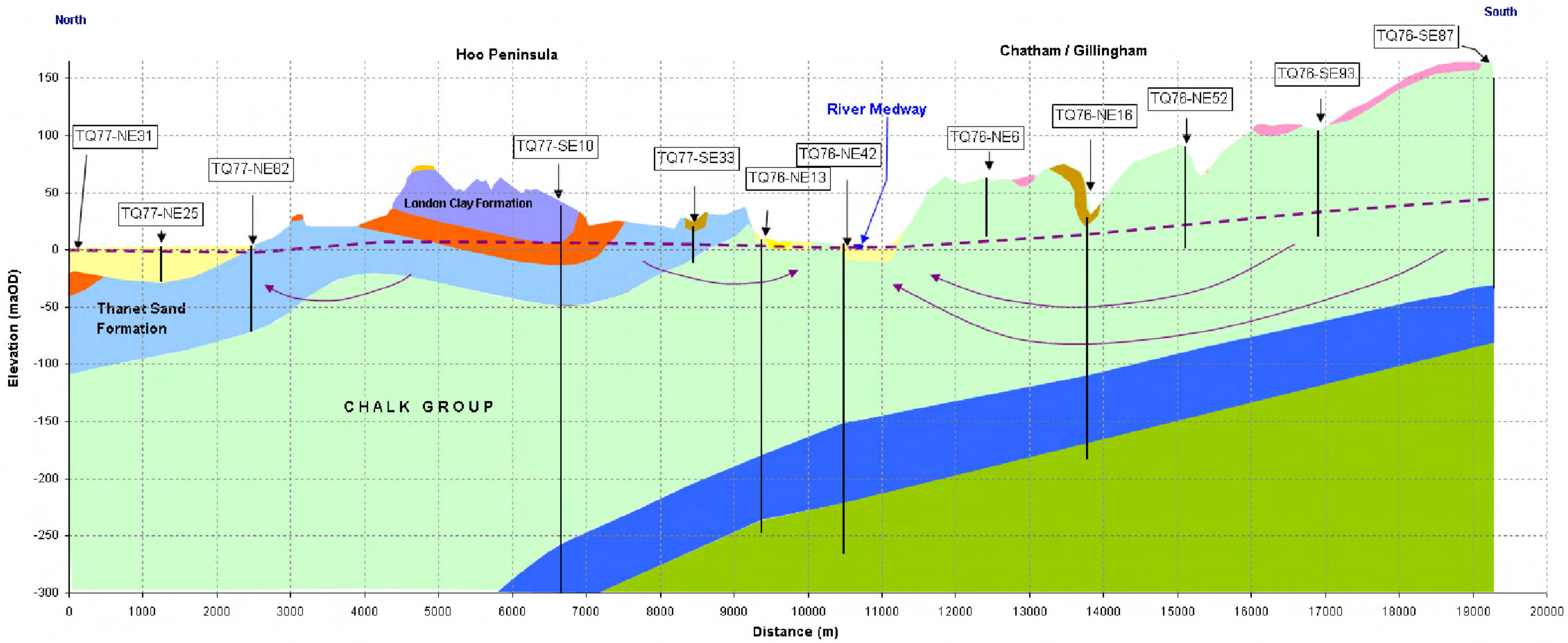
PROJECT TITLE

MEDWAY COUNCIL LFRMS
TECHNICAL APPENDIX 2
GROUNDWATER ASSESMENT

DRAWING TITLE

FIGURE 3
BEDROCK & SUPERFICIAL GEOLOGY MAP

ORIGINATED BY	DRAWN BY	CHECKED BY	APPROVED BY	SCALE	STATUS
BTV	BTV	SC	SC	Scale @ A3 1:80,000	FINAL
DATE	DATE	DATE	DATE	DRAWING NUMBER	REVISION
08/06/2012	08/06/2012	08/06/2012	08/06/2012	47061941_GW_DRW002	2



KEY

Superficial Geology

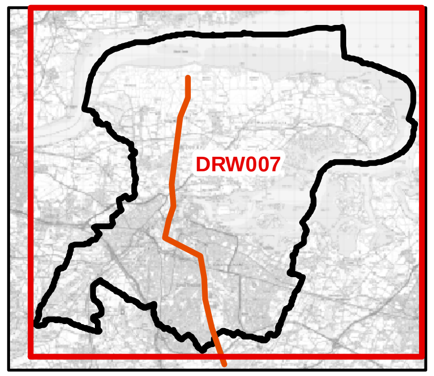
- Head (Clay, Silt, Sand and Gravel)
- Alluvium (Clay, Silt, Sand & Gravel)
- Beach & Tidal Flat Deposits (Undiff)
- Clay with Flints Formation - Clay Silt Sand Gravel

Bedrock Geology

- London Clay Formation
- Lambeth Group
- Thanet Sand Formation
- Chalk Formation (Undifferentiated))
- Gault Formation
- Folkestone Formation

- Groundwater Piezometery
- Inferred Groundwater Flow Direction

KEY PLAN



Medway COUNCIL

CAPITA SYMONDS URS
Flood Risk Management

STRATEGIC FLOOD RISK MAPPING

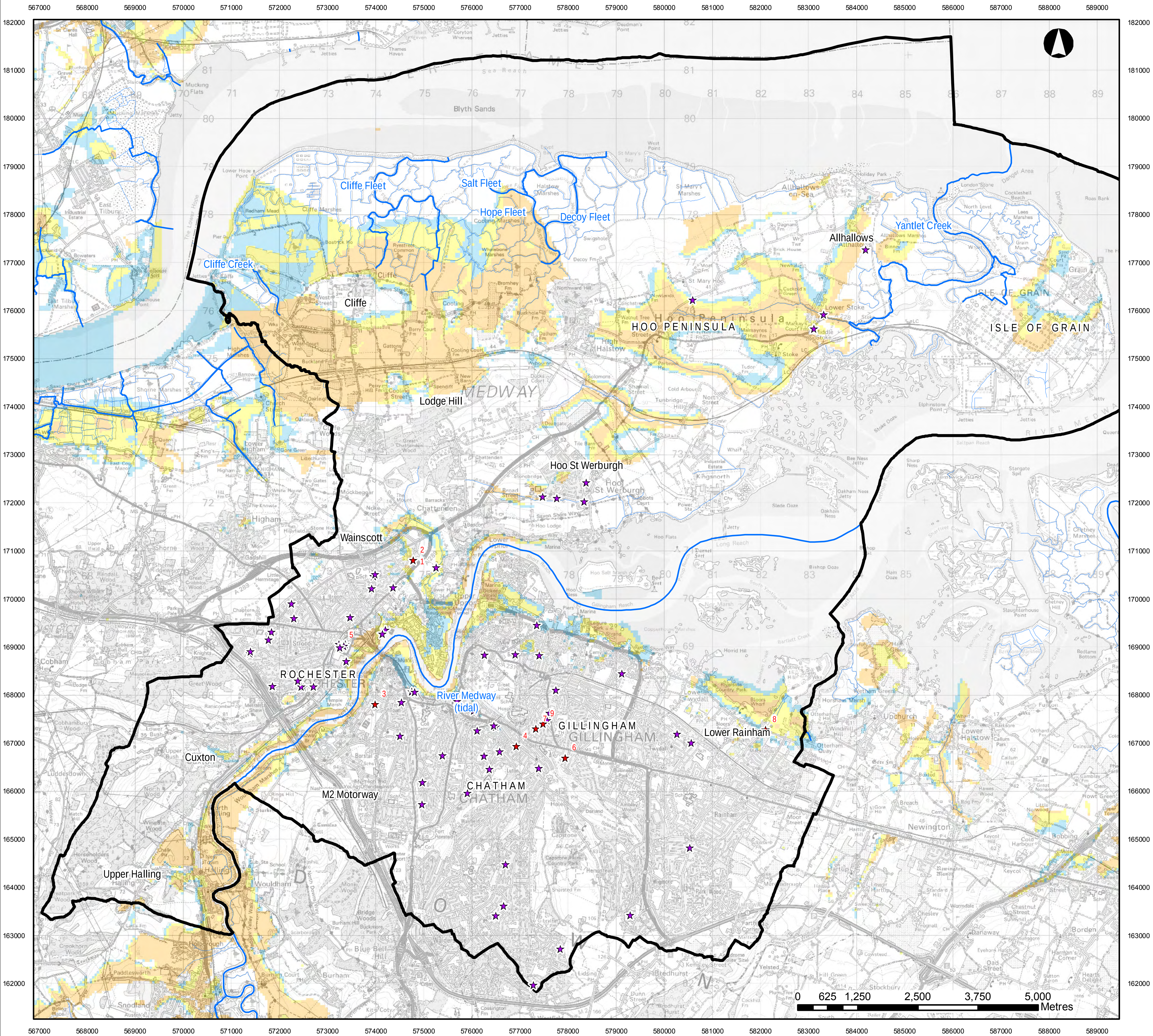
PROJECT TITLE

MEDWAY COUNCIL LFRMS
TECHNICAL APPENDIX 2
GROUNDWATER ASSESMENT

DRAWING TITLE

FIGURE 4
BGS GEOLOGICAL CROSS SECTION

ORIGINATED BY	DRAWN BY	CHECKED BY	APPROVED BY		STATUS
CW	CW	SC	SC		FINAL
DATE	DATE	DATE	DATE	DRAWING NUMBER	REVISION
23/04/2012	23/04/2012	26/04/2012	26/04/2012	47061941_GW_DRW007	2



KEY

- Medway Council Administrative Area
- Rivers
- Historic Flooding Event (all events)
- Historic Flooding Event (basements / cellars)

BGS Groundwater Flooding Susceptibility

- Very High
- High
- Moderate

TECHNICAL NOTE
This map shows an approximate guide to areas that may be susceptible to groundwater flooding. However, for all new developments, site investigation is required to confirm local groundwater levels and therefore risk of groundwater flooding

USER NOTE
This plan has been produced in accordance with Planning Policy Statement 25 – development and flood risk. Because the information is indicative rather than specific, local planning authorities will nevertheless need to consult the Environment Agency on individual applications.

FLOODABLE AREAS NOT SHOWN
This study does not consider those areas susceptible to tidal, fluvial, surface water or pluvial flooding.

Medway Council | CAPITA SYMONDS | URS Flood Risk Management

STRATEGIC FLOOD RISK MAPPING

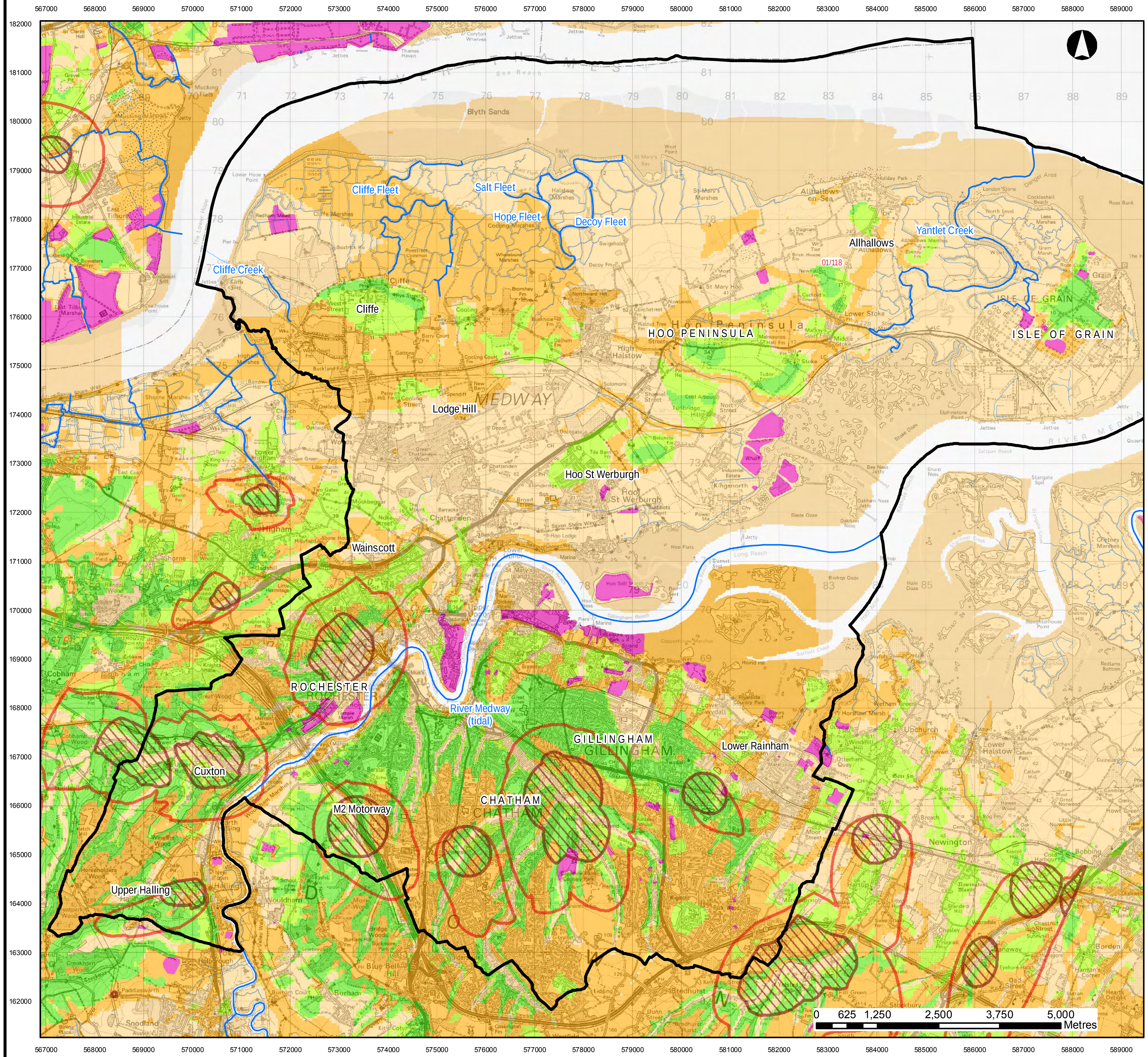
PROJECT TITLE

MEDWAY COUNCIL LFRMS
TECHNICAL APPENDIX 2
GROUNDWATER ASSESMENT

DRAWING TITLE

FIGURE 5
BGS GROUNDWATER FLOODING SUSCEPTIBILITY MAP

ORIGINATED BY	DRAWN BY	CHECKED BY	APPROVED BY	SCALE	STATUS
BTV	BTV	SC	SC	Scale @ A3 1:80,000	FINAL
DATE	DATE	DATE	DATE	DRAWING NUMBER	REVISION
08/06/2012	08/06/2012	08/06/2012	08/06/2012	47061941_GW_DRW001	2



KEY

- Medway Council Administrative Area
- Rivers

Historic Landfill Sites

- Historic Landfill Sites

Groundwater Source Protection Zones

- Inner Zone (Zone 1)
- Outer Zone (Zone 2)

BGS Infiltration SUDS Suitability

- Highly Compatible for Infiltration SUDS
- Probably Compatible for Infiltration SUDS
- Opportunities for bespoke Infiltration SUDS
- Very Significant Constraints are indicated

TECHNICAL NOTE
This map forms an approximate guide to infiltration SUDS suitability.
However, for all new developments, site investigation is required to confirm local permeabilities and infiltration rates.

USER NOTE
This plan has been produced in accordance with Planning Policy Statement 25 – development and flood risk. Because the information is indicative rather than specific, local planning authorities will nevertheless need to consult the Environment Agency on individual applications.

FLOODABLE AREAS NOT SHOWN
This study does not consider those areas susceptible to tidal, fluvial, surface water or pluvial flooding.

Medway COUNCIL

CAPITA SYMONDS | URS
Flood Risk Management

STRATEGIC FLOOD RISK MAPPING

PROJECT TITLE

MEDWAY COUNCIL LFRMS
TECHNICAL APPENDIX 2
GROUNDWATER ASSESMENT

DRAWING TITLE

FIGURE 6
INFILTRATION SUDS SUITABILITY MAP

ORIGINATED BY	DRAWN BY	CHECKED BY	APPROVED BY	SCALE	STATUS
BTV	BTV	SC	SC	Scale @ A3 1:80,000	FINAL
DATE	DATE	DATE	DATE	DRAWING NUMBER	REVISION
08/06/2012	08/06/2012	08/06/2012	08/06/2012	47061941_GW_DRW001	2

Appendix 3 – Flood risk management roles and responsibilities

Roles and responsibilities of Medway Council

	Medway Council Flood Risk Management functions
Flood and Water Management Act 2010	Medway Council has a duty to lead on local flood risk management, including establishing effective partnerships within their local authority as well as with other Risk Management Authorities such as the EA, Southern Water, Internal Drainage Boards, Highways Authority and neighbouring Local Authorities.
	Medway Council have a duty to investigate and record details of significant flood events within their area. This duty includes identifying which authorities have flood risk management functions and what their have done or intend to do with respect to the incident, notifying Risk Management Authorities where necessary and publishing the results of any investigations carried out. (FWMA Part 1 Section 19).
	Medway Council has a duty to develop, maintain, apply and monitor a strategy for local flood risk management in their area. The LLFA must publish a summary of its strategy (including guidance about the availability of relevant information). It may also issue guidance about the application of the strategy in its area. The LLFA must consult other Risk Management Authorities and the public who may be affected by the strategy. (FMWA Part 1 Section 9).
	Medway Council has a duty to maintain a register of structures or features which are likely to have a significant effect on flood risk in its area, including details on ownership and condition as a minimum. The register must be available for inspection. (FWMA Part 1 Section 21).
	Medway Council must aim to make a contribution towards the achievement of sustainable development when exercising a flood risk management function. (FWMA Part 1 Section 27).

	Medway Council Flood Risk Management functions
	Medway Council has a duty to act as a Sustainable Drainage Systems (SuDS) Approving Body (SAB) for any new drainage system affecting more than one property. The SAB must approve, adopt and maintain any new SuDS within their area, which confirm to the National SuDS standards. (FWMA Part 1 Section This responsibility is not anticipated to commence before April 2013. (FWMA Schedule 3).
	Medway Council has a consenting and enforcement responsibility for ordinary watercourse regulation **for those ordinary watercourses that are not maintained by the Internal Drainage Board.**
	Medway Council has powers to request **a person to provide information in connection with the authority's flood and coastal erosion risk management functions. (FWMA Part 1 Section 14).**
	Medway Council has powers to designate structures and features that affect flooding in order to safeguard assets that are relied upon for flood risk management. Once a feature is designated, the owner must seek consent from the authority to alter, remove or replace it. (FWMA Schedule 1 Section 1).
	Medway Council have powers to undertake works to manage flood risk from surface water or groundwater, consistent with the strategy for their area. (FWMA Schedule 2 Section 29).
FRR 2009	Medway Council must revise the Preliminary Flood Risk Assessment (PFRA) at least every 6 years. The first review must be published by 22nd June 2017. (FRR Part 2 Section 10).
	Medway Council must prepare flood hazard and flood risk maps of relevant flood risk areas by 22nd June 2013 and revise these at least every 6 years. (FRR Part 3 Section 19).
	Medway Council must prepare a flood risk management plans for each flood risk area by 22nd June 2015 and revise these plans at least every 6 years. (FRR Part 4 Section 26).
	Medway Council has a duty to cooperate with other authorities exercising their functions under the FRR. (FRR Part 6 Section 35).

	Medway Council Flood Risk Management functions
	Medway Council has powers to require information reasonably required in connection with their responsibilities as LLFA under the FRR from the authorities listed in Part 6 Section 36 Sub-section 3 of the FRR. (FRR Part 6 Section 36).
Civil Contingencies Act 2004[11]	Medway Council has a duty to: • assess the risk of an emergency occurring; • maintain plans for the purpose of ensuring that if an emergency occurs the person or body is able to continue to perform its functions; • arrange for the publication of all or part of assessments made and plans maintained for the purposes of preventing an emergency, reducing, controlling or mitigating the effects of an emergency, or enabling other action to be taken in connection with an emergency; and, • maintain arrangements to warn the public, and to provide information and advice to the public, if an emergency is likely to occur or has occurred. (Civil Contingencies Act 2004 Part 1 Section 2).
NPPF 2012	Medway Council, as LPA, should adopt proactive strategies to mitigate and adapt to climate change, taking full account of flood risk, coastal change and water supply and demand considerations. (NPPF Paragraph 94).
	Medway Council's Local Plans should be supported by Strategic Flood Risk Assessment and should develop policies to manage flood risk from all sources, taking account of advice from the EA and other relevant flood risk management bodies. (NPPF Paragraph 100).

[11] HMSO and the Queen's Printer of Acts of Parliament (2004) Civil Contingencies Act

Roles and responsibilities of the Environment Agency

	Environment Agency Flood Risk Management functions
Flood and Water Management Act 2010	The EA has a duty to develop, maintain, apply and monitor a strategy for flood and coastal erosion risk management in England. The EA must publish a summary of its Strategy. It may also issue guidance about the application of the Strategy in its area. The EA must consult Risk Management Authorities and public on the National Strategy. (FMWA Part 1 Section 7).
	The EA must cooperate with other RMAs in the exercise of their flood risk management function and may share information with other RMAs for the purpose of discharging this duty. (FWMA Part 1 Section 13).
	The EA has powers to request a person to provide information in connection with the authority's flood and coastal erosion risk management functions. (FWMA Part 1 Section 14).
	The EA has powers to designate structures and features that affect flooding in order to safeguard assets that are relied upon for flood risk management. Once a feature is designated, the owner must seek consent from the authority to alter, remove or replace it. (FWMA Schedule 1 Section 1).
FRR 2009	The EA has a duty to prepare preliminary assessment maps and reports in relation to each river basin district with respect to flooding from the sea, main rivers and reservoirs. (FRR Part 2 Section 9).
	The EA has a duty to determine in relation to each river basin district whether there is a significant flood risk from the sea, main rivers or reservoirs. (FRR Part 2 Section 13).
	The EA has a duty to prepare in relation to each flood risk area, flood hazard and flood risk maps relating to flooding from the sea, main rivers and reservoirs. (FRR Part 3 Section 19).
	The EA has a duty to prepare flood risk management plans in relation to each flood risk area identified under Section 13. (FRR Part 4 Section 25).
	The EA has a duty to cooperate with other authorities exercising their functions under the FRR. (FRR Part 6 Section 35).

	Environment Agency Flood Risk Management functions
	The EA must comply with a request of Medway Council to provide information reasonably required in connection with their responsibilities as LLFA under the FRR. (FRR Part 6 Section 36).
Civil Contingencies Act 2004	As a Category 1 Responder, the EA has a duty to: • assess the risk of an emergency occurring; • maintain plans for the purpose of ensuring that if an emergency occurs the person or body is able to continue to perform its functions; • arrange for the publication of all or part of assessments made and plans maintained for the purposes of preventing an emergency, reducing, controlling or mitigating the effects of an emergency, or enabling other action to be taken in connection with an emergency; and, • maintain arrangements to warn the public, and to provide information and advice to the public, if an emergency is likely to occur or has occurred. (Civil Contingencies Act 2004 Part 1 Section 2).

Roles and responsibilities of Southern Water

	Southern Water Flood Risk Management functions
Water Industry Act 1991[12]	Southern Water has a duty to develop and maintain an efficient and economical system of water supply within its area and to ensure that all such arrangements have been made — • for providing supplies of water to premises in that area and for making such supplies available to persons who demand them; and • for maintaining, improving and extending the water undertaker's water mains and other pipes (Water Industry Act, 1991)
	Southern Water has a duty to provide and maintain a system of public sewers so that the areas for which they are responsible are effectually drained (Water Industry Act, 1991).

[12] HMSO and the Queen's Printer of Acts of Parliament (1991) Water Industry Act

	Southern Water Flood Risk Management functions
	Southern Water must prepare, consult, publish and maintain a Water Resources Management Plan consisting of: • the water undertaker's estimate of the quantities of water required to meet their obligations; • the measures which the water undertaker intends to take or continue to manage and develop water resources so as to be able, and continue to be able, to meet its obligations; • the likely sequence and timing for implementing those measures; and • such other matters as the Secretary of State may specify in directions • A new plan must be produced every 5 years (Water Industry Act, 1991)
FWMA 2010	Southern Water must cooperate with other RMAs in the exercise of their flood risk management function and may share information with other RMAs for the purpose of discharging this duty. (FWMA Part 1 Section 13).
FRR 2009	Southern Water has a duty to cooperate with other authorities exercising their functions under the FRR. (FRR Part 6 Section 35).
	Southern Water must comply with a request of Medway Council to provide information reasonably required in connection with their responsibilities as LLFA under the FRR. (FRR Part 6 Section 36).

Roles and responsibilities of Lower Medway Internal Drainage Board

	Lower Medway IDB Flood Risk Management functions
Land Drainage Act 1991	Medway IDB has a duty to exercise a general supervision over all matters relating to the drainage of land within their district.
	Medway IDB has powers to maintain existing works, that is to say, to cleanse, repair or otherwise maintain in a due state of efficiency any existing watercourse or drainage work.

	Lower Medway IDB Flood Risk Management functions
	Medway IDB has powers to improve any existing works, that is to say, to deepen, widen, straighten or otherwise improve any existing watercourse or remove or alter mill dams, weirs or other obstructions to watercourses, or raise, widen or otherwise improve any existing drainage work.
	Medway IDB has powers to construct new works, that is to say, to make any new watercourse or drainage work or erect any machinery or do any other act required for the drainage of any land.
	If any person is liable to do any work in relation to any watercourse, bridge or drainage work (whether by way of repair, maintenance or otherwise); and fails to do the work, the drainage board concerned may serve a notice on that person requiring him to do the necessary work with all reasonable and proper despatch.
	Medway IDB may control development which affects watercourses within the Internal Drainage District by the use of application based consenting. • No person shall erect any mill dam, weir or other like obstruction to the flow of any ordinary watercourse or raise or otherwise alter any such obstruction; or erect any culvert that would be likely to affect the flow of any ordinary watercourse or alter any culvert in a manner that would be likely to affect any such flow, without the consent in writing of the drainage board concerned. • Where any ordinary watercourse is in such a condition that the proper flow of water is impeded, then, unless the condition is attributable to subsidence due to mining operations (including brine pumping), the drainage board or local authority concerned may require that the land or waterway owner remedy's that condition.
Flood and Water Management Act 2010	Medway IBD must cooperate with other RMAs in the exercise of their flood risk management function and may share information with other RMAs for the purpose of discharging this duty. (FWMA Part 1 Section 13).
	Medway IDB must aim to make a contribution towards the achievement of sustainable development when exercising a flood risk management function. (FWMA Part 1 Section 27).

	Lower Medway IDB Flood Risk Management functions
	Medway IDB has powers to designate structures and features that affect flooding in order to safeguard assets that are relied upon for flood risk management. Once a feature is designated, the owner must seek consent from the authority to alter, remove or replace it. (FWMA Schedule 1 Section 1).
	Medway IDB has powers to undertake works to manage flood risk from surface water or groundwater, consistent with the LFRMS for their area. (FWMA Schedule 2 Section 29).
FRR 2009	Medway IDB has a duty to cooperate with other authorities exercising their functions under the FRR. (FRR Part 6 Section 35).
	Medway IDB must comply with a request of Medway Council to provide information reasonably required in connection with their responsibilities as LLFA under the FRR. (FRR Part 6 Section 36).