Flood & Water Management

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Medway Council

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Medway Surface Water Management Plan

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List of Acronyms

1D	One Dimensional
2D	Two Dimensional
AEP	Annual Exceedence Probability
DSM	Digital Surface Model
DTM	Digital Terrain Model
EA	Environment Agency
FCERM	Flood Coastal Erosion Risk Management
FEH	Flood Estimation Handbook
FFMfSW	Flood Map for Surface Water
FRR	Flood Risk Regulations
FWMA	Flood and Water Management Act
GiA	Grant in Aid
GIS	Geographical Information System
ICM	Integrated Catchment Modelling
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LFRMS	Local Flood Risk Management Strategy
PFRA	Description
ReFH	Revitalised Flood Hydrograph
SFRA	Strategic Flood Risk Assessment
SWMP	Surface Water Management Plan
uFMfSW	Updated Flood Map for Surface Water

Executive Summary

This document forms the Surface Water Management Plan (SWMP) for Medway Council. The SWMP investigates the risks of surface water flooding and proposes a surface water management strategy for Medway Council. Surface water flooding describes flooding from sewers, drains, groundwater, runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall.

The aim of a SWMP is to understand and resolve complex, high risk surface water flooding problems in urbanised areas. A SWMP brings together key local partners, with responsibility for surface water and drainage, to collaborate to investigate the causes of surface water flooding and agree the most cost effective way of managing surface water flood risk. The SWMP has been prepared in three phases: Preparation, Risk Assessment and Options Assessment. The final phase, Implementation and Review, is to be carried out by Medway Council and the Project Steering Group.

The project is led by Medway Council as Lead Local Flood Authority, which forms the leadership of the Project Steering Group that is actively supported by the Environment Agency, Southern Water and Medway Lower Internal Drainage Boards. In order to provide an integrated approach to surface water management, it is important that key stakeholders with responsibility for different flood mechanisms are able to work together in a holistic manner.

A high-level assessment of the risk of surface water flooding was undertaken using previous modelling results included in the Local Flood Risk Management Strategy, referred to as 'the strategy', as well as the Environment Agency's updated Flood Map for Surface Water. The purpose of the risk assessment phase is to determine the level of probable future risk within Medway, prioritise higher risk areas for further investigation and identify 'quick win' flood mitigation actions. Priority for detailed assessment was determined using a combination of known historic incidents, potential for future development, coverage of surface water drainage infrastructure and predicted number of buildings flooded.

The prioritisation process undertaken during the strategy identified the following settlements for further detailed assessment:

- Strood
- Rochester
- Chatham
- Gillingham

The remaining settlements with a high risk of surface water flooding, as identified in the strategy (including Lower and Middle Stoke and Hoo St. Werburgh), were assessed at the intermediate level only and are the subject of separate investigations outside of this SWMP.

A detailed risk assessment using computer modelling based methods was undertaken in the four key study catchments. The risk assessment process identifies the areas of probable flooding (the 'impacts') and the surrounding area that contributes runoff (the 'catchment'). The results of the baseline hydraulic modelling were mapped to show both flood depth and flood hazard. In addition, the number of flooded properties within each study catchment was identified.

The options assessment defines which options are generally available for reducing flood risk within the study area and specific concept level mitigation solutions for each of the study catchments. As well as surface water, consideration is given to other sources of flooding and their interactions with surface water flooding. Approximate capital cost estimates of the potential options have been determined, but it should be noted that no funding has been confirmed or is guaranteed at present. Potential funding opportunities will undergo further investigation by the Steering Group.

1 Introduction

1.1 Background

Following widespread flooding in 2007, Sir Michael Pitt published a report entitled 'Learning Lessons from the 2007 Floods'. The report outlined the need for changes in the way the UK is adapting to the increased risk of flooding. An important part of the Governments response to this report was the Flood and Water Management Act (FWMA) 2010 which placed a duty on local authorities to take the lead in local flood risk management.

In order for Medway Council, as Lead Local Flood Authority (LLFA), to document their long-term strategy to manage local flood risk, a Local Flood Risk Management Strategy (LFRMS) was produced. The strategy report is supported by area-wide surface water flood risk modelling which was used to identify appropriate objectives to manage local flood risk and measures to deliver these objectives. The strategy highlighted the need for further assessment of local flood risk in order that areas at 'significant risk' can be identified and potential mitigation measures outlined.

The outcomes of the strategy will form a basis of this detailed Surface Water Management Plan (SWMP) to identify areas of significant flood risk and describe mitigation measures required to deliver objectives outlined in the strategy.

1.2 What is a Surface Water Management Plan

A SWMP is a framework to help understand the causes of surface water flooding and agree a preferred strategy for the management of surface water flood risk. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, ordinary watercourses and ditches that occurs as a result of heavy rainfall. No detailed assessment is included within the SWMP for the risk of groundwater flooding; the strategy should be consulted for the risk of groundwater flooding within Medway.

The SWMP study covers the Medway Council jurisdiction and is to be undertaken in consultation with local flood risk management partners who are responsible for surface water management, these include:

- Environment Agency
- Highways Authority (within Medway Council)
- Lower Medway Internal Drainage Board
- Southern Water

The partners are working together to understand the causes and effects of surface water flooding so that they can agree the most cost effective way of managing surface water flood risk in the long term.

1.3 Surface Water Management Plan Process

The Defra SWMP Technical Guidance (2010) provides the framework for preparing SWMPs. This report has been prepared to reflect the four principal stages identified by the guidance:

1. **Preparation:** Identify the need for a SWMP, establish a partnership with the relevant stakeholders and scope SWMP (refer to Section 2);

2. **Risk Assessment:** Select an appropriate level risk assessment and complete it ; a combination of risk assessment methods were selected for this study (refer to Section 3);

3. **Options**: Identify options/measures (with stakeholder engagement) which seek to alleviate the surface water flood risk within Critical Drainage Areas (refer to Section 4);

4. **Implementation and Review:** Prepare Action Plan and implement the monitoring and review process for these actions (process identified in Section 5).

The scope of this study includes the first three phases of the process. These phases and their key components are illustrated in Figure 1-1 below.

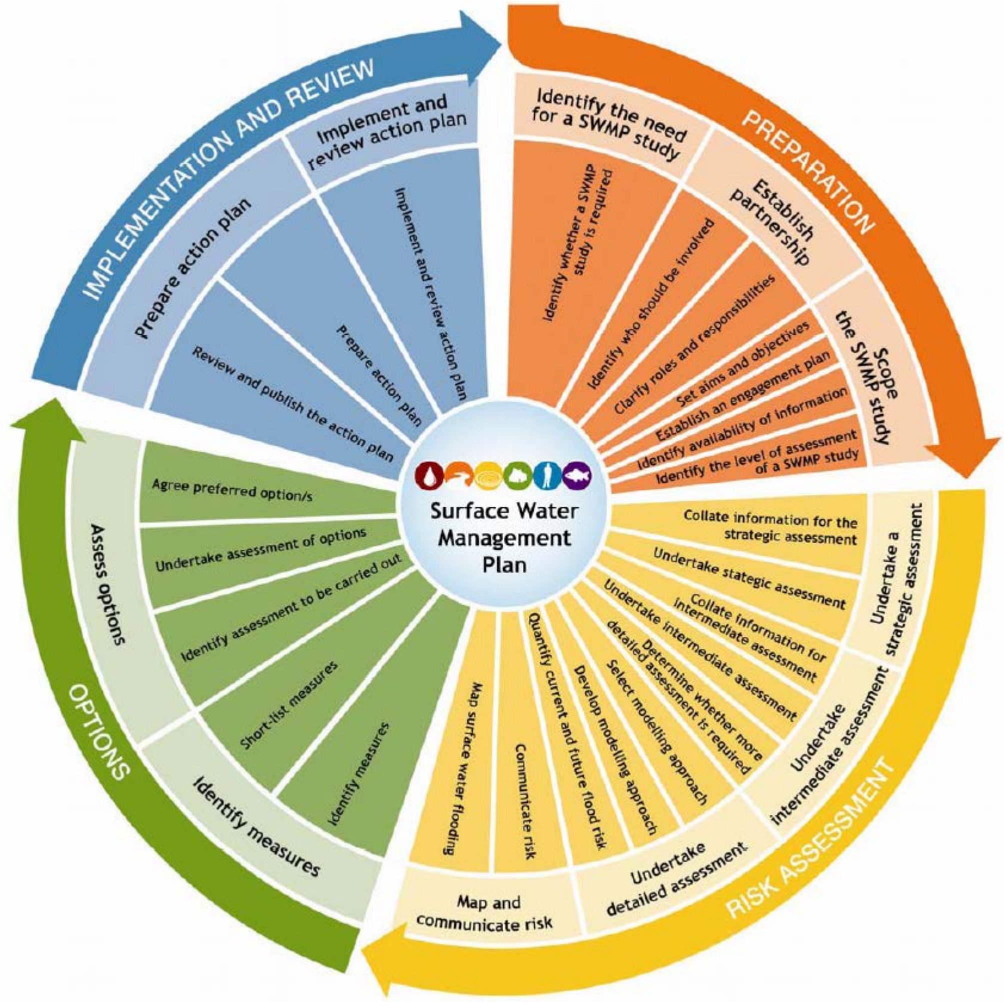


Figure 1-1 - Recommended Defra SWMP Process (Source Defra 2010)

1.4 Aim

The primary aim of the study is to produce a SWMP tailored to the local needs of Medway Council and its professional partners. The SWMP in combination with the strategy, Strategic Flood Risk Assessment (SFRA) and Preliminary Flood Risk Assessment (PFRA) will enable the comprehensive planning, phasing, delivery and management of surface water flooding by relevant utility companies, agencies and authorities whilst not adversely affecting the environment.

1.5 Objectives

The following objectives will be met through undertaking the SWMP study:

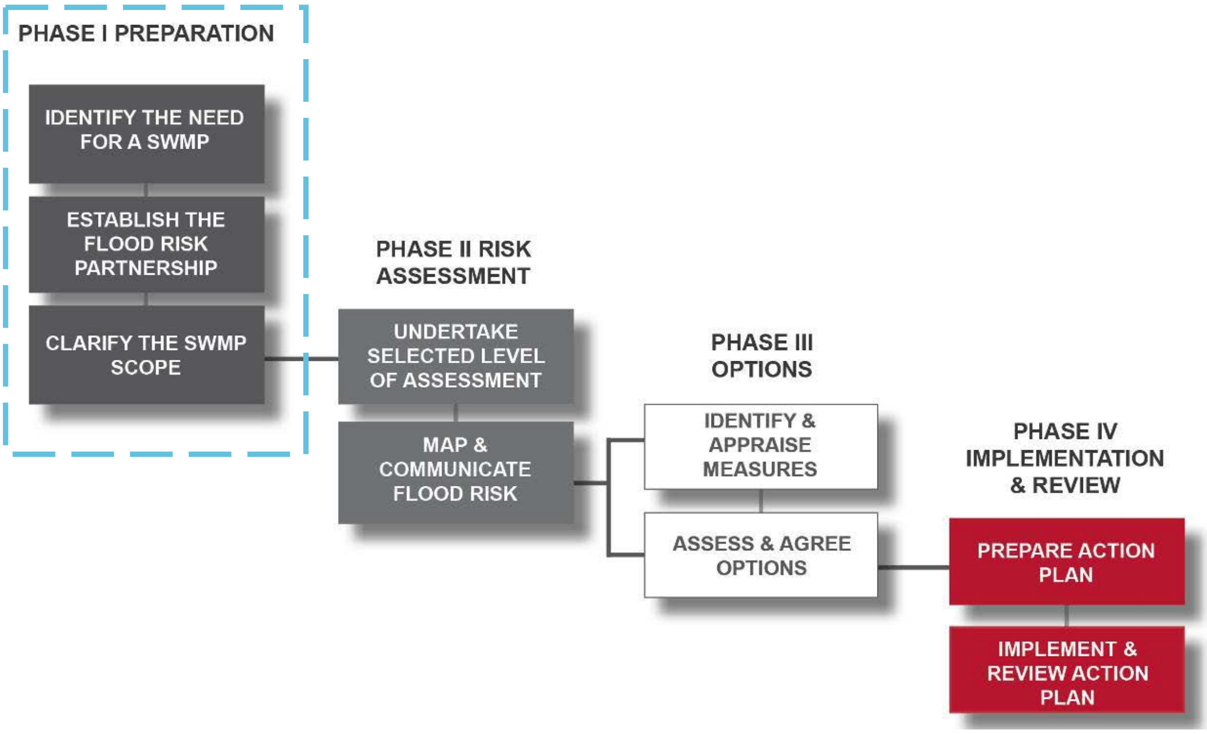
- Increase Medway Council's understanding of the causes, probability and consequences of flooding in areas considered to have a high risk of surface water flooding;
- Increase the understanding of where surface water flooding is likely to occur in order to inform spatial and emergency planning functions;
- Provide an understanding of the costs and benefits of measures that partners could use as a means to implement suitable measures to mitigate surface water flooding;
- Increase awareness of the duties and responsibilities for managing flood risk of different partners and stakeholders, and;
- Improve public engagement and understanding of surface water flooding.

1.6 Linking and Integrating Surface Water Management

This document builds upon the strategy to establish a long-term action plan to manage surface water and will influence future capital investment, maintenance, public engagement and understanding, land-use planning, emergency planning and future developments. Surface water management is often instrumental to many of these initiatives and strategies and so it is important that a consistent, integrated and sustainable approach to surface water management is adopted across Medway.

Section 2.0 of the strategy contains an overview of the key legislative documents and policy context for flood risk management in England and should be referred to for further information.

Phase I: Preparation



2 Phase I Preparation

2.1 Identify the need for a Surface Water Management Plan

The SWMP Technical Guidance issued by Defra in March 2010 emphasises that SWMPs may not be required in all locations. Studies should be prioritised in areas considered to be at greatest risk of surface water flooding or where partnership working is essential to both understand and subsequently address surface water flooding issues. The outcomes of the strategy have identified the need for this SWMP to build upon findings to:

- Identify local flood risk areas requiring further in depth flood risk modelling;
- Provide further detail on drainage system interactions in areas identified as being high risk;
- Provide a greater level of flood risk information in areas at risk which will inform the Medway Local Plan; and,
- Identify a range of options to alleviate surface water flood risk (these should concentrate on structural measures and support policy measures outlined in the strategy).

2.2 Establish Flood Risk Partnership

2.2.1 Benefits of Collaborative Working

As LLFA, Medway Council are required by legislation to work alongside partners and key stakeholders on local flood risk management issues. A number of benefits will arise from this collaborative working including:

- A greater understanding of urban drainage;
- A shared understanding of flood risk;
- Efficiency savings for essential stakeholders and partners through achieving outcomes;
- Appraisal of surface water drainage options;
- Greater certainty for developers concerning appropriate drainage;
- Quicker, more consistent decisions on development and infrastructure provision; and
- Overall reduction in flood risk across Medway; dependent on available funding.

2.2.2 Flood Risk Partners and Existing Flood Risk Collaboration

The strategy specified Risk Management Authorities and their functions. Key duties, powers, roles and responsibilities of each of the Risk Management Authorities are included in Appendix 4 of the strategy. The key flood risk partners for Medway are identified as:

- Medway Council (as LLFA and Highways Authority);
- Environment Agency;
- Southern Water; and,
- Lower Medway Internal Drainage Board.

A flood risk working group was formed during completion of the strategy. Workshops were held with representatives of all Risk Management Authorities throughout the production of this SWMP. A workshop was held during the inception phase of the project in August 2015 to discuss the study areas, availability of data and the historic flood mechanisms within the study catchments. A second workshop was held following the completion of baseline modelling in late 2015 to discuss the validity of the results, as well as considering the mitigation options to be modelled.

2.3 Clarifying the Scope of the Surface Water Management Plan

2.3.1 Identify Availability of Information

Data has been collected from each of the following organisations:

- Medway Council;
- Environment Agency; and,
- Southern Water.

Table 2-1 provides a summary of the data sources held by the organisations listed above and provides a description of each dataset, and how the data was used in preparing the SWMP.

Table 2-1 - Data Sources and use

Source	Dataset	Description	Use in this SWMP
Environment Agency	National Receptors Dataset	A nationally consistent dataset of social, economic, environmental and cultural receptors including residential properties, schools, hospitals, transport infrastructure and electricity substations.	Utilised for property/infrastructure flood counts.
	Detailed River Network	GIS dataset identifying the location of Main Rivers across they study area	To define watercourse locations within the study area.
	Environment Agency Flood Map for Planning (River and the Sea Flood Zones)	Shows extent of flooding from rivers during a 1 in 100yr flood and 1 in 1000yr return period flood. Shows extent of flooding from the sea during 1 in 200yr and 1 in 1000yr flood events. Ignores the presence of flood defences.	To identify the fluvial and tidal flood risk within the study area and areas benefiting from fluvial and tidal defences.
	Updated Flood Map for Surface Water	A national outline of surface water flooding held by the Environment Agency as a result of national modelling.	To assist with the verification of the pluvial modelling
	LiDAR topographic data.	1m/2m resolution terrain model complied from aerial surveys	Creation of terrain model for pluvial modelling
	Historic Flood Outline	Attributed spatial flood extent data for flooding from all sources.	Used to assist with the verification of modelling results
	Areas Susceptible to Groundwater Flooding	Mapping showing areas susceptible to groundwater flooding	To assess groundwater flood risk
	Medway Catchment Flood Management Plan	Summarises the scale and extent of flooding now and in the future, and set policies for managing flood risk within the catchment.	To ensure a coordinated approach is taken for mitigation solutions
	Anecdotal information relating to local flood history and flood	Records of flooding from surface water, groundwater and ordinary watercourses.	Where available used to assist with the verification of modelling results

Source	Dataset	Description	Use in this SWMP
	risk areas		
	OS Mapping / MasterMap	Topographic maps of the study area	Used to derive modelling parameters
Medway Council	Local Plans	Development plan setting out how Medway will develop	Understanding of areas of future development.
	Medway Strategic Flood Risk Assessment (SFRA)	Contains useful information on historic flooding, including local sources of flooding from surface water and groundwater.	Provides a background to flood risk in the study area.
	Medway Local Flood Risk Management Strategy (LFRMS)	Summarises the strategy for the management of flooding within Medway, including the responsibilities for flood risk and the activities to be undertaken.	Provide a background to flood risk in the study area.
	Preliminary Flood Risk Assessment (PFRA)	Summary of known historic flooding and potential future flooding from all sources	Prioritisation of study areas
	Flood Alleviation Schemes	Location and description of existing flood alleviation schemes within the study area.	Used in Phase 3: Options Assessment to determine options in each study catchment.
	Historic Flood Records	Locations of historic flooding	Used to assist with the verification of modelling results
Southern Water	InfoWorks CS Sewer model	Hydraulic model outlining the main drainage catchments and the location of surface water, foul and combined sewers across the study area. Includes pipe size and some information on invert levels.	Model build, verifying detailed modelling and Phase 3:Options Assessment
	DG5 Records	Records of internal and external sewer flooding occurring more than once in 20yrs. Resolution provided was to street level (not individual property)	Validation of modelling results
	Historic flooding records	Locations of historic flooding	Validation of hydraulic modelling results

Although not a key flood risk partner, it was considered important that Network Rail were consulted given the presence of railway lines passing through the urban areas of Medway, which have the potential to act as a barrier to flow, as well as the construction of a new station within Rochester. Information regarding the existing track drainage and other flood management practices within Network Rail land was requested but was not received at the time of undertaking the SWMP.

2.3.2 Security, Licensing and Use Restrictions

A number of datasets used in the preparation of this SWMP are subject to licensing agreements and use restrictions. The following national datasets provided by the Environment Agency are available to LLFA for local decision making:

– EA Flood Zone Map;
– Areas Susceptible to Groundwater Flooding;
– Updated Flood Map for Surface Water; and
– National Receptor Database.

A number of the data sources used are publicly available documents, such as:

- Local Flood Risk Management Strategy;
- Strategic Flood Risk Assessment;
- Catchment Flood Management Plan;
- Preliminary Flood Risk Assessment; and
- Index of Multiple Deprivation.

The use of some of the datasets made available for this SWMP is restricted. These include:

- Records of property flooding held by Medway Council; and
- DG5 register records from Southern Water.

Necessary precautions must be taken to ensure that all restricted information given to third parties is treated as confidential. The information must not be used for anything other than the purpose stated in the terms and conditions of use accompanying the data. No information may be copied, reproduced or reduced to writing, other than what is necessary for the purpose stated in the agreement.

2.4 Chosen Level of Assessment for the Medway Surface Water Management Plan

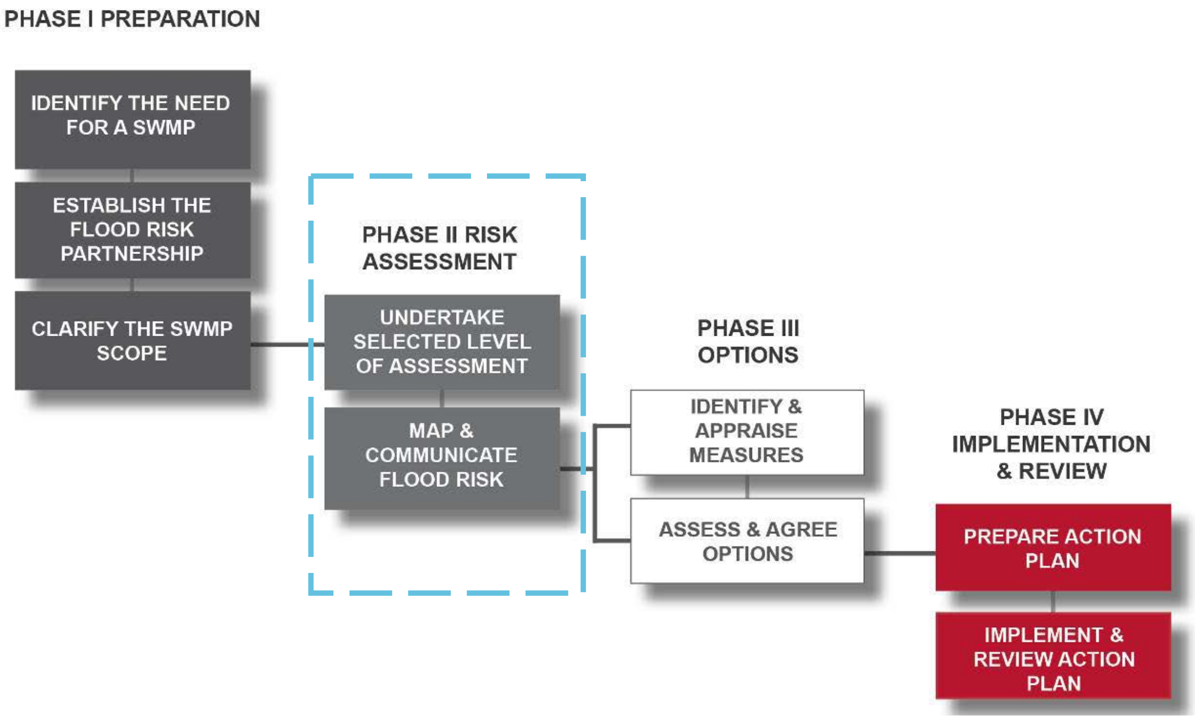
Defra SWMP Guidance (2010) outlines that a risk based approach should be adopted to assess surface water flooding. With this in mind, this SWMP will focus on areas of higher risk of surface water flooding as identified in the strategy. This information was cross referenced against areas of potential increased future development to ensure the most cost-effective use of available budgets and resourced through the SWMP study. The three potential levels of SWMP assessment are outlined in Table 2-2 below.

Table 2-2 - Levels of Assessment in a SWMP Study

Level of Assessment	Scale	Outputs
Strategic Assessment	County or Large conurbation	– Broad understanding of locations that are more vulnerable to surface water flooding – Prioritised list for further assessment – Outline maps to inform spatial and emergency planning
Intermediate Assessment	Area / District *(Medway LFRMS)*	– Identify flood hotspots which may require further assessment through detailed assessment – Identify immediate measures which can be implemented 'quick wins' – Inform spatial and emergency planning
Detailed Assessment	Small towns e.g. Chatham Flooding Hotspots *(Medway SWMP)*	– Detailed assessment of the cause and consequences of flooding – Use to understand flooding mechanisms and test mitigation measures through modelling of surface and sub-surface drainage systems

While overarching policies and approaches outlined in the SWMP will be applicable to the entire Medway administrative area, information contained in the strategy has enabled Medway to identify flooding hotspots, which will be used as the basis for the SWMP. Therefore this assessment constitutes a '**Detailed Assessment'**.

Phase II: Risk Assessment



3 Phase II Risk Assessment

3.1 Surface Water Flooding Overview

Based on a high level review of all available surface water flood risk information, the following areas within Medway were identified in the strategy as being at particular risk of surface water flooding:

- Strood;
- Rochester;
- Chatham;
- Gillingham;
- Lower and Middle Stoke; and
- Hoo St Werburgh.

Through discussion with the Steering Group, it was agreed that the four highest priority areas (Strood, Rochester, Chatham and Gillingham) would be taken further through the Detailed Assessment phase, with the four model boundaries presented in Figure 3-1. The remaining settlements with a high risk of surface water flooding (Lower and Middle Stoke and Hoo St Werburgh) were assessed at the intermediate level only as they are subject to separate investigations outside of this SWMP.

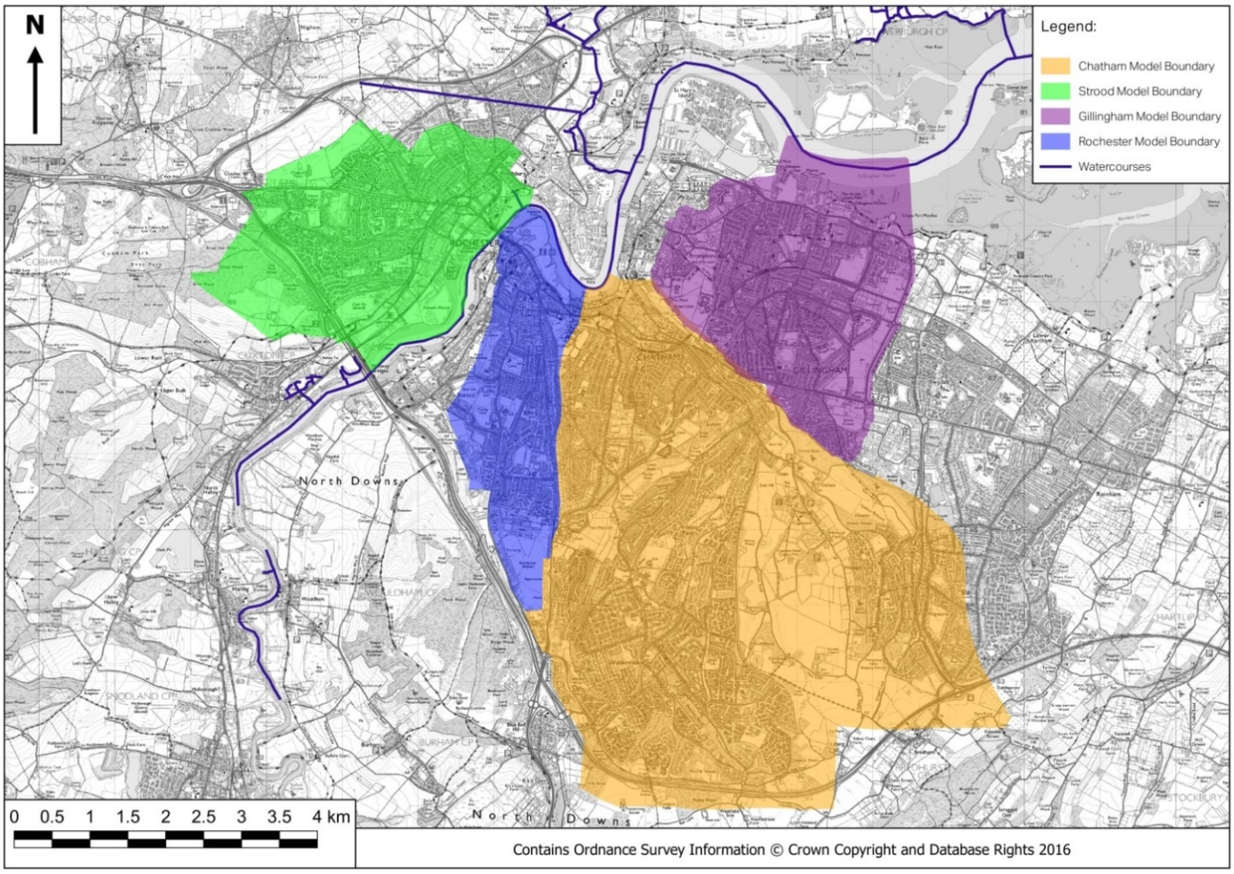


Figure 3-1 - Study catchment model boundaries

The following sections of this report (s3.4 to s3.8) provide a high level assessment of the flooding mechanisms, historic flood incidents and proposed developments within each of the areas identified above. For those areas selected for detailed modelling a description of the baseline model and results is also included. This is supported by Appendix B which contains a detailed model build report.

3.2 SWMP Baseline Modelling Data Outputs

3.2.1 Flood Depth

The main output from the detailed pluvial modelling is mapping of the maximum flood depth experienced across the four study areas. The maximum flood depth experienced at each mesh element across the model domain above 0.1m was thematically mapped using the legend displayed in the following table.

Figure 3-2 - Maximum flood depth legend

Final baseline flood depth maps are presented within Appendix A. The map references for each of the flood depth model scenarios for each study catchment are shown in Table 3-1 below.

Table 3-1 - Baseline flood depth mapping figure reference

Return Period (AEP)	Map Reference	
Chatham		
	North	*South*
2 year (50% AEP)	CHA-D-M2.1	CHA-D-M2.2
20 year (5% AEP)	CHA-D-M20.1	CHA-D-M20.2
75 year (1.33% AEP)	CHA-D-M75.1	CHA-D-M75.2
100 year (1% AEP)	CHA-D-M100.1	CHA-D-M100.2
100 year (1% AEP) +40% Climate Change	CHA-D-M100CC.1	CHA-D-M100CC.2
Strood		
2 year (50% AEP)	STR-D-M2.1	---
20 year (5% AEP)	STR-D-M20.1	---
75 year (1.33% AEP)	STR-D-M75.1	---
100 year (1% AEP)	STR-D-M100.1	---
100 year (1% AEP) +40% Climate Change	STR-D-M100CC.1	---

Return Period (AEP)	Map Reference	
Rochester		
	North	*South*
2 year (50% AEP)	RO-D-M2.1	RO-D-M2.2
20 year (5% AEP)	RO-D-M20.1	RO-D-M20.2
75 year (1.33% AEP)	RO-D-M75.1	RO-D-M75.2
100 year (1% AEP)	RO-D-M100.1	RO-D-M100.2
100 year (1% AEP) +40% Climate Change	RO-D-M100CC.1	RO-D-M100CC.2
Gillingham		
2 year (50% AEP)	GIL-D-M2.1	---
20 year (5% AEP)	GIL-D-M20.1	---
75 year (1.33% AEP)	GIL-D-M75.1	---
100 year (1% AEP)	GIL-D-M100.1	---
100 year (1% AEP) +40% Climate Change	GIL-D-M100CC.1	---

3.2.2 Flood hazard

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 element within the 2D mesh was assigned one of four hazard categories: 'Extreme Hazard', 'Significant Hazard', 'Moderate Hazard', and 'Low Hazard: Caution'.

The derivation of these categories is based on Flood Risks to People FD2320[1], using the following equation:

Flood Hazard Rating = ((v+0.5)*D) + DF
(Where v = velocity (m/s), D = depth (m) and DF = debris factor)

The depth and velocity outputs from the 2D hydrodynamic modelling are used in this equation, along with a suitable debris factor.

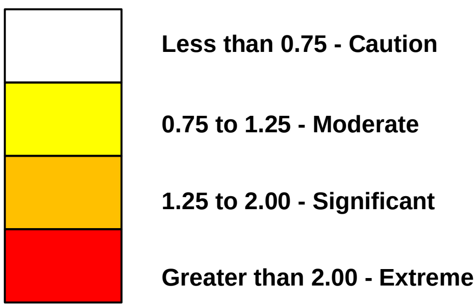


Figure 3-3 - Hazard categories based on FD2320, Defra & Environment Agency (2005)

Final baseline flood hazard maps are presented in Appendix 2 of the Medway Surface Water Management Plan. The map references for each of the flood hazard model scenarios for each study catchment are shown in Table 3-2 below.

1 Environment Agency/Defra (2006), Flood Risk Assessment Guidance for New Development

Table 3-2 - Baseline flood hazard mapping figure reference

Return Period (AEP)	Map Reference	
Chatham		
	North	*South*
2 year (50% AEP)	CHA-H-M2.1	CHA-H-M2.2
20 year (5% AEP)	CHA-H-M20.1	CHA-H-M20.2
75 year (1.33% AEP)	CHA-H-M75.1	CHA-H-M75.2
100 year (1% AEP)	CHA-H-M100.1	CHA-H-M100.2
100 year (1% AEP) +40% Climate Change	CHA-H-M100CC.1	CHA-H-M100CC.2
Strood		
2 year (50% AEP)	STR-H-M2.1	---
20 year (5% AEP)	STR-H-M20.1	---
75 year (1.33% AEP)	STR-H-M75.1	---
100 year (1% AEP)	STR-H-M100.1	---
100 year (1% AEP) +40% Climate Change	STR-H-M100CC.1	---
Rochester		
	North	*South*
2 year (50% AEP)	RO-H-M2.1	RO-H-M2.2
20 year (5% AEP)	RO-H-M20.1	RO-H-M20.2
75 year (1.33% AEP)	RO-H-M75.1	RO-H-M75.2
100 year (1% AEP)	RO-H-M100.1	RO-H-M100.2
100 year (1% AEP) +40% Climate Change	RO-H-M100CC.1	RO-H-M100CC.2
Gillingham		
2 year (50% AEP)	GIL-H-M2.1	---
20 year (5% AEP)	GIL-H-M20.1	---
75 year (1.33% AEP)	GIL-H-M75.1	---
100 year (1% AEP)	GIL-H-M100.1	---
100 year (1% AEP) +40% Climate Change	GIL-H-M100CC.1	---

3.2.3 Property Counts

In order to provide a quantitative assessment of potential flood risk, building footprints (taken from the OS MasterMap dataset) and the National Receptor Dataset were overlaid onto the flood depth maps to estimate the number of properties at risk within each model boundary area. The National Receptor Dataset is not entirely comprehensive and may not include all known or recent properties (and may contain properties that no longer exist) however, it is the best available data at this time.

Since the model meshes contain raised property thresholds for individual buildings, flood depth results were extracted for the maximum depth internally and immediately adjacent to the property boundary. For each return period, the numbers of predicted flooded properties are reported for two 'bands' being:

- expected internal depth greater than 0.1m (0.25m externally); and,
- greater than 0.5m (0.65m externally).

Table 3-3 identifies the vulnerability classifications used in the assessment of flooded properties.

Table 3-3 – Flood risk vulnerability classification

Category	Description
Essential Infrastructure	– Electricity generating power stations and grid and primary substations
Highly Vulnerable	– Police stations, Ambulance stations, Fire stations, Command Centres and telecommunications installations – Installations requiring hazardous substances consent
More Vulnerable	– Residential dwellings – Caravans, mobile homes and park homes intended for permanent residential use – Student halls of residence, residential care homes, children's homes, social services homes and hostels – Hospitals – Health Services – Education establishments, nurseries – Landfill, waste treatment and waste management facilities for hazardous waste – Sewage treatment works – Prisons
Less Vulnerable	– Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'More Vulnerable' class; and assembly and leisure. – Land and buildings used for agriculture and forestry.

3.2.4 Effect of Climate Change

The effect of climate change on surface water flood risk has been analysed through the risk assessment phase of this study. Based on current knowledge and understanding, the effects of future climate change are predicted to increase the intensity and likelihood of summer rainfall events, meaning surface water flooding may become more severe and more frequent in the future.

The Environment Agency' updated its guidance[2] to account for the uncertainty in climate change projections, with increases in rainfall intensity predicted to range between 20% and 40%. The more conservative of these (40%) was chosen as the event to be used in the SWMP modelling contained in this study.

3.3 Phase II Risk Assessment: Strood

3.3.1 Flood Mechanisms

There are two primary drainage catchments within Strood: the first encompasses the north-eastern parts of Strood (primarily Wainscott) and is associated with the catchment of the Whitewall Creek; while the second includes the town centre and surrounding urban areas. Within Strood itself there are four main surface water sub-catchments, which are

2 Environment Agency, 2016. Can be accessed online at URL: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances , last accessed June 2016.

referred to as the Sycamore Road, Darnley Road, London Road and Cliffe Road sub-catchments. These sub-catchments culminate in the low lying Strood Riverside area of the town centre, as shown in Figure 3-4.

The risk of flooding in Strood is dominated by relatively steep catchments with well-defined flow paths through residential areas converging in a large flat area that encompasses the town centre and main industrial/commercial areas adjacent to the River Medway. Property flooding is predicted to occur where the flow paths leave the highway carriageway and cross residential areas, as well as where surface water is unable to get into the surface water drainage system and be discharged into the River Medway.

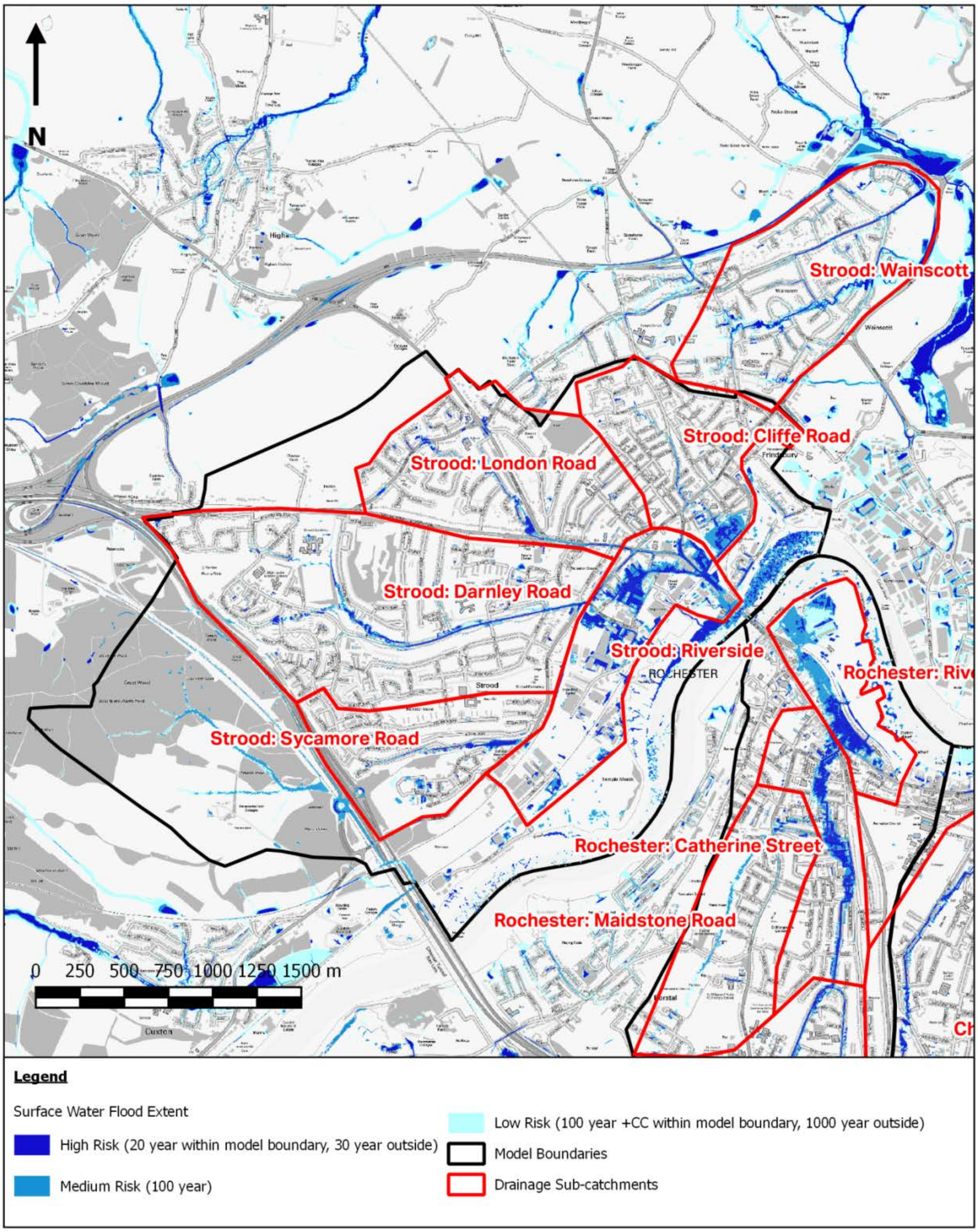


Figure 3-4 - Strood Surface Water Flood Risk Overview

A more comprehensive assessment of the risk of flooding in each of the sub-catchments can be found in Appendix C.

3.3.2 Recommended Level of Assessment

Due to the presence of a surface water sewer network within the low-lying areas of Strood, as well as the potential for greater infiltration than was previously assumed in flood modelling for the strategy and the uFMfSW, detailed modelling was undertaken for the main surface water sub-catchments that contribute flow towards the low-lying district centre of Strood.

3.3.3 Strood Baseline Hydraulic Modelling

Model Overview

The model area for Strood includes the topographic catchment that contributes surface water overland flow to the low-lying centre of Strood adjacent to the River Medway. The boundary of the Strood model area is shown in Figure 3-1.

The hydraulic model in Strood was constructed to represent the rainfall runoff processes in the urban catchment, rural runoff and infiltration processes where ground conditions are favourable to infiltration. Surface water sewers were identified in GIS asset records and highway drainage gullies were identified and included in the hydraulic model where surface water sewers are present. A more detailed description of the structure of the hydraulic model within Strood can be found in the Model Build Report (Appendix B).

Modelling Results

Baseline model results for the Strood study catchment for a range of return period events are provided in Appendix A. The resulting predicted flooding is generally less extensive than predicted in the uFMfSW due to the inclusion of significant Southern Water sewerage infrastructure in the lower parts of the study catchment, as well as a greater allowance for infiltration in the upper catchment.

Table 3-4 identifies the approximate number of predicted properties and critical infrastructure which may be affected within the Strood model catchment for a range of rainfall events and flood depth ‘bands’.

Table 3-4 - Summary of predicted flooded properties within the Strood detailed study catchment

Event	2 year (50% AEP)		20 year (5% AEP)		75 year (1.33% AEP)		100 year (1% AEP)		100 year (1% AEP) +40% Climate Change	
Flood depth	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**
Essential Infrastructure	0	0	0	0	1	0	1	0	1	1
Highly Vulnerable	2	1	2	1	2	2	2	2	2	2
More Vulnerable	73	8	289	49	475	115	543	133	738	180
Less Vulnerable	14	0	49	10	84	24	89	30	113	39
Other	9	1	41	7	72	11	75	16	93	22
Total	**98**	**10**	**381**	**67**	**634**	**152**	**710**	**181**	**947**	**244**

3.3.4 Strood Regeneration Areas

A programme of strategic development has been outlined for the ‘district centre’ of Strood which is one of Medway’s key development sites. The priorities for the district centre are to provide between 500 and 600 new homes with a recreational waterfront incorporating new public spaces and leisure facilities. Proposed regeneration will improve access to Strood station, the town centre and the Medway City Estate, as well as providing community support facilities.

The first phase of development for Strood Riverside, including homes and a landscaped play area called Watermill Gardens, was completed in the 1990s.

3.4 Phase II Risk Assessment: Rochester

3.4.1 Flood Mechanisms

The primary drainage catchment for Rochester is a narrow, linear catchment extending from Rochester Airport in the south to Rochester Riverside in the north, as shown in Figure 3-5 below. There is a tributary sub-catchment that joins the main catchment close to John Street. The primary catchment will be referred to as the Catherine Street catchment, with the tributary catchment referred to as the Maidstone Road catchment. The risk of surface water flooding in the centre of Rochester will be discussed separately, as will be referred to as the Rochester Riverside area.

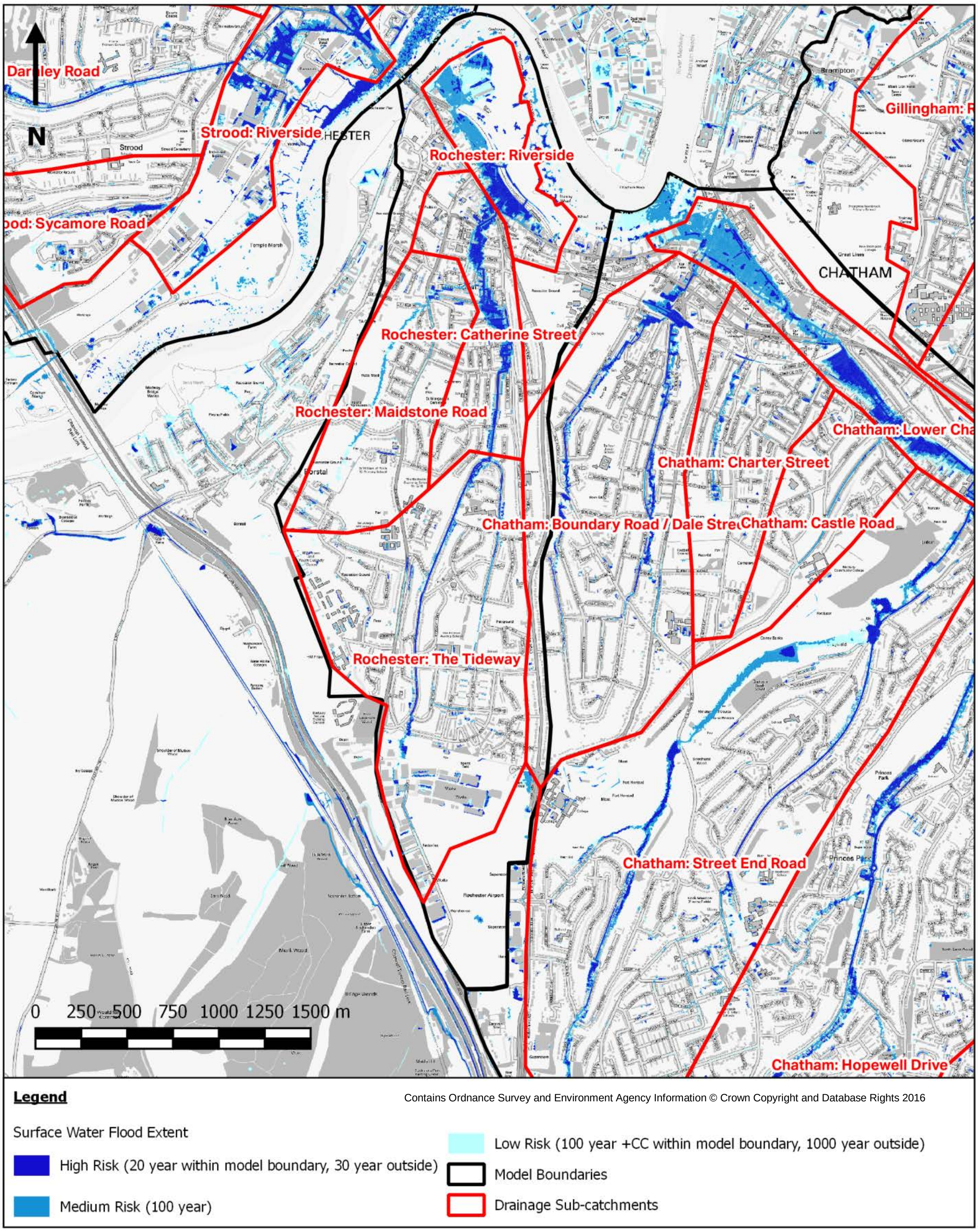


Figure 3-5 - Rochester Surface Water Flood Risk Overview

A more comprehensive assessment of the risk of flooding in each of the sub-catchments can be found in Appendix C.

3.4.2 Recommended Level of Assessment

Due to the presence of a surface water sewer network within the low-lying areas of Rochester, as well as the potential for greater infiltration than was previously assumed in flood modelling for the strategy and the uFMfSW, detailed modelling was undertaken for the main surface water sub-catchments that contribute flow towards the centre of Rochester.

3.4.3 Rochester Baseline Hydraulic Modelling

Model Overview

The model area for Rochester includes the topographic catchment that contributes surface water overland flow to the centre of Rochester adjacent to the River Medway. The boundary of the Rochester model area is shown in Figure 3-1.

The hydraulic model in Rochester was constructed to represent the rainfall runoff processes in the urban catchment, rural runoff and infiltration processes where ground conditions are favourable to infiltration, surface water sewers were identified in GIS asset records and highway drainage gullies were identified and included where surface water sewers are present. A more detailed description of the structure of the hydraulic model within Rochester can be found in the Model Build Report (Appendix B).

Modelling Results

Baseline model results for the Rochester study catchment for a range of return period events are provided Appendix A. The results are less extensive than predicted in the uFMfSW due to the inclusion of significant Southern Water sewerage infrastructure in the lower parts of the study catchment, as well as a greater allowance for infiltration in the upper catchment. The inclusion of detailed drainage gully information in the lower parts of the model has also been shown to improve the confidence in the model results.

Table 3-5 identifies the approximate number of predicted properties and critical infrastructure which may be affected within the Rochester model catchment for a range of rainfall events.

Table 3-5 - Summary of flooded properties within the Rochester detailed study catchment

Event	2 year (50% AEP)		20 year (5% AEP)		75 year (1.33% AEP)		100 year (1% AEP)		100 year (1% AEP) +40% Climate Change	
Flood depth	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**
Essential Infrastructure	0	0	0	0	0	0	0	0	0	0
Highly Vulnerable	0	0	0	0	1	0	1	0	1	0
More Vulnerable	157	42	364	151	590	208	641	216	833	309
Less Vulnerable	10	1	57	16	73	38	76	46	111	68
Other	15	4	69	17	108	41	114	49	137	76
Total	**182**	**47**	**490**	**184**	**772**	**287**	**832**	**311**	**1082**	**453**

3.4.4 Rochester District Centre

A programme of strategic development has been identified for the Rochester District Centre. To the north of the centre of Rochester the Rochester Riverside development comprises 21 hectares of brownfield development land, stretching from Rochester Bridge to the north and Doust Way to the south. In addition to residential developments, regeneration is planned to bring other benefits including a range of publicly accessible open spaces, retail and leisure facilities as well as improved linkage between the River Medway and Rochester High Street.

At the southern extent of the Rochester study area, Rochester Airfield has also been identified as a potential regeneration area within Medway.

3.5 Phase II Risk Assessment: Chatham

3.5.1 Flood Mechanisms

The contributing drainage catchment for Chatham is large and includes a number of tributary drainage flow paths, as shown in Figure 3-6. The main tributary sub-catchments, from west to east, are referred to as Boundary Road/Dale Street, Charter Street, Castle Road, Street End Road, Hopewell Drive, Capstone Road, and Wigmore. The risk of surface water flooding in the centre of Chatham is discussed separately, and will be referred to as the Lower Chatham area.

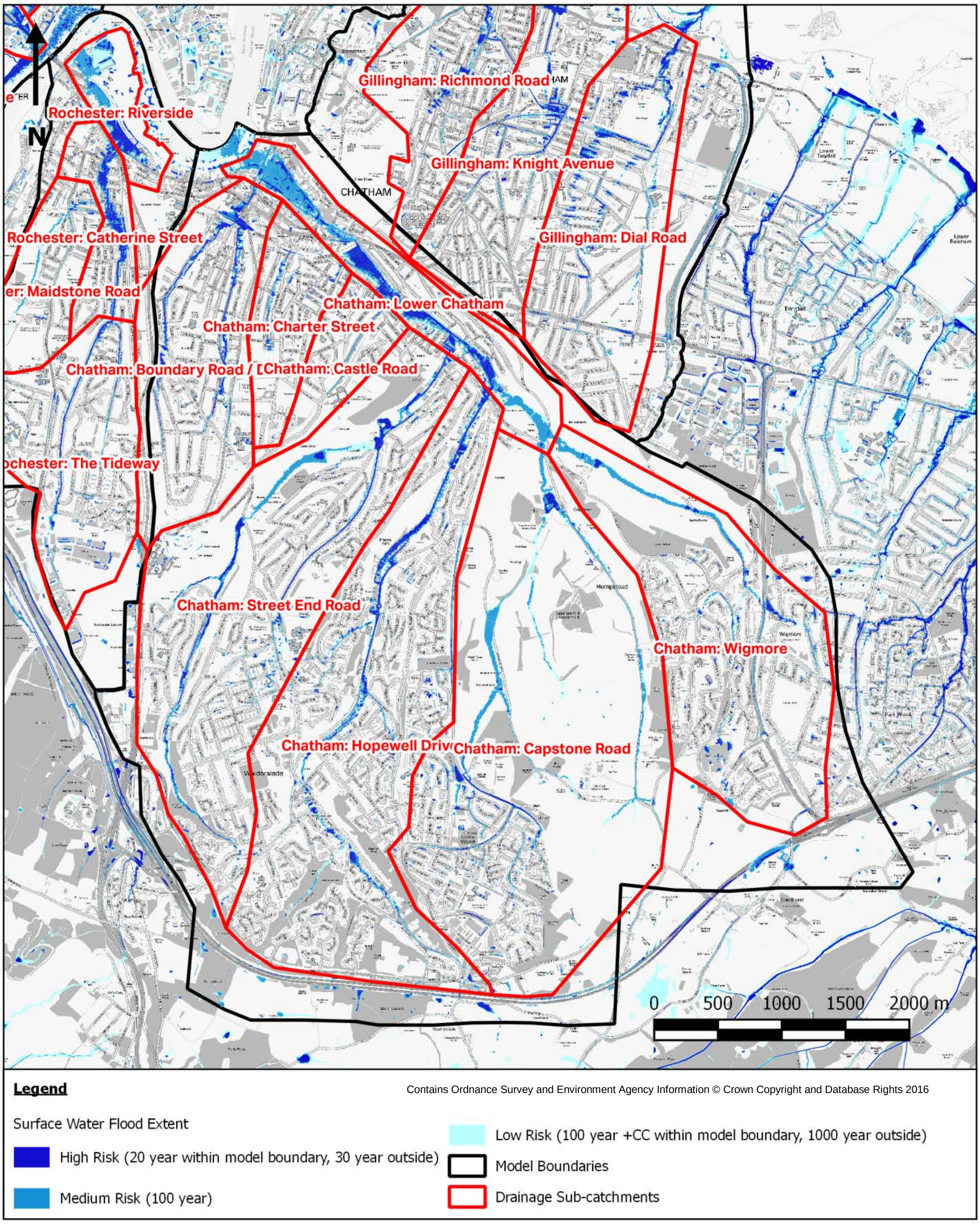


Figure 3-6 - Chatham Surface Water Flood Risk Overview

A more comprehensive assessment of the risk of flooding in each of the sub-catchments can be found in Appendix C.

3.5.2 Recommended Level of Assessment

Due to the presence of a surface water sewer network within the majority of Chatham, as well as the potential for greater infiltration than was previously assumed in flood modelling for the strategy and the uFMfSW, detailed modelling was undertaken for the main surface water sub-catchments that contribute flow towards the centre of Chatham.

3.5.3 Chatham Baseline Hydraulic Modelling

Model Overview

The model area for Chatham includes the entire topographic catchment that contributes surface water overland flow to the centre of Chatham and the waterside area. The boundary of the Chatham model area is shown in Figure 3-1.

The hydraulic model in Chatham was constructed to represent the rainfall runoff processes in the urban catchment, rural runoff and infiltration processes where ground conditions are favourable to infiltration. The Southern Water sewer network (including combined, foul and surface water assets) and highway drainage gullies where surface water sewers are present are also included in the detailed hydraulic model. A more detailed description of the structure of the hydraulic model within Chatham can be found in the Model Build Report (Appendix B).

Modelling Results

Baseline model results for the Chatham study catchment for a range of return period events are provided in Appendix A. The results are generally less extensive than predicted in the uFMfSW due to the inclusion of significant Southern Water sewerage infrastructure in the lower parts of the study catchment, as well as a greater allowance for infiltration in the upper catchment.

Table 3-6 identifies the approximate number of predicted properties which may be affected within the Chatham model catchment for a range of rainfall events.

Table 3-6 - Summary of flooded properties within the Chatham detailed study catchment

Event	2 year (50% AEP)		20 year (5% AEP)		75 year (1.33% AEP)		100 year (1% AEP)		100 year (1% AEP) +40% Climate Change	
Flood depth	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**
Essential Infrastructure	0	0	2	0	3	1	3	1	3	1
Highly Vulnerable	3	3	4	3	5	4	5	4	5	5
More Vulnerable	462	68	1384	363	2280	649	2512	736	3240	1173
Less Vulnerable	28	8	94	20	220	104	241	132	299	176
Other	33	6	108	21	254	108	273	125	341	181
Total	**526**	**85**	**1592**	**407**	**2762**	**866**	**3034**	**998**	**3888**	**1536**

3.5.4 Chatham Potential Regeneration

Medway Council has identified Chatham, including the waterfront area, railway station and commercial centre with an aim for Chatham to become Medway's civic and cultural heart which will also function as a sub-regional shopping centre. This area lies at the base of all flow paths from the upper catchment, and is also adjacent to the formal flood defences.

3.6 Phase II Risk Assessment: Gillingham

3.6.1 Flood Mechanisms

The majority of the Gillingham study area is predominantly urban and there is very little open space in the upper catchments. There are three main flow paths within the Gillingham study catchment, all of which commence in the south and flow in a northerly direction towards the River Medway estuary, as shown in Figure 3-7 below. The flow paths pass along highways, as well as though residential areas of Gillingham.

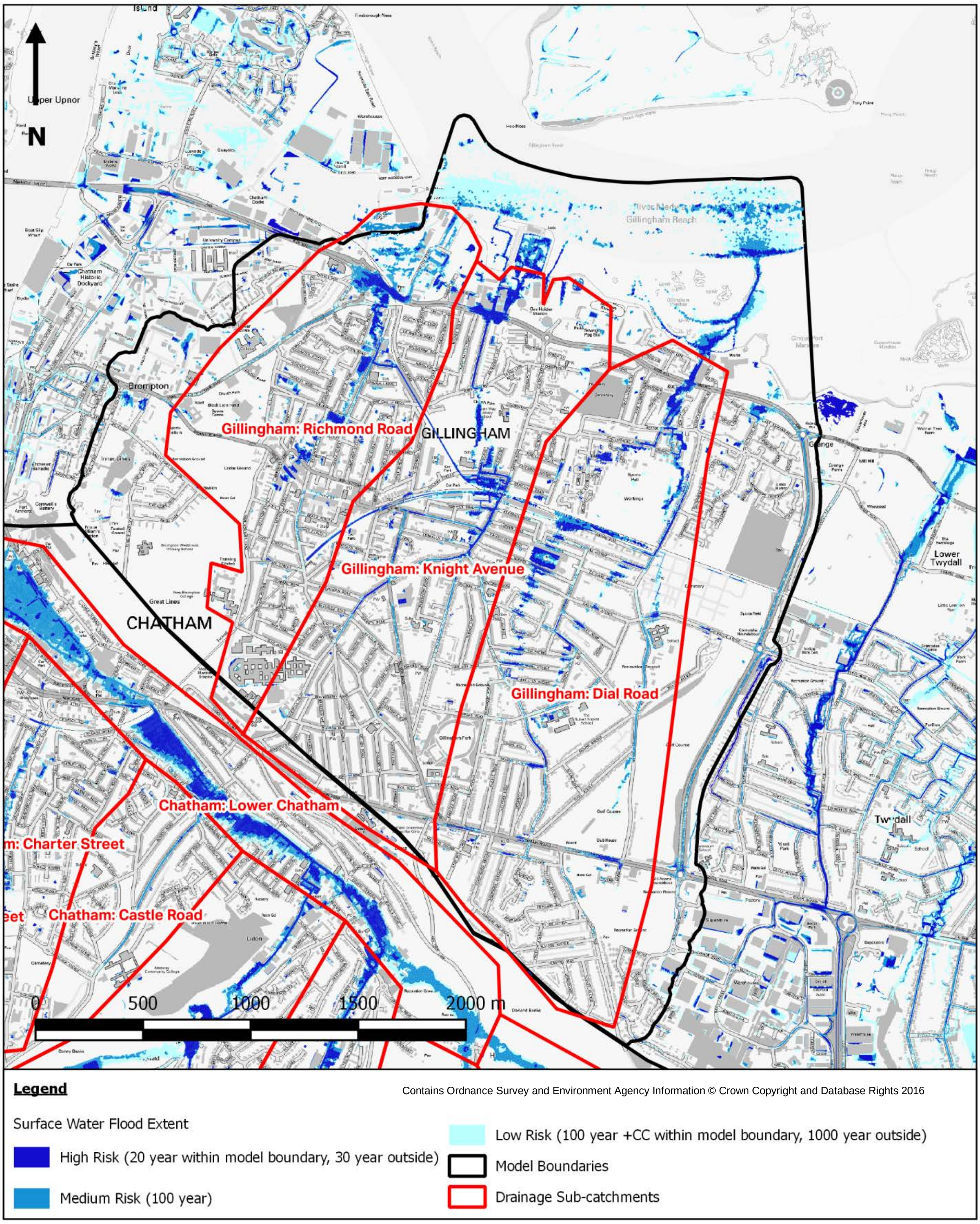


Figure 3-7 - Gillingham Surface Water Flood Risk Overview

A more comprehensive assessment of the risk of flooding in each of the sub-catchments can be found in Appendix C.

3.6.2 Recommended Level of Assessment

Due to the presence of a surface water sewer network within the majority of Gillingham, including pumping stations and combined sewer networks, detailed modelling was undertaken for the main surface water sub-catchments that pass through the main urban areas of Gillingham.

3.6.3 Gillingham Baseline Hydraulic Modelling

Model Overview

The model area for Gillingham includes the entire topographic catchments that form the three primary flow paths through the urban area of Gillingham. The combined boundary of the Gillingham model area is shown in Figure 3-1.

The hydraulic model in Gillingham was constructed to represent the rainfall runoff processes in the urban catchment, rural runoff and infiltration processes where ground conditions are favourable to infiltration. The Southern Water sewer network (including combined, foul and surface water assets) and highway drainage gullies where surface water sewers are present has also been included. A more detailed description of the structure of the hydraulic model within Gillingham can be found in the Model Build Report (Appendix B).

Modelling Results

Baseline model results for the Gillingham study catchment for a range of return period events are provided in Appendix A. The results are generally less extensive than predicted in the uFMfSW due to the presence and inclusion of significant Southern Water sewerage infrastructure within the entire study catchment.

Table 3-7 identifies the approximate number of predicted properties and critical infrastructure which may be affected within the Gillingham model catchment for a range of rainfall events.

Table 3-7 - Summary of flooded properties within the Gillingham detailed study catchment

	2 year (50% AEP)		20 year (5% AEP)		75 year (1.33% AEP)		100 year (1% AEP)		100 year (1% AEP) +40% Climate Change	
	>0.1m	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**	**>0.1m**	**>0.5m**
Essential Infrastructure	0	0	1	0	1	0	1	0	1	0
Highly Vulnerable	1	0	1	0	1	0	1	0	1	0
More Vulnerable	151	15	517	53	817	123	903	139	1168	193
Less Vulnerable	20	1	40	7	54	9	63	13	79	17
Other	21	1	59	2	78	9	85	13	115	20
Total	**193**	**17**	**618**	**62**	**951**	**141**	**1053**	**165**	**1364**	**230**

3.6.4 Gillingham District Centre

Gillingham is identified as a district centre where significant change is required through a programme of strategic development. It is anticipated that this may include development within the waterfront marina areas to the north of Gillingham town centre, referred to as Chatham Waters and Gillingham Waters.

3.7 Phase II Risk Assessment: Lower and Middle Stoke

3.7.1 Flood Mechanisms

Parts of Lower and Middle Stoke, to the north of the River Medway estuary, are identified on the updated Flood Map for Surface Water as being at risk of surface water and ordinary watercourse flooding, as shown in Figure 3-8.

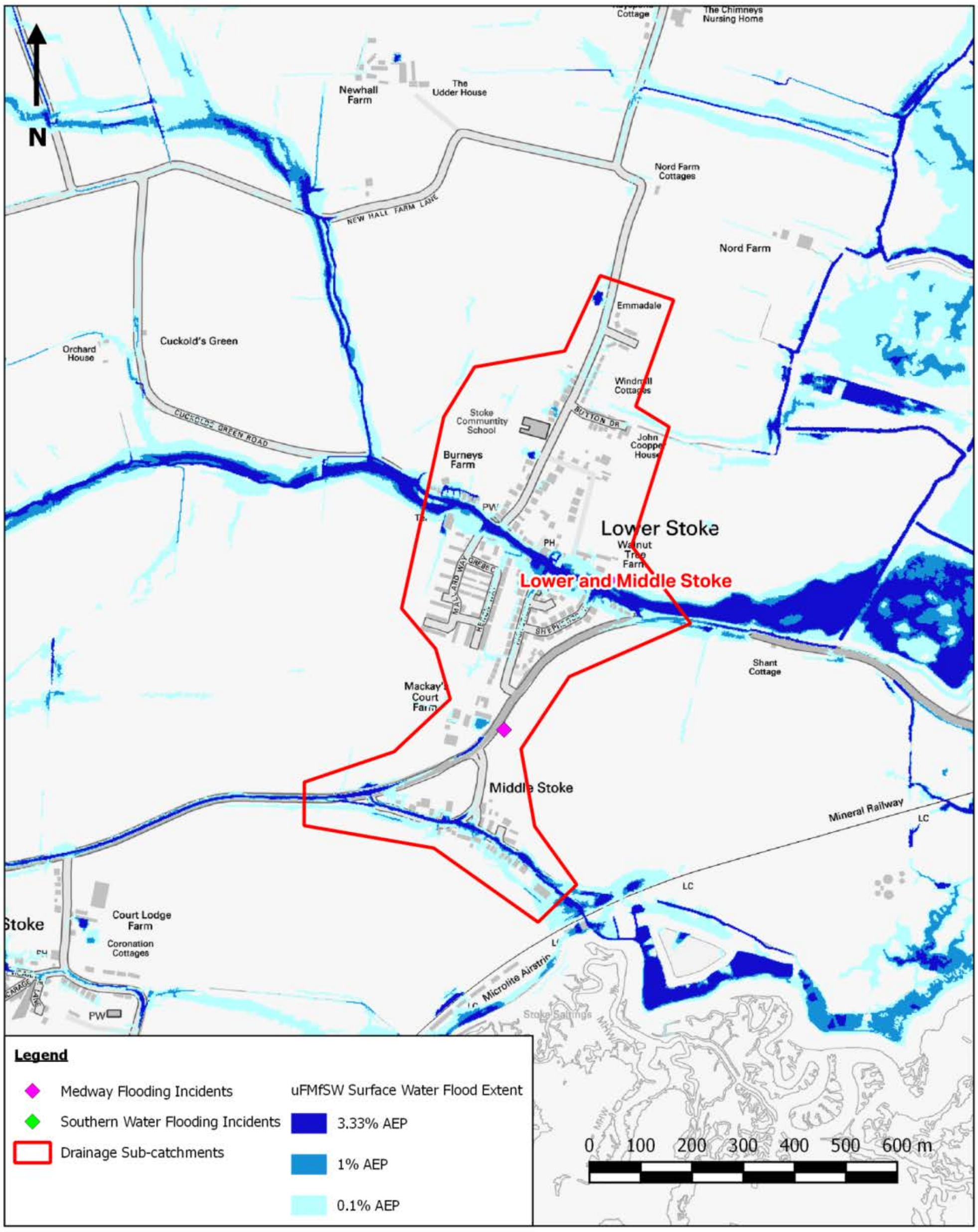


Figure 3-8 – Lower and Middle Stoke Surface Water Flood Risk Overview

A more comprehensive assessment of the risk of flooding in Lower and Middle Stoke can be found in Appendix C.

3.7.2 Recommended Level of Assessment

A number of investigations have been undertaken within Lower and Middle Stoke to review the risk of flooding. In addition, the risk of flooding is well defined in the updated Flood Map for Surface Water for both surface water and ordinary watercourse flooding. Although there is surface water drainage infrastructure in Lower and Middle Stoke, existing data provides a clear outline of flood mechanisms in the catchment. Therefore, detailed modelling has not been completed in this catchment as part of the SWMP.

3.8 Phase II Risk Assessment: Hoo St Werburgh

3.8.1 Flood Mechanisms

Parts of Hoo St. Werburgh, to the north of the River Medway estuary, are identified on the updated Flood Map for Surface Water as being at risk of surface water and ordinary watercourse flooding, as shown in Figure 3-9.

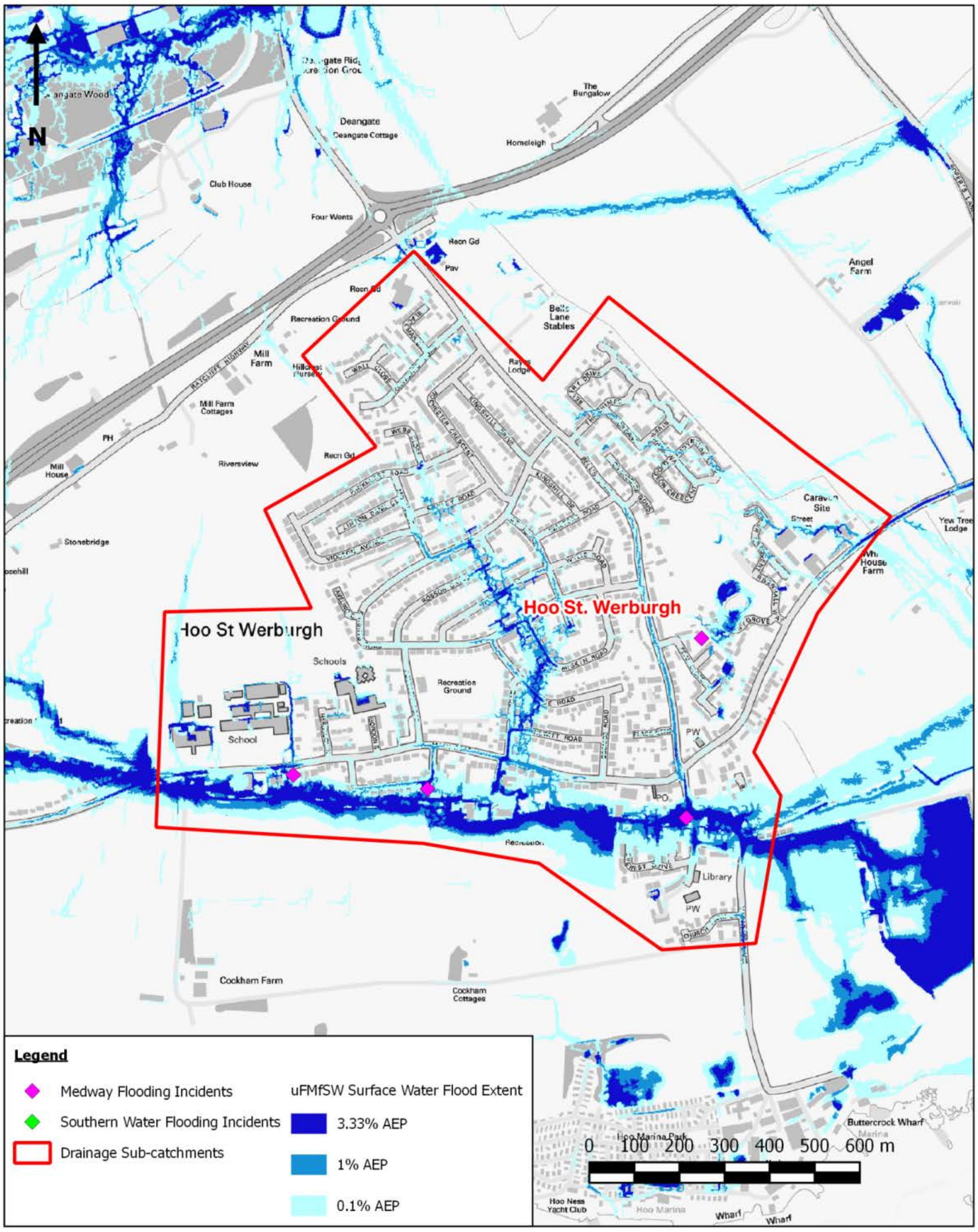


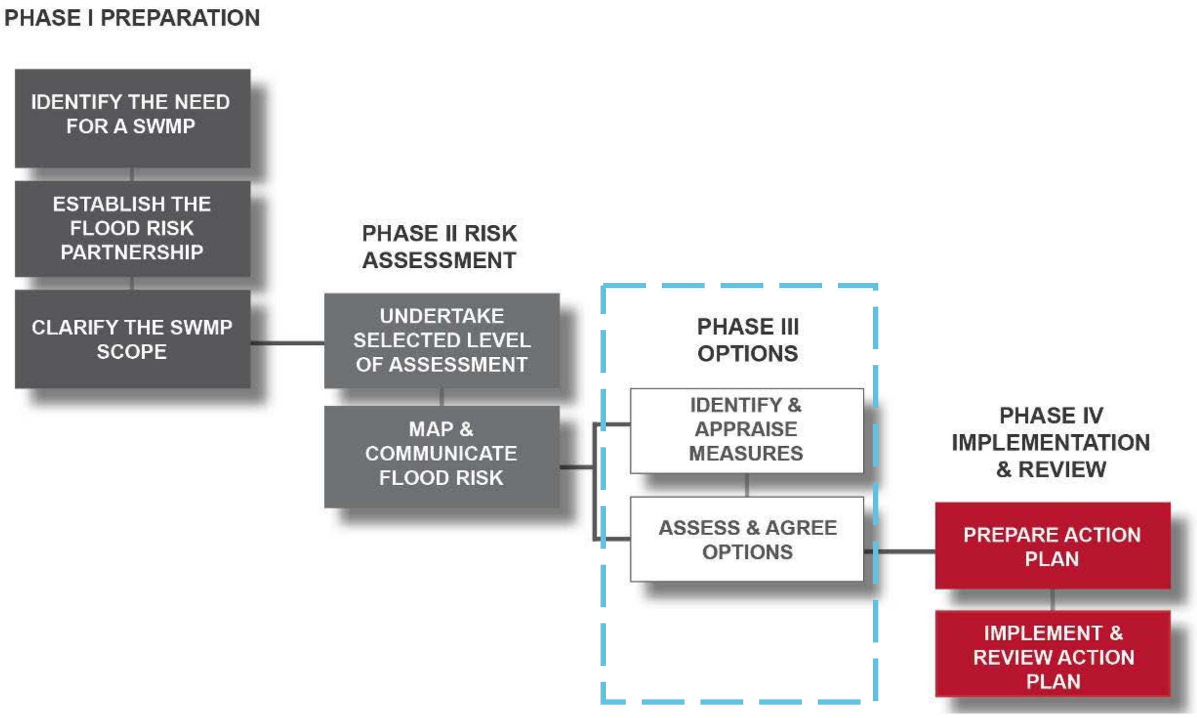
Figure 3-9 - Hoo St. Werburgh Surface Water Flood Risk Overview

A more comprehensive assessment of the risk of flooding in Hoo St. Werburgh can be found in Appendix C.

3.8.2 Recommended Level of Assessment

A number of investigations have been undertaken within Hoo St. Werburgh to review the risk of flooding. In addition, the risk of flooding is well defined in the updated Flood Map for Surface Water for both surface water and ordinary watercourse flooding. Although there is surface water drainage infrastructure in Hoo St. Werburgh, existing data provides a clear outline of flood mechanisms in the catchment. Therefore, detailed modelling has not been completed as part of this SMWP.

Phase III: Options


PHASE I PREPARATION
IDENTIFY THE NEED FOR A SWMP
ESTABLISH THE FLOOD RISK PARTNERSHIP
CLARIFY THE SWMP SCOPE
PHASE II RISK ASSESSMENT
UNDERTAKE SELECTED LEVEL OF ASSESSMENT
MAP & COMMUNICATE FLOOD RISK
PHASE III OPTIONS
IDENTIFY & APPRAISE MEASURES
ASSESS & AGREE OPTIONS
PHASE IV IMPLEMENTATION & REVIEW
PREPARE ACTION PLAN
IMPLEMENT & REVIEW ACTION PLAN

4 Phase III Options

4.1 Overview

Following the identification of flooding mechanisms within each study catchment (SWMP Phase II) a shortlist of potential flood alleviation options were identified in tandem with advice from Medway Council and local Risk Management Authorities. Representatives of the project steering group reviewed the shortlist of options and agreed a selection of three options per modelled study catchment for further evaluation through the options modelling stage.

Technical details of the options modelling are included in Appendix B of this SWMP and typical unit rates / costs are included in Appendix D.

4.2 Assessment Methodology

4.2.1 Objectives

Phase III delivers a high level assessment of potential options and mitigation measures for each catchment identified in Phase II. This involves identifying a range of structural and non-structural options for alleviating flood risk and assessing the feasibility of these options. As well as surface water, consideration is given to other sources of flooding and their interactions with surface water flooding, with particular focus on options which will provide flood alleviation from combined flood sources.

The purpose of this phase of work is to assess and shortlist options in order to eliminate those that are not feasible or cost beneficial. Options which are not suitable are discarded and the remaining options are developed and tested against their relative effectiveness, benefits and costs. Measures which achieve multiple benefits, such as water quality, biodiversity or amenity, are encouraged and promoted.

The options assessment presented here follows the high level methodology described in the Defra SWMP Guidance and is focussed on highlighting areas for further analysis and immediate 'quick win' actions.

4.2.2 Links to Funding Plans

It is important to consider local investment plans and initiatives and committed future investment when identifying measures that could be implemented within the study area. The following schemes could provide linked funding solutions to flood alleviation work in the study area, which would provide a cost effective and holistic approach to surface water flood risk management:

- Local Green Infrastructure Delivery Plans;
- The Environment Agency Medium Term Plan (MTP) and associated Flood Coastal Erosion Risk Management (FCERM) Grant in Aid (GiA) / Local Levy opportunities;
- Local Investment Plan and Programme (funding plan for delivery of the Local Plan);
- Major commercial and housing development is an opportunity to retro-fit surface water management measures (housing associations and private developers);
- Medway Council highways department and Highways Agency investment plans; and
- Southern Water Business Plan / Asset Management Plan

Although costing estimates of the potential options measures were provided, no funding is confirmed or is guaranteed at present.

4.2.3 Options Identification

The Defra SWMP Technical Guidance defines measures and options as:

"A measure is defined as a proposed individual action or procedure intended to minimise current and future surface water flood risk or wholly or partially meet other agreed objectives of the SWMP. An option is made up of either a single, or a combination of previously defined measures."

At this stage the option identification pays no attention to constraints such as funding or delivery mechanisms to enable a robust technical assessment. The assessment considers all types of options including[3]:

- Options that change the source of risk;
- Options that modify the pathway or change the probability of flooding;
- Options that manage or modify receptors to reduce the consequences;
- Temporary as well as permanent options;
- Options that work with the natural processes wherever possible;
- Options that are adaptable to future changes in flood risk;
- Options that require actions to be taken to deliver the predicted benefits (for example, closing a barrier, erecting a temporary defence or moving contents on receiving a flood warning);
- Innovative options tailored to the specific needs of the project; and,
- Options that can deliver opportunities and wider benefits, through partnership working where possible.

4.2.4 Identifying Measures

Surface water flooding is often highly localised and complex. There are few solutions which will provide benefits in all locations, and therefore, its management is largely dependent upon the characteristics of the study area.

The SWMP Plan Technical Guidance (Defra 2010) identifies the concept of Source, Pathway and Receptor as an appropriate basis for understanding and managing flood risk, as described below:

- Source Control: Source control measures aim to reduce the rate and volume of surface water runoff through increasing infiltration or storage, and hence reduce the impact on receiving drainage systems. Examples include retrofitting SUDS (e.g. bioretention basins, wetlands, green roofs etc) and other methods for reducing flow rates and volume.
- Pathway Management: These measures seek to manage the overland and underground flow pathways of water in the urban environment, and include: increasing capacity in drainage systems; separation of foul and surface water sewers etc.
- Receptor Management: This is considered to be changes to communities, property and the environment that are affected by flooding. Mitigation measures to reduce the impact of flood risk on receptors may include improved warning and education or flood resilience measures.

3 Environment Agency (March 2010) *'Flood and Coastal Flood Risk Management Appraisal Guidance',* Environment Agency: Bristol.

Table 4-1 - Typical Surface Water Flood Risk Management Measures

	Generic measures	Site specific measures
	– Do Nothing (do not continue maintenance) – Do Minimum (continue current maintenance)	
Source control	– Rain gardens – Soakaways, water butts and rainwater harvesting – Green roofs – Permeable paving – Underground storage; – Other 'source' measures	– Swales – Detention basins – Street planting; – Ponds and wetlands – Land management practices
Pathway Management	– Improved maintenance regimes – Increase gulley assets	– Increase capacity in drainage system – Separation of foul & surface water sewers – Managing overland flows – Land Management practices – Other 'pathway' measures
Receptor Management	– Improved weather warning – Planning policies to influence development – Social change, education and awareness – Improved resilience and resistance measures – Raising Doorway/Access Thresholds – Other 'receptor' measures	– Temporary or demountable flood defences - collective measure

4.2.5 High Level Construction Cost Estimates, Assessment Guidance and Local Constraints

A high level construction cost estimate is calculated for each flood mitigation solution proposed. These should be considered as approximate order of magnitude costs only. Unit cost estimates, standard assumptions and design life estimates are included in Appendix D.

A high-level scoring system for each of the options was utilised to short-list preferred options. The approach to short-listing options is based on the guidance in FCERM and Defra's SWMP guidance with the scoring criteria provided in Appendix D and results presented in **Appendix E – Options Assessment Table.**

Groundwater conditions can restrict the type of SuDS options that are likely to be approved by the Environment Agency and need to be considered as part of the options assessment phase of the SWMP. Further detail is provided within Appendix D.

4.3 Strood Options Assessment

4.3.1 High-level Options Appraisal

The high-level assessment of potential flood risk mitigation options in Strood is presented in Appendix E. On the whole, the risk of flooding in Strood is categorised by a predominantly urban catchment with flow paths running along and traversing the public highways. This presents constraints on the potential for catchment management or large scale attenuation options within Strood. The extent of flood risk increases in the lower areas close to the town centre, which presents opportunities for increasing drainage collection capacity where possible but is constrained by restrictions in pumping capacity of the surface water sewer network.

The options that were short-listed following the high level assessment include:

- Attenuation storage along surface water flow paths within the study catchment, such as along Darnley Road;
- Rainwater harvesting on a local scale where possible, both through retrofit solutions and through potential strategic schemes;
- Highway drainage collection capacity improvements, including the provision of additional drainage gullies in the lower parts of the study area in Strood
- Increase maintenance regimes for high-risk surface water drainage assets;
- Structural modifications to the highway to prevent surface water flow paths leaving the carriageway, such as in Rede Court Road and Darnley Close; and
- Property level protection in areas of high surface water flood risk where alternative mitigation options may not be possible.

As local funding becomes available, or as local planning applications and highways improvement works come forward, the short-listed options should be reviewed to ensure that those not taken forward to hydraulic modelling at this time are retained as viable options.

4.3.2 Options Modelling

Following shortlisting of options, potential options to be taken forward to the detailed hydraulic modelling stage were agreed with stakeholders. The short-listed options that presented the greatest potential for flood risk reductions in the hydraulic model were chosen ahead of those that are strategically favourable but are unlikely to be accurately represented within the model. The options within Strood that were taken forward to hydraulic modelling include:

STR-OP-001 - Attenuation storage features within public open space areas along the Darnley Road flow path within Strood.

STR-OP-002 - PLP within areas close to Strood town centre that are a high risk of surface water flooding.

STR-OP-003 - Additional drainage collection capacity in the lower parts of Strood.

A description and figures showing how the options in Strood were modelled is presented below, along with estimated costs associated with their implementation.

STR-OP-001 - Darnley Road Attenuation Storage Areas

Along the main surface water flow path that flows down Darnley Road in western Strood, there are seven open space areas adjacent to the main flow path that have been identified as being potentially suitable for attenuation storage areas, as identified in yellow on Figure 4-2. These areas are not significant in size when compared with the scale of the contributing catchment, but have been assessed as having the potential to provide localised flood risk benefits. As described in the High Level Assessment included in Appendix C (STR-003), there are anecdotal reports and videos showing water flowing down Darnley Road in 2014. In addition, this flow path contributes a significant catchment area to lower Strood.

The attenuation storage basins in the six open space areas along the main flow path of Darnley Road were represented in the model by lowering the 2D mesh by 0.5m over the majority of the green space areas, excluding a marginal buffer to allow for safe side slopes to the lowered areas. In order to retain pedestrian access to the properties, and to activate more of the storage, intermediary porous walls were created to act as check dams in the storage areas. The combined surface area of the six storage basins is approximately 7,000m^2. Inlets to the storage areas were provided by lowering the kerb to the west of each storage area to present a pathway for water to leave the carriageway.

An additional attenuation storage area was created on the green open space adjacent to Carnation Road further up the flow path to the west. This area was lowered with a base level of 42.5m AOD, associated with an approximate depth of between 0.5m-1m. Kerbs were lowered along the southern extent of the storage area to allow surface water to enter from the carriageway.

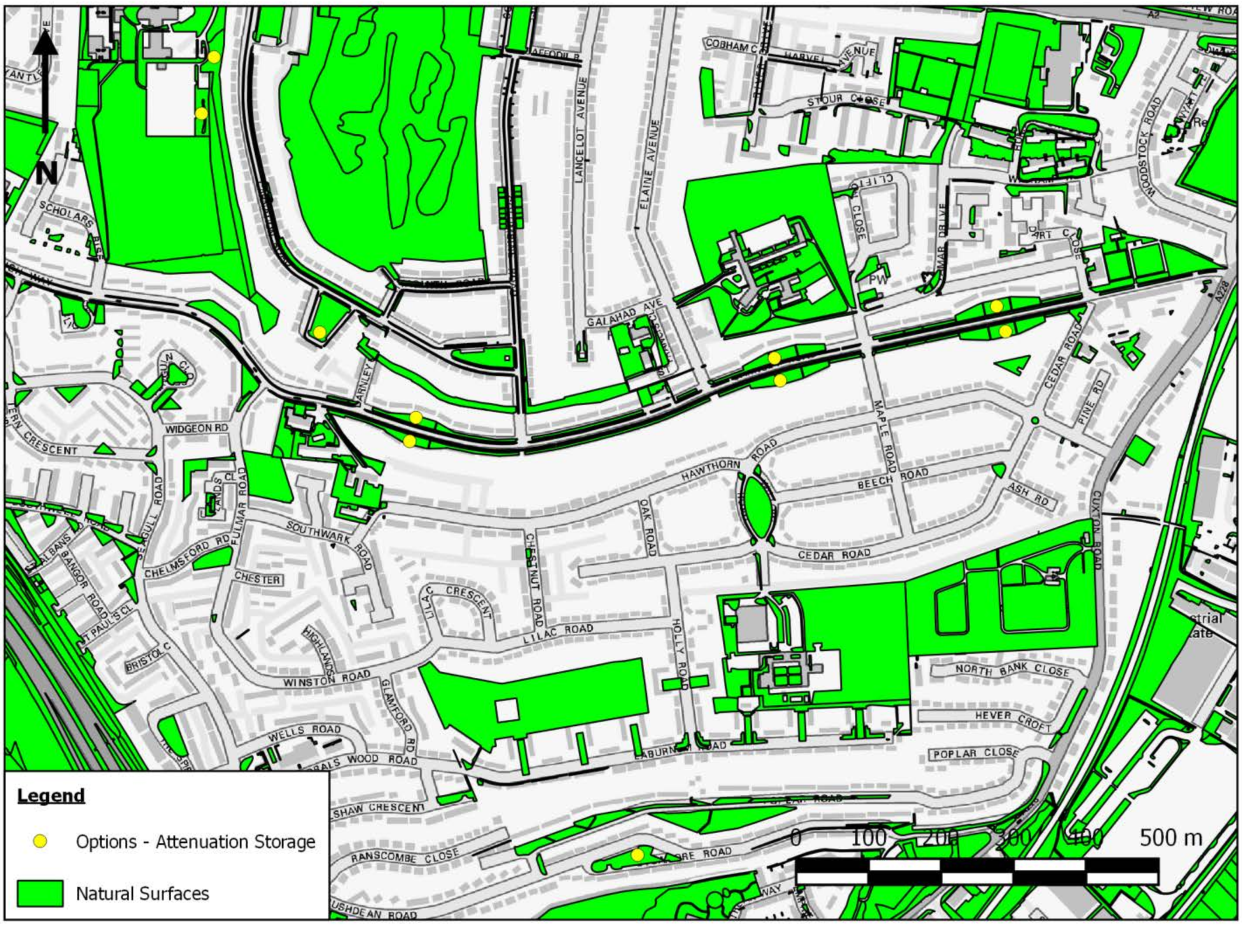


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Figure 4-1 – Option STR-OP-001 Darnley Road, Strood attenuation storage

It is estimated that the construction cost for this scheme could be between £180,000 to £270,000, which includes survey costs of £10,000 to £12,000, and the majority of the cost relating to disposal of excavated material. The cost of the scheme is likely to increase should the survey identify any below-ground services that will need to be diverted or avoided. This cost does not included detailed design and assessment costs associated with the scheme.

STR-OP-002 - Lower Strood Property Level Protection

The baseline modelling identified a high concentration of properties at risk of flooding in lower Strood in areas that have experienced historic flooding previously. In this area, an option was entered into the model whereby PLP was adopted to improve the resistance of properties to internal flooding. This was represented in the model through increasing the threshold level of the property to 1m in height. A value of 1m was chosen since it is widely understood that flood protection measures such as flood doors or temporary flood barriers at a property level have a depth of water up to which they are considered to be effective. Above this depth, the structural stability of the measure could be compromised.

A total of 106 properties were raised to account for PLP, as identified in Figure 4-3. These properties are clustered around Smith Street, Alma Road, Roach Street, Charles Street and High Street in Strood. The feasibility of fitting devices to individual properties has not been reviewed and should be considered at a more detailed design stage.

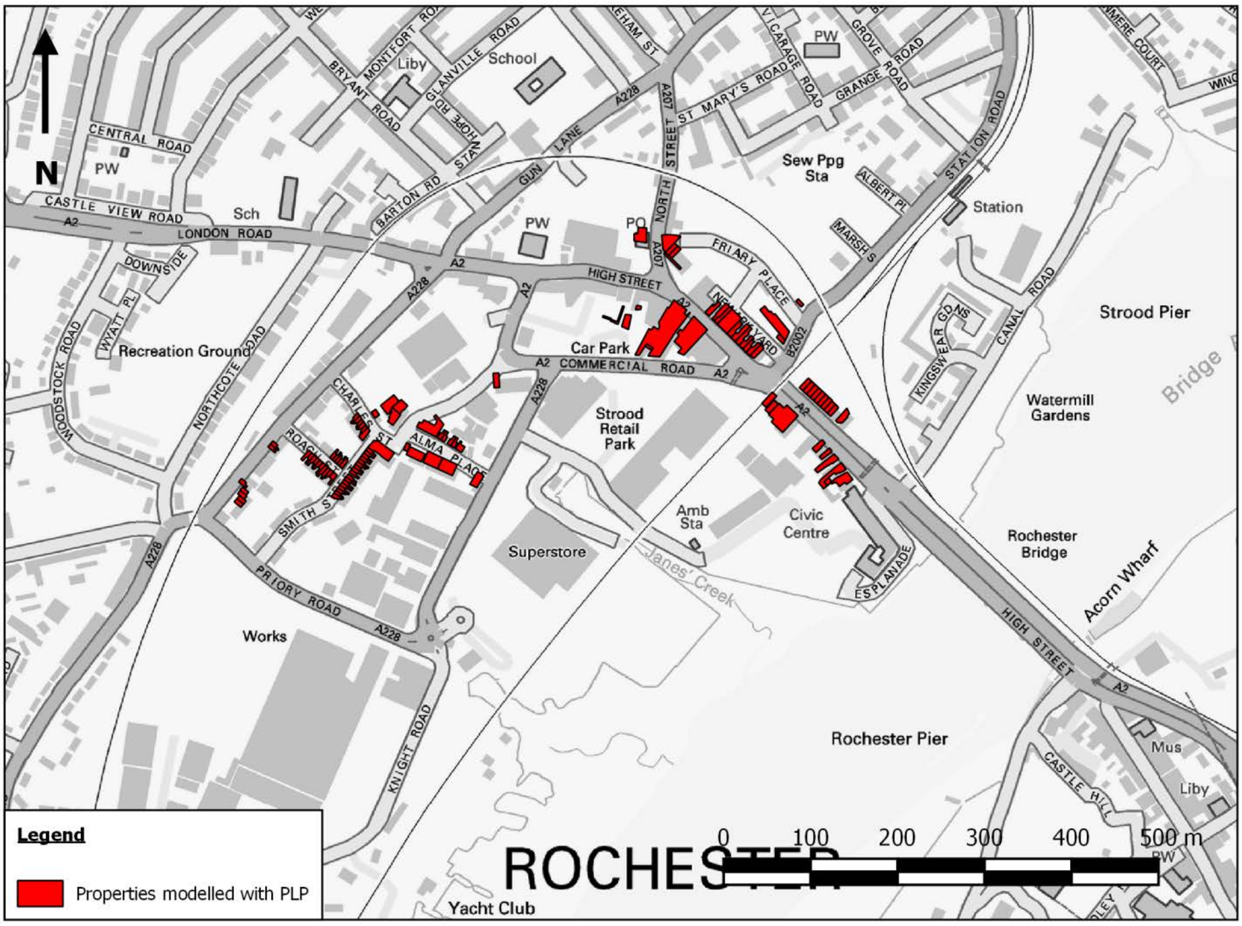

Figure 4-2 - Option STR-OP-002 Lower Strood Property Level Protection

As shown in Appendix D, it is estimated in industry guidance that the average cost of PLP measures for a residential dwelling is between £4,000 and £6,000 per property protected. A total of 106 properties were modelled as benefiting from property level protection in the hydraulic model for this option, resulting in a total scheme cost of between £424,000 and £636,000. There is the potential to undertake a proportionate approach to the implementation of property level protection within this area, which will result in a reduction to scheme costs.

STR-OP-003 - Lower Strood Collection Drainage Capacity

The baseline model results show that overland flow enters low-lying parts of Strood and is unable to enter the surface water drainage system. There are limited overland exceedance routes through which surface water flooding can discharge into the River Medway. A review of the current coverage of surface water drainage gullies identified locations whereby additional drainage gullies could be constructed to improve the connectivity with the surface water drainage network. Figure 4-4 identifies the locations of the 18 additional drainage gullies that were entered into the hydraulic model in Strood to represent this surface water management option.

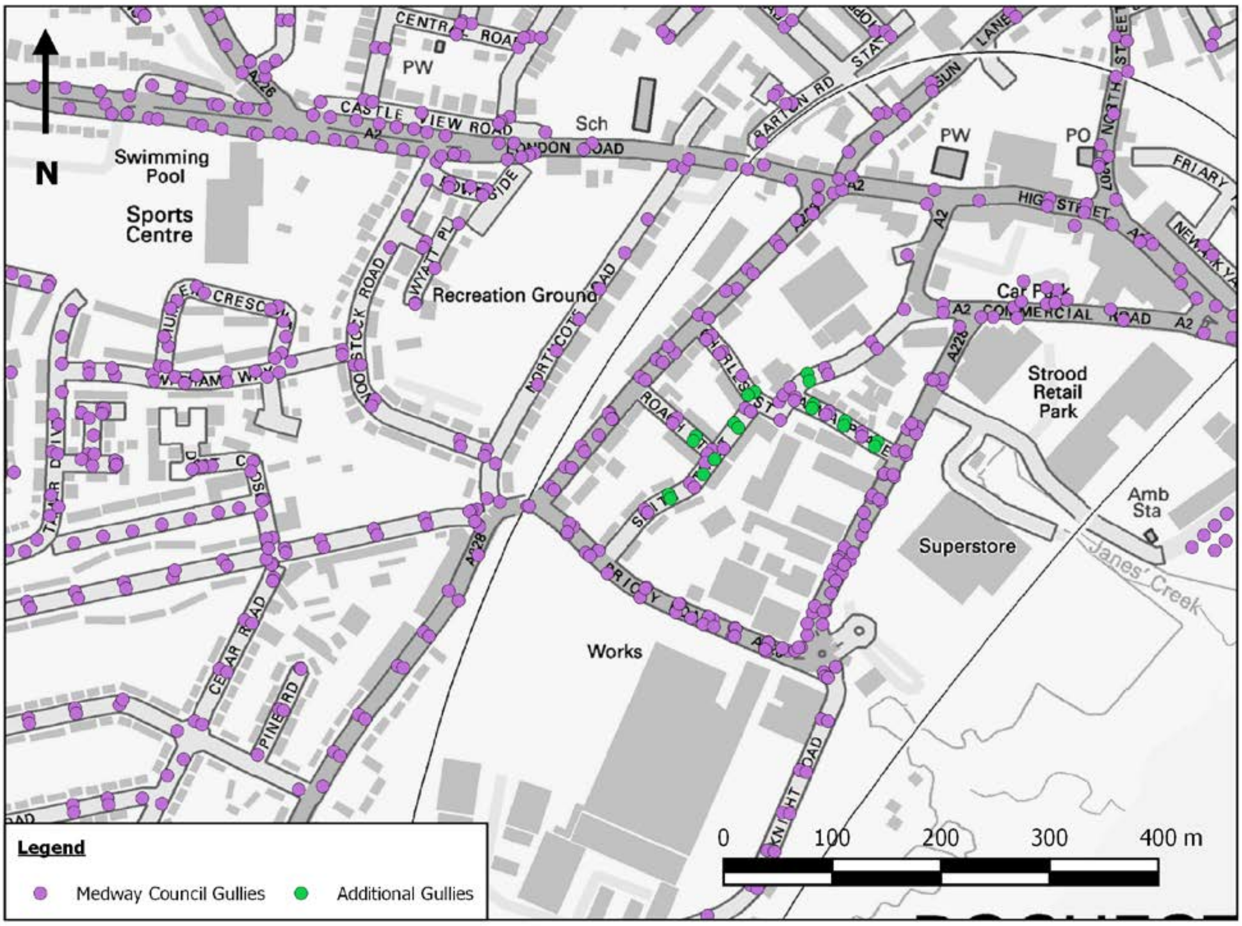

Figure 4-3 - Option STR-OP-003 Lower Strood Drainage Capacity Improvements

An addition 18 gullies were included in the model to represent this option. An estimate cost of between £400 and £600 for the installation of additional gullies has been assumed, which results in a total scheme cost of between £7,200 and £10,800.

4.3.3 Strood Option Benefits

The reduction in properties shown to flood associated with implementing the options in Strood for the main FCERM Grant in Aid significant bandings is provided in Table 4-5.

Table 4-2 - Flooded property reductions associated with Strood options

	20 year (5% AEP) Very Significant		75 year (1.33% AEP) Significant		100 year (1% AEP) Moderate[4]	
	Flood >0.1m	**Flood >0.5m**	**Flood >0.1m**	**Flood >0.5m**	**Flood >0.1m**	**Flood >0.5m**
STR-OP-001	-6	-6	-7	-9	-8	-12
STR-OP-002[5]	-1	-2	-2	-3	-1	-4
STR-OP-003	-6	-7	-6	-7	-5	-8

As shown, Option STR-OP-001 will remove 8 properties from being internally flooded greater than 100mm compared to the baseline for the 100 year (1% AEP) event and 6 properties from the Very Significant 20 year (5%AEP) flood event. The

4 100 year (1% AEP) used as substitute to 200 year (0.5%) for Moderate significance banding

5 In addition to the 106 properties protected due to the use of PLP

performance of Option STR-OP-001 is on the whole more effective than the other two options, with Option STR-OP-002 performing less favourably than Option STR-OP-003.

4.4 Rochester Options Assessment

4.4.1 High-level Options Appraisal

The high-level assessment of potential flood risk mitigation options in Rochester is presented in Appendix E. Surface water flood risk in Rochester is dominated by a long, linear flow path that commences in the upper urban areas of Rochester. The flow path initially is predominantly within the highways before traversing a number of residential terraces. In the lower areas of Rochester, the main flow path is prevented from discharging into the River Medway by historic land raising activities in the location of the Rochester Riverside regeneration area. The catchment is almost entirely urban, which presents constraints on the potential for catchment management or large scale attenuation options within Rochester.

The options that were short-listed following the high level appraisal (Appendix E) include:

- Attenuation storage along surface water flow paths within the study catchment, such as from the Maidstone Road sub-catchment to the south-west of the junction of Maidstone Road and Ethelbert Road;
- Rainwater harvesting on a local scale where possible, both through retrofit solutions and through potential strategic schemes;
- Highway drainage collection capacity improvements, including the provision of additional drainage gullies along the main flow path to remove surface water from the surface at Cossack Street, Castle Avenue and Rochester Avenue;
- Increase maintenance regimes for high-risk surface water drainage assets;
- Structural modifications to the highway to prevent surface water flow paths leaving the carriageway, such as in Rochester Avenue and Church Street;
- Creation of an exceedance route through the Rochester Riverside regeneration area to prevent the accumulation of surface water during extreme events in lower Rochester;
- Runoff management from Rochester Riverside regeneration area; and,
- Property level protection in areas of high surface water flood risk where alternative mitigation options may not be possible.

As local funding becomes available, or as local planning applications and highways improvement works come forward, the short-listed options should be reviewed to ensure that those not taken forward to hydraulic modelling at this time are retained as viable options.

4.4.2 Options Modelling

Hydraulic modelling was undertaken for three options within the Rochester study catchment. The short-listed options that presented the greatest potential for flood risk reductions in the hydraulic model were chosen ahead of those that are strategically favourable but are unlikely to be accurately represented within the model. The options within Rochester that were taken forward to hydraulic modelling include:

ROC-OP-001 - Additional drainage collection capacity along main flow path.

ROC-OP-002 – Runoff management from the Rochester Riverside regeneration area.

ROC-OP-003 – Formalise exceedance route through Rochester Riverside regeneration area.

A description and figures showing how the options in Rochester were modelled is presented below, along with estimated costs associated with their implementation.

ROC-OP-001 – Drainage Capacity Improvements

The baseline model results show that where the main flow path leaves the carriageway and traverses through residential properties and highways, such as Cossack Street, Castle Avenue, Rochester Avenue, Ross Street and Foord Street, there are areas of surface water ponding on the highway. A review of the current coverage of surface water drainage gullies identified locations whereby additional drainage gullies could be constructed to improve the connectivity with the surface water drainage network. Figure 4-5 identifies the locations of additional drainage gullies that were entered into the hydraulic model in Rochester to represent this surface water management option.

Figure 4-4 - Option ROC-OP-001 Rochester Drainage Capacity Improvements

An additional 30 gullies were included in the model to represent this option. An estimate cost of between £400 and £600 for the installation of additional gullies has been assumed, which results in a total scheme cost of between £12,000 and £18,000.

ROC-OP-002 – Rochester Riverside Runoff Management

There is no positive drainage within the hydraulic model for the majority of the Rochester Riverside regeneration area. In addition, the runoff coefficient for the area is high as the surface is not considered to be natural. As such, runoff from this area contributes a relatively significant volume to the local drainage network where the topography drains towards the south. This option directs all surface water falling on the Rochester Riverside regeneration area, as identified in Figure 4-6, to a private drainage system with an outfall into the River Medway to ensure that it does not contribute any runoff volume to the existing surface water drainage system.

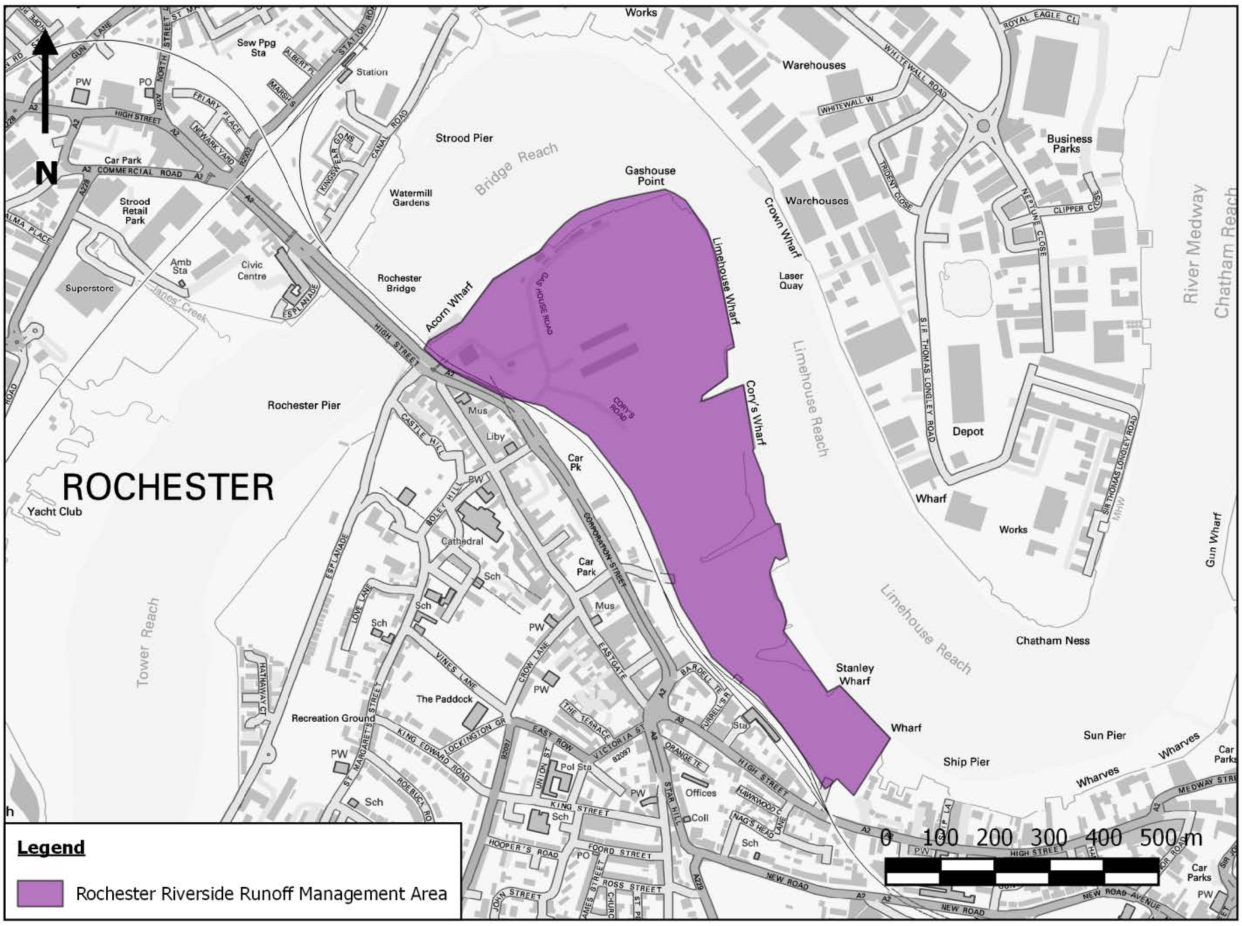

Figure 4-5 - Option ROC-OP-002 Rochester Riverside Runoff Management

There are considered to be no direct costs associated with this option since it has been assumed that the drainage strategy has not been finalised for the majority of the proposed development area. This option is to inform policy rather than for the construction of an engineered solution. Any associated additional costs would therefore fall to the developer.

ROC-OP-003 – Rochester Riverside Exceedance Route

One of the contributing factors in the extent of flooding in lower Rochester is the inability of the main surface water flow path to continue to the north beyond the railway line due to historic land raising activities in the Rochester Riverside area. This option seeks to formalise an exceedance route beyond the existing underbridge beneath the railway line by lowering a section of the previously raised land, as identified in Figure 4-7. This was carried out in the model through the use of a mesh zone to lower the ground level to continue at the same level as beneath the railway.

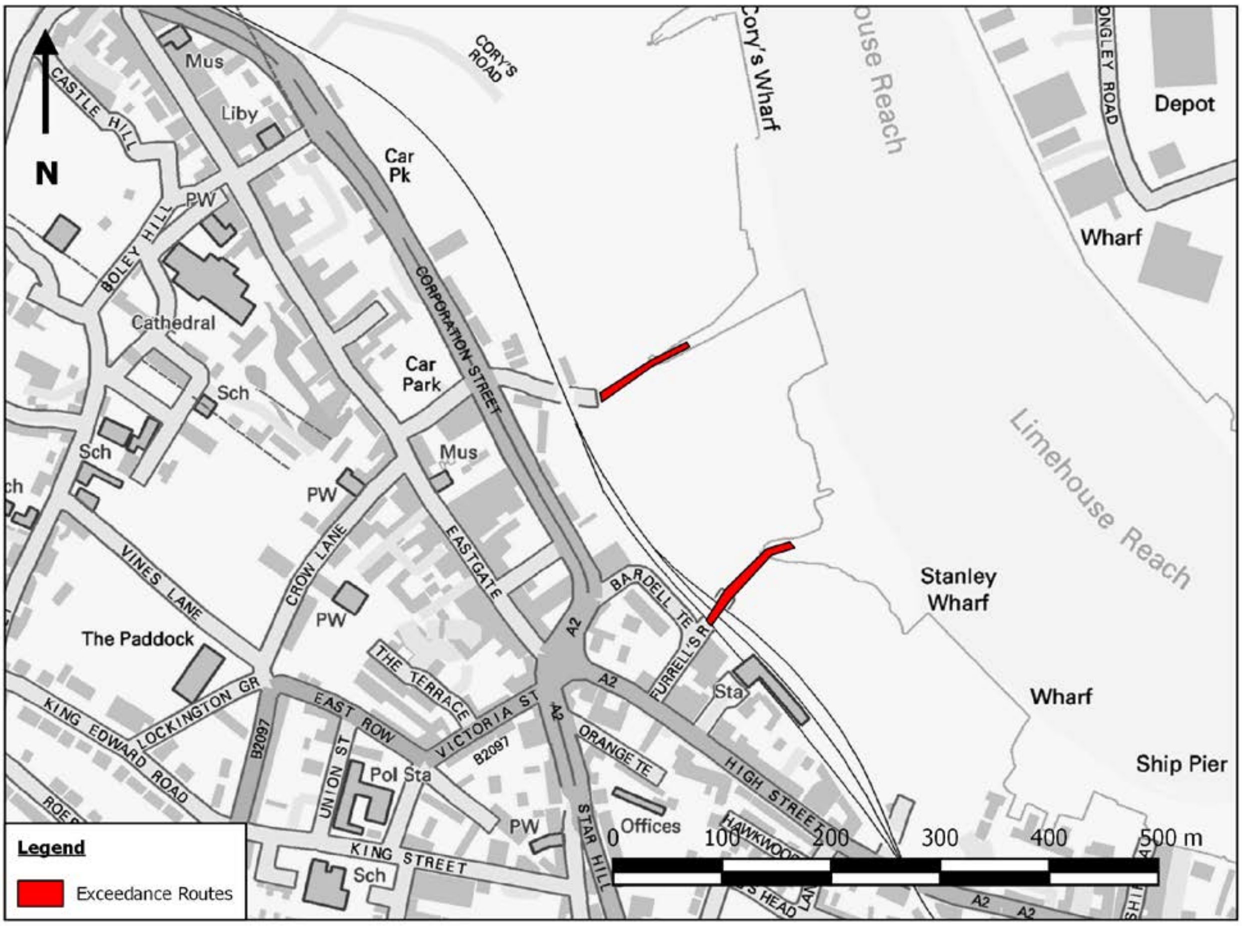

Figure 4-6 - Option ROC-OP-003 Lower Rochester Exceedance Management

The costs associated with implementing this option are highly dependent on the interaction with the existing flood defences, as well as the current proposals for the regeneration area. A high-level estimate of the potential costs associate with this option is between £122,000 and £230,000, which is predominantly related to works to the flood defences, as well as initial survey and excavation works.

4.4.3 Rochester Option Benefits

The reduction in properties shown to flood associated with implementing the options in Rochester for the main FCERM Grant in Aid significant bandings is provided in Table 4-6.

Table 4-3 - Flooded property reductions associated with Rochester options

	20 year (5% AEP) Very Significant		75 year (1.33% AEP) Significant		100 year (1% AEP) Moderate[6]	
	Flood >0.1m	**Flood >0.5m**	**Flood >0.1m**	**Flood >0.5m**	**Flood >0.1m**	**Flood >0.5m**
ROC-OP-001	-11	-15	-8	-7	-8	-4
ROC-OP-002	-2	-12	-5	-17	-8	-14
ROC-OP-003	-16	-20	-34	-42	-45	-42

As shown, Option ROC-OP-003 will remove 45 properties from being internally flooded greater than 100mm compared to the baseline for the 100 year (1% AEP) event and 16 properties from the Very Significant 20 year (5%AEP) flood event.

6 100 year (1% AEP) used as substitute to 200 year (0.5%) for Moderate significance banding

The performance of Option ROC-OP-003 is substantially more effective than the other two options, with the other two options performing better independently for either extreme or more frequent flood events.

4.5 Chatham Options Assessment

4.5.1 High-level Options Appraisal

The high-level assessment of potential flood risk mitigation options in Chatham is presented in Appendix E. There are a number of extensive surface water flow paths within the study catchment that flow through both rural and urban areas in the upper catchment. This therefore provides opportunities for attenuation features in open space areas within the catchment. In the lower areas of Chatham, the flow paths combine into an extensive area at risk of surface water flooding.

The options that were short-listed following the high level appraisal (Appendix E) include:

- Attenuation storage along surface water flow paths within the study catchment, such as to the immediate south-west of Kingfisher Drive, to the south of Mitchell Avenue, Hook Meadow playing fields, Tunbury Wood, Capstone Farm, Star Lane, Pattens Lane;
- Rainwater harvesting on a local scale where possible, both through retrofit solutions and through potential strategic schemes;
- Highway drainage collection capacity improvements, including the provision of additional drainage gullies along the main flow path to remove surface water from the road surface;
- Increase maintenance regimes for high-risk surface water drainage assets;
- Structural modifications to the highway to prevent surface water flow paths leaving the carriageway, such as in Dove Close, Hill View Way, Vale Drive, Woodhurst, Boundary Road, Dale Street, Medway Street;
- Creation of an exceedance route and attenuation in the Chatham regeneration area between Chatham Station and the town centre; and,
- Property level protection in areas of high surface water flood risk where alternative mitigation options may not be possible, including the lower Chatham flow path around King's Road and Lester Road.

As local funding becomes available, or as local planning applications and highways improvement works come forward, the short-listed options should be reviewed to ensure that those not taken forward to hydraulic modelling at this time are retained as viable options.

4.5.2 Options Modelling

Hydraulic modelling was undertaken for three options within the Rochester study catchment. The short-listed options that presented the greatest potential for flood risk reductions in the hydraulic model were chosen ahead of those that are strategically favourable but are unlikely to be accurately represented within the model. The options within Chatham that were taken forward to hydraulic modelling include:

CHA-OP-001 – Flood storage area (FSA) close to Kingfisher Drive.

CHA-OP-002 – Storage and runoff exceedance management between station and High Street

CHA-OP-003 – PLP close to King's Road and Lester Road

A description and figures showing how the options in Chatham were modelled is presented below, along with estimated costs associated with their implementation.

CHA-OP-001 – Kingfisher Drive FSA

There is a significant flow path that passes through the grounds of the Kingfisher Primary School. From here, the flow path is shown to continue to the north-east towards the centre of Chatham though residential areas. The option was represented in the model as a bund in the far north of the playing fields to hold back overland flow should it occur on the ground surface, as shown in Figure 4-8. The height of the bund was limited to 1m to ensure that its height remained satisfactory. The volume of water able to be stored behind the bund is dependent on the slope of the ground to the south-west of the bund.

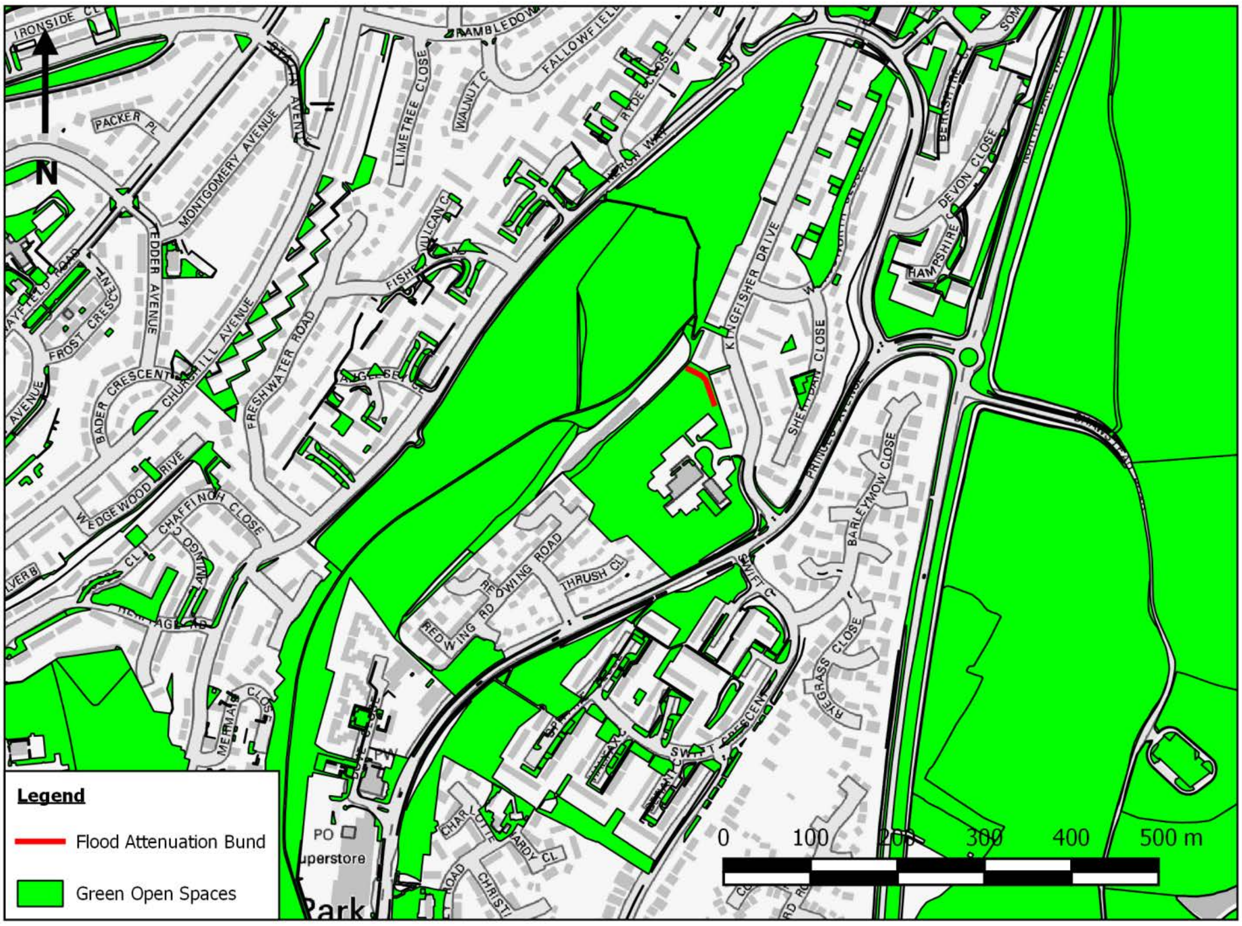

Figure 4-7 - Option CHA-OP-001 Kingfisher Drive Flood Storage Area

The bund for the flood storage area is proposed to be within a public open space that is assumed to have good vehicular access. The estimated costs for this option are dependent on survey works, for which there are known to be buried services. It is estimated that this option could cost between £25,000 and £30,000 excluding detailed design work. The costs could be greater due to the impact on below-ground services.

CHA-OP-002 – Chatham Station Exceedance Management

As part of the regeneration of the area between Chatham Station and Chatham town centre, this option seeks to provide attenuation and formalise exceedance route. This has been modelled by lowering the car park of the existing Wickes store to the north of the station, where surface water overland flow is shown to enter the car park before continuing to the north. In addition, a wall has been created to prevent overland flow along Railway Street from continuing to the town centre, and is instead directed along Waterfront Way. This option should be considered in addition to improvements to the carriageway and pedestrian areas, such as tree pits and rain gardens, which are unlikely to show improvements in the hydraulic modelling.

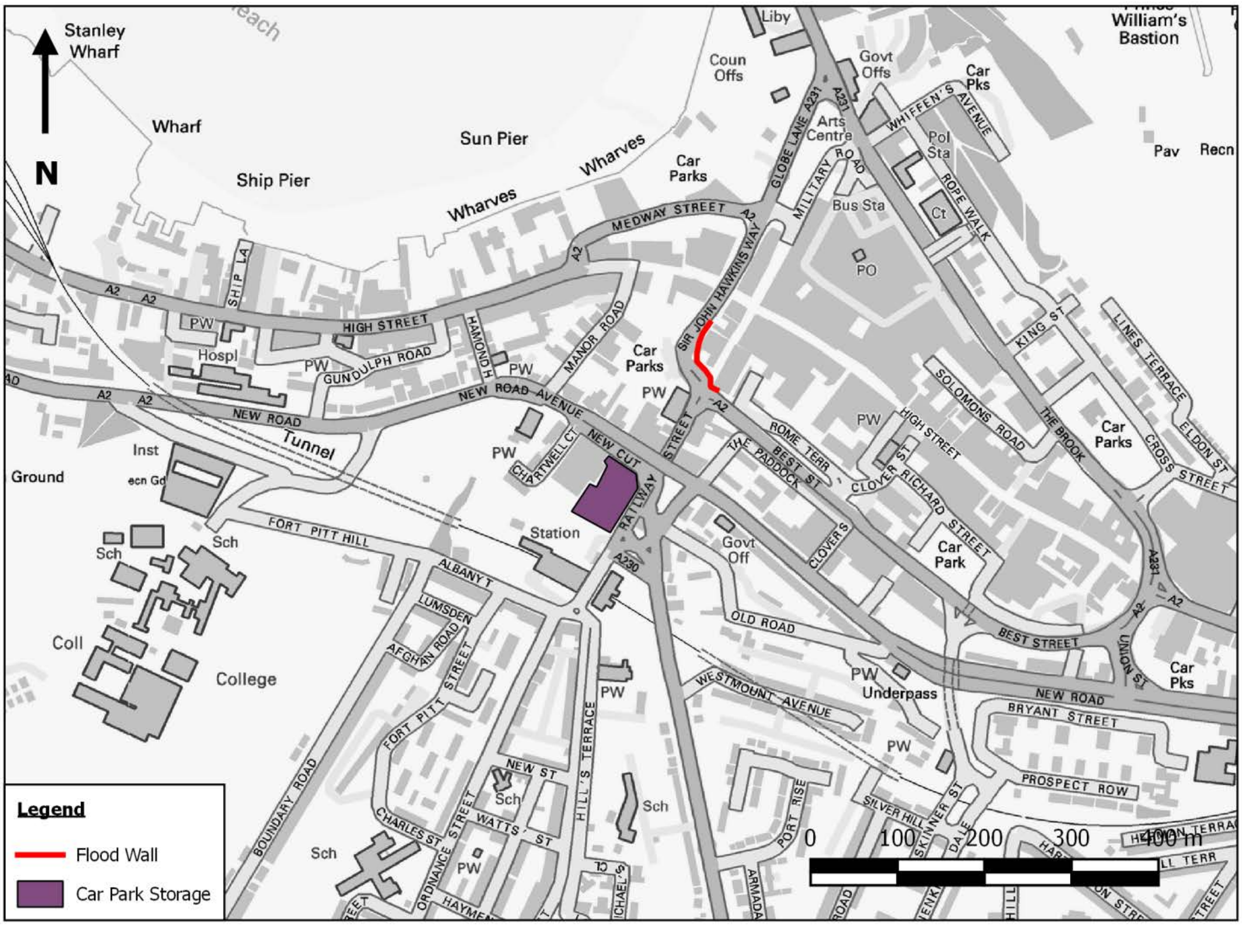

Figure 4-8 - Option CHA-OP-002 Chatham Station to town centre exceedance route

The costs associated with this option are highly dependent on the proposals for the regeneration along this flow path and the potential for alterations to the road and car park area to be developer led rather than separately funded. It is estimated that this option could cost between £180,000 and £230,000, depending on the nature of the proposed attenuation in the car park and the results of surveys of below-ground utilities.

CHA-OP-003 – Lower Chatham Property Level Protection

The flooding mechanisms in lower Chatham are dominated by multiple flow paths from the various sub-catchments in upper Chatham converging within the lower urban area. It is unlikely that it would be feasible to prevent overland flow from all sub-catchments from contributing to flooding. In addition, there is considered to be a significant concentration of highway drainage assets in Chatham. Consequently, an option was modelled to provide PLP for those properties that were at high risk of surface water flooding along the main flow path in Chatham to determine the influence of protecting these properties on the risk of flooding elsewhere.

A total of 293 properties were raised by 1m to account for PLP, as identified in Figure 4-10. These properties are clustered around Nelson Terrace, Maida Road, Reform Road, Lester Road, Newham Street and Henry Street. The feasibility of fitting devices to individual properties has not been reviewed and should be considered at a more detailed design stage.

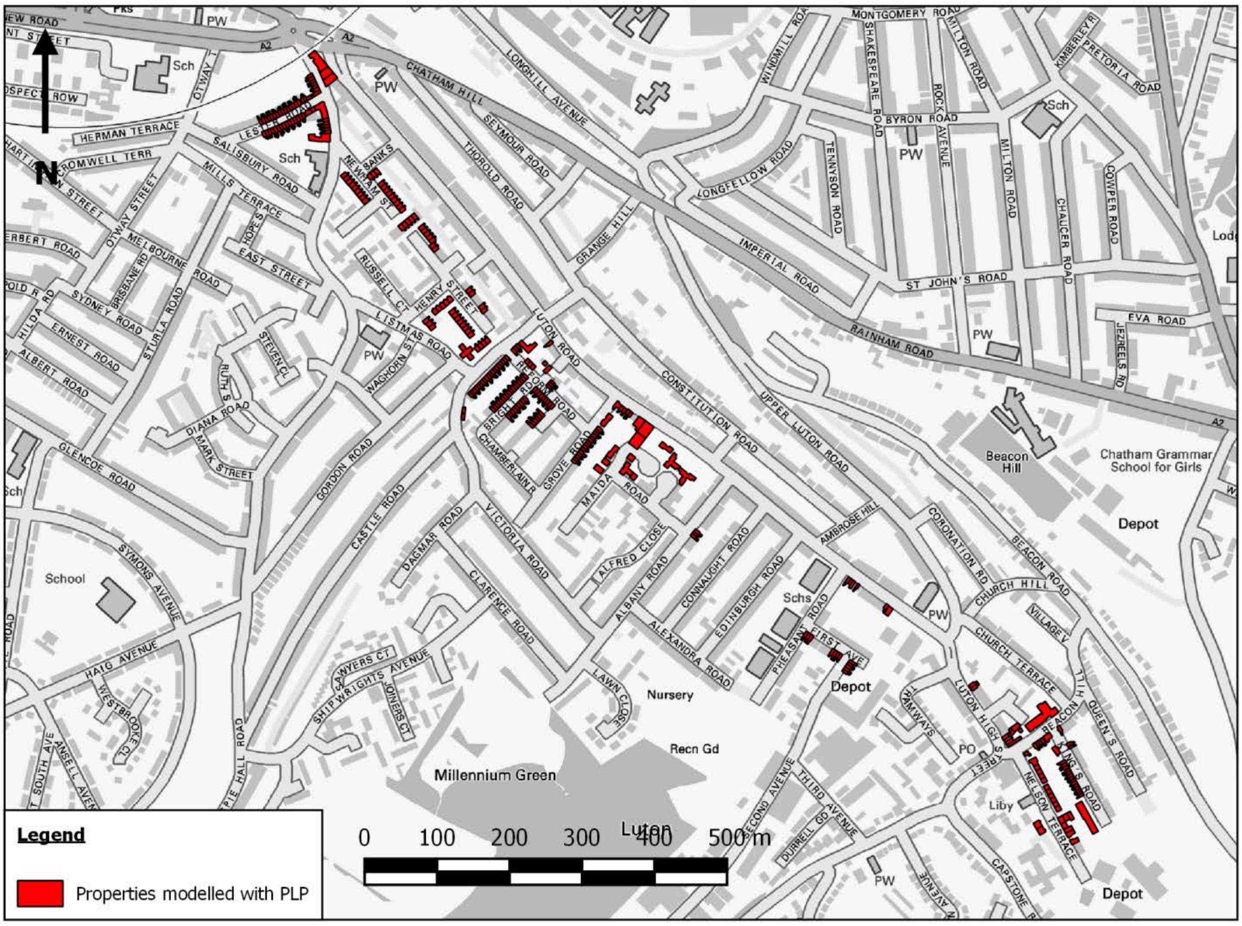

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Figure 4-9 - Option CHA-OP-003 Lower Chatham PLP

As shown in Table 4-2, it is estimated in industry guidance that the average cost of PLP measures for a residential dwelling is between £4,000 and £6,000 per property protected. A total of 293 properties were modelled as benefiting from property level protection in the hydraulic model for this option, resulting in a total scheme cost of between £1,170,000 and £1,758,000. There is the potential to undertake a proportionate approach to the implementation of property level protection within this area, which will result in a reduction to scheme costs.

4.5.3 Chatham Option Benefits

The reduction in properties shown to flood associated with implementing the options in Chatham for the main FCERM Grant in Aid significant bandings is provided in Table 4-7.

Table 4-4 - Flooded property reductions associated with Chatham options

	20 year (5% AEP) Very Significant		75 year (1.33% AEP) Significant		100 year (1% AEP) Moderate[7]	
	Flood >0.1m	**Flood >0.5m**	**Flood >0.1m**	**Flood >0.5m**	**Flood >0.1m**	**Flood >0.5m**
CHA-OP-001	-27	-21	-28	-27	-37	-29
CHA-OP-002	-16	-4	-20	-11	-25	-13
CHA-OP-003[8]	-6	-5	-7	-8	-9	-13

7 100 year (1% AEP) used as substitute to 200 year (0.5%) for Moderate significance banding

8 In addition to the 293 properties protected due to the use of PLP

Option CHA-OP-001 will remove 37 properties from being internally flooded greater than 100mm compared to the baseline for the 100 year (1% AEP) event and 27 properties from the Very Significant 20 year (5%AEP) flood event. The performance of the other two options is also favourable, with reductions in flood depths in all rainfall events.

4.6 Gillingham Options Assessment

4.6.1 High-level Options Appraisal

The high-level assessment of potential flood risk mitigation options in Gillingham is presented in Appendix E. There are three primary flow paths within the Gillingham study catchment. The catchment is almost entirely urban, which presents constraints on the potential for catchment management or large scale attenuation options within Chatham.

The options that were short-listed following the appraisal (Appendix E) include:

- Attenuation storage along surface water flow paths within the study catchment, such as within the grounds of Saxon Way Primary School or to the south of Groombridge Drive;
- Rainwater harvesting on a local scale where possible, both through retrofit solutions and through potential strategic schemes;
- Highway drainage collection capacity improvements, including the provision of additional drainage gullies along the main flow paths such as in Canadian Avenue, Sturdee Road, Toronto Avenue;
- Increase maintenance regimes for high-risk surface water drainage assets;
- Structural modifications to the highway to prevent surface water flow paths leaving the carriageway, such as close to the junction of Ingram Road and Railway Street close to the Railway station;
- Roof drainage disconnection within the eastern flow path to promote local infiltration where possible; and,
- Property level protection in areas of high surface water flood risk where alternative mitigation options may not be possible.

As local funding becomes available, or as local planning applications and highways improvement works come forward, the short-listed options should be reviewed to ensure that those not taken forward to hydraulic modelling are retained as viable options.

4.6.2 Options Modelling

Hydraulic modelling was undertaken for three options within the Gillingham study catchment. The short-listed options that presented the greatest potential for flood risk reductions in the hydraulic model were chosen ahead of those that are strategically favourable but are unlikely to be accurately represented within the model. The options within Gillingham that were taken forward to hydraulic modelling include:

GIL-OP-001 - Canadian Avenue / Sturdee Avenue Property Level Protection

GIL-OP-002 – Drainage Capacity Improvements

GIL-OP-003 – Local Roof Drainage Disconnection

A description and figures showing how the options in Gillingham were modelled is presented below, along with estimated costs associated with their implementation.

GIL-OP-001 – Canadian Avenue / Sturdee Avenue Property Level Protection

There are parts of the flow path that crosses Canadian Avenue and Sturdee Avenue that are shown to enter residential properties that lie at the topographic low point along this drainage path. Due to the urbanised nature of this catchment, there are limited options available for the management of this flow path. As such, an option was modelled to represent PLP for those properties at high risk of surface water flooding to determine the potential influence of flood protection measures on the risk of flooding elsewhere.

A total of 92 properties were raised to account for PLP, as identified in Figure 4-11. These properties are clustered around Third Avenue, Canadian Avenue, Sturdee Avenue, Valley Road and Chicago Avenue. The feasibility of fitting devices to individual properties has not been reviewed and should be considered at a more detailed design stage.

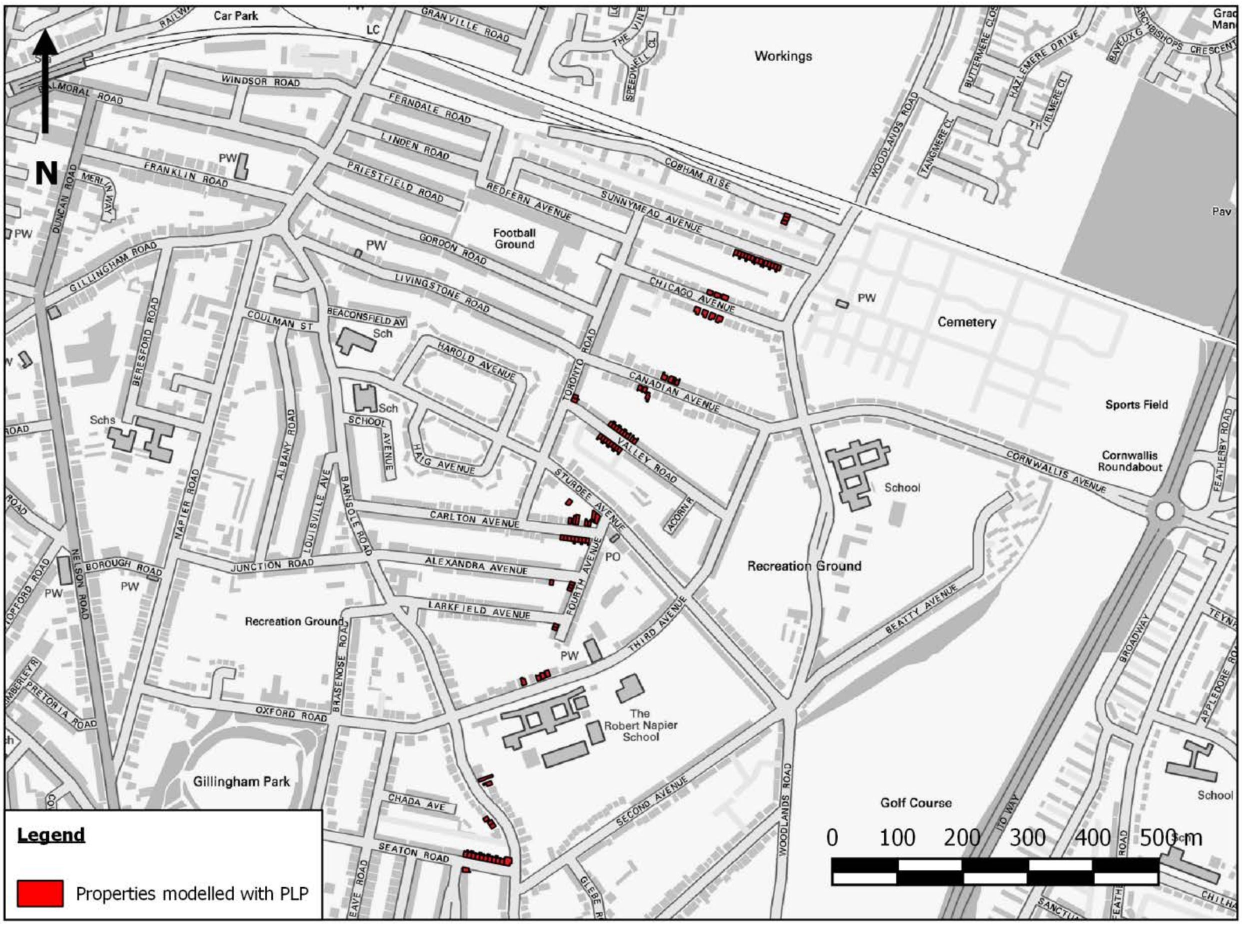

Figure 4-10 - Option GIL-OP-001 Gillingham PLP

As shown in Table 4-2, it is estimated in industry guidance that the average cost of PLP measures for a residential dwelling is between £4,000 and £6,000 per property protected. A total of 92 properties were modelled as benefiting from property level protection in the hydraulic model for this option, resulting in a total scheme cost of between £368,000 and £552,000. There is the potential to undertake a proportionate approach to the implementation of property level protection within this area, which will result in a reduction to scheme costs.

GIL-OP-002 – Drainage Capacity Improvements

The baseline model results show that where the main flow path leaves the carriageway and traverses through residential properties and highways along the Canadian Avenue / Sturdee Avenue flow path, there are areas of surface water ponding on the highway. A review of the current coverage of surface water drainage gullies identified locations whereby additional drainage gullies could be constructed to improve the connectivity with the surface water drainage network. Figure 4-12 identifies the locations of additional drainage gullies that were entered into the hydraulic model in this part of Gillingham to represent this surface water management option.

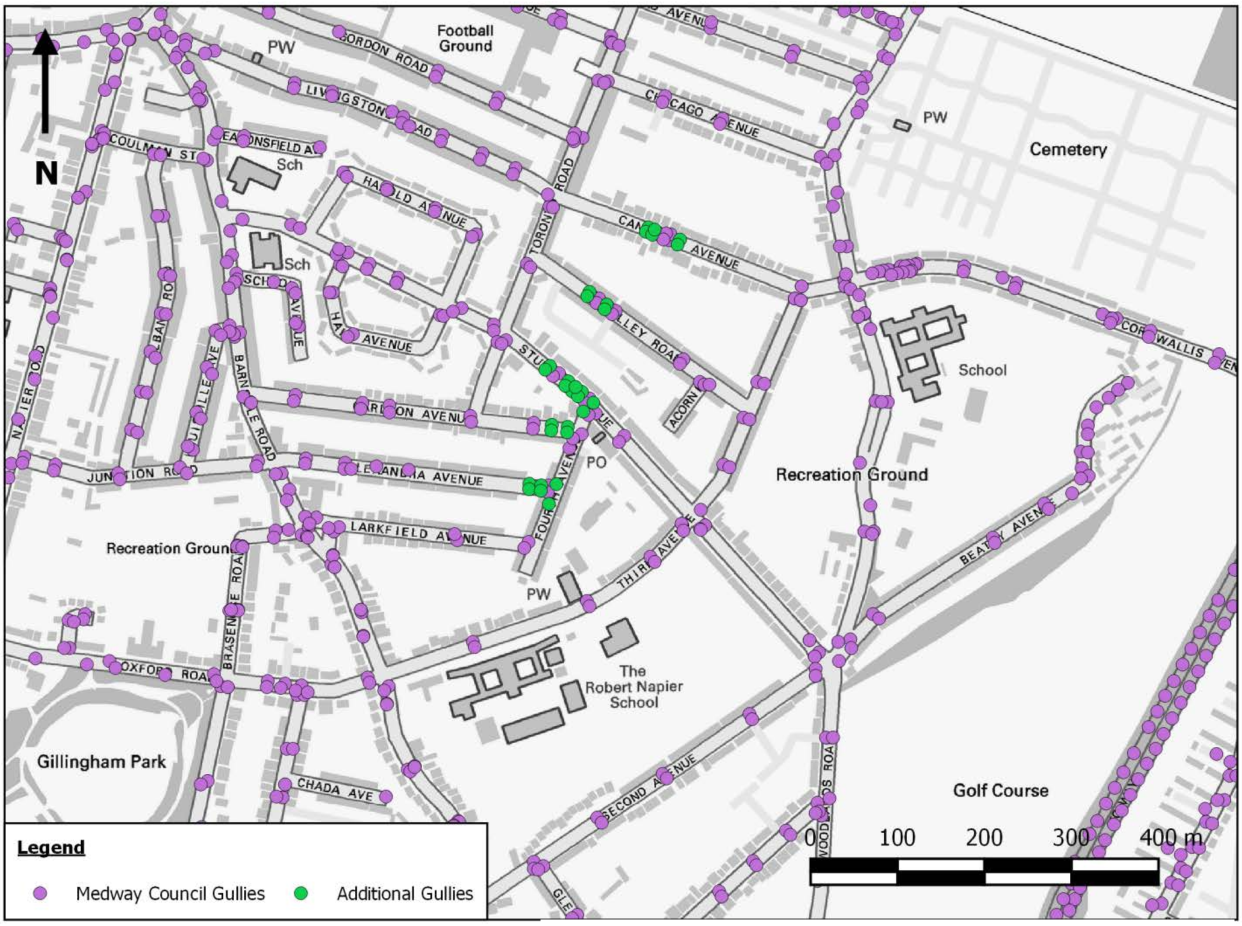

Figure 4-11 - Option GIL-OP-002 Gillingham Drainage Capacity Improvements

An additional 30 gullies were included in the model to represent this option. An estimate cost of between £400 and £600 for the installation of additional gullies has been assumed, which results in a total scheme cost of between £12,000 and £18,000.

GIL-OP-003 – Local Roof Drainage Disconnection

There are limited options for upstream attenuation in Gillingham due to the coverage of the urban area. There is full coverage of surface water and combined sewers across the network that has been modelled with roof areas as sub-catchments connected directly to the closest appropriate manhole. This option seeks to disconnect a proportion of the roof areas within this drainage sub-catchment to reduce the contribution of flow to the sewer network to increase available capacity elsewhere. The option has not considered the detailed feasibility of disconnections from each individual property, and relies on agreement from individual property owners. Figure 4-13 identifies the properties that were disconnected from the surface water sewer network within Gillingham to represent this surface water management option.

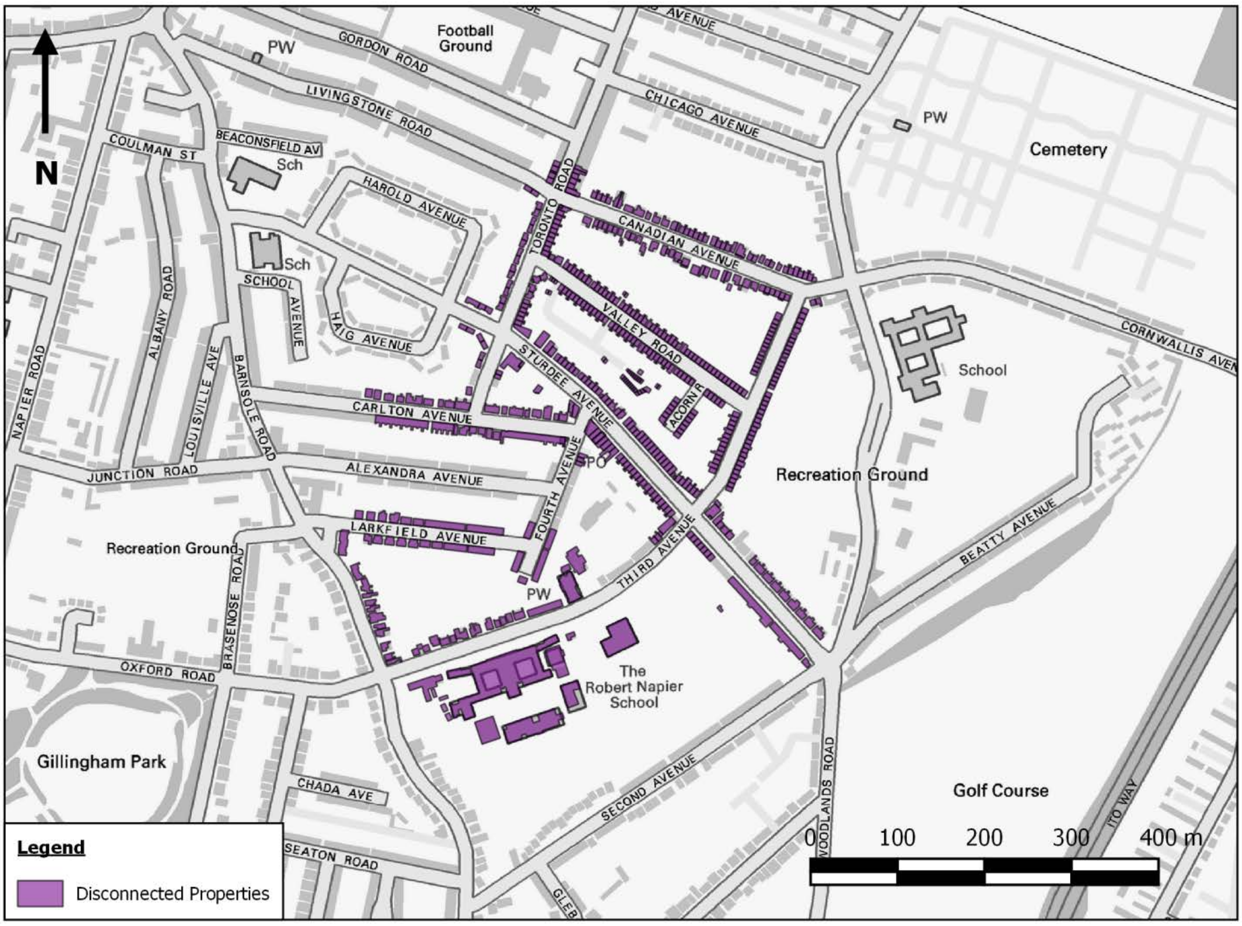

Figure 4-12 - Option GIL-OP-003 Gillingham Roof Disconnection

The costs associated with disconnections have been based on the assumption that rainwater harvesting or soakaways will be installed in each of the properties. Based on Table 4-2, it is estimated that such an installation could cost between £900 and £1,200 per property.

4.6.3 Gillingham Option Benefits

The reduction in properties shown to flood associated with implementing the options in Gillingham for the main FCERM Grant in Aid significant bandings is provided in Table 4-8.

Table 4-5 - Flooded property reductions associated with Gillingham options

	20 year (5% AEP) Very Significant		75 year (1.33% AEP) Significant		100 year (1% AEP) Moderate[9]	
	Flood >0.1m	**Flood >0.5m**	**Flood >0.1m**	**Flood >0.5m**	**Flood >0.1m**	**Flood >0.5m**
GIL-OP-001[10]	0	-1	0	+4	0	+4
GIL-OP-002	0	-1	0	+1	-1	0
GIL-OP-003	-2	-9	0	-7	-1	-4

Option GIL-OP-003 will reduce internal flooding to below 0.5m for 4 properties compared to the baseline for the 100 year (1% AEP) event and 9 properties from the Very Significant 20 year (5%AEP) flood event. Option GIL-OP-002 is almost entirely ineffective, which is believed to be related to the capacity of the surface water drainage system. In addition, Option

9 100 year (1% AEP) used as substitute to 200 year (0.5%) for Moderate significance banding

10 In addition to the 92 properties protected due to the use of PLP

GIL-OP-001 causes 4 additional properties to flood to a depth greater than 0.5m internally as a result of a loss in available flood storage volume due to the use PLP.

4.7 Other Study Area Wide Actions

Table 4-9 details the preferred surface water flood risk management options across the entire study area. Further detail on each of the options proposed is included herein.

Update of strategic planning policy: Medway Council should consider updates to strategic planning policies reflect the catchment specific options.

Preferential overland flow paths (Urban Blue Corridors): Surface water can be managed through the designation of existing highways as Urban Blue Corridors. This concept aims to manage the conveyance of surface water across an area of the catchment through the redesign of the urban landscape to create specific channels to convey surface water. This can be achieved through increasing kerb heights and property thresholds to retain water on the roads. This option could be combined with existing highways maintenance and improvement projects and funding which would make it more cost-effective.

Improve maintenance of the drainage network: Drainage maintenance schedules should be evaluated to reflect the findings of this study. The potential for blockages in the drainage network would exacerbate surface water flooding; this would be a particular issue in all the areas identified as being at risk of surface water flooding during an extreme event. It is recommended that a risk-based approach is applied so that drainage infrastructure in key areas is kept clear and maintained.

Despite overall funding cuts, by targeting key areas for more frequent and comprehensive maintenance while reducing maintenance in other areas, overall cost savings may be achieved in addition to reducing the chance of blockages in key areas.

Plans should be put in place to warn residents of when the gullies (and land drains/swales) are due to be cleaned and request that cars are parked elsewhere if necessary.

Improve drainage network capacity: A key recommendation of this study is to look at improving the drainage network capacity across the study area, especially within areas that may have capacity issues. When undertaking pipe replacement works it is recommended that an assessment is undertaken to confirm the area can benefit from an increase in pipe size rather than a like-for-like replacement. It is recommended that work is carried out in collaboration with Southern Water to assess the possibility of upgrading the network capacity in these key areas, which would reduce the risk of surface water flooding in these areas.

Improve community resilience: It is recommended that a general approach to improving community resilience is adopted across the study area, particularly in areas that are identified as being at risk. This should include establishing a flood warning system and improving emergency planning procedures (described in more detail below) as well as encouraging property resilience through the installation of individual property protection measures, such as raising property thresholds or installing flood gates or air brick covers.

Emergency planning (flood incident management): Reviewing the emergency planning procedures in areas at risk from surface water flooding, where currently available, will help to ensure the safety of people and to develop additional planning where required.

Due to the rapid nature of surface water flooding following a rainfall event, resources will need to be in place for immediate implementation following a weather warning for rainfall from the Met Office. Within flooded areas, actions such as the closure of roads and diversion of traffic may be required. A strategy for the safe evacuation of residents should be created based on the surface water modelling outputs contained within this document.

Table 4-6 - Summary of Study Area Wide Options Assessment

Location	Option Category	Option Description	Options Assessment							Summary of Scheme
			Technical	Economic	Social	Environmental	Objectives	Overall	Take Forward?	
Medway Council Administrative Study Area (all areas 'at risk')	Do nothing	Do nothing	-	-	-	-	-	-	N	Make no intervention or maintenance – no benefit to area
	Do minimum	Do minimum	-	-	-	-	-	-	N	Continue existing maintenance regimes – minimal benefit and (currently) does not include increased maintenance for the predicted increase in rainfall as a result of climate change.
	Planning Policy	Adapt strategic planning policies	2	2	1	0	2	7	Y	Adapt strategic planning policy for all new developments, especially within areas identified at high risk of surface water.
	Improved Maintenance	Improved maintenance of drainage network	2	1	2	1	1	7	Y	Improved and targeted maintenance of the drainage network to avoid potential blockages that reduce the drainage network capacity
	Community Resilience	Improve community resilience to reduce damages from flooding	2	1	2	0	1	6	Y	Improve community resilience to flooding through establishing a flood warning system, reviewing emergency planning practices and encouraging the installation of individual property protection measures (such as flood-gates).
	Source Control, Attenuation and SUDS	Install rainwater harvesting systems water-butts, and bioretention features	2	2	1	1	2	8	Y	Install rainwater harvesting systems, bioretention systems and water-butts in key risk areas in order to reduce the rate and volume of surface water runoff. Upstream attenuation via wetlands and ponds could also be considered where suitable land is available. This option has the added benefit of improving biodiversity
	Flood Storage / Permeability	Install permeable paving in key areas	2	2	1	1	2	8	Y	Install permeable paving systems in key areas and along key overland flow paths in order to reduce local runoff.

Location	Option Category	Option Description	Options Assessment							Summary of Scheme
			Technical	Economic	Social	Environmental	Objectives	Overall	Take Forward?	
	Improvement to Drainage Infrastructure	Improve drainage network capacity within key risk areas	2	1	0	0	2	5	Y	Work collaboratively with Southern Water to assess the possibility of increasing sewer network capacity in key areas (or those identified as having poor capacity). This could be integrated with the AMP planning process where appropriate.
	Preferential Overland Flow Routes	Increase kerb heights and/or lower road levels along key flow paths	2	1	2	1	1	7	Y	Investigate the potential of increasing footpath heights and/or lowering road levels along key flow paths in order to retain flood water within the roads and channel it away from properties at risk of flowing.
	Other	Infrastructure resilience	2	1	2	0	1	6	Y	Identification of at risk infrastructure (electricity sub-stations, telephone exchanges, gas supply manifolds etc.) and proactive management of risks
	Other	Community Awareness	2	2	2	0	1	7	Y	Increase awareness of flooding within communities at risk through the use of newsletters, drop-in workshops, websites and social media.

Raising community awareness: Communicating the risk of flooding and raising awareness within local communities across the study area can be implemented in the short-term and provides a 'quick win' measure to surface water management. This will mean residents are more aware of the flood risk across modelled settlements (and wider study area) and can encourage people to become more proactive within their community. Increasing awareness can be achieved through public consultation events, newsletters and online resources such as council websites and social media.

It is also important that technology is fully utilised in order to communicate with the local community. The Environment Agency have produced an iPhone App which delivers data from their online fluvial flood warning service straight to people's phones; this is an excellent example of how innovative thinking and technology can be applied to the communication of flood risk. In the first instance, it is recommended that social media platforms such as Google+, Facebook or Twitter are utilised as a way of communicating with local residents and providing information on the council's flood and water management activities.

Improve infrastructure resilience: The surface water flooding risk identified by the SWMP should be provided to local utility operators (electricity, gas, telephone etc.). This will ensure they are aware of the potential risk to their assets are able to proactively manage them.

Permeable paving: Installing permeable paving in key risk areas and along key overland flow routes. These systems can assist in reducing the amount of runoff entering the drainage network, and assist in reducing the overall risk of flooding from an extreme rainfall event.

Rainwater harvesting and water-butts: Improving the resilience of local communities to flooding can be achieved through raising awareness of simple measures and systems that can be installed at their homes. Local residents and property owners may, for example, be encouraged to install simple systems such as water butts to capture roof runoff. Alternatively, rainwater harvesting systems could be installed in new developments or schools.

The principle of rainwater harvesting is that rainfall from roof areas is passed through a filter and stored within large underground tanks. When 'grey water' is required, it is delivered from the storage tank to toilets, washing machines and garden taps for use. Any excess water can be discharged via an overflow to a soakaway or into the local drainage network.

One of the preferred options to reduce peak discharges and downstream flood risk is the implementation of water butts on all new development within the existing urban areas, and in addition, retrofitting these to existing properties where possible.

Water butts often have limited storage capacity given that when a catchment is in flood, water butts are often full and have no spare capacity for flood waters. However, it is still considered that they have an important role to play in the sustainable use of water. There is potential to use 'leaky' water butts that provide overflow devices to soakaways or landscaped areas to ensure that there is always some volume available for storage during heavy rainfall events.

Larger rainwater harvesting systems should also be implemented within suitable developments within the study area (e.g. school facilities, commercial buildings etc)

Retrofitting bioretention/rain gardens car park bays: Retrofitting bioretention features in key risk areas and along key overland flow routes will act as a source control measure to reduce the amount of runoff entering the drainage network, and reducing the overall risk of flooding from an extreme rainfall event. These devices also can enhance the aesthetics and biodiversity of an area due to their landscaping. These devices have been found to assist in reducing the total amount of phosphorus and nitrogen that discharge into downstream waterways as a result of adsorption and absorption processes within the filter media and plant growth and die off and therefore improve the quality of the runoff discharging into the downstream network.

Hydrometric monitoring: It is recommended that installing a series of hydrometric monitoring systems across the study area would provide a stronger understanding of rainfall patterns and flows that lead to surface water flooding across Medway. Rain gauges and flow gauges should be installed in targeted areas so that a detailed understanding of the catchment hydrology can be established. This evidence base can be used to inform future studies and flood alleviation projects across the study area. Monitoring stations could also be linked to local flood warning systems to provide some early indication of intense rainfall travelling across the study area.

Medway Council should develop an integrated framework to support emergency response and flood incident management. In conjunction with this, it is recommended that rainfall gauging stations can be used to assist with this aim, as well as to assist with the Council’s responsibility of investigating flood incidents as required under the FWMA 2010.

5 Next Steps

5.1 Conclusions

This SWMP has investigated the risk of surface water flooding within Medway. It provides a greater understanding of the complex surface water flooding problems in the urbanised areas of Medway. The SWMP has been undertaken in collaboration with key Risk Management Authorities within Medway, including Medway Council, Southern Water and the Environment Agency.

Detailed hydraulic modelling was undertaken in four study catchments in Medway: Strood, Rochester, Chatham and Gillingham. The results of the baseline hydraulic modelling were mapped to show both flood depth and flood hazard. In addition, the number of flooded properties within each study catchment was identified.

An options assessment was undertaken to define which options are generally available for reducing flood risk within the study area, as well as identifying specific concept level mitigation solutions for each of the study catchments, which were represented in the hydraulic model. The options were assessed against the numbers of properties benefiting from a reduction in flood risk for the major significance bandings. There are a number of steps for Medway Council and stakeholders to take forward, both in developing the options further and the development of an actions plan.

5.2 Option Development

Before any works are undertaken in each of the study catchments, it is recommended that the options are developed to further confirm the risk, reduce costs of a preferred option / measure and establish the benefit of the proposed scheme. For each study catchment, it is recommended that the following is undertaken:

- Undertake a detailed feasibility study which includes:
  - Asset investigations (e.g. Inspection / CCTV of existing infrastructure to confirm condition, size and connectivity);
  - Improvements to the modelling in the location of the option in line with the limitations identified in the Model Build Report presented in Appendix B (i.e. refine highway drainage network through asset surveys);
  - Initial underground service investigations (obtain and review relevant service plans); and,
  - Conceptual sizing and locating of proposed measures / options based on updated data and constraints.
- Complete further public consultation:
  - Development of a community flood plan;
  - Raise awareness of measures that residents can implement themselves (for example water butts, rainwater harvesting and retrofitting permeable surfacing); and,
  - Review current maintenance practices and adapt where appropriate.
- Review all benefits of proposed schemes and identify links with partner organisation goals
  - Water quality benefits (improved water quality in River Medway);
  - Reduced surface water runoff volume (lower volume entering Southern Water systems leading to reduced overflow operation frequency and reduced volume transferred to wastewater treatment plant);
  - Improved biodiversity through urban green spaces (improved local amenity and wider ecological benefits);
  - Establish links with local community groups (flood resilience groups, nature groups and make use of local skills / resources for delivery); and,
  - Increased number of potential funding sources.

5.3 Phase IV – Action Plan

An Action Plan outlines a wide range of recommended measures that should be undertaken to manage surface water within the study area more effectively. The actions are linked with the recommendations made in Section 4. The Action Plan should identify:

- *General flood risk management actions* to integrate outcomes, recommendations and new information from this study into the practices of all Steering Group organisations;
- *Strategic Planning Policy actions* to assist Medway Council to manage future developments in the context of local flood risk management;
- *Maintenance actions* to prompt possible review of current schedules in the context of new information presented in this study;
- *High priority actions* to be considered to better understand flood risk in specific areas and proactively manage operational risks;
- *All actions* to be considered across all areas of high surface water flood risk identified within this study; and
- *Transport Infrastructure risk assessment* actions to investigate at risk major roads and pedestrian underpasses to understand the potential risk associated with each.

The Action Plan should be developed and read in conjunction with details of the preferred options and recommended actions. It is the intention that the Action Plan is a live document, maintained and regularly updated by the Steering Group, as actions are progressed and investigated.

5.4 Incorporating New Datasets

The following tasks should be undertaken when including new datasets in the SWMP:

- Identify new dataset;
- Save new dataset/information; and
- Record new information in log so that next update can review this information.

5.5 Updating SWMP Reports and Figures

In recognition that the SWMP will be updated in the future, the report is structured in chapters according to the SWMP guidance provided by Defra. By structuring the report in this way, it is possible to undertake further analyses on a particular source of flooding and only have to supersede the relevant chapter, whilst keeping the remaining chapters unaffected.

In keeping with this principle, the following tasks should be undertaken when updating SWMP reports and figures:

- Undertake further analyses as required after SWMP review;
- Document all new technical analyses by rewriting and replacing relevant chapter(s) and appendices;
- Amend and replace relevant SWMP Maps; and
- Reissue to departments within Medway Council and other stakeholders.

Appendix A. Maps

(Page holder for maps)

Appendix B.
Model Build Report

(Page holder for model build report)

Appendix C. High-level Assessment Summaries

(Page holder for high level assessment summaries)

Appendix D.
Costing Assessments

(Page holder for costing assessments)

Appendix E. High-level Options Assessments

(Page holder for high level options assessments)

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