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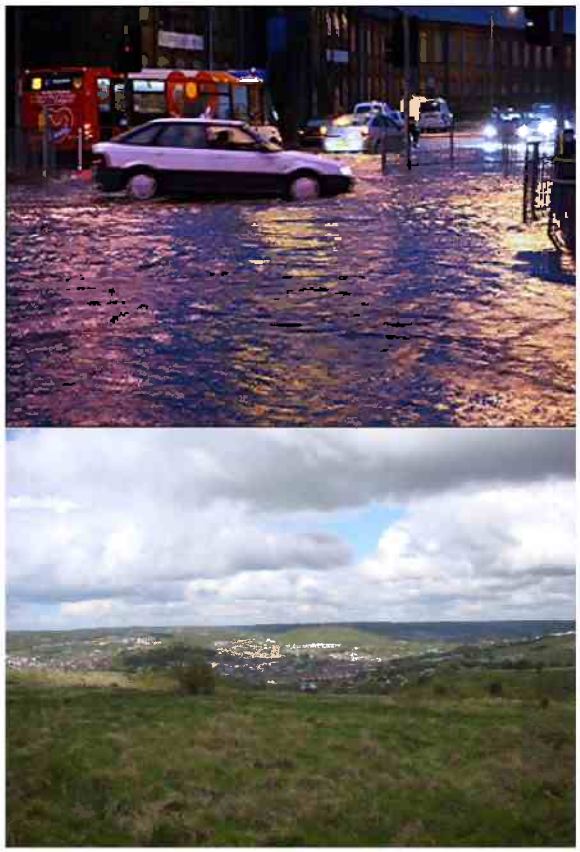
Dover Surface Water Management Plan

Volume 1 – Summary Report and Action Plan



Flood photos courtesy of Karol Steele, Paul Turvey and http://news.bbc.co.uk

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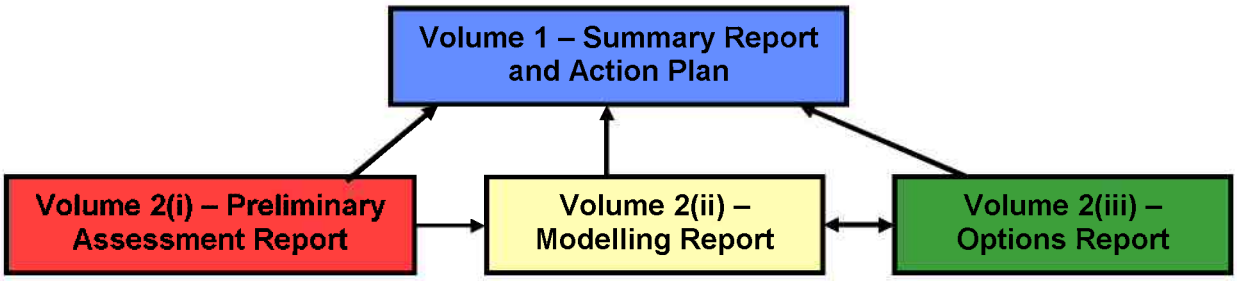
Map for the Dover Surface Water Management Plan

Structure of the Reports



SWMP Report	Key Contents
Summary Report and Action Plan	• Study background and key surface water flooding issues (Sections 1.1 & 1.2) • Modelling results including predicted pattern of flooding and economic damages (Section 1.3 and Appendices A – G for individual areas) • Description of individual measures and appraisal of options (Section 1.4) • Description of Dover-wide and location-specific options (Section 2) • Discussion of funding opportunities (Sections 2.3)
Preliminary Risk Assessment	• Records of flooding in Dover (Section 3 & Appendix A map) • Observations from site inspections (Section 5)
Modelling Report	• Details of model development (Section 3 and 4) • Economic damage assessment in the current situation (Section 6 & Appendix J map) • Results of modelling selected management options (Section 7 & Appendix K) • Maps of maximum depth and velocity (Appendices E-I)
Options Report	• Details of individual measures (Section 2 & Appendices F - V) • Opportunities and constraints of options (Section 3)

Where to Find…

Topic	Report Section
Recommended actions	This report – Section 2 and Appendix H map
Detailed information on all options	Options Report – Appendices F – V
Appraisal of options through indicative benefit:cost analysis, multi-criteria analysis and feedback from the options workshop	This report – Section 3, Appendices A – G for individual areas and Options Report Section 3
Natural drainage routes, topographic depressions, locations of past flooding etc.	Preliminary Risk Assessment Report Appendix A map
Maps of maximum depth of flooding in all design events	Modelling Report Appendix E - I maps
Details and maps of economic damage due to surface water flooding	Modelling Report Section 6 and Appendix J map
Details of modelling of selected options	Modelling Report Section 7

Contents

List of Boxes

List of Figures

List of Tables

Glossary and Abbreviations Used in This Report

Term	Definition
AEP	Annual Exceedance Probability. A flood or rainfall event with a 1 in 100 (1%) chance of being exceeded in any year has an AEP of 1/100 or 1%.
Climate Change	Long term variations in global temperature and weather patterns caused by natural and human actions.
Culvert	A channel or pipe that carries water below the level of the ground.
Defra	Department for Environment, Food and Rural Affairs
DDC	Dover District Council
EA	Environment Agency
FMfSW	Environment Agency Flood Map for Surface Water
Flood & Water Management Act	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which (partly) is to clarify the legislative framework for managing surface water flood risk in England.
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a river.
KCC	Kent County Council
LLFA / Lead Local Flood Authority	Local Authority responsible for taking the lead on local flood risk management (for Dover this is KCC)
Main River	A watercourse shown as such on the Main River Map, and for which the Environment Agency has responsibilities and powers. N.B. Main River designation is not an indication of size, although it is often the case that they are larger than Ordinary Watercourses.
MCA	Multi Criteria Analysis (MCA) is a tool to assist decision-making where there are a number of different factors to consider. Each factor is scored and weighted to weigh up the benefits of different intervention options.
NPD	National Property Database – a collection of risk receptors produced by the Environment Agency
Partner	A person or organisation with responsibility for the decision or actions that need to be taken.
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
SuDS / Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Surface water	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.
SW	Southern Water
Swale	A shallow vegetated channel designed to conduct and retain water, but also may permit infiltration. The vegetation filters particulate matter.

Term	Definition
SWMP / Surface Water Management Plan	A SWMP (Surface Water Management Plan) identifies the risk of surface water flooding in a local area as well as viable measures to manage that risk.
UKCP09	The UK Climate Projections provide climate information designed to help those needing to plan how they will adapt to a changing climate. The data is focussed on the UK.

1 Summary of the Dover SWMP

1.1 Background and Motivation

Based on national mapping provided by the Environment Agency, Defra identified that a significant number of properties in the urban area of Dover may be susceptible to surface water flooding. Subsequently, Kent County Council (KCC), as the Lead Local Flood Authority (LLFA) was allocated funding to prepare a Surface Water Management Plan (SWMP) covering the urban area of Dover.

Surface water flooding in Dover could be caused by intense rainfall before it enters the River Dour or sewer network, overland flow resulting from high groundwater levels, exceedance of the capacity of the surface water or combined sewer networks and 'out of bank flow' from open-channel or culverted sections of the River Dour which results from runoff within the urban area. In addition to damage to properties, roads and other infrastructure, the onset of surface water flooding can be relatively sudden and can lead to both high velocity flows in steep areas and deep ponding of flood water. There is, therefore, a risk to life associated with surface water flooding.

The purpose of the SWMP study is to identify sustainable responses to manage surface water flooding and to prepare an Action Plan. The Action Plan provides an evidence base for future decisions and funding applications for putting the recommendations into practice. Preparation of the Action Plan for Dover has followed the latest Defra guidance. The Action Plan is presented in Chapter 2 of this Summary Report. Full technical detail can be found in the supporting reports which are listed in Table 1.1.

Table 1.1 Structure of the Dover SWMP reports

Report Volume	Title	Defra Guidance Stage
Volume 1 (this report)	SWMP Summary Report and Action Plan	Implementation and Review
Volume 2(i)	Preliminary Risk Assessment	Preparation
Volume 2(ii)	Modelling Report	Risk Assessment
Volume 2(iii)	Options Report	Options

1.2 Partnership Approach to Flood Risk Management

The SWMP project started in February 2010 and has followed on from previous studies, particularly the Strategic Flood Risk Assessment[1,2] and the Flood Risk Appraisal of the River Dour. The partnership approach to integrated flood risk management, as encouraged by the Flood & Water Management Act 2010[3], has been strengthened in this SWMP through integrated working between KCC (lead partner), Dover District Council (DDC), the Environment Agency (EA) and Southern Water (SW). The vision for the project was agreed by the SWMP Partnership as shown in Figure 1.1.

[1] JBA (2007) Dover District Council Strategic Flood Risk Assessment. Final Report. September 2007
[2] Capita (2010) Flood Risk Appraisal of the River Dour. Report for Dover District Council. May 2010
[3] http://www.legislation.gov.uk/ukpga/2010/29/contents

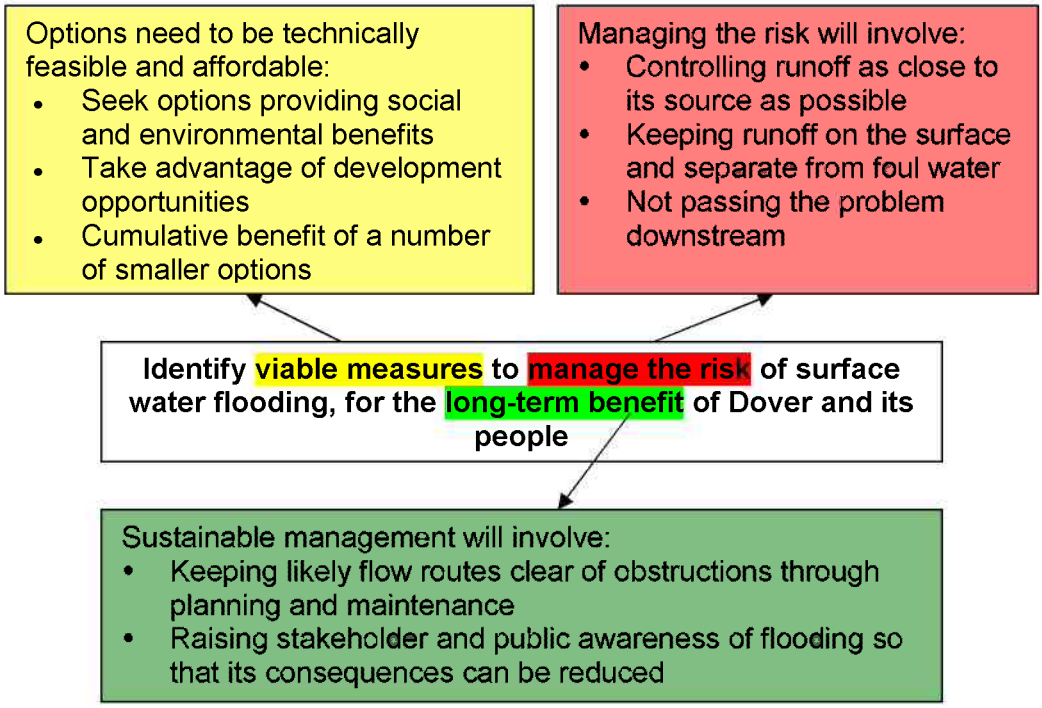


Figure 1.1 The SWMP vision statement highlighting key concepts

Consultation with partner organisations, stakeholders and representatives of the public has been a key element throughout development of the SWMP. Following the agreed Communication & Engagement Plan, a 'stakeholder workshop' was held on 15 December 2010 with a number of councillors and technical experts in the councils to discuss key flooding issues and gather local information to help direct the study. There was general confirmation of the evidence upon which the study was being founded and support for the project and its direction.

Key flooding issues identified at the outset of this SWMP are summarised in Box 1. More detailed observations for each key risk area are provided in the following sections, presented in clockwise order:

Appendix A: Folkestone Road Area
Appendix B: Tower Hamlets Area
Appendix C: Coombe Valley Road
Appendix D: River and Crabble
Appendix E: Temple Ewell and Kearsney
Appendix F: Buckland
Appendix G: Mid Town

1.3 Risk Assessment through Modelling

A two dimensional hydraulic model has been developed to support the SWMP Action Plan. The model has been used to better understand the locations and mechanisms of flooding and inform identification and development of management options. The model covers the highest risk locations within the urban area of Dover and is able to represent:

Key flooding issues identified in the urban area of Dover

- There is demonstrable history of surface water and groundwater flooding across the urban area of Dover, for example in June 2007 and the winter of 2000/1. The flooding has affected both residential and non-residential properties as well as critical transport links.
- There are some significant natural drainage paths entering the urban area from the surrounding chalk valleys. Although these are typically dry, they could become conduits for surface water flow during intense rainfall and/or when the surrounding chalk hills become saturated or frozen. A number of these flowpaths are down steep roads. The velocity of flow could present a significant hazard.
- There are numerous basement premises throughout Dover with entrances at or near road level where surface water could readily flow into the basement if it overtops the kerbs. There is evidence of deep flooding in some of these basements which poses a significant hazard.
- The River Dour channel is complex with numerous culverted sections. It is severely constrained and includes potential obstructions to high flows. There are numerous surface water drains discharging into the River Dour which could become 'tide-locked' by high levels in the River Dour.

Box 1 Key flooding issues

- direct rainfall on the urban area;
- overland flow through the built environment at a suitably high resolution;
- groundwater discharge from the surrounding Chalk valleys;
- interaction with Southern Water's surface water and combined sewer network; and
- interaction with the River Dour and the influence of the tidal boundary.

The model has been used to predict the maximum flood depths and velocities for the following range of design rainfall events: 50% (1 in 2) AEP, 3.33% (1 in 30) AEP, 1% (1 in 100) AEP and 0.5% (1 in 200) AEP. The potential impacts of climate change have been represented in the models by increasing the rainfall intensities for the 1% (1 in 100) AEP events by 12%, in accordance with the latest UKCP09 guidance[4]. A summary of the pattern of flooding in each key risk area, as predicted by the model, is provided in Appendices A to G. General observations from the modelling are summarised in Box 2. It is noted that the model represents a large and hydrologically complex area and that a number of simplifications have had to be made. Therefore, the model should only be used for large-scale purposes similar to this study and any detailed design should include necessary improvements and refinements to the model.

[4] http://ukclimateprojections.defra.gov.uk/

General observations from the modelling

- Predictions of deep and/or extensive flooding are largely consistent with recorded evidence of surface water flooding. Key risk areas identified by the model and historical evidence include locations along Folkestone Road, Tower Hamlets Street and East Street, Coombe Valley Road, Buckland (London Road and the junction with Crabble Hill) and in Mid Town. Little flooding is predicted in Crabble (except Crabble Avenue), River, Temple Ewell and Kearsney which is consistent with anecdotal evidence.
- In Folkestone Road, Tower Hamlets, Buckland and Mid Town the extent of flooding predicted by the SWMP model and the EA Flood Map for Surface Water (FMfSW) is similar. In Crabble, River, Temple Ewell and Kearsney the SWMP model predicts less flooding than the FMfSW which is most likely due to the different assumptions about runoff from the permeable Chalk which dominates in these less urbanised areas.
- During the summer and autumn months, the large Chalk catchments draining to Dover are likely to be unresponsive to extreme rainfall (e.g. 1% AEP storm of 5 hours duration). The effective rainfall first recharges the aquifer so the impact evident in the outflow is delayed for a number of months. Should such an extreme storm occur on a typical wet catchment, peak outflows will substantially increase but only after a few weeks. If an extreme storm occurs on a saturated catchment, the catchment responds in a matter of days although the peak flows are not substantially higher.
- The maximum flood depths within the urban area of Dover are not substantially influenced by the different flows from the chalk valleys (including in the River Dour at Kearsney) arising from typical wet or dry catchments. The influence of outflows from the Chalk similar to those experienced in the winter of 2000/1 have not been tested since the long term rainfall leading to the 2000/1 event had a probability less than 1% and the coincidence of this with a further extreme short duration (e.g. 5 hour) storm over Dover urban area is a highly unlikely scenario.
- Comparison of the maximum flood depths in the 1% (1 in 100) AEP event indicates that a 12% increase in rainfall intensity due to climate change could result in an increase in flood depths of approximately 15%.

Box 2 General observations from the modelling

Maximum depths at individual properties in the Environment Agency National Property Database (NPD) have been used to estimate economic damages due to surface water flooding in the existing ('do minimum') situation. Assuming a standard property threshold level of 0.15m above surrounding ground level, it is estimated that approximately £250M of damage (including indirect, intangible and emergency service costs where applicable) due to surface water flooding will be experienced across the modelled urban area of Dover in the next 100 years. For the 2,300 or so residential properties which are predicted to experience flooding, the average annual damage could be around £3,500 which equates to approximately £100,000 of damage per residential property over the next 100 years. These high values are due in part to the predicted shallow flooding in high frequency events. However, they are in line with Defra guidance on flood damage which assumes £30,000 of damage per property per flood event. The proportion of total residential properties in the modelled area experiencing flooding at some point in the 100 years is about 20%.

This is slightly above the national estimate, made by the Environment Agency, that 17% (1 in 6) of all properties are at risk of flooding from the rivers, sea or surface water.

1.4 Options for Sustainable Management of Surface Water Flooding

Undertaking no maintenance on existing infrastructure and not planning for any improvement in flood risk management will result in an increasing flood risk as existing drainage capacity, resistance and resilience deteriorates and future climate change increases the frequency of extreme events. Therefore, a range of options has been identified to improve management of surface water flooding across the urban area of Dover. The options have been developed from a review of previous studies, Multi-Criteria Analysis (MCA) of individual measures, site inspection, modelling and consultation with project partners and stakeholder organisations. The options have been designed to fit within the overall philosophy as outlined in Box 3.

Philosophy for the Identified Options

- Seek management options providing social and environmental benefits – schemes with multiple benefits are more likely to attract funding
- Manage runoff and sediment transport close to its source and keep runoff on the surface wherever possible – this will be sustainable and have reduced maintenance costs
- Keep likely flow routes clear of obstructions through planning and maintenance – to reduce both the likelihood and consequences of flooding
- Raise stakeholder and public awareness of flooding – this will reduce the consequences of flooding and improve reporting and evidence of issues
- Implement identified options incrementally and take advantage of opportunities as they arise – 'piggy-back' flood risk management activities with other schemes

Box 3 Philosophy for the identified options

Options have been developed by combining individual measures (which are introduced in Table 1.2) under the following headings:

- **Source control and Sustainable Drainage Systems (SuDS)**: Source control measures aim to reduce the rate and volume of surface water runoff through infiltration or storage. They can also provide some natural removal of pollutants and sediments, as well as aquifer recharge, which all provide environmental benefits. In constrained and highly developed urban areas like Dover, controlling inflows entering the urban area will be a particularly desirable option, as will reducing sediments and pollutants from entering the drainage system and the River Dour.

- **Design for exceedance:** Roads, buildings and other features can be designed to control overland flow and direct it safely through the urban environment, such that floodwater is less likely to enter buildings or other structures. Designing for exceedance recognises that flows that exceed the below ground drainage capacity are always possible but can be managed to some degree by creating designated flow routes or other measures such as threshold raising at access points. These measures could be particularly successful in Dover which has

limited available open space along some key natural flow routes. However, potentially high flow velocities will require careful coordination with emergency planners.

- **Increasing capacity:** Adding storage and/or increasing the capacity of the sewer network and the River Dour could improve the conveyance of floodwater and limit overland flow and flooding. This may be particularly relevant to the highly culverted and constrained River Dour through Mid Town.

- **Separation of foul and surface water:** Alongside effective surface water management, this can reduce flooding and pollution. Misconnections between the surface water and foul systems should be rectified as opportunities arise throughout Dover.

- **Non-structural measures:** Non-structural measures can reduce the consequences for the receptors of flooding, e.g. people, property and the environment. In most cases, these are likely to be implemented across Dover through the introduction of council policy.

The principal concepts for improved surface water management are listed for each key risk area in Appendices A to G. In these sections, the potential location-specific options for improved surface water management in the area are listed, separated into those which have been considered during the study but subsequently discounted and those which are included in the Action Plan in Chapter 2. Location-specific options included in the Action Plan are marked on the Options Map provided in Appendix H. Options have been appraised through an analysis of the following criteria:

- **Technical** – Is the option technically possible and will it actually improve management of surface water flooding? Where possible, the model has been used to represent the proposed option or otherwise inform its technical feasibility.

- **Economic** – Is there a sufficient demonstrable flood risk and is the reduction in risk from implementing the option likely to outweigh the financial cost of the option? Where possible, the model representation of the option has been used to estimate the number of properties protected and give an indication of the benefit:cost ratio of implementing the option. However, the high level nature of this economic assessment and the need for further feasibility studies is emphasised.

- **Social** – Will the community benefit or suffer from implementation of the option?

- **Environmental** – Will the environment benefit or suffer from implementation of the option?

- **SWMP** – The majority of proposed options were discussed at an Options Workshop held on 20 June 2011, to which all SWMP Partners and other stakeholders were invited. The degree of support for each option has informed selection those options included in the Action Plan in Chapter 2.

Table 1.2 Introduction to individual measures considered to improve surface water flood risk management

Category	Measure	Illustration	Category	Measure	Illustration	Category	Measure	Illustration
Source control and Sustainable Drainage Systems (SuDS)	**Fringe Interception** of runoff could reduce the volume of water entering the Dover urban area via overland flow or in the River Dour. The hills to the west of Dover are characterised by a number of dry valleys. Potentially, runoff from the saturated Chalk could be attenuated in detention basins or through alternative land management practices (e.g. contour ditching or afforestation).		Source control and SuDS	**Soakaways** are filled excavations which store runoff from single properties or larger developments and roads and allow infiltration into the surrounding soil. They only work in freely draining soils.		Separation of foul and surface water	**Greenfield developments** are usually separately sewered and such opportunities should be maximised. **Brownfield development** opportunities are generally as for Greenfield but the existing drainage system may be combined. Opportunities should be taken to convert to a separate piped system where practical.	
	Detention basins are surface water storage areas which provide flow control and reduction through attenuation. They are normally dry and therefore could be used as car parks (including underground car parks), recreational facilities etc for much of the time. It may be possible to reuse the stored water on site (e.g. irrigation or aquifer recharge) depending on storage arrangements.			**Water butts** are used to collect rainwater from individual properties for outside use although some capacity must be available at the start of a storm. Alternatively, downpipes can be disconnected from discharging directly into surface water drains and be routed through a SuDS attenuation feature. **Rainwater harvesting** collects rainwater for non-potable reuse both internally and externally.			**Misconnections** between the surface water and foul systems should be rectified as opportunities arise. This can reduce pollution associated with surface water flooding.	
	Ponds and wetlands are designed to be areas of permanent standing water which can provide attenuation of flows and a certain degree of treatment. In doing so they can provide some improvement in water quality. They can provide ecological, aesthetic and amenity benefits.		Design for exceedance	**Surface flow routes**, formalised through road profiling etc, can be used to safely route exceedance flows through urban areas. **Green Streets** use attractive kerbside planters into which surface water on the road is directed. The plants provide some cleaning of the water, attenuation of peak flows and possibly infiltration of the stored water.			**Maintenance, desilting and removal of obstructions** can ensure that the River Dour and drainage infrastructure (particularly road gullies) are operating to their design potential. In the case of surface water features (e.g. watercourses, ponds, swales etc) this also provides improved amenity and aesthetic value.	
	Swales are shallow linear vegetated drainage features which can store and convey surface water. As part of an engineered flowpath, they can pass water from one storage/treatment area to the next and provide infiltration where underground conditions are suitable. Swales can be designed to be permanently wet or generally dry and are often located next to roads, car parks or other open spaces.			**Resistance and resilience** measures can be fitted to prevent surface water entering buildings and minimise the damage caused by flood water. Some form of grant assistance could be allocated to property owners for installation. The practicality of resistance or resilience measures that are deployed upon receipt of a flood warning would need to be carefully considered.		Non-structural measures	**Raising Awareness** of surface water flood risk within the councils, partner organisations and with the public may encourage property owners to consider property level resistance and resilience measures; discourage paving over property curtilage, building over the Dour or otherwise blocking natural drainage routes; and encourage reporting and recording of flooding.	
	Green roofs covered with vegetation can intercept and retain precipitation to reduce the volume of runoff and attenuate peak rainfall. Large flat or gently sloping roofs (e.g. commercial buildings, schools and hospitals) are particularly suited and cost-effective.		Increasing capacity	**Increasing the capacity of the current drainage network** may be possible through enlarging existing sewers, adding new sewers (which can be oversized to provide additional storage) or providing overground storage through interruption of the existing sewers. These could reduce the likelihood of discharge of potentially polluted floodwater through Combined Sewer Overflows.			**Flood Warning:** the Met Office and the EA operate an Extreme Rainfall Alert Service which provides county-scale alerts of extreme rainfall to Category 1 and 2 responders. Given the knowledge of areas most susceptible to surface water flooding, these alerts could be used to target responsive action.	
	Pervious pavements are suitable for pedestrian and vehicular traffic. Construction can use porous material which permits infiltration across the entire surface or material which is impervious to water but which is laid with void spaces to permit infiltration. The sub-base of the pavement may use geocellular block systems which provide storage.			**Widening and/or regrading of the watercourse** and opening up of culverted sections have the potential to improve the capacity of the watercourses to receive and convey flood flows. Where rapidly passing peak flows could cause flooding downstream, any local improvement in conveyance should be offset with increased storage to attenuate the peak.			**Planning policies** could be developed and adopted by DDC to steer new development away from known surface water flood risk areas and flow paths or, if necessary, to control their development. Basements should be given particular consideration. Policies should also aim to control or limit urban creep.	

2 SWMP Action Plan

2.1 Generic and Location-specific Actions

Based on the work summarised in Chapter 1, the Action Plan presented in Table 2.2 and Table 2.3 presents the list of the most viable options to manage the risk of surface water flooding, for the long-term benefit of Dover and its people.

Table 2.2 lists the options which could be implemented generically across the area. Table 2.3 lists the location-specific options which are illustrated on the map in Appendix B of the *Options Report*. Both tables provide the following information:

- **Where?** For location-specific options, the location.
- **What?** The description of the option.
- **How?** The suggested approach to implementing the option, including any identified priority actions.
- **Who?** The partner organisation which is best placed to lead implementation.
- **When?** An indication of the timescales within which the option is suggested to be implemented:
  - Priority 1: A 'quick win' or action urgently required within 12 months
  - Priority 2: Consider now for implementation in the next 1-5 years
  - Priority 3: Consider now for longer term implementation (5 years+)
  - Priority O: Consider implementing if opportunity arises

  This priority therefore balances the degree of flood risk with the likely required timescale for implementation.
- **Multi-Criteria Appraisal:** For location-specific options, the sum of scores based on criteria in Table 2.1 (maximum score of 10 per option). Where applicable, technical (T) and economic (Ec) scores have been assigned on the basis of modelling and indicative benefit:cost analysis. However, the high level nature of this economic assessment and the need for further feasibility studies is emphasised. SWMP scores have been assigned based on feedback from the Options Workshop and subsequent discussion with the core Partners.

Ideas for funding opportunities are provided in Section 2.3. Location-specific options included in Table 2.3 are marked on the Options Map provided in Appendix H.

Table 2.1 Criteria and scoring for Multi-Criteria Analysis of actions

Criteria	Description	Score
Technical (T)	Is it technically possible and do-able? Will the option actually reduce flood risk?	-2 severe negative outcome -1 moderate negative outcome 0 neutral outcome 1 moderate positive outcome 2 high positive outcome
Economic (Ec)	Is there a sufficient existing risk? Will benefits exceed costs?	
Social (S)	Will the community benefit or suffer from its implementation	
Environmental (Env)	Will the environment benefit or suffer from its implementation	
SWMP	Did the wider SWMP Partnership support this option via discussion at the Options Workshop?	

Table 2.2 Generic management options

Generic Option ('What?')	Priority Actions ('How?)	Primary Action Owners ('Who?')[1]	Priority ('When?')[2]
Develop and implement a targeted maintenance schedule KCC, EA and SW should develop and implement a targeted maintenance schedule so that the highway gullies, drains and other drainage assets (including SuDS), the River Dour and sewers operate effectively to their design capacity.	1. Identify and record where existing drainage infrastructure is and who owns and/or is responsible for maintaining it. Records of assets should be available to all partners. 2. Partners to develop a coordinated maintenance schedule using information in the SWMP (areas at high risk of flooding, natural flow routes).	• KCC • EA • SW	1
	3. Communicate coordinated maintenance activities with the public to manage expectations.	• KCC • DDC	2
Raise awareness of surface water flood risk Raise awareness of surface water flood risk within DDC and with the wider public, particularly focussing on basement properties. Link with encouraging use of rainwater harvesting, rain gardens and other source control measures, as well as uptake of property level resistance and resilience measures. Improved recording of flood events will benefit future funding applications.	1. Brief DDC (and KCC) council teams (particularly Development Management officers) on surface water flood risk using SWMP materials 2. Improve record keeping of flood events as evidence to support grant applications. Link with KCC role as LLFA 3. Provide guidance on use of rainwater harvesting, water butts, other source control measures and property level resistance and resilience measures. 4. Using information in this SWMP, maintain a list of properties with basements and target owners for awareness raising and guidance on resistance/resilience measures.	• DDC • KCC	1
	5. EA and DDC to work jointly to provide guidance and, where possible, to enforce policy of not paving over front gardens with impermeable material and not extending properties into River Dour channel. 6. Remain vigilant for future government grants for property level resistance/resilience works	• DDC • EA	1
	7. Investigate opportunities to build longer-term drainage expertise within DDC through partnering with KCC as LLFA	• DDC • KCC	2
Develop and implement a policy to use green roofs and pervious paving where practicable Where practicable, green roofs should be the preferred option for new large non-residential buildings and retrofitted where existing roofs are being replaced. Similarly, car parks should be designed to allow shallow storage of surface water and/or use pervious paving during re-surfacing works or as part of new development.	1. DDC and EA to agree on common policy position regarding use of green roofs and pervious paving so responses to planning applications are consistent.	• DDC • EA	1
	2. Using information in the SWMP, identify existing buildings and car parks with potential for green roofs or shallow storage/pervious paving	• DDC	1
	3. Develop DDC policy regarding use of green roofs and pervious paving where practicable	• DDC	2
Further develop DDC planning policy with respect to flood risk (including use of SuDS) Adopt a map indicating natural drainage routes which future development should respect. Development should also respect local landform to ensure sufficient property thresholds. Adopt a map indicating the suitability of locations for appropriate SuDS. Where appropriate, develop Supplementary Planning Documents (SPDs) to encourage developers of a particular site to contribute to flood risk management of the wider area.	1. EA, DDC and KCC to agree that the SWMP material can be used in response to planning applications and to develop policy. DDC to consider making the SWMP a material consideration. 2. Brief DDC council teams on natural drainage routes and suitability of locations for appropriate SuDS using simplified maps	• DDC • EA • KCC	1
	3. Promote use of appropriate SuDS through enhancing council policy (currently DM17) using information in the SWMP 4. Investigate feasibility of developing SPDs which can inform applications for redevelopment of strategic sites. Link drainage targets with seeking multiple benefits.	• DDC	2
Improve flood warning and emergency response Investigate the feasibility of a flood warning service on the River Dour. Encourage emergency responders to link Flood Forecasting Centre alerts with mapping of areas at risk of surface water flooding.	1. DDC and KCC to use information in this SWMP for emergency planning and response.	• DDC • KCC	1
	2. EA to investigate the feasibility of extending their flood warning service to cover flooding from the River Dour, particularly through Mid Town	• EA	2
Develop KCC policy for highways to be used as exceedance routes Develop policies to permit temporary routing of surface flow along roads, using traffic calming as required.	1. Develop KCC policy regarding use of roads for temporary flow routing, using traffic calming as required. Also consider shallow storage in lowered roundabouts and use of green street planters for kerb-side drainage.	• KCC	2

Generic Option ('What?')	Priority Actions ('How?)	Primary Action Owners ('Who?')[1]	Priority ('When?')[2]
Misconnections and surface water sewer interruption SW (with council support) should proactively seek to rectify misconnections. SW should develop a policy (in conjunction with other Partners) which could permit schemes to interrupt surface water sewers to provide overground attenuation and storage in extreme events. Individual schemes would still need to be justified.	1. SW (supported by DDC) to proactively identify/rectify misconnections between the foul and surface water sewers 2. SW to develop policy of sewer interruption based on discussions with Ofwat and other providers	• SW • DDC	2
Improve management of agricultural land to reduce runoff volume and sediment transport Maintain and further improve land management practices on the urban fringe to reduce surface runoff and associated erosion and sediment transport.	1. Using information in the SWMP identify agricultural land adjacent to primary natural flow routes which could be considered for Higher Level Stewardship schemes. 2. Promote and assist with applications to Higher Level Stewardship which tackle potential impacts of climate change, diffuse pollution, erosion, water quality and quantity.	• DDC	2

Notes:
[1] EA – Environment Agency; DDC – Dover District Council; KCC – Kent County Council; SW – Southern Water
[2] Priority 1: A 'quick win' or action urgently required within 12 months; Priority 2: Consider now for implementation in the next 1-5 years; Priority 3: Consider now for longer term implementation (5 years+); Priority O: Consider implementing if opportunity arises

Table 2.3 Location-specific management options (in order of indicative priority)

Area	Option[1] Location ('Where?')	Location-specific Option ('What?')	Priority Actions ('How?')	Primary Action Owners ('Who?')[2]	Priority ('When?')[3]	Multi Criteria Analysis: Technical	Economic[4]	Social	Environmental	SWMP	Overall MCA Score (max. 10)	Potential Funding Route (see Section 2.3)
Folkestone Road	**A1** Folkestone Road	***Property resistance/ resilience*** Improve property resistance/ resilience for identified properties on Folkestone Road.	1. Encourage uptake of resistance/ resilience measures at identified properties on Folkestone Road opposite junction with Malvern Road.	• DDC	**1** Urgent/ quick win with available funding	2 Products available	2 £101-£250k to protect 14 properties. Indicative B:C ratio of 8:1	0 No wider social benefits	0 No wider environmental benefits	2 Strong support	**6**	Defra/EA funding secured
Tower Hamlets	**B1** Tower Hamlets Street, East Street	***Property resistance/ resilience*** Improve property resistance/ resilience for identified properties on East Street.	1. Encourage uptake of resistance/ resilience measures at identified properties on East Street.	• DDC	**1** Urgent/ quick win with available funding	2 Products available	2 £101-£250k to protect 10 properties. Indicative B:C ratio of 8:1	0 No wider social benefits	0 No wider environmental benefits	2 Strong support	**6**	Defra/EA funding secured
Mid Town	**G1** Maison Dieu Road	***Property resistance/ resilience*** Improve property resistance/ resilience for identified properties on Maison Dieu Road.	1. Encourage uptake of resistance/ resilience measures at identified properties on Maison Dieu Road.	• DDC	**1** Urgent/ quick win with available funding	2 Products available	2 £51-£100k to protect 6 properties. Indicative B:C ratio of 8:1	0 No wider social benefits	0 No wider environmental benefits	2 Strong support	**6**	Defra/EA funding secured
Folkestone Road	**A2** Folkestone Road	***Property resistance/ resilience*** Improve property resistance/ resilience for additional selected properties on Folkestone Road.	1. Submit a funding bid to EA/Defra for property level protection supplemented by any property-owner evidence of flood history	• DDC	**1** High priority due to clear flood risk	2 Products available	2 £101-£250k to protect 20 properties. Indicative B:C ratio of 8:1	0 No wider social benefits	0 No wider environmental benefits	1 Likely to be supported by partnership	**5**	Local Levy to collate evidence of previous flooding
Crabble	**D1** Crabble Avenue	***Property resistance/ resilience*** Improve property resistance/ resilience for selected properties on Crabble Avenue.	1. Submit a funding bid to EA/Defra for property level protection supplemented by any property-owner evidence of flood history.	• DDC	**1** High priority due to flood history	2 Products available	1 £51-£100k to protect 1-5 properties (based on judgement from model). Indicative B:C ratio of 8:1	0 No wider social benefits	0 No wider environmental benefits	1 Likely to be supported by partnership	**5**	Local Levy to collate evidence of previous flooding
Temple Ewell & Kearsney	**E1** London Road between junctions with Kearsney Avenue and Alkham Road	***Property resistance/ resilience*** Improve property resistance for the properties adjacent to the NHS establishment on the south side of London Road by raising kerbs between the junctions of Kearsney Avenue and Alkham Road.	1. Site investigation to consider 'quick win' raising of kerbs on London Road to protect properties adjacent to the NHS establishment if resurfacing works are being undertaken anyway.	• KCC	**1** Quick win if road works already planned	1 Possible depending on access requirements	2 <£25k to protect 1-5 properties (based on judgement from model). Indicative B:C ratio of 13:1	0 No wider social benefits	0 No wider environmental benefits	1 Weak support due to low perceived risk	**4**	KCC as part of highway works

Area	Option[1] Location ('Where?')	Location-specific Option ('What?')	Priority Actions ('How?')	Primary Action Owners ('Who?')[2]	Priority ('When?')[3]	Multi Criteria Analysis: Technical	Economic[4]	Social	Environmental	SWMP	Overall MCA Score (max. 10)	Potential Funding Route (see Section 2.3)
Tower Hamlets	**B2** Tower Hamlets Street and De Burgh Street	***Property resistance/ resilience*** Improve property resistance/ resilience for additional selected properties in Tower Hamlets (e.g. Tower Hamlets Street and De Burgh Street).	1. Encourage uptake of resistance/ resilience measures at additional properties in Tower Hamlets. 2. Submit a funding bid to EA/Defra for property level protection if any property-owner evidence indicates a flood history.	• DDC	**2** Relatively low perceived risk	2 Products available	2 £51-£100k to protect 6-20. Indicative B:C ratio of 8:1	0 No wider social benefits	0 No wider environmental benefits	1 Likely to be supported by partnership	**5**	Local Levy to collate evidence of previous flooding
Coombe Valley Road	**C1** Coombe Valley Road	***Property resistance/ resilience*** Improve property resistance/ resilience for selected properties along Coombe Valley Road.	1. Encourage uptake of resistance/ resilience measures at identified properties on Coombe Valley Road. 2. Submit a funding bid to EA/Defra for property level protection supplemented by any property-owner evidence of flood history.	• DDC	**2** Low perceived risk	2 Products available	1 £51-£100k to protect 1-5 properties (based on judgement from model). Indicative B:C ratio of 8:1	0 No wider social benefits	0 No wider environmental benefits	1 Weak support due to low perceived risk	**4**	Local Levy to collate evidence of previous flooding
Buckland Valley and Buckland	**F1** Buckland Valley Sports Ground to junction of Crabble Hill and Buckland Avenue	***Attenuation and routing of surface flows*** Attenuate upstream flows in a detention basin in Buckland Valley Sports Ground. Route exceedance flows along Sheridan Road and across Roosevelt Road into a detention basin upstream of Winant Way. Route exceedance flows along Glenfield Road, Brookfield Avenue and Old Park Road. Raise pedestrian crossing at junction of Crabble Hill and Buckland Avenue to direct flow into the River Dour. Improve property resistance/ resilience along route as required.	1. Raise pedestrian crossing at junction of Crabble Hill and Buckland Avenue to stop continuation flow along Brookfield Place and route surface flows into the River Dour. 2. Raise kerb adjacent to NHS establishment on Brookfield Avenue opposite junction with Glenfield Road 3. Investigate feasibility of detention basins and designing exceedance routes.	• DDC • KCC	**2** Time required for feasibility study	1 Individual elements technically possible but requires feasibility study	1 £251-500k to protect 21-50 properties in 3.33% AEP event (based on modelling of option). Indicative B:C ratio of 4:1	0 No wider social benefits	0 No wider environmental benefits	2 Strong support	**4**	Flood Defence Grant in Aid (FDGiA) to undertake feasibility study
Mid Town	**G2** Frith Road / Maison Dieu Road / Crafford Street	***Surface flow routing and attenuation*** Route exceedance flows from Frith Road into the River Dour adjacent to Morrison's supermarket, and route exceedance flows from Maison Dieu Road into (i) the River Dour via Crafford Street and (ii) a pond, wetland or underground storage sited in the existing Maison Dieu Road car park. Improve property resistance/ resilience along route as required.	1. Consider raised pedestrian crossing of Maison Dieu Road at Morrisons to direct surface flow from Frith Road into the River Dour 2. Investigate feasibility of designing Crafford Street for routing exceedance flows from Maison Dieu Road into the River Dour. In addition, investigate feasibility of developing Maison Dieu car park as a pond, wetland or underground storage for high flows from the River Dour and runoff from Maison Dieu Road.	• DDC • KCC	**2** Time required for feasibility study	1 Individual elements technically possible but requires feasibility study	2 £251-£500k to protect 21-50 properties in 3.33% AEP event (based on modelling of option). Indicative B:C ratio of 12:1	0 Loss of car park space offset by improved social environ-ment	2 Improved environment from pond or wetland	1 Support for reduced flooding in Dour Street and improved environ-ment in Mid Town	**6**	Flood Defence Grant in Aid (FDGiA) to undertake feasibility study

Area	Option[1] Location ('Where?')	Location-specific Option ('What?')	Priority Actions ('How?')	Primary Action Owners ('Who?')[2]	Priority ('When?')[3]	Multi Criteria Analysis: Technical	Economic[4]	Social	Environmental	SWMP	Overall MCA Score (max. 10)	Potential Funding Route (see Section 2.3)
Mid Town	**G3** Western Docks	***Increase channel capacity*** Fit tide-excluding gates at outlet of Wellington Dock. Manage tide levels in the dock during periods of high river flow to maintain low tide levels and improve conveyance in the Dour channel.	1. Investigate feasibility of changing water level management rules in the Dock and closing tide-excluding gates upon receipt of a warning of high flows in the Dour	• DDC • EA	**3** Time required for feasibility study, construction and impact of sea level rise	1 Requires feasibility study	1 £51-£100k if Dover Harbour Board pays for gate. Number of properties protected not known. Indicative B:C ratio not known	0 No wider social benefits	0 No wider environmental benefits	1 Support to investigate feasibility	**3**	Local Levy to further investigate feasibility
Folkestone Road	**A3** Great Farthingloe and St Johns Road	***Attenuation of surface flows*** Attenuate upstream flows in a detention basin, pond or wetland as part of redevelopment of Great Farthingloe. Route exceedance flows from Folkestone Road into a pond or wetland sited adjacent to the Government Immigration Buildings off St John's Road as part of any redevelopment.	1. Consider requirement for an 'oversized' detention basin, pond or wetland in Great Farthingloe as part of any redevelopment, in order to reduce flood risk downstream. 2. Investigate feasibility of a pond or wetland adjacent to the Government Immigration Buildings to receive surface runoff from Folkestone Road as part of any redevelopment of the site	• DDC • SW	**O** Seek to include with proposed develop-ment	1 Individual elements technically possible but requires feasibility study	2 £101-£250k (if developers pay for ponds) to protect 21-50 properties in 3.33% AEP event (based on modelling of similar option). Indicative B:C ratio of 10:1	1 Social environ-ment improved by ponds	1 Environment improved by ponds	1 Support for works as part of site develop-ment	**6**	Council/ developer funded investigation if development opportunity arises
Coombe Valley Road	**C2** Coombe Valley Road / Lorne Road	***Attenuation and routing of surface flows*** Route exceedance flows along Coombe Valley Road and Lorne Road and into the River Dour, with an off-line detention basin or pond at the Buckland Hospital site as part of site redevelopment. Improve property resistance/ resilience along route as required.	1. Consider raised pedestrian crossing of London Road at the junction of Coombe Valley Road and Lorne Road to direct flow into Lorne Road and then the River Dour 2. Consider alternative access route to the Coombe Valley Industrial Estate, via Barwick Road if depression on Poulton Close becomes flooded. 3. Investigate feasibility of surface flow route and detention basin/pond in hospital site as part of any future redevelopment	• DDC • KCC	**O** Seek to include with proposed develop-ment	1 Individual elements technically possible but requires feasibility study	2 £51-£100k (assuming developer pays for pond) to protect 6-20 properties in the 3.33% AEP event (based on modelling of option). Indicative B:C ratio of 9:1	1 Social environ-ment improved by pond	1 Environment improved by pond	1 Weak support due to low perceived risk	**6**	Council/developer funded investigation if development opportunity arises
Temple Ewell & Kearsney	**E2** High Street, Temple Ewell	***Property resistance/ resilience*** Improve property resistance/ resilience for low threshold properties along High Street.	1. Site investigation to check that surface water cannot enter properties on Temple Side from the rear, and that flows are routed down the footpath to the existing flood barrier. 2. Identify properties with low thresholds along the High Street and encourage uptake of resistance/ resilience measures in case of exceedance flows from Temple Side.	• DDC	**O** Low perceived risk but seek funding	2 Products available	1 £101-£250k to protect 6-20 properties (based on judgement). Indicative B:C ratio of 8:1	0 No wider social benefits	0 No wider environmental benefits	1 Weak support due to low perceived risk	**4**	Local Levy to collate evidence of previous flooding

Area	Option[1] Location ('Where?')	Location-specific Option ('What?')	Priority Actions ('How?')	Primary Action Owners ('Who?')[2]	Priority ('When?')[3]	Multi Criteria Analysis: Technical	Economic[4]	Social	Environmental	SWMP	Overall MCA Score (max. 10)	Potential Funding Route (see Section 2.3)
Temple Ewell & Kearsney	**E3** Kearsney Lakes	***Increase capacity*** Increase storage of flows in the River Dour in the existing ponds at Kearsney.	1. Establish arrangements with Kearsney Lakes operators to draw down lake levels in advance of predicted prolonged high rainfall or high flow event	• DDC	**O** Upon forecast of a flood event	2 Process has previously been followed	0 <£25k to protect an unknown number of properties. Indicative B:C ratio not known	0 No wider social benefits	0 No wider environmental benefits	1 Support due to previous experience	**3**	Local Levy to establish procedures
River & Crabble	**D2** Cowper Road / Common Lane	***Property resistance/ resilience*** Improve property resistance/ resilience measures for selected properties in the valley between Cowper Road and Common Lane	1. Identify properties with low thresholds on Cowper Road and encourage uptake of resistance/ resilience measures 2. Submit a funding bid to EA/Defra for property level protection if any property-owner evidence indicates a flood history.	• DDC	**O** Low perceived risk but seek funding if any flood evidence	2 Products available	1 £51-£100k to protect 1-5 properties (based on judgement from model). Indicative B:C ratio of 8:1	0 No wider social benefits	0 No wider environmental benefits	1 Weak support due to low perceived risk	**4**	Local Levy to collate evidence of previous flooding
River & Crabble	**D3** Minnis Lane	***Surface flow route*** Route exceedance flows down Minnis Lane and into the River Dour on the upstream side of Minnis Lane. Improve property resistance/ resilience along route as required.	1. Investigate feasibility of designing Minnis Lane for exceedance.	• KCC • DDC	**O** Low perceived risk but seek to link with any planned works	1 Individual elements technically possible and could be beneficial if resurfacing works being undertaken anyway	1 <£25k to protect 1-5 properties (based on judgement from model). Indicative B:C ratio of 8:1	0 No wider social benefits	0 No wider environmental benefits	1 Weak support due to low perceived risk	**3**	KCC as part of highway works

Notes:
[1] Option reference numbers refer to Appendices – e.g. Option A1 is listed under the Folkestone Road area options in Table A.2 of Appendix A
[2] EA – Environment Agency; DDC – Dover District Council; KCC – Kent County Council; SW – Southern Water
[3] Priority 1: A 'quick win' or action urgently required within 12 months; Priority 2: Consider now for implementation in the next 1-5 years; Priority 3: Consider now for longer term implementation (5 years+); Priority O: Consider implementing if opportunity arises
[4] B:C ratio is the benefit cost ratio – i.e. the present value of the estimated benefits arising from reduced flood damages divided by the present value of the estimated costs.

2.2 Implementation and Review

Improved and sustainable management of surface water flooding is unlikely to arise through implementation of some of the proposed options alone. Instead, the overall philosophy developed through the SWMP study is for *incremental* change which *takes advantage of opportunities* as they arise to implement options which *cumulatively* have the effect of better managing flood risk. Therefore, all options should be kept in mind by the key DDC, KCC, EA and SW teams and their potential reviewed on a regular basis. To this end, it is **strongly recommended that the SWMP Partnership continues to meet bi-annually** (in the first instance) to review the progress of implementing the options and identify further opportunities. An ongoing forum may be best facilitated by KCC in its Lead Local Flood Authority role. Box 4 highlights some similar key messages which have been developed throughout the SWMP study. It is **recommended that these key messages are considered alongside the options** in Table 2.2 or Table 2.3.

Key SWMP Messages

Sustainable surface water flood risk management requires considering flood risk when undertaking other council or stakeholder activities. If this is done:

- flood risk will be managed through the cumulative benefit of numerous smaller schemes;
- opportunities for 'piggy-backing' flood management activities onto other works will be identified and could result in cost savings and efficiencies;
- Dover will incrementally adapt to the potential impacts of climate change through creative water management, leading to multiple benefits and win-win solutions; and
- awareness will be raised and maintained which will develop expertise.

Examples of putting these into practice should include:

- When **new developments** are being considered – Could the layout be modified to better respect the natural drainage routes? Could larger SuDS features be created which also store high flows from outside the site?
- When **existing developments** are being modified – Could the building support a green roof or rainwater harvesting? Could the car park be made pervious or support shallow temporary storage? Could the resistance or resilience to flooding be improved?
- When **road works** are being undertaken – Could existing road drainage be cleaned or 'quick win' improvements be made? Could the road be re-surfaced so that surface water drains more easily?
- When **sewers** are being maintained – Could oversized pipes be retrofitted? Could misconnections be identified and rectified?

Box 4 Key SWMP messages

2.3 Funding Opportunities

The following streams may provide opportunities to fund implementation of the options:

- **Kent County Council:** As the Lead Local Flood Authority for the county which includes Dover District, KCC will be in receipt of formula grant funding provided by Defra to undertake the lead authority role. This grant is not ring fenced and so KCC will need to determine, in consultation with the other risk management authorities, how much is spent on which local priorities. Although KCC will retain overall responsibility for managing local flood risk, some of its responsibilities can be delegated. Therefore, there may be opportunities for DDC to work with KCC to build expertise and invest some of the available funding in improving surface water management in Dover.
- **Local Levy (Environment Agency):** The EA administers this source of funding which is raised by way of a levy on the county councils and unitary authorities within the Southern Regional Flood and Coastal Committee boundary. The local levy is used to support, with the approval of the relevant committee, flood risk management projects that are not considered to be national priorities and hence do not attract national funding through Flood Defence Grant in Aid (see next). The local levy allows locally important projects to go ahead to reduce the risk of flooding within the committee area.
- **Environment Agency/Defra Flood Defence Grant-in-Aid (FDGiA) funding**: The EA administers Flood Defence Grant in Aid (FDGiA) which is government money allocated to Risk Management Authorities, which now includes local authorities. The funding is for capital works which manage and reduce flooding, including for property level flood protection. Projects arising from flooding from ordinary watercourses, surface runoff, or from groundwater, are now eligible, although those arising from flooding from sewerage systems are not. To allocate FDGiA funding, the EA collates and appraises applications on an annual basis. From 2012/13 onwards, a fixed amount of FDGiA funding will be offered to any project, based on the outcomes it will deliver. Projects whose costs do not qualify for full FDGiA funding will require cost savings to be found and/or local contributions to proceed.
- **Developer's Section 106 contribution / Community Infrastructure Levy (CIL):** When new development occurs within Dover, a levy can be charged by the council which is designed to cover the cost of new public facilities required as a result of the development. The larger strategic developments proposed within Dover (e.g. Mid Town) have the potential to generate Section 106 / Community Infrastructure Levy (CIL) funds which could be used to contribute to some of the options proposed in this SWMP and especially those which will have multiple benefits, e.g. ponds or wetlands which can receive surface water as well as providing improved amenity value.
- **Southern Water - Investment Plan 2010 – 2015:** By 2015, Southern Water has committed to reduce flooding to around 80 properties on its 'risk register' which have flooded internally and around 90 which have flooded externally at least once every twenty years. For Southern Water to consider implementing a scheme to reduce flooding, the cause must be related to the hydraulic inadequacy of the public sewerage system. Southern Water works within a framework of cost and benefit so that where solution options do not meet specific criteria for affordability or benefit they do not proceed and more local measures (e.g. property resistance/resilience) may be considered. Working with the councils and the EA to implement some of the schemes proposed in this SWMP may be more cost-beneficial than, for example, enlarging the sewers. However, Southern Water investment in any scheme will have to be justified by the severity and frequency of sewer flooding and must be agreed with Ofwat at the start of the next five year period (2016 - 2020). Reporting sewer flooding to Southern Water is therefore crucial to seeking future investment.

Appendix A Folkestone Road Area

A.1 Description of Area

For the purposes of this study, the Folkestone Road area comprises Clarendon, Elms Vale, Maxton which lie adjacent to Folkestone and Elms Vale Roads to the south west of Dover. Elms Vale and Folkestone Road represent two significant dry valleys which converge in Clarendon. At this point, Folkestone Road is in a valley with Tower Hamlets on high ground to the north and Western Heights on high ground to the south. The area is predominantly residential although it contains Priory Station, Government buildings (off St John's Road), the Ambulance Station, nursing homes, schools with associated playing fields and some local retail premises.

Drainage in this area is via the Southern Water surface water and combined sewer networks which convey surface water eastwards towards Mid Town, running parallel along Folkestone Road. Two combined sewer pipes of the same diameter (675mm) from Folkestone Road and Elms Vale Road combine into a single 675mm pipe under Folkestone Road at the junction with Malvern Road. The separate surface water sewer increases in size to a diameter of 1200mm by Priory Station.

Low property thresholds at junction of Folkestone Road and Elms Vale Road

Looking towards basement properties on Folkestone Road from Malvern Road

Playing field adjacent to Great Farthingloe

Harbour school playing field adjacent to Elms Vale Road

Figure A.1 Photographs of some key features in the Folkestone Road area

A.2 Preliminary Risk Assessment

Based on desk-based assessment of available information and site inspection, the Folkestone Road area was assigned a preliminary hazard rating from Moderate at

the western extent to Severe towards Priory Station. The following were key observations:

- Flooding of basement properties along Folkestone Road, particularly near the junction with Malvern Road, was recorded in the summers of 2004 and 2007. The area also has a history of flooding from the combined sewer network.
- A number of properties have low thresholds, including many with steps down to basement properties. There are credible reports of flooding of between 3 and 4 feet deep in basement properties in 2004 and 2007.
- The junction of Folkestone Road and Elms Vale Road is a confluence of two major flowpath systems which converge and extend to the topographic depression at the junction with Malvern Road. Folkestone Road then slopes up to pass over the railway at Priory Station. The only land below this low point is the site of the Government buildings on St John's Road.
- The area is identified from the Environment Agency Flood Map for Surface Water as an area where surface water flooding in the 3.33% (1:30 year) and more extensively in the 0.5% (1:200 year) could be deep (>0.3m).
- Flowpath contributions from the steep sided valleys in the area (e.g. from the vicinity of the new development opposite Winchelsea Road and Eaton Road) could reach high velocities.

A.3 Development Plans and Opportunities

The Site Allocations process[5] has identified sites in the Folkestone Road area for which development may be considered. Options for improved flood risk management (Section A.6) have been identified which could involve the following locations:

- Land at Farthingloe (NS10DOV): Approximately 55ha of land, aligned with the base of the dry valley, could be considered for a Mixed Use scheme
- Land at Western Heights (NS11DOV): Approximately 49ha of land, aligned with the high ground to the south of Folkestone Road, could be considered for a Mixed Use scheme
- Land to the rear of Dover Priory Railway Station (UCS004 & UCS019): Approximately 0.6ha of land which could be considered for residential housing

A.4 Environmental Designations and Other Possible Constraints

The following environmental designations are noted:

- The dry valleys adjacent to Folkestone Road and Elms Vale Road are designated as part of the Kent Downs Area of Outstanding Natural Beauty. This includes the majority of Farthingloe.
- Land surrounding the top of Western Heights is designated as a local nature reserve, with the portion to the north identified as Lowland Calcareous Grassland.
- Some areas of woodland, e.g. Elms Wood and Long Wood are designated as ancient woodland

The area to the north of Folkestone Road is designated as Source Protection Zone 1 (inner). The Folkestone Road area is also identified as a zone where groundwater levels could be close to the surface in a winter hydrologically similar to 2000/1. Selection of appropriate SuDS in this area should therefore consider the need for pollution control and the possibility that high groundwater levels may impede infiltration.

[5] Dover District Council (2010) Site Allocations Document – Interim Consultation. October 2010

A.5 Model Results

The modelling predicts the following pattern of surface water flooding as summarised in Table A.3 and shown for the 0.5% (1 in 200) AEP event in Figure A.2.

A.6 Surface Water Management in the Folkestone Road Area

A.6.1 Key Concepts for the Options

In addition to a series of generic options for improved surface water management included in the Action Plan, the following concepts are particularly relevant to the Folkestone Road area:

- Basement properties should be protected from water ponding on the roads. This may include raising thresholds or kerbs.
- Due to the topographic depression at the junction of Folkestone Road and Malvern Road and limited capacity in the combined sewer, options to convey flood water away from this location are limited and likely to be expensive. Therefore, limiting runoff from fringe areas (e.g. land at Western Heights, Farthingloe, Elms Vale) is of primary importance.
- Redevelopment should seek to safeguard and utilise natural ponding areas (e.g. site of Government Immigration Building) and respect natural flow routes (e.g. dry valley at Farthingloe).

A.6.2 Location-specific Options not Included in the Action Plan

The options for improved management of flooding listed in Table A.1 have been considered during the appraisal process but are not included in the Action Plan:

Table A.1 Folkestone Road options not included in the Action Plan

Option Considered	Reasons for Excluding from SWMP Action Plan
Detention basins in the playing fields for Astor College for the Arts (on Noah's Ark Road) and Dover Grammar School (on Astor Avenue)	• The playing fields lie on a watershed and will therefore attenuate minimal flows down Astor Avenue and Eaton Road.
Detention basin in existing playing field at Great Farthingloe adjacent to Manor Road.	• A detention basin, pond or wetland included as part of redevelopment of land at Farthingloe is more likely to be feasible and beneficial.
Detention basins formed by bunds across dry valley at Elms Farm and Elmswood Farm adjacent to Elms Vale Road	• Detention basins are likely to need the bund lining, supported by piling or grouting of the Chalk in order to support the structure and reduce leakage through the Chalk due to the additional head of water stored. Piling or grouting risks stopping and/or diverting natural groundwater flow. • The bunds may be only seldom used if groundwater floods similar to those of 2000/1 only occur with a frequency of between 1 and 0.5%. • The volumes of water generated during extreme groundwater conditions are large and will require large storage areas to be available for, potentially, many months. • Whilst grassed bunds could be blended into the landscape they may still detract from the attractive chalk valleys of the Kent Downs which are designated an AONB.

Option Considered	Reasons for Excluding from SWMP Action Plan
Detention basin in the Dover College cricket and hockey ground (bordered by Folkestone Road, Cow Lane and Church Road).	• The existing pitch is raised by over 1 metre relative to the levels along Folkestone Road and will therefore require substantial lowering to provide sufficient storage volume. • Drainage of the lowered pitch may have to be through a pumped system.
Detention basin in the playing field of Harbour School adjacent to Elms Vale Road.	• Located upstream of urban area so limited attenuation of runoff other than baseflow from the Chalk. • Modelling suggests minimal benefit in 3.33% AEP event.
Attenuation tank for high flows in the combined sewer under the disused land adjacent to Priory Station	• Volume of storage required will be large (>2,000m^3 for 3.33% AEP event) and a tank expensive. • Increasing the capacity of the combined sewer network is not a sustainable option and not in the long-term interests of surface water management • The land adjacent to Priory Station is anticipated by DDC to be developed before Southern Water is able to consider implementing any scheme.

A.6.3 Location-specific Options Included in the Action Plan

The options for improved management of flooding listed in Table A.2 are included in the SWMP Action Plan. The primary reasons for inclusion are given.

Table A.2 Folkestone Road options included in the Action Plan

Option	Primary Reasons for Inclusion in the Action Plan
A1 Improve property resistance/ resilience for identified properties on Folkestone Road.	• Fourteen basement properties on Folkestone Road at the junction with Malvern Road could be funded for property level resistance/resilience works following a grant from Defra.
A2 Improve property resistance/ resilience for additional selected properties on Folkestone Road.	• Modelling indicates a clear risk of flooding at a number of additional properties on Folkestone Road; on the south side adjacent to the junction with Malvern Road and Belgrave Road, and on the north side adjacent to the junction with Elms Vale Road.
A3 Attenuate upstream flows in a detention basin, pond or wetland as part of redevelopment of Great Farthingloe. Improve property resistance/ resilience for basement properties at key locations along Folkestone Road flow route. Route exceedance flows from Folkestone Road into a pond or wetland sited adjacent to the Government Immigration Buildings off St John's Road, particularly as part of any redevelopment.	• Attenuation of surface flows upstream of Folkestone Road junction with Malvern Road is of primary importance. • Land at Great Farthingloe which is proposed for redevelopment is on the natural flow path along the dry valley and could be considered for redevelopment. • The Government Immigration Buildings site is a natural depression behind the railway line and a natural storage area for surface water from the Elms Vale and Folkestone Road catchments. Any available opportunity to return it to use as a storage area for surface runoff should be considered. • Routing flows from Folkestone Road into the storage areas will most likely require a piped connection due to the raised topography of St John's Road. This may be best considered during any future redevelopment of the site.

Table A.3 Predicted pattern of flooding in the Folkestone Road area

Rainfall Event (AEP)	Key Pattern of Flooding
50% (1 in 2)	Isolated ponding of direct rainfall, with basement properties on Folkestone Road opposite the junction with Malvern Road flooding first.
3.33% (1 in 30)	Ponding to depths of over 0.5m on Folkestone Road at the junction with Malvern Road, with depths in adjacent basement properties of over 1.5m. Depths of over 0.5m are predicted at the Government buildings off St John's Road, as well as basement properties along Folkestone Road adjacent to the junction with Belgrave Road. The combined sewer surcharges, particularly around the junction with Malvern Road.
1% (1 in 100)	Ponding of up to 2m in the basement properties opposite the junction of Malvern Road, over 0.5m in basement properties on the junction with Belgrave Road and on St John's Road and in the nearby Government buildings. Surface water is predicted to flow along Folkestone Road from the junction with Maxton Road to depths of over 0.2m and flows into the disused land adjacent to Priory Station.
0.5% (1 in 200)	Almost continuous flow of surface water is predicted along Folkestone Road from Manor Road to St John's Road, as well as along Elms Vale Road from around the junction with Kings Road. Groups of basement properties which are particularly susceptible to deep ponding are those opposite the junction with Malvern Road, on the junction with Belgrave Road, opposite the junction with Underdown Road and on the corner of Manor Road in Maxton. Velocities of over 1.0m/s are predicted along some sections of Folkestone Road.

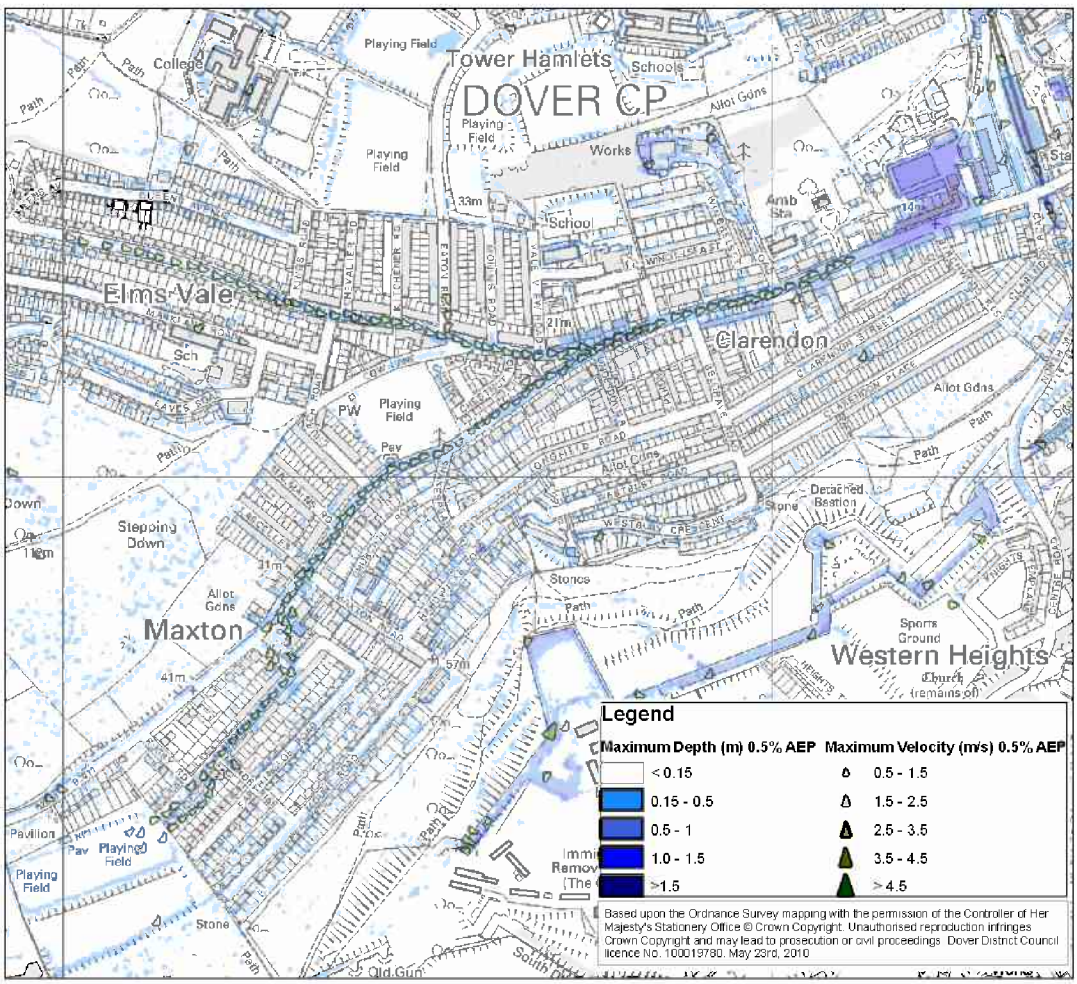


Figure A.2 Maximum depth and velocities in the 0.5% AEP rainfall event

Note: Malvern Road is shown erroneously on this OS Map as Birchwood Rise.

Appendix B Tower Hamlets Area

B.1 Description of Area

For the purposes of this study, the Tower Hamlets area comprises the area bordered by Harbour View Road to the north, Astor Avenue and Priory Hill to the south, Astor College for the Arts (on Noah's Ark Road) to the west and High Street to the east. The majority of Tower Hamlets is on relatively high ground which slopes away on its north, south and east sides into the Coombe Valley, Folkestone Road and Mid Town areas respectively. The area is predominantly residential although it contains other infrastructure including a shallow cutting for the railway line, two schools with associated playing fields and some local retail premises.

Drainage in this area is predominantly via the Southern Water surface water sewer network, although a section of combined sewer starting around West Street also conveys surface water eastwards towards Mid Town. Southern Water's plans show that the surface water sewer discharges into the Dour at Bridge Street, and that the combined sewer joins the 1500mm combined sewer running south east from DeBurgh Street. The surface water sewer size increases to 675mm diameter as it passes down Tower Hamlets Road.

Basement properties in West Street ponding area

Looking down Tower Hamlets Road flow route towards West Street

Rise over railway line along Tower Hamlets Road

College playing fields at catchment watershed

Figure B.1 Photographs of key features in the Tower Hamlets area

B.2 Preliminary Risk Assessment

Based on desk-based assessment of available information and site inspection, the Tower Hamlets area was assigned a preliminary hazard rating of Severe. The following were key observations:

- The topography slopes steadily downwards from the west, north and south to a local low point at the junction of East Street, West Street, Tower Hamlets Street, Eldred Road and Ethelbert Road. Tower Hamlets Road then slopes up to pass over the railway. The only land lower than this low point is the railway which runs in a cutting.
- The railway forms a barrier to further eastwards flow at the surface from this area. Furthermore, since the line lies in a shallow cutting, it will make any culverting of surface flows under the railway extremely challenging.
- A number of properties have low thresholds, including retail premises along the High Street and many residential properties with steps down to basements.
- Flooding of basement properties in the East Street area is recorded in the summer of 2007, with previous flooding of roads, gardens and properties in 1992, 1995, 2003 and 2004. There is a credible report of flooding causing a car to float down the road in 2004. Flooding along the High Street has occurred in various years including 1994/5 and 2000/1 which could be as a result of high groundwater levels. The area has a history of flooding from the combined sewer network.
- The East Street area is a confluence of a number of flowpaths along roads and is identified from the Environment Agency Flood Map for Surface Water as an area where surface water flooding in the 3.33% (1:30 year) and more extensively in the 0.5% (1:200 year) could be deep (>0.3m).
- Flowpath contributions along the roads could reach high velocities, particularly along Tower Hamlets Street and between Templar Road and Tower Hamlets Road.

B.3 Development Plans and Opportunities

The Site Allocations process has identified two sites in the Tower Hamlets area for which development may be considered. However, neither of these parcels of land would provide significant opportunity for improved management of surface water to either the Tower Hamlets or Coombe Valley areas:

- Land at Noah's Ark Road (NS07DOV): Approximately 0.3ha of land which could be considered for residential housing
- Land to the north of Eldred Road (NS12DOV): Approximately 0.1ha of land which could be considered for residential housing

B.4 Environmental Designations and Other Possible Constraints

The following environmental designations are noted:

- The area of land to the north of Tower Hamlets is designated as High Meadow Local Nature Reserve
- Land to the west of Astor College for the Arts is designated as Lowland Calcareous Grassland.

The area to the west of the railway line is designated as Source Protection Zone 1 (inner) and 2 (outer). The Tower Hamlets Road area is also identified as a zone of where groundwater levels could be close to the surface in a winter hydrologically similar to 2000/1. Selection of appropriate SuDS in this area should therefore consider the need for pollution control and the possibility that high groundwater levels may impede infiltration.

B.5 Model Results

The modelling predicts the pattern of surface water flooding as summarised in Table B.2 and shown for the 0.5% (1 in 200) AEP event in Figure B.2.

B.6 Surface Water Management in the Tower Hamlets Area

B.6.1 Key Concept for the Option

In addition to a series of generic options for improved surface water management included in the Action Plan, the following concept is particularly relevant to the Tower Hamlets area:

- Basement properties should be protected from water ponding on the roads. This may include raising of thresholds or kerbs. Due to the break line in natural drainage caused by the railway cutting, options to store or convey flood water away from the junction of East Street, West Street, Tower Hamlets Street, Eldred Road and Ethelbert Road are limited and likely to be expensive. Although limiting runoff within the catchment is important, opportunities in the dense residential area are also limited.

B.6.2 Location-specific Options not Included in the Action Plan

The options for improved management of flooding listed in Table B.2 have been considered during the appraisal process but are not included in the Action Plan:

Table B.1 Tower Hamlets options not included in the Action Plan

Option Considered	Reasons for Excluding from SWMP Action Plan
Detention basins in the playing fields for Astor College for the Arts (on Noah's Ark Road) and Dover Grammar School (on Astor Avenue)	• These grassed areas are at the watershed at the top of the catchment and will therefore receive minimal flow to attenuate.
Surface flow route connecting Tower Hamlets Street and Templar Street via a culvert under the railway line.	• The railway at this location is in a cutting. Routing a culvert under the railway will be technically difficult and expensive.
Increasing surface runoff into the combined sewer which runs in a 750mm pipe from West Street to Templar Street before joining a 1500mm pipe running south down De Burgh Street.	• Increasing flow in the combined sewer is not a sustainable option and could potentially lead to increased flooding downstream. • Increasing the number of entries to the combined sewer at the East Street junction in the model suggests it will have a negligible impact on flood levels in the area.
New surface water drainage following the railway from adjacent to East Street to discharge near the Tidal Basin.	• There is minimal space adjacent to the railway tracks, especially through the tunnels and Priory Station, to site a drainage channel. • Network Rail has confirmed that a pipe under the railway track would need to be at least 2m below track level so as not to interfere with railway infrastructure and there would be no opportunity for inspection chambers. • Installing an underground pipe would be extremely expensive to construct given the need to close and remove the railway track for either surface digging or tunnelling methods.

Table B.2 Predicted pattern of flooding in the Tower Hamlets area

Rainfall Event (AEP)	Key Pattern of Flooding
50% (1 in 2)	Isolated ponding of direct rainfall, with basement properties on DeBurgh Street flooding first.
3.33% (1 in 30)	In addition to flow of up to 0.3m along Tower Hamlets Street and Ethelbert Road, ponding to depths of up to 0.5m at basement properties on East Street and of over 0.5m on DeBurgh Street is predicted. Flooding of over 1.0m is predicted for the area behind the Charlton Shopping Centre. The surface water sewer surcharges at various locations between East Street and Bridge Street.
1% (1 in 100)	Almost continual flow of over 0.2m is predicted along Wyndham Road, Tower Hamlets Street and Ethelbert Road, with ponding of over 0.5m at basement properties on East Street. Most properties between Tower Hamlets Road and Templar Street are predicted to flood.
0.5% (1 in 200)	The surface water flowpath between Wyndham Road and Bridge Street, through the East Street properties and those between Tower Hamlets Road and Templar Street is well established. Maximum flood depths approaching 1.5m are predicted for the area behind the Charlton Shopping Centre. Velocities of over 1.0m/s are predicted along the main flow route.

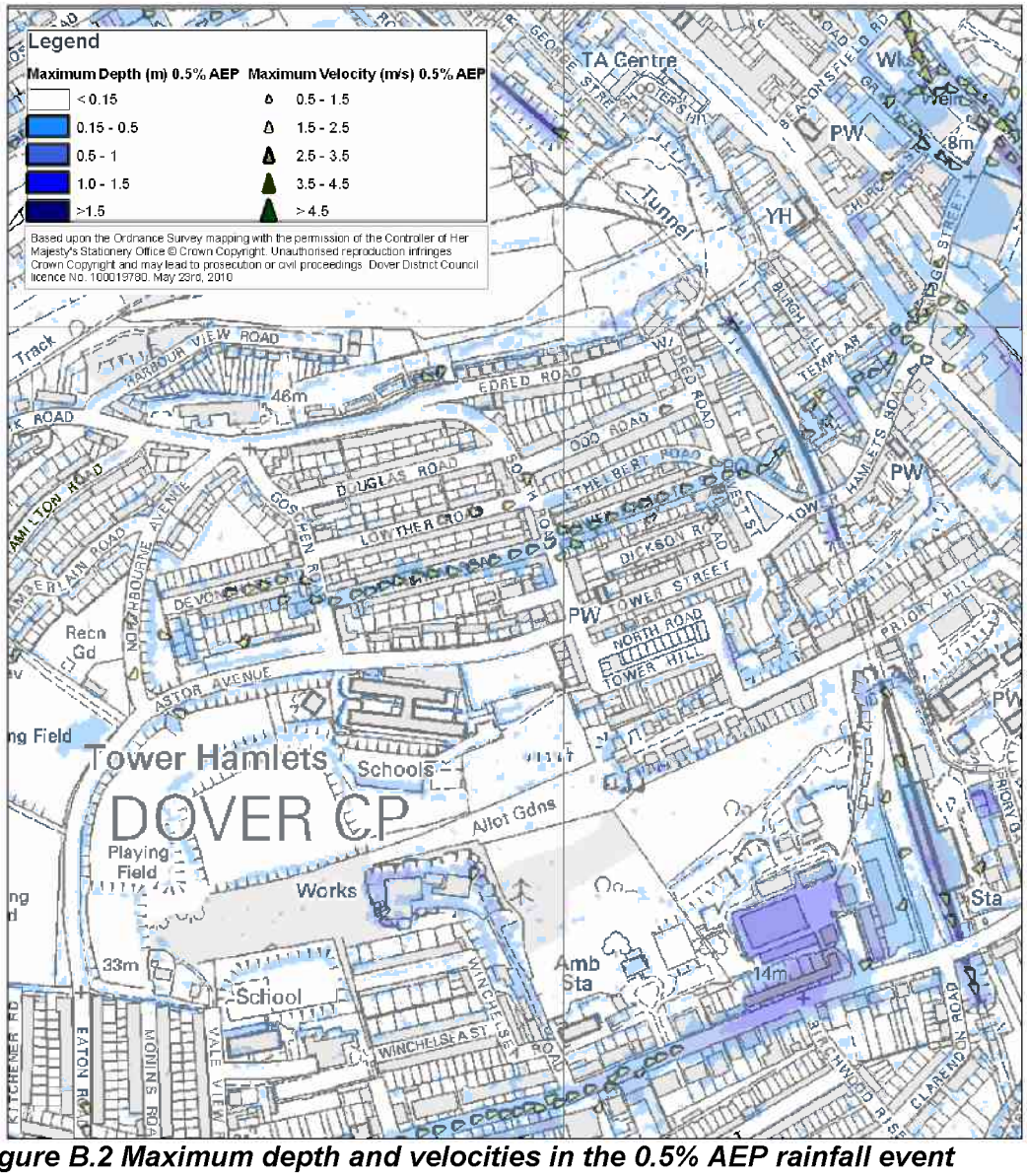


Figure B.2 Maximum depth and velocities in the 0.5% AEP rainfall event

B.6.3 Location-specific Options Included in the Action Plan

The options for improved management of flooding listed in Table B.3 are included in the SWMP Action Plan. The primary reasons for inclusion are given.

Table B.3 Tower Hamlets option included in the Action Plan

Option	Primary Reasons for Inclusion in the Action Plan
B1 Improve property resistance/ resilience for selected properties on East Street	• Ten basement properties on East Street could be funded for property level resistance/resilience works following a grant from Defra.
B2 Improve property resistance/ resilience for additional selected properties in Tower Hamlets (e.g. Tower Hamlets Street and De Burgh Street).	• Modelling indicates a clear risk of flooding at a number of additional properties on south-west side of De Burgh Street and south side of Tower Hamlets Street.

Appendix C Coombe Valley Road

C.1 Description of Area

For the purposes of this study, the Coombe Valley Road area comprises the area bordered by St Radigunds Road to the north, high ground between Coombe Valley Road and Noah's Ark Road to the south, Coombe Valley Road Industrial Estate to the west and London Road to the east. The Eric Road area is also included. Coombe Valley Road runs approximately along the base of the valley from which the land slopes upwards to the north and south. Coombe Valley represents a significant dry valley which falls steadily downwards towards the London Road and the River Dour to the east. The area is a mix of residential and business use, with Buckland Hospital and industrial premises to the south and west and predominantly residential properties with a school and nursing/care homes to the north. The railway is elevated above the valley bottom as it runs northwest parallel to London Road.

Drainage in this area is via the Southern Water surface water sewer network in the predominantly residential areas, with a combined sewer running along Coombe Valley Road from the junction with Barwick Road. Southern Water's plans show the surface water sewer, which starts in Poulton Close and Barwick Road, increasing in diameter to 750mm as it approaches London Road, with outfalls discharging into the Dour at Lorne Road and Cherry Tree Avenue. Both the combined sewer (450mm) along Coombe Valley Road and a branch serving Eric Road join the 600mm combined sewer running along London Road.

Low thresholds to basement properties at the bottom of Coombe Valley Road

Coombe Road climbing through the dry Chalk valley

Depression in Poulton Close before road continues to slope steadily downwards

Weir on the River Dour upstream of Lorne Road

Figure C.1 Photographs of some key features in the Coombe Valley area

C.2 Preliminary Risk Assessment

Based on desk-based assessment of available information and site inspection, the Coombe Valley area was assigned a preliminary hazard rating of Moderate at the western extent and Severe at London Road. The following were key observations:

- Flooding of properties towards the bottom of Coombe Valley Road, along London Road and Eric Road has been recorded over a number of years (e.g. 2003, 2004 and 2007) and temporary flood barriers were observed across entrances to some basement properties. The area around Eric Road and London Road has a history of flooding from the combined sewer network.
- A number of properties have low thresholds, including retail premises along London Road and residential properties with steps down to basements.
- Coombe Valley Road is a substantial flowpath from the dry valley to the west, and is identified from the Environment Agency Flood Map for Surface Water as an area where surface water flooding in the 3.33% (1:30 year) and more extensively in the 0.5% (1:200 year) could be deep (>0.3m).
- The topography slopes steadily downwards from the west to the River Dour which is on the far side of London Road. Any water at the surface must therefore cross London Road.
- In the Coombe Valley Industrial Estate there is a significant depression (approximately 2m deep) in the road which water at the surface must overtop before flowing down Poulton Close and Coombe Valley Road.
- Flow along Coombe Valley Road could reach moderately high velocities.

C.3 Development Plans and Opportunities

The Site Allocations process has identified sites in the Coombe Valley Road area for which development may be considered. Options for improved flood risk management (Section C.6) have been identified which could involve the following locations:

- Buckland Hospital site (SAD19A): Approximately 3.19ha of land which could be considered for residential housing
- Land enclosed by Coombe Valley Road, Edgar Road and Prospect Place (LDF031): Approximately 0.9ha of land which could be considered for residential housing
- Barwick Road (LDF036): Approximately 3.68ha of land which could be considered for mixed use development.

C.4 Environmental Designations and Other Possible Constraints

The following environmental designations are noted:

- Coombe Valley, including a portion of the Industrial Estate and land to the north of St Radigund's Road is designated as part of the Kent Downs Area of Outstanding Natural Beauty (AONB).
- A number of portions of land within the AONB as well as to the south of the Industrial Estate are identified as Lowland Calcareous Grassland.
- Land to the south of Coombe Valley is designated as two Local Nature Reserves: Whinless Down and High Meadow

Portions of the Coombe Valley area are designated as Source Protection Zones 1 (inner), 2 (outer) and 3 (total). The base of Coombe Valley Road is also identified as a zone of where groundwater levels could be close to the surface in a winter hydrologically similar to 2000/1. Selection of appropriate SuDS in this area should therefore consider the need for pollution control and the possibility that high groundwater levels may impede infiltration.

C.5 Model Results

The modelling predicts the pattern of surface water flooding as summarised in Table C.1 and shown for the 0.5% (1 in 200) AEP event in Figure C.2.

Table C.1 Predicted pattern of flooding in the Coombe Valley Road area

Rainfall Event (AEP)	Key Pattern of Flooding
50% (1 in 2)	Ponding of direct rainfall of up to approximately 0.5m is predicted for the properties on Beaufoy Road near the junction with Coombe Valley Road, as well as isolated properties between Primrose Road and Coombe Valley Road and between Oswald Road and London Road.
3.33% (1 in 30)	Ponding of over 1m at the depression on Poulton Close and at the railway underpass on Coombe Valley Road, and up to around 0.3m on London Road adjacent to Eric Road. Ponding to around 0.5m at properties on Edgar Road, the junction of Coombe Valley Road and MacDonald Road and at the bottom of Coombe Valley Road.
1% (1 in 100)	Almost continual flow of over 0.3m is predicted along Coombe Valley Road between the junction with Primrose Road and the railway underpass, as well as deeper ponding on London Road adjacent to the junction with Eric Road, the depression on Poulton Close and at properties identified above.
0.5% (1 in 200)	The surface water flowpath down Coombe Valley Road from the junction with Beaufoy Road is well established and almost continual ponding is predicted on London Road between the junctions with Coombe Valley Road and Bunker's Hill. Flood depths of over 1m are predicted at key groups of properties. Velocities of over 1.0m/s are predicted along Coombe Valley Road.

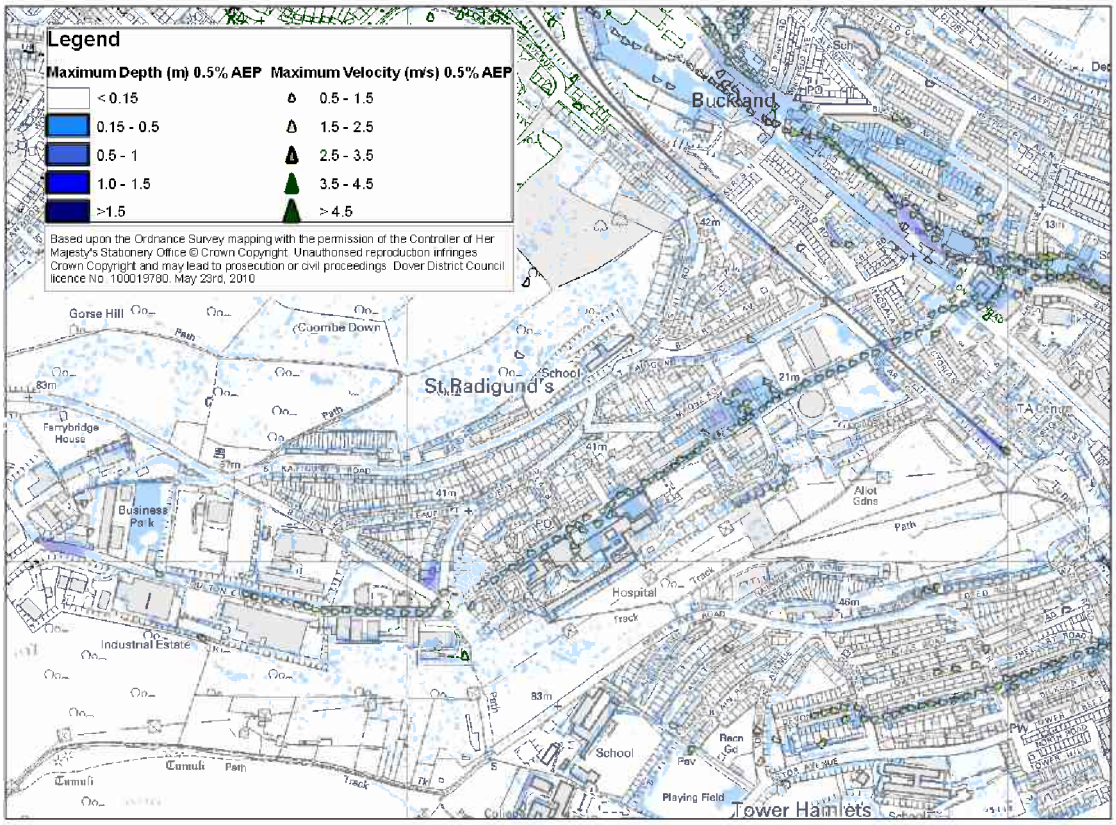


Figure C.2 Maximum depth and velocities in the 0.5% AEP rainfall event

C.6 Surface Water Management in the Coombe Valley Road Area

C.6.1 Key Concepts for the Options

In addition to a series of generic options for improved surface water management included in the Action Plan, the following concepts are particularly relevant to the Coombe Valley Road area:

- Basement properties should be protected from water ponding on the roads. This may include raising of thresholds or kerbs.
- Surface water which has exceeded the capacity of the drainage network along Coombe Valley Road must cross the key traffic route of London Road to enter the River Dour. Therefore, attenuating surface flow along Coombe Valley Road, including limiting runoff from the Coombe Valley fringe is of primary importance.
- Redevelopment of the Industrial Estate should recognise the potentially useful role of the depression in Poulton Close to limit any surface flow from Coombe Valley. Connections to the surface water sewer from the industrial estate should be limited and alternative access via Barwick Road could be considered to maintain access if Poulton Close becomes impassable.

C.6.2 Location-specific Options not Included in the Action Plan

The options for improved management of flooding listed in Table C.2 have been considered during the appraisal process but are not included in the Action Plan:

Table C.2 Coombe Valley Road options not included in the Action Plan

Option Considered	Reasons for Excluding from SWMP Action Plan
Fringe interception immediately upstream of the Coombe Valley industrial estate or at the location of Square Wood	• See the reasoning for exclusion of detention basins in the dry valleys upstream of Folkestone Road in Table A.1. • In addition, the natural depression in Poulton Close will act to limit onwards surface flow.
Swales adjacent to Coombe Valley Road	• There is limited space for construction of swales adjacent to Coombe Valley Road
Improve property resistance and resilience measures for properties on Eric Road.	• The flooding is primarily a result of insufficient sewer capacity which is being addressed by Southern Water. The surface water flow down Eric Road is not predicted to be substantial.

C.6.3 Location-specific Options Included in the Action Plan

The options for improved management of flooding listed in Table C.3 are included in the SWMP Action Plan. The primary reasons for inclusion are given.

Table C.3 Coombe Valley Road option included in the Action Plan

Option	Primary Reasons for Inclusion in the Action Plan
C1 Improve property resistance/ resilience for identified properties along Coombe Valley Road	• Flooding at various properties along Coombe Valley Road has been recorded and basement properties are particularly susceptible to flow from the road. • DDC could use experience which will arise from property level resistance/resilience works proposed for other areas to encourage uptake of measures.
C2 Route exceedance flows along Coombe Valley Road and Lorne Road and into the River Dour, with an off-line detention basin or pond at the Buckland Hospital site as part of site redevelopment. Improve property resistance/ resilience along route as required.	• The hospital site is proposed for redevelopment. However, land enclosed by Coombe Valley Road, Edgar Road and Prospect Place is also proposed for redevelopment and could provide an alternative to attenuation in the hospital site.

Appendix D River and Crabble

D.1 Description of Area

For the purposes of this study, the areas of Crabble and River are considered together and comprise the area bordered by Kearsney Abbey lakes to the north, the River Dour to the north and east, the Crabble Athletic Ground to the south and the urban fringe to the west. The land falls downwards, often steeply, towards the River Dour in the north east. The area is predominantly residential, although it includes River Primary School, Crabble Recreation Ground and Crabble Athletic and Football Grounds. The railway line crosses the Dour valley on a high embankment as it runs northwest parallel to London Road.

Drainage in this area is predominantly via the Southern Water surface water sewer network in the residential areas, with a combined sewer running along Lower Road and Crabble Avenue before crossing the Buckland Mill site to continue down London Road. Southern Water plans indicate that the surface water sewers discharge into the Dour at various locations, with diameters up to 300mm.

Low thresholds to basement properties along Crabble Avenue

Properties in dry valley between Cowper Road and Common Lane

River Dour between Minnis Lane and Kearsney lakes

River Dour upstream of Crabble Mill weir

Figure D.1 Photographs of some key features in River and Crabble

D.2 Preliminary Risk Assessment

Based on desk-based assessment of available information and site inspection, the River and Crabble areas were assigned a preliminary hazard rating of High. The following were key observations:

- A few properties were observed to have low thresholds, including basement properties along Crabble Avenue and Hillside Road. Crabble Avenue rises towards the junction with Hillside Road such that a local depression is formed. Surface water flowing along Crabble Avenue will not be able to pass under the railway arch to Buckland Mill unless it ponds to sufficient depth (~0.5m) on Crabble Avenue.
- Flooding from the combined sewer along Lower Road has been recorded, as well as flooding to basement properties on Crabble Avenue at various times (e.g. 2001, 2003 and 2004).
- Flow down the steep valley sides (particularly Minnis Lane) could reach high velocities.
- Minnis Lane and the valley between Cowper Road and Common Lane are potentially substantial flowpaths from dry valleys to the west, and are identified from the Environment Agency Flood Map for Surface Water as an area where surface water flooding in the 0.5% (1:200 year) could be deep (>0.3m).
- The combined sewer reduces from 900mm to 450mm between Crabble Lane and Crabble Avenue.
- The River Dour passes from Kearsney Abbey land under Minnis Lane through a small culvert which could be liable to block.

D.3 Development Plans and Opportunities

The Site Allocations process has identified three sites in Crabble for which development may be considered. However, none of these parcels of land provides significant opportunity for improved management of surface water since they are elevated above major flow routes:

- Crabble Athletic Ground (SHL098): Approximately 4.13ha of land which could be considered for residential housing
- Crabble Athletic Football Ground (SAD18): Approximately 2.77ha of land which could be considered for residential housing
- Land at Crabble Lane (NS05DOV): Approximately 5.15ha of land which could be considered for residential housing

D.4 Environmental Designations and Other Possible Constraints

The following environmental designations are noted:

- The majority of land to the west of River and Crabble is designated as part of the Kent Downs Area of Outstanding Natural Beauty (AONB).
- Land to the south of Crabble Athletic Ground is identified as Lowland Calcareous Grassland.
- River Bottom Wood and Frandham Wood are designated as Ancient Woodlands, with Alkham, Lydden & Swingfield Woods additionally designated as a Site of Special Scientific Interest.

The majority of the area is designated as Source Protection Zone 1 (inner) or 2 (outer). An area adjacent to the River Dour is also identified as a zone where groundwater levels could be close to the surface in a winter hydrologically similar to 2000/1. Selection of appropriate SuDS in this area should therefore consider the need for pollution control and the possibility that high groundwater levels may impede infiltration.

D.5 Model Results

The modelling predicts the pattern of surface water flooding as summarised in Table D.1 and shown for the 0.5% (1 in 200) AEP event in Figure D.2.

Table D.1 Predicted pattern of flooding in River and Crabble

Rainfall Event (AEP)	Key Pattern of Flooding
50% (1 in 2)	Ponding of direct rainfall is predicted for a small group of properties in the valley between Cowper Road and Common Lane.
3.33% (1 in 30)	Ponding at a small group of basement properties along Crabble Avenue. A flowpath down Cowper Road is established. The River Dour overtops Minnis Lane near the junction with Lower Road.
1% (1 in 100)	Ponding of around 0.3m in basement properties along Crabble Avenue. Flood depths approaching 0.5m for isolated properties adjacent to Cowper Road. Fluvial fooding of a small group of properties adjacent to the River Dour on the corner of Lower Road and Crabble Road.
0.5% (1 in 200)	Flooding in Crabble Avenue of up to 0.5m as well as flooding of up to 0.3m in adjacent basement properties. Flooding of properties at the bottom of Minnis Lane and between Cowper Road and Common Lane. Velocities of over 0.5m/s are predicted down Minnis Lane, adjacent to Cowper Road and adjacent to Crabble Lane.

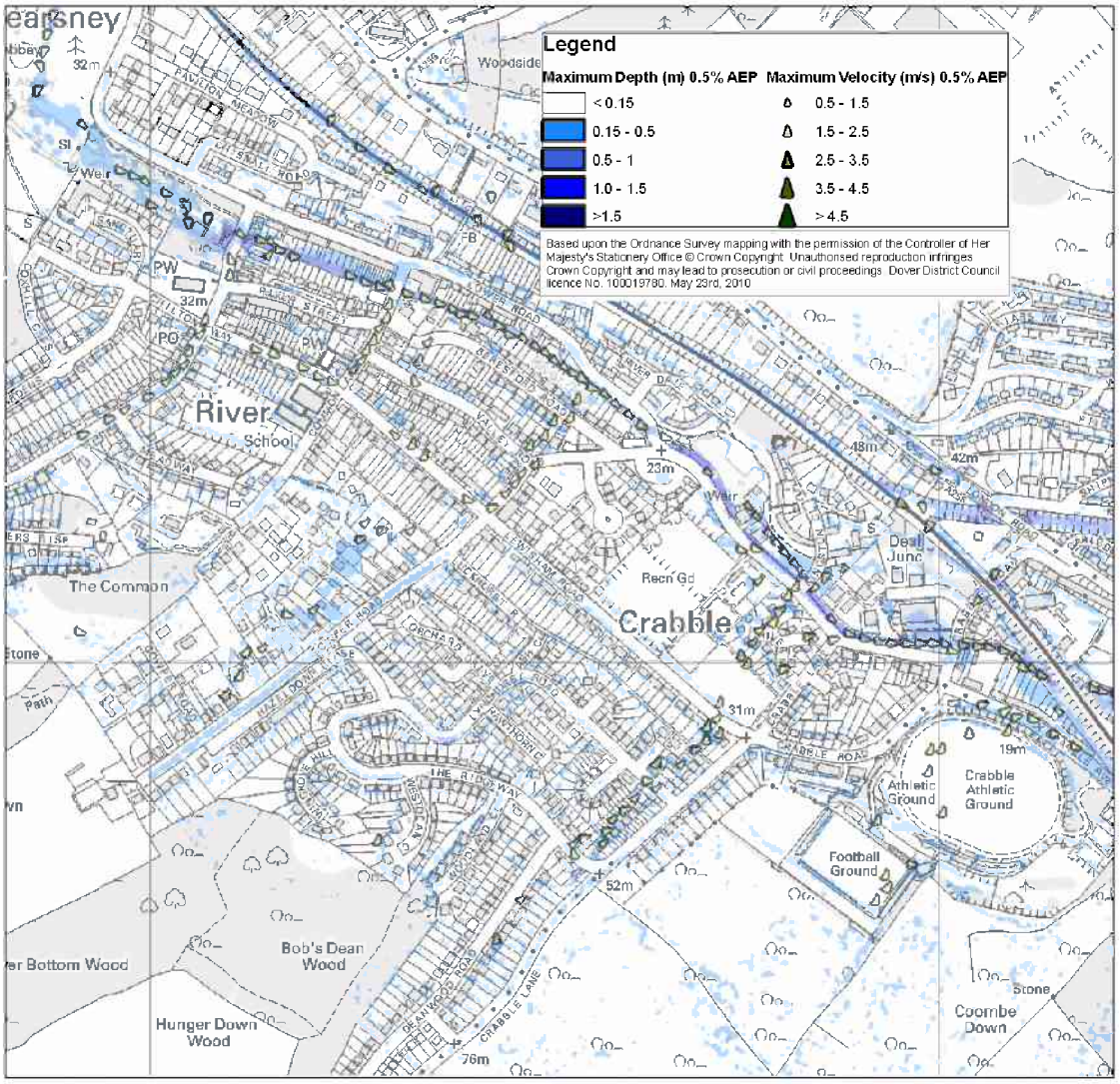


Figure D.2 Maximum depth and velocities in the 0.5% AEP rainfall event

D.6 Surface Water Management in River and Crabble

D.6.1 Key Concepts for the Options

In addition to a series of generic options for improved surface water management included in the Action Plan, the following concepts are particularly relevant to River and Crabble:

- Basement properties should be protected from water ponding on the roads, as well as from high groundwater levels. This may include raising of thresholds or kerbs, as well as tanking of basements and fitting of other resistance/resilience measures.
- Although limiting runoff from the dry valleys to the west of these areas is of primary importance, surface water which has exceeded the capacity of the drainage network along Minnis Lane, Cowper Road or Crabble Lane must be routed towards the River Dour as safely as possible.

D.6.2 Location-specific Options not Included in the Action Plan

The options for improved management of flooding listed in Table D.2 have been considered during the appraisal process but are not included in the Action Plan:

Table D.2 River and Crabble options not included in the Action Plan

Option Considered	Reasons for Excluding from SWMP Action Plan
Fringe interception in the dry valleys discharging at Minnis Lane and Cowper Road.	• See the reasoning for exclusion of detention basins in the dry valleys upstream of Folkestone Road in Table A.1. • Flow along Minnis Lane is not likely to be significant. • A detention basin at the top of the valley between Cowper Road and Common Lane does not appear feasible since any outflow would continue to be through the properties at risk.
Detention basin in the grounds of River Primary School	• There is no natural flow route between Minnis Lane and the grounds of River Primary School and additional drainage infrastructure is likely to be expensive. • Flow down Minnis Lane predicted by the modelling is not likely to be significant.
Route exceedance flows down Crabble Lane and into a detention basin in Crabble Recreation Ground. Consider sewer interruption into detention basin.	• Flow down Crabble Lane predicted by the modelling is not likely to be significant. • There is a substantial rise in the topography between the low point on the The Ridgeway at the junction with Deanwood Road and Crabble Lane which makes rerouting surface flow down Crabble Lane impractical. • There is no history of flooding from the surface water sewer in this area to justify a sewer interruption scheme.

D.6.3 Location-specific Options Included in the Action Plan

The options for improved management of flooding listed in Table D.3 are included in the SWMP Action Plan. The primary reasons for inclusion are given.

Table D.3 River and Crabble options included in the Action Plan

Option	Primary Reasons for Inclusion in the Action Plan
D1 Improve property resistance/ resilience for selected properties on Crabble Avenue.	• There is a history of basement flooding at certain properties along Crabble Avenue which could be used as evidence to support a funding application to the EA/Defra. Experience from proposed works on Folkestone Road, East Street and Maison Dieu Road could be usefully applied.
D2 Improve property resistance/ resilience measures for selected properties in the valley between Cowper Road and Common Lane	• Although there are no records of flooding at this location, modelling indicates that some properties may be at risk.
D3 Route exceedance flows down Minnis Lane and into the River Dour on the upstream side of Minnis Lane. Improve property resistance/resilience along route as required.	• KCC may be planning works along Minnis Lane. Consider reprofiling of Minnis Lane to direct exceedance flow into the River Dour.

Appendix E Temple Ewell and Kearsney

E.1 Description of Area

For the purposes of this study, the areas of Temple Ewell and Kearsney are considered together and comprise the area bounded by the A2 to the north, Kearsney lakes and the River Dour to the south, Great Watersend Farm to the west and the A256 (Whitfield Hill) to the east. The land falls downwards to the south west towards the River Dour. The area is a mix of rural Chalk landscape, parkland and residential development, with a number of nursing and care homes, an NHS establishment and a railway station. The railway line is elevated above the valley bottom in the vicinity of Kearsney Station by an embankment as it runs north west parallel to London Road.

Drainage in this area is via the Southern Water surface water and combined sewer networks. The combined sewer commences in Temple Ewell as a 300mm diameter pipe and runs along Lower Road, increasing in size to 600mm. The surface water sewers appear to discharge into the Dour at various locations, with diameters up to 300mm.

Alkham valley below Alkham

Playing fields in Whitfield Valley above Kearsney Avenue

Abbey Lake in the grounds of Kearsney Abbey

Flood bar at the junction of Temple Side and London Road in Temple Ewell

Figure E.1 Photographs of some key features in Temple Ewell and Kearsney

E.2 Preliminary Risk Assessment

Based on desk-based assessment of available information and site inspection, the Temple Ewell and Kearsney areas were assigned preliminary hazard ratings of High and Low, respectively. The following were key observations:

- Although no basement properties were observed, a few properties were observed to have low thresholds, particularly those on High Street in Temple Ewell.
- Runoff from the surrounding Chalk hills could contribute to surface water flooding. Indeed, some flooding has been reported, specifically from flow along Kearsney Avenue which crosses London Road and passes down Alkham Road.
- Temple Side/High Street and Kearsney Avenue/Alkham Road are potentially substantial flowpaths and are identified from the Environment Agency Flood Map for Surface Water as an area where surface water flooding in the 0.5% (1:200 year) could be deep (>0.3m).
- Flow down the steep valley sides (particularly Temple Side) could reach high velocities.

E.3 Development Plans and Opportunities

The Site Allocations process has identified two sites in the Temple Ewell and Kearsney areas where development may be considered. Although neither of these areas presents opportunities for improved management of existing surface water flooding issues, it is important that runoff from any development is kept to a minimum.

- Land south of A2 and Herald Wood, Whitfield (SHL077): Approximately 20.33ha of land which could be considered for residential housing.
- Manor Farmyard, Egerton Road, Temple Ewell (SHL045): Approximately 0.74ha of land which could be considered for residential housing.

E.4 Environmental Designations and Other Possible Constraints

The following environmental designations are noted:

- The majority of open land to the west of Kearsney is designated as part of the Kent Downs Area of Outstanding Natural Beauty (AONB).
- Land to the north of Temple Ewell is designated as Lydden Temple Ewell national nature reserve, which includes the Lydden and Temple Ewell Downs Special Area of Conservation and Site of Special Scientific Interest and areas of Lowland Calcareous Grassland

The majority of the area is designated as Source Protection Zone 1 (inner), 2 (outer) or 3 (total). An area adjacent to the River Dour is also identified as a zone where groundwater levels could be close to the surface in a winter hydrologically similar to 2000/1. Selection of appropriate SuDS in this area should therefore consider the need for pollution control and the possibility that high groundwater levels may impede infiltration.

E.5 Model Results

Only the south eastern portion of the area is covered by the model which predicts the pattern of surface water flooding as summarised in Table E.1 and shown for the 0.5% (1 in 200) AEP event in Figure E.2.

Table E.1 Predicted pattern of flooding in the modelled portion of Temple Ewell and Kearsney

Rainfall Event (AEP)	Key Pattern of Flooding
50% (1 in 2)	Ponding of direct rainfall is predicted on Alkham Road as it passes under the railway, as well as along the approach road to the station and the bowling green.
3.33% (1 in 30)	Deeper flooding at these same locations
1% (1 in 100)	Deeper flooding at these same locations
0.5% (1 in 200)	Deeper flooding at these same locations with ponding of over 1.0m predicted on Alkham Road under the railway underpass and approaching 0.5m on the approach to the station. Velocities of over 0.5m/s are predicted from Kearsney Avenue across London Road and along Alkham Road between the railway underpass and Lower Road.

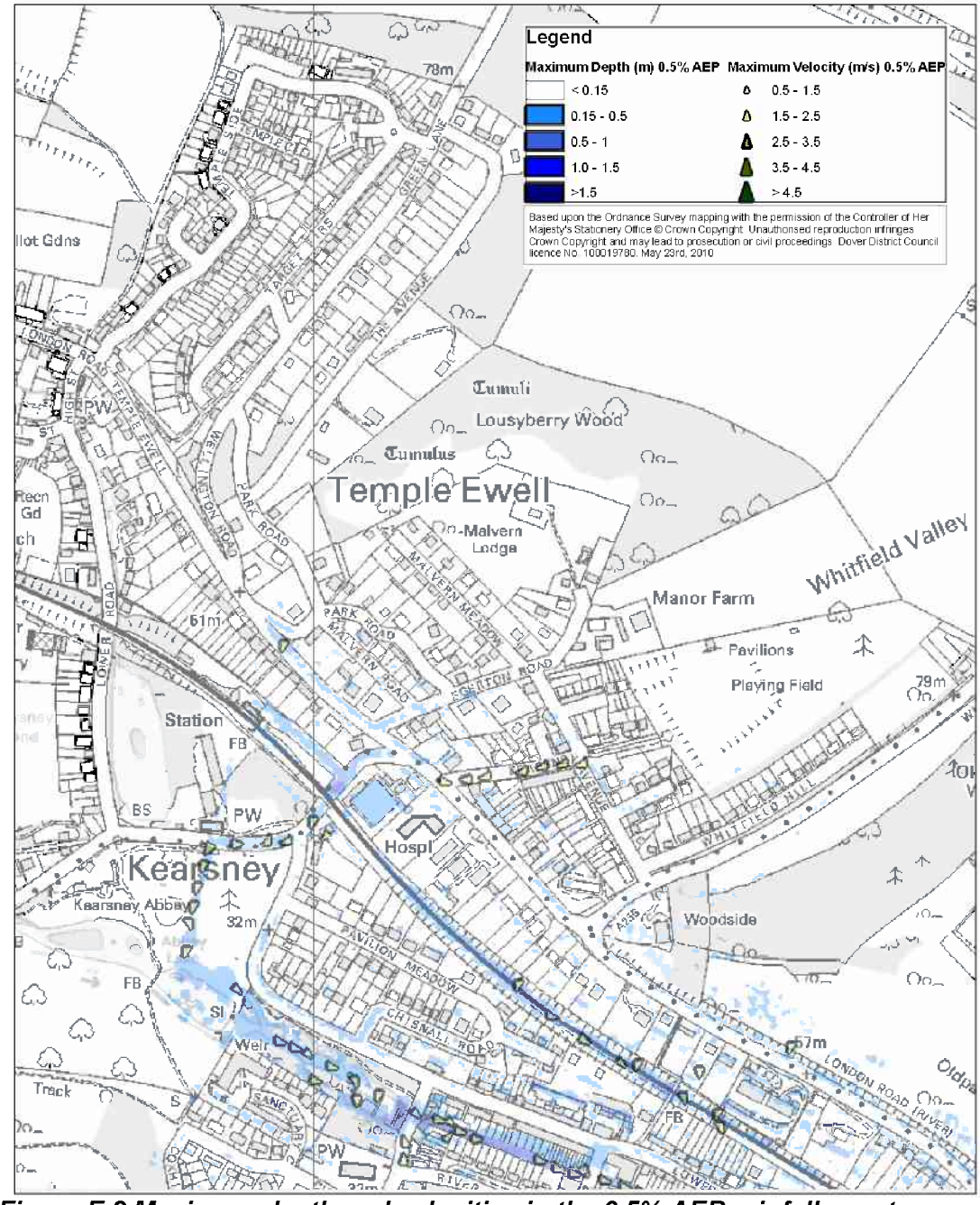


Figure E.2 Maximum depth and velocities in the 0.5% AEP rainfall event

E.6 Surface Water Management in Temple Ewell and Kearsney

E.6.1 Key Concepts for the Options

In addition to a series of generic options for improved surface water management included in the Action Plan, the following concept is particularly relevant to Temple Ewell and Kearsney:

- Runoff from the chalk hills and from any future development should be minimised.

E.6.2 Location-specific Options not Included in the Action Plan

The options for improved management of flooding listed in Table E.2 have been considered during the appraisal process but are not included in the Action Plan:

Table E.2 Temple Ewell and Kearsney options not included in the Action Plan

Option Considered	Reasons for Excluding from SWMP Action Plan
Fringe interception in the dry Alkham valley discharging at the lakes in Keasney.	• See the reasoning for exclusion of detention basins in the dry valleys upstream of Folkestone Road in Table A.1. • Control of the levels in Kearsney lakes is likely to be a more feasible alternative, although will provide significantly less storage.

E.6.3 Location-specific Options Included in the Action Plan

The options for improved management of flooding listed in Table E.3 are included in the SWMP Action Plan. The primary reasons for inclusion are given.

Table E.3 Temple Ewell and Kearsney options included in the Action Plan

Option	Primary Reasons for Inclusion in the Action Plan
E1 Improve property resistance for the properties adjacent to the NHS establishment on the south side of London Road by raising kerbs between the junctions of Kearsney Avenue and Alkham Road.	• Although a substantial attenuation option such as a detention basin above Kearsney Avenue and routing of exceedance flows to Alkham Road does not appear to be justified, there is some evidence of flooding along this route and protection of the properties adjacent to the NHS establishment could be a quick win.
E2 Improve property resistance/ resilience for low threshold properties along High Street.	• Although there are no records of flooding at this location, national mapping and flow path modelling indicates that some properties may be at risk.
E3 Increase storage of flows in the River Dour in the existing ponds at Kearsney.	• Levels in the lakes at Kearsney can be controlled by DDC and have been done so to limit high flows in the past.

Appendix F Buckland

F.1 Description of Area

For the purposes of this study, the areas of Buckland and Buckland Valley are considered together and comprise the area from the north end of the Buckland Valley residential development to the River Dour to the south. , The open space of Old Park Hill forms the boundary to the north west and Beaconsfield Avenue and Stanhope Road to the east. The land falls generally to the south towards the River Dour. The area is predominantly residential although contains some industrial premises, nursing homes, schools with associated playing fields, allotments, and some local retail premises.

Drainage in this area is predominantly via the Southern Water surface water sewer network, although a combined sewer runs along London Road, having come across Buckland Mill estate from Crabble. The combined sewer increases from 450mm diameter pipe to 900mm along London Road adjacent to Buckland Avenue. An additional and parallel 300mm combined sewer runs under London Road from this point. The surface water sewer appears to discharge into the Dour at various locations, with diameters up to 750mm at the junction of London Road and Buckland Avenue.

Steep slopes could lead to high flow velocities along roads

Basement properties with low thresholds

Flooding of major traffic intersections and properties has occurred

Open spaces could be used for attenuation of runoff

Figure F.1 Photographs of some key features in the Buckland area

F.2 Preliminary Risk Assessment

Based on desk-based assessment of available information and site inspection, the Buckland and Buckland Valley areas were assigned a preliminary hazard rating of Severe. The following were key observations:

- A number of properties have low thresholds, including a number with steps down to basement properties.
- Surface flow from Buckland Valley is constrained by topography and the railway embankment to pass through the underpass at the top of Glenfield Road. Flowpath contributions from the steep sided valleys of Buckland Avenue (e.g. Glenfield Road) could reach high velocities which pose a risk to life (e.g. NHS establishment off Brookfield Avenue at the bottom of Glenfield Road)
- Flooding of properties (e.g. low threshold properties along London Road) and roads (e.g. junction of London Road and Buckland Avenue) is recorded as having occurred throughout the area, including a number of sewer flooding incidents from the surface water and combined networks around Brookfield Place.
- The junction of London Road and Buckland Avenue is a confluence of two major flowpath systems (the River Dour and overland flow down Buckland Valley) and is identified from the EA FMfSW as an area where surface water flooding in the 3.33% (1:30 year) and more extensively in the 0.5% (1:200 year) could be deep (>0.3m).

F.3 Development Plans and Opportunities

The Site Allocations process has identified sites in the Buckland area for which development may be considered. Although none of these areas presents opportunities for improved management of existing surface water flooding issues, it is important that runoff from any development is kept to a minimum.

- Land at Old Park Hill (SHL070): Approximately 3.1ha of land which could be considered for residential housing
- Land at Wycherley Crescent and Milton Road (NS08DOV): Approximately 0.56ha of land which could be considered for residential housing
- Land to the north of Melbourne Avenue (SAD15): Approximately 0.5ha of land which could be considered for residential housing
- Land adjacent to Former Melbourne County Primary School (SHL062): Approximately 0.35ha of land which could be considered for residential housing

Note that consideration was given in the early stages of this study to use of the Buckland Paper Mill site (LDF030) for surface water attenuation. However, planning permission has been granted for a Mixed Use development for which plans are advanced.

F.4 Environmental Designations and Other Possible Constraints

No environmental designations have been identified in this area.

The majority of the Buckland Valley area is designated as Source Protection Zone (SPZ) 2 (outer), with land towards Connaught Barracks being in zone 1 (inner). Although Buckland adjacent to the River Dour is not in an SPZ, it is identified as a zone where groundwater levels could be close to the surface in a winter hydrologically similar to 2000/1. Selection of appropriate SuDS in these areas should therefore consider the need for pollution control in SPZs and the possibility that high groundwater levels may impede infiltration near the Dour.

F.5 Model Results

The modelling predicts the pattern of surface water flooding as summarised in Table F.1 and shown for the 0.5% (1 in 200) AEP event in Figure F.2.

F.6 Surface Water Management in the Buckland Area

F.6.1 Key Concepts for the Option

In addition to a series of generic options for improved surface water management included in the Action Plan, the following concepts are particularly relevant to the Buckland area:

- Basement properties and those with low thresholds should be protected from water ponding on the roads. This may include raising of thresholds or kerbs.
- Development of fringe areas should limit potential runoff into the Buckland area.

F.6.2 Location-specific Options not Included in the Action Plan

The options for improved management of flooding listed in Table F.2 have been considered during the appraisal process but are not included in the Action Plan:

Table F.2 Buckland options not included in the Action Plan

Option Considered	Reasons for Excluding from SWMP Action Plan
Detention basin upstream of Green Park Primary School.	• A detention basin in the adjacent sports ground is more feasible.
Attenuation of surface water from Buckland Valley and of high flows in the Dour in a detention basin, ponds or a wetland sited in the disused Buckland Paper Mill site.	• Plans to develop the Buckland Mill industrial site have been approved and are already advanced. • Use of the Buckland Mill site for improving flood management in the wider area is unlikely to be a feasible constraint to impose on developers.
A detention basin in the allotment gardens between Green Lane and Glenfield Road.	• The allotment gardens slope steeply from Green Lane to Glenfield Road. Attenuating the majority of the runoff, which is likely to be down Glenfield Road, would require major excavation.

F.6.3 Location-specific Option Included in the Action Plan

The option for improved management of flooding listed in Table F.3 is included in the SWMP Action Plan. The primary reasons for inclusion are given.

Table F.3 Buckland option included in the Action Plan

Option	Primary Reasons for Inclusion in the Action Plan
F1 Attenuate upstream flows in a detention basin in Buckland Valley Sports Ground. Route exceedance flows along Sheridan Road and across Roosevelt Road into a detention basin upstream of Winant Way. Route exceedance flows along Glenfield Road, Brookfield Avenue and Old Park Road. Raise pedestrian crossing at junction of Crabble Hill and Buckland Avenue to direct flow into the River Dour. Improve property resistance/ resilience along route as required.	• There is a history of flooding in the area, including at the junction of Buckland Avenue and Crabble Hill • Flows down the steep sided Buckland Valley may reach high velocities which could pose a risk to life • Sports ground and land amongst properties on Winant Way is DDC land.

Table F.1 Pattern of flooding in Buckland as predicted by the model

Rainfall Event (AEP)	Key Pattern of Flooding
50% (1 in 2)	Isolated ponding of direct rainfall
3.33% (1 in 30)	A flowpath down Glenfield Road is established and there is ponding of approximately 0.3m predicted at the junction of Buckland Avenue and Crabble Hill which extends into Brookfield Place, as well as the Buckland Paper Mill site.
1% (1 in 100)	Almost continuous flow is predicted between Roosevelt Road and the junction of Buckland Avenue/Crabble Hill. Flooding of some properties along Buckland Avenue and Lorne Road is predicted, with ponding along Alfred Road. Maximum depths are generally greater than 0.3m.
0.5% (1 in 200)	Deeper flooding of roads and properties is predicted along the flowpath between Roosevelt Road and the junction of Buckland Avenue/Crabble Hill, as well as between Brookfield Place/Buckland Avenue and Cherry Tree Avenue. Maximum depths generally approach 0.5m. Maximum velocities along the major flow routes are generally greater than 1.0m/s.

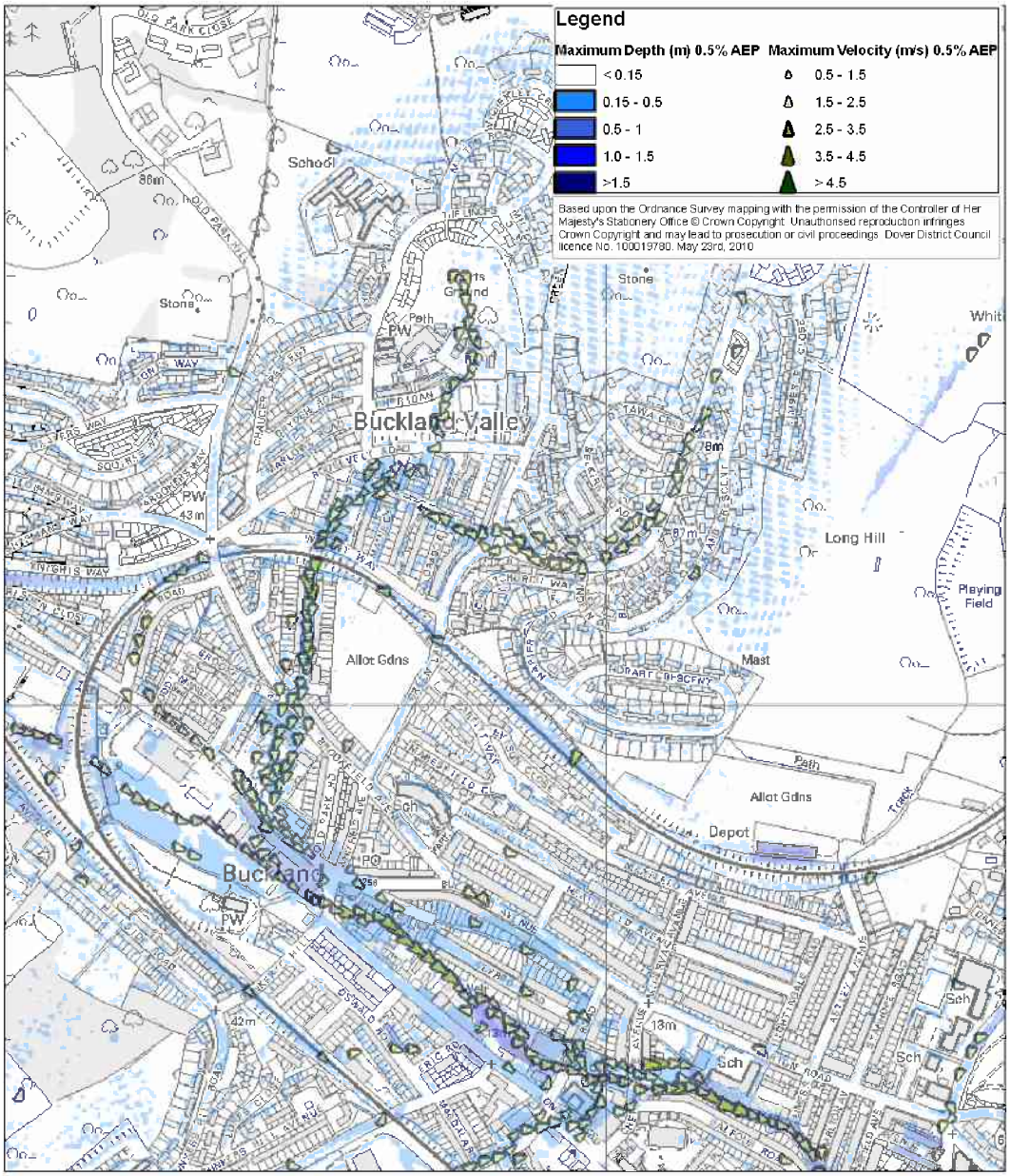


Figure F.2 Maximum depth and velocities of flooding in the 0.5% (1 in 200) AEP rainfall event

Appendix G Mid Town

G.1 Description of Area

For the purposes of this study, the Mid Town area of Dover comprises the area bounded by Beaconsfield Road and the railway to the west, Connaught Park and Barracks to the north and the sea to the south and east. The land falls to the south and to the east towards the River Dour and the sea. The area is mixed use with predominantly residential developments on the often steep sided hills to the north and commercial development along the River Dour corridor. The area contains key infrastructure (including emergency services), the main retail centre of Dover, some industrial premises, nursing homes, schools with associated playing fields and parkland.

Drainage is via the Southern Water surface water and combined sewer networks. Combined sewers of diameters up to 1500mm run down Maison Dieu Road, High Street and Effingham Street before converging at the junction of York Street and Townwall Street. From Bulwark Street, the combined sewer operates via a pump to transfer the contents to Broomfield Bank Waste Water Treatment Works. Surface water networks discharge into the River Dour at various points from pipes ranging in size up to 450mm diameter. The River Dour discharges into the sea via Wellington Dock where minimum water levels are maintained. Levels in the Dock and up the River Dour vary freely with rising tides.

Low property thresholds and basement properties

Maison Dieu road car park and other low lying areas are at risk of flooding

Weir and culverts constrict the River Dour

Dour outfalls into Wellington Dock which does not exclude high tides

Figure G.1 Photographs of some key features in the Mid Town area

G.2 Preliminary Risk Assessment

Based on desk-based assessment of available information and site inspection, the Mid Town area was assigned hazard ratings of High in the north, Severe in central Mid Town and Moderate towards the coast. The following were key observations:

- Flowpath contributions from the steep sided valleys from Connaught Barracks (e.g. Old Charlton Road, Castle Hill Road) and Tower Hamlets (e.g. Tower Hamlets Road) could reach high velocities
- A large number of properties have low thresholds, including many with steps down to basement properties and many retail premises.
- Flooding of properties (e.g. basement properties along Maison Dieu Road and the High Street) and roads (e.g. Maison Dieu Road) is recorded as having occurred throughout the area over many years, including a number of sewer flooding incidents from the combined sewer network.
- Mid Town is a confluence of major natural flowpath systems from Folkestone Road, Tower Hamlets, the River Dour through Buckland and Connaught Barracks. It is identified from the EA FMfSW as an area where surface water flooding in the 3.33% (1:30 year) and more extensively in the 0.5% (1:200 year) could be deep (>0.3m).
- The River Dour channel is complex with numerous culverted sections. It is severely constrained and includes potential obstructions to high flows. The capacity of the River Dour to receive surface runoff from the surface water drains is a key constraint during periods of high flow. Areas between Park Street and Pencester Road have been identified as the functional floodplain of the River Dour (i.e. likely to flood in a 5% AEP event).
- The shallow topography and gradient for drainage in the area is likely to result in ponding of surface water falling directly on Mid Town or running off from the surrounding land.

G.3 Development Plans and Opportunities

The Site Allocations process has identified sites in the Mid Town area for which development may be considered. Options for improved flood risk management (Section G.6) have been identified which could involve the following locations:

- Mid Town (CP9): Strategic Allocation site of 5.9 hectares which is proposed for mixed development of public sector uses, retail and residential. Integral to the development will be improvement of public areas centred on river frontages.
- Charlton Green Sorting Office (LDF06): 0.69ha of land which could be considered for residential housing
- Charlton Shopping Centre (SHL006): 0.63ha of land which could be considered for residential housing
- St James's (LDF024): 3.6ha of land which could be considered for mixed use development
- Dover Waterfront (CP8): Strategic Allocation site of 12.2 hectares which is proposed for mixed use development including residential homes, a hotel, offices and retail centres.
- Former Connaught Barracks (CP10): Strategic Allocation site of 12.5ha which is proposed for residential development.

G.4 Environmental Designations and Other Possible Constraints

The land to the east of Castle Hill Road is designated as part of the Kent Downs Area of Outstanding Natural Beauty (AONB). Dour Street is a conservation area and the area is archaeologically important.

The majority of the area to the north of the River Dour is designated as Source Protection Zone 1 (inner), 2 (outer) or 3 (total). An area adjacent to the River Dour is also identified as a zone where groundwater levels could be close the surface in a winter hydrologically similar to 2000/1. Selection of appropriate SuDS in this area should therefore consider the need for pollution control and the possibility that high groundwater levels may impede infiltration.

G.5 Model Results

The modelling predicts the pattern of surface water flooding as summarised in Table G.1 and shown for the 0.5% (1 in 200) AEP event in Figure G.2.

Table G.1 Pattern of flooding in Mid Town as predicted by the model

Rainfall Event (AEP)	Key Pattern of Flooding
50% (1 in 2)	Isolated ponding of direct rainfall including in some basement properties and the car park on Maison Dieu Road
3.33% (1 in 30)	Ponding up to depths of ~0.3m on roads and properties around Maison Dieu Road (including out-of-bank flow from the Dour across the car park), Dour Street (flow from Maison Dieu Road via Crafford Street) and Pencester Road (from Maison Dieu Road and the Dour across the College site). Depths of over ~0.5m predicted in the Maison Dieu Road car park.
1% (1 in 100)	Widespread flooding of over ~0.5m at roads and properties between the Dour and Maison Dieu Road from Beaconsfield Road to Townwall Street, and between Pencester Gardens and Castle Street on the opposite bank. As well as ponding of direct rainfall, flooding is caused by out-of-bank flow from the Dour along Granville Street and Charlton Green (due in part to the weir and culvert adjacent to Halfords superstore), Maison Dieu Road (due to the low left hand bank downstream of Park Street), Pencester Road and Stembrook/Church Street).
0.5% (1 in 200)	Widespread flooding across Mid Town with depths of over ~1m at some basement properties and the car parks on Maison Dieu and Pencester roads. Flow routes as for 1% event, with velocities of over 0.5m/s along Frith Road, Maison Dieu Road and Dour Street.

G.6 Surface Water Management in Mid Town

G.6.1 Key Concepts for the Options

In addition to a series of generic options for improved surface water management included in the Action Plan, the following are particularly relevant to Mid Town:

- Basement properties should be protected from water ponding on the roads, as well as from high groundwater levels. This may include raising of thresholds or kerbs, as well as tanking of basements and fitting of other resistance/resilience measures.
- Passage of high flows in the River Dour should be safeguarded and improved where possible. This may include removal of weirs and culverts, channel regrading and, with climate change, management of high tidal levels.
- Redevelopment should seek to safeguard and utilise natural ponding areas and respect natural flow routes. Wherever possible, source control measures should be included, particularly green street planters, green roofs and shallow storage in car parks.
- Development of fringe areas (e.g. former Connaught Barracks) should limit potential runoff into the Mid Town area.

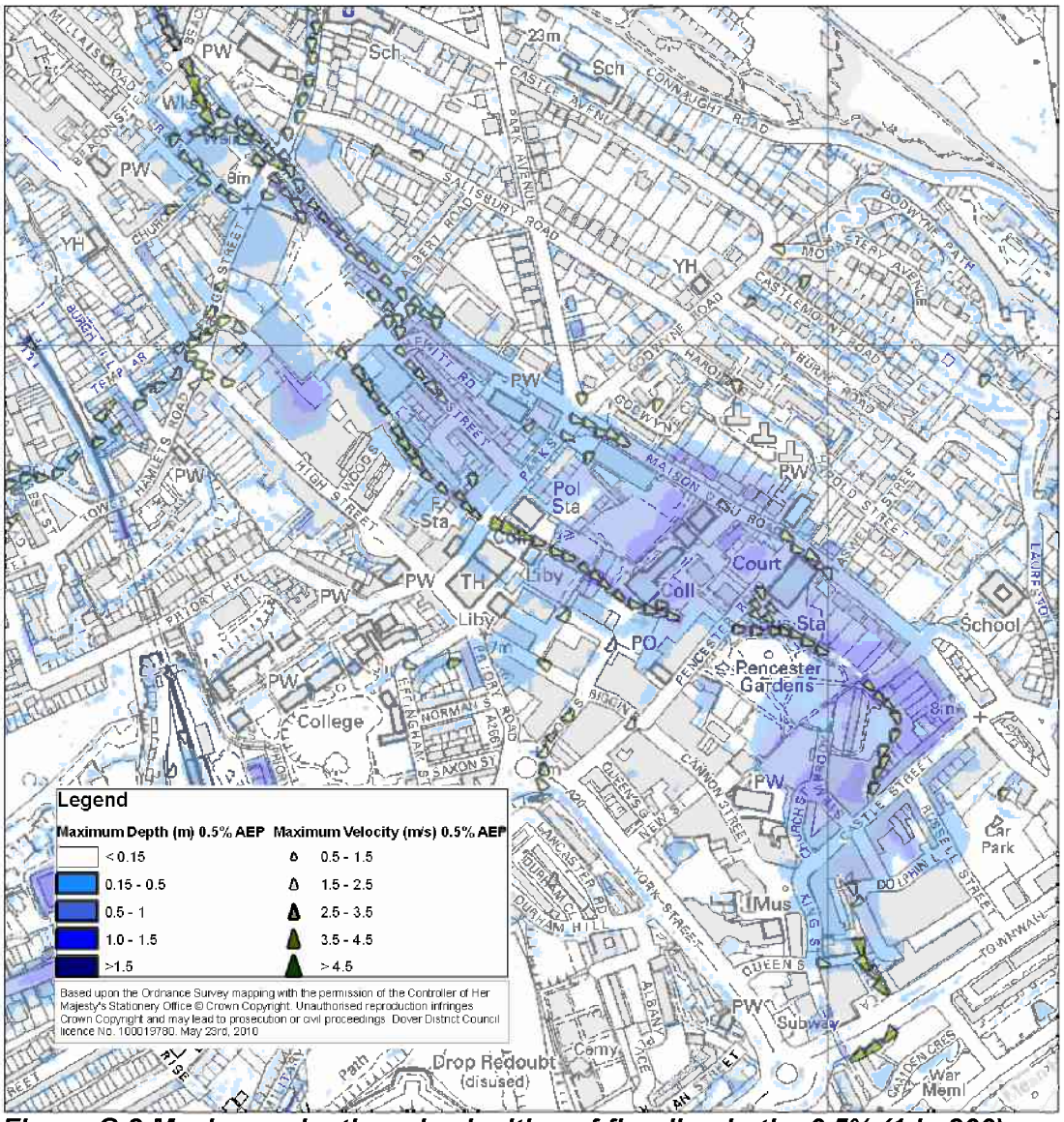


Figure G.2 Maximum depth and velocities of flooding in the 0.5% (1 in 200) AEP rainfall event

G.6.2 Location-specific Options not Included in the Action Plan

The options for improved management of flooding listed in Table G.2 have been considered during the appraisal process but are not included in the Action Plan:

Table G.2 Mid Town options not included in the Action Plan

Option Considered	Reasons for Excluding from SWMP Action Plan
Detention basins at The Danes recreation ground and sports ground at Long Hill	• Limited flows are anticipated at both locations. • Outflow from a detention basin at The Danes would be down a steep slope through which retained water will most naturally seep. Furthermore, outflow is into the cemetery which may be difficult to justify.
Route exceedance flows along Old Charlton Road and Frith Road and improve property resistance/ resilience along route as required.	• Contributions from Old Charlton Road and Frith Road are likely to be small • Reducing continuation flows down Maison Dieu Road could be achieved as part of the wider option included in the Action Plan

Option Considered	Reasons for Excluding from SWMP Action Plan
Dour bypass channel linking online storage/detention basins/ponds at current sites of Morrison's car park, Maison Dieu Road car park, Pencester Road car park, Pencester Gardens and Russell Street car park as part of Mid Town strategic redevelopment.	• Dour Street is unlikely to be redeveloped and is not wide enough for a channel and parking • Bypass channel to eliminate fluvial flooding in the 1% AEP event plus climate change would be up to 6m wide requiring substantial land take • Costs are likely to be prohibitive • Low flow issues in existing Dour channel would mean that bypass channel would often be dry and therefore social and environmental benefits would be limited
Removal of weir adjacent to Halfords store and regrading of the channel between Beaconsfield Road and Bridge Street.	• Regrading of the ~150m section between Beaconsfield Road and Bridge Street provides a minimal reduction in flood risk in the 3.33% AEP and 1% AEP rainfall events. This is likely to be due in part to increased flow velocities which are unable to pass through the existing culvert under Bridge Street. • It is recognised that removal of such obsolete structures is likely to lead to improvements in fish passage and the potential for local narrowing which are objectives of the Water Framework Directive. However, this option is unlikely to be motivated by improvements to surface water flood risk management. Any regrading should consider a longer length of channel and measures to reduce flow velocities.
Regrading of the channel between Park Street and Wellington Dock.	• Regrading over the ~1km length could result in an over-deep channel which suffers from poor light penetration and requires extensive reinforcement of the banks. • Regrading through Pencester Road and Castle Street culverts is likely to be highly problematic. • Costs are likely to be prohibitive • Changed bed profile could mean tidal influence extends further into Mid Town, particularly with sea level rise, and change the character of the river

G.6.3 Location-specific Options Included in the Action Plan

The options for improved management of flooding listed in Table G.3 are included in the SWMP Action Plan. The primary reasons for inclusion are given

Table G.3 Mid Town options included in the Action Plan

Option	Primary Reasons for Inclusion in the Action Plan
G1 Improve property resistance and resilience measures for identified properties on Maison Dieu Road.	• Six basement properties on Maison Dieu Road could be funded for property level resistance/resilience works following a grant from Defra.
G2 Route exceedance flows from Frith Road into the River Dour adjacent to Morrison's supermarket, and route exceedance flows from Maison Dieu Road into (i) the River Dour via Crafford Street and (ii) a pond, wetland or underground storage sited in the existing Maison Dieu Road car park. Improve property resistance/ resilience along route as required.	• There is a natural flow route from Maison Dieu Road into the topographic depression along Dour Street which could be redirected via kerb raising and use of traffic calming along Crafford Street. • Maison Dieu Road is a natural ponding area for high flows from the River Dour and should be used as such whilst improving the social environment as part of strategic redevelopment.
G3 Fit tide-excluding gates at outlet of Wellington Dock. Manage tide levels in the dock during periods of high river flow to maintain low tide levels and improve conveyance in the Dour channel.	• As part of the strategic redevelopment of Wellington Dock, Dover Harbour Board (DHB) has agreed in principle to funding and fitting tide-excluding gates to the new proposed outlet of Wellington Dock. • Consideration is also being given by DHB to allowing the gates to be closed in the event of a storm surge to improve flood management. There may, therefore, be a precedent for operating the gates for management of levels in the River Dour. • Although current MHWS tidal levels do not appear to impound high flows in the Dour channel through Mid Town, rise in sea level with climate change could make this option more beneficial.

Appendix H Options Map