Maldon Causeway Area Flood Risk Appraisal

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Essex County Council
Flood Services

VERSION CONTROL

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0 EXECUTIVE SUMMARY

0.0.1 This Appraisal undertakes an investigation into flood risk to aid with future planning and development decisions. It covers the Causeway Regeneration Area (CRA) in Maldon and Heybridge, which primarily forms the area between the River Chelmer and the Chelmer and Blackwater Navigation.

0.0.2 This Appraisal looks to ensure future development can be built safely within the CRA. As such, this Appraisal encourages sustainable development that not only mitigates against flood risk but also achieves wider socio-environmental benefits in relation to biodiversity, amenity and multifunctionality.

0.0.3 Despite the apparent flood risk, there are several examples of flood resilience measures that have been delivered within the CRA to mitigate against flooding as well as realising further benefits in accordance with local planning policy and supporting documentation. Notable flood risk mitigation measures and schemes include The Granaries, The Canal Chunker, Langford Storage and Blackwater Retail Park, all of which have improved flood resilience within the CRA and demonstrate the importance of new development. This Appraisal looks to build upon the precedent set by these developments and continue to enable sustainable schemes that achieve wider benefits for the local area.

0.0.4 Both national and local level planning policies have been reviewed, as well as relevant strategic and supplementary planning documents, to ensure a holistic approach is applied to mitigating flood risk whilst also encouraging new development within the CRA. These policies and documents include:

- National Planning Policy Framework (NPPF)
- Environment Agency Climate Change Allowances
- The Essex SuDS Design Guide
- The Essex Green Infrastructure Strategy
- The Essex Local Flood Risk Management Strategy
- The Maldon District Local Development Plan
- The Causeway Development and Improvement Plan
- The Maldon and Heybridge Central Area Masterplan SPD
- The North Quay Development Brief SPD
- Maldon District Green Infrastructure Strategy SPD

0.0.5 This Appraisal provides a Flood Risk Overview for the CRA from each flood risk source including surface water, groundwater, fluvial and tidal. The overview includes incidents of historic flooding within the CRA, informed by data from flood risk stakeholders. Details pertaining to specific properties flooded are omitted from this Appraisal in line with General Data Protection Regulations (GDPR), but generic locations are provided.

0.0.6 No specific information is given for flooding from adopted sewers, however the Appraisal does include DG5 records provided by the Local Water Authority. The study area is within an area of high risk from fluvial and tidal flooding but is protected by existing defences. Much of the study area is at high risk of flooding from groundwater.

0.0.7 Existing surface water, fluvial and tidal flood modelling has been reviewed to help assess flood risk and to identify smaller flood risk 'Hotspots'. Of the 10 Hotspots identified through the review, 6 were progressed for further investigation:

- Hotspot 1: Area north-east of the Chelmer and Blackwater Navigation
- Hotspot 2: Area around Hall Road
- Hotspot 3: Area west of the Heybridge Creek
- Hotspot 4: Area west of The Causeway, including Galliford Road
- Hotspot 5: Area north of the River Chelmer and west of Fullbridge
- Hotspot 6: Area around Station Road

0.0.8 Following further site-specific investigations, high level options are provided that could be implemented to mitigate flood risk along with the benefits and risks associated with each and further details on planning considerations. All options are given to facilitate further discussions regarding flood risk mitigation within the study area. The options identified are:

- Green roofs
- Rainwater re-use
- Localised ground reprofiling and bio retention areas
- Green walls
- Permeable paving
- Downpipe measures (including planters, rain gardens and water butts)
- Non-return valves
- Improving existing fluvial defences
- New drainage connections
- Attenuation areas
- Changes to planning policy (Maldon District LDP Review 2021-2023)

0.0.9 Construction and total project costs are provided for each option along with a breakdown of aspects involved and assumptions that may impact costs. The costs provided are high-level estimates and are given to allow comparison between potential options and to provide a starting point for any conversations surrounding CIL or Section 106 contributions.

0.0.10 Further details are provided on which options could be implemented in each hotspot area with further details on specific locations that may be best suited to mitigate the specific flood risks in each area.

0.0.11 This appraisal has been compiled using flood modelling data and records from several flood risk stakeholders including Essex County Council, Maldon District Council, the Environment Agency, and Anglian Water.

0.0.12 This report has used all up to date hydraulic modelling available at the time of writing but should be updated in conjunction with local planning policy, including the Local Development Plan and Supplementary Planning Documents.

0.0.13 Maldon District Council declared a Climate Change Emergency in February 2021. The Maldon District Climate Change Statement can be found in Section 2 of this document.

0.0.14 Maldon District Council is preparing a Climate Change Strategy for November 2021 with a consequent Climate Action Plan following thereafter.

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GLOSSARY AND ABBREVIATIONS

Annual Exceedance Probability	AEP	The probability of a rainfall or flood event occurring in a given year. A 1% AEP event is likely to occur on average once every 100 years.
Anglian Water	AW	The sewerage provider covering Maldon with ownership and responsibility of adopted foul and surface water sewers.
Areas Susceptible to Groundwater Flooding	AStGWF	Digital mapping produced by the Environment Agency and British Geological Survey showing groundwater flood risk.
British Geological Society	BGS	The organisation who hold geological survey and borehole data for the UK
Buildings Research Establishment Environmental Assessment Method	BREEAM	An international scheme that provides independent third-party certification of the sustainability performance of buildings and projects through a rating system
Brownfield Site		Land that is or has been developed upon which is not currently in use and is considered for redevelopment
Critical Drainage Area	CDA	A smaller catchment area identified within a wider Surface Water Management Plan (SWMP) study area as being at higher risk of surface water flooding.
Critical Infrastructure		Infrastructure that are essential for the continued delivery of goods and services and the maintaining of economic and social well-being. This includes, but is not limited to energy, transport, digital communications, and water.
Community infrastructure Levy	CIL	A contribution from developers as part of new developments which contributes towards wider community infrastructure, such as road, community spaces or flood mitigation
Construction Industry Research and Information Association	CIRIA	An independent organisation which produces technical guidance for the construction industry
Causeway Regeneration Area	CRA	The Causeway and surrounding area covered by this flood risk appraisal
Environment Agency	EA	The authority responsible for managing the risk of flooding from main rivers and the sea.

Essex SuDS Design Guide 2020	ESDG	The Essex SuDS Design Guide 2020 is the most up to date guide produced by the LLFA. It was produced to highlight the standards and expectations in regard to surface water drainage schemes for all new developments in Essex. It is referred to when the LLFA review surface water drainage schemes.
Flood and Coastal Erosion Risk Management	FCERM	The term for activities and actions undertaken by RMA's to reduce flood risk and coastal erosion.
Flood Risk Assessment	FRA	A report evidencing and highlighting the different types of flood risk associated with a specific site. They also can be accompanied by mitigation proposals if associated with a development
Flood and Water Management Act 2010	FWM	The Act that implemented the recommendations of the Pitt Review 2008 and created Lead Local Flood Authorities.
Green Infrastructure	GI	A network of multi-functional green space and other green features, both urban and rural, which delivery quality of life and environmental benefits for communities
Ground Investigations	GIs	These include investigations such as soil type and makeup, ground water monitoring, stability investigations, infiltration testing and soil contamination investigations
Greenfield Runoff Rate	GRR	The peak rate of runoff from a given area of land for a specified return period rainfall event. It is used to determine the rate that flow from a new development should be restricted to
Local Development Plan	LDP	The Local Development Plan is a plan for the future development of the local area, drawn up by the Local Planning Authority. It guides decisions on whether or not planning applications can be granted. In law it is described as the development plan documents adopted under the Planning and Compulsory Purchase Act 2004. A Local Plan can consist of one or more documents.

Local flood risk		The risk of flooding from ordinary watercourses, surface water and groundwater, as defined by the Flood and Water Management Act 2010.
Local Flood Risk Management Strategy	LFRMS	A strategic document produced by a LLFA as a requirement of the Flood and Water Management Act 2010. It sets out how local flood risk will be managed.
Lead Local Flood Authority	LLFA	A unity authority or county council with responsibility for managing local flood risk.
Local Planning Authority	LPA	A unitary authority or district council whose duty it is to carry out specific planning functions (producing Local Plans and determining planning applications) for a particular geographical area.
National Planning Policy Framework	NPPF	The NPPF sets out the UK government's current planning policies for England and how they are to be implemented by Local Planning Authorities.
Non-Return Valve	NRV	A mechanical valve that closes due to water pressure to only allow flows in a single direction
Property Flood Resilience	PFR	A suite of measures that can be installed to an existing property to prevent the ingress of water
Planning Policy Statement 25	PPS25	A document produced by the UK Government setting out national policy on development and flood risk. It was replaced by the NPPF in 2012
Risk of Flooding from Surface Water	RoFSW	The latest Environment Agency digital mapping showing the risks of flooding from surface water. These are split into three layers showing the 3.33%AEP, 1%AEP and 0.1% AEP events.
Risk Management Authority	RMA	Any authority with a responsibility for managing flood or coastal erosion risks.
Shoreline Management Plan	SMP	A strategic document that sets out policies to assist decision making on coastal flooding and erosion risk management over the next 20, 50 and 100 years.
Supplementary Planning Document	SPD	Documents which add further detail to the policies in the Local Plan. They can be used to provide further guidance for development on specific sites, or on issues, such as design.
Sustainable Drainage Systems	SuDS	Measures that manage runoff from a development site by sustainably mimicking natural processes.

		Many features have wider benefits to water quality, ecology, and local amenity
Surface Water Management Plan	SWMP	A district wide study into surface water flood risk which identifies Critical Drainage Areas (CDAs) that are considered for receipt of a flood alleviation scheme.

1 INTRODUCTION

1.0 Document Purpose

1.0.1 This appraisal constitutes an investigation into flood risk in the Causeway Regeneration Area (CRA) to aid with future planning decisions.

1.0.2 It summarises documentation and policies regarding planning and flood risk mitigation to highlight information relevant to future development within the study area. This appraisal should not be used as a tool to prevent development in the CRA, but to ensure that any development is properly mitigated against flood risk and that maximum benefit to the local area is achieved.

1.0.3 A review has been undertaken of existing flood modelling and other flood risk information to summarise flood risks in the CRA to allow appropriate consideration and mitigation during future developments. Historic evidence of flooding within the CRA is also reviewed within this appraisal to inform an overview of flood risk from different sources and identify the risk to local critical infrastructure.

1.0.4 The modelling review identifies flood risk hotspots, six of which were investigated further to provide high-level cost-estimated options to allow for the consideration of flood risk mitigation measures during future development.

1.1 Scope and Limitations

1.1.1 This appraisal has undertaken a modelling review of the latest available surface water, fluvial and tidal models. Sewer modelling information was not made available for review, however information relating to the local sewage network can be obtained from the Local Water Authority, Anglian Water. Groundwater flood risk has been assessed using the latest available Environment Agency (EA) and British Geological Society (BGS) data.

1.1.2 The hydraulic models reviewed as part of this appraisal were provided by several key flood risk partners including Essex County Council, Maldon District Council, and the Environment Agency.

1.1.3 Modelling combining information on all flood risk sources was not created due to the significant time and costs involved. Each respective hydraulic model was reviewed individually and overlayed to enable a complete review of all data received from key stakeholders.

1.1.4 The modelling review has identified hotspots, 6 of which were progressed for further investigation into site specific flood risk and potential mitigation options.

1.1.5 The options provided are not exhaustive and are included to provide an indication of potential measures that could be undertaken and the relevance to planning policies and requirements.

1.1.6 The costs provided for options are high-level and it should be noted that site specific investigations should be undertaken to give more accurate estimates. Costs are provided to aid comparison between potential measures and provide a starting point for any discussions regarding Community Infrastructure Levy (CIL) or Section 106 contributions.

1.2 Definition of Event Frequencies

1.2.1 Rainfall and flood events are defined based on the frequency at which they are predicted to occur. Historically this has been expressed as a return period with a form of 1 in x; so, a 1 in 20-year storm is likely to occur on average once every 20 years and a 1 in 100-year storm on average once every 100 years.

1.2.2 To reduce confusion this has subsequently be redefined to become Annual Exceedance Probability (AEP) by the Environment Agency. This method details the risk of an event happening each year as a percentage, with a 1 in 20-year storm becoming a 5% AEP event and a 1 in 100-year storm a 1% AEP event.

1.2.3 This flood risk appraisal refers to flood risk in the form of AEP. All flood risk and rainfall probabilities should be expressed in this format to comply with EA best practice[1].

[1] Environment Agency Fluvial Design Guide (January 2010); http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide/Chapter2.aspx?pagenum=4

2 PLANNING FRAMEWORK

2.0.1 This section identifies all high level and strategic documents relevant to planning and development within the Causeway Regeneration Area along with any other documentation that should be considered when assessing flood risk for new developments.

2.0.2 Relevant aspects of each are outlined within this section to provide an overview of the requirements and policies that will be applied regarding the mitigation of flood risk for development within the study area.

2.0.3 The potential mitigation options provided in Section 6 have also been determined using the subsequent documents and policies to provide a selection of measures that best align with planning policy and other relevant documentation.

2.1 National Planning Policy Framework (NPPF) (updated 2019)

2.1.1 The NPPF[2] sets out the Government's planning policies for England and how these should be applied and provides a framework within which locally prepared plans for housing and other development can be produced. The NPPF states that when determining any planning applications, Local Planning Authorities should ensure that flood risk is not increased elsewhere.

2.1.2 Section 163 of the NPPF[3] states that any major developments, or any developments proposed in Flood Zones 2 or 3 (major or minor) are required to be accompanied by a site-specific flood risk assessment. Development should only be allowed in areas at risk of flooding where, in the light of this assessment (and the sequential and exception tests, as applicable) it can be demonstrated that:

a) within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;
b) the development is appropriately flood resistant and resilient;
c) it incorporates Sustainable Drainage Systems (SuDS), unless there is clear evidence that this would be inappropriate;
d) any residual risk can be safely managed; and

[2] The National Policy Planning Framework section 1
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf
[3] The National Policy Planning Framework section 163
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf

e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

2.1.3 Further to this, Section 165[4] explains that any major developments should incorporate SuDS unless there is clear evidence that this would be inappropriate. The systems used should:

a) take account of advice from the lead local flood authority;
b) have appropriate proposed minimum operational standards;
c) have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development; and
d) where possible, provide multifunctional benefits.

2.1.4 As well as mitigating against flood risk, the NPPF goes further to say in Section 170[5] (d, e, f) that planning policies and decisions should contribute to and enhance the natural and local environment by:

d) minimising impacts on and providing net gains for biodiversity, including by establishing coherent ecological networks that are more resilient to current and future pressures;
e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, considering relevant information such as river basin management plans; and
f) remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate.

2.2 Climate Change Allowances (2016)

2.2.1 The NPPF (2019) requires climate change allowances to be included as part of any flood risk assessment to ensure future development is both, resilient and sustainable[6]

[4] The National Policy Planning Framework section 165
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf
[5] The National Planning Policy Framework Section 170
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf
[6] National Planning Policy Framework (February 2019) Section 14

2.2.2 New values for both rainfall events and fluvial flooding events have been modelled using updated CO_2 emissions and scenario predictions. The results are categorised into upper end, higher central and central based on the likelihood of the scenarios occurring. Sea level rise values were also recently amended based on this updated modelling.

2.2.3 In Essex, both the higher central and upper end values must be used to ensure that the range of uncertainty regarding the magnitude of flow or rainfall changes is explored. This allows any potential impacts to the development or land use change because of the variance in climate change uncertainty to be understood by both planners and developers, ensuring the safest and most sustainable development.

2.2.4 Different values exist for different periods of time over the next century and those used should be chosen based on the lifetime of proposed developments.

2.2.5 Within Essex, the Development and Flood Risk Team at Essex County Council advise using the upper (residential) climate change allowances for non-residential developments. As such, this will need to be considered for all future planning applications relating to these sites.

2.3 Current Asset Standards of Protection and Climate Change Impacts

2.3.1 The Central Area of Maldon is protected by significant sections of coastal and fluvial defences. These are managed by the Environment Agency and include features such as flood embankments and walls with sluice gates in some locations to prevent tide-locking.

2.3.2 There are no other specifically designed or installed flood alleviation assets present within the study area, however all existing drainage features and piped systems will provide capacity during flood events and therefore play an essential role in minimising flood risk.

2.3.3 The locations and standards of protection of the existing flood defence assets are held by the Environment Agency.

2.3.4 Inspections and maintenance are undertaken regularly by the Environment Agency to maintain the defences and ensure they continue to provide protection. Further information on the latest conditions and management of Environment Agency assets can be found online[7] or by contacting the local EA assets team (Appendix 1).

2.4 Fluvial Climate Change Allowances

2.4.1 Fluvial climate change allowances apply to the peak flood flows in rivers. They apply to Flood Zones only and should be used where a development abuts or contains a watercourse or main river or lies within a floodplain.

2.4.2 Climate change allowances are calculated by region. Maldon falls within the Anglian region with Table 2.1 showing the relevant fluvial climate changes values. The upper end and higher central values shown highlighted in grey should be considered in line with the above guidance and lifetime of the proposed development.

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper End	25%	35%	65%
Higher Central	15%	20%	35%
Central	10%	15%	25%

Table 2.1: Regional fluvial climate change allowances[8] with the required values to use within Maldon district highlighted

[7] Environment Agency interactive asset management map: https://environment.data.gov.uk/asset-management/index.html
[8] Government Guidance; Flood Risk Assessments and Climate Change Allowances (September 2020); https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1 (Table1)

2.5 Surface Water Climate Change Allowances

2.5.1 Surface water climate change allowances apply to peak rainfall intensity and the subsequent surface water flooding that the storms cause. They apply to runoff calculations and must be used to determine future greenfield runoff rates and storage volumes to ensure appropriate Sustainable Drainage Systems (SuDS) are utilised.

2.5.2 Table 2.2 shows the pluvial climate changes values applying to Maldon. The upper end values shown in bold should be considered in line with the above guidance and lifetime of the proposed development.

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper End	10%	20%	40%
Central	5%	10%	20%

Table 2.2: Nationwide peak rainfall intensity climate change allowances[9] with the required value to use within Maldon district highlighted

2.6 Coastal Climate Change Allowances

2.6.1 Coastal climate change is expressed as the amount of sea level rise for a given geographical area. Values are provided as rates per year, or how much the sea will rise year on year and are given for specific time periods. Those further into the future have greater annual sea level rise rates than those closer to the present day.

2.6.2 Rates apply to developments adjacent to the coast and on estuaries. Where a development is within an area identified by the Environment Agency as being currently protected by coastal defences, climate change allowances should be used to assess potential defence overtopping.

[9] Government Guidance; Flood Risk Assessments and Climate Change Allowances (September 2020); https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-2 (Table 2)

2.6.3 The sea level rise value for a development will be the value for the year that is the design lifetime period after the year of construction. For example, a development with a lifetime of 50 years being built in 2025 will require the total sea level rise to be calculated up to 2075.

2.6.4 It should be noted that Environment Agency models already include sea level rise up to the year of their creation and as such this should be used and adjusted to reach the total sea level rise value. Cumulative totals for each epoch are provided within Table 2.3 to aid such calculations.

2.6.5 As such for the previous example of a 50-year development being constructed in 2025 the total sea level rise for the development, assuming a model year of 2020, will be; 5.8mm x 15 years (for 2020 to 2035 within the 2000 to 2035 epoch), plus 255mm (for the entire 2036 to 2065 epoch) plus 9 x 11.6mm (for 2065 to 2075 within the 2066 to 2095 epoch). This gives a total of 446.4mm (0.45m) of sea level rise above the 2020 model baseline sea level.

2.6.6 These values do not take account of any changes that may result in wave heights due to increased water depths, nor changes to the frequency, duration, or severity of storms. As such any coastal developments must include appropriate sensitivity testing to assess, understand and mitigate these impacts. Further information on these factors can be found in Table 4 of the online guidance[10].

	2000 to 2035	**2036 to 2065**	**2066 to 2095**	**2096 to 2125**
Rate of increase	5.8 mm/yr	8.7 mm/yr	11.6 mm/yr	13 mm/yr
Total cumulative rise across the entire epoch	203mm	261mm	348mm	390mm

Table 2.3: Anglian Region sea level increases given as the rate of rise per year within the epoch with the values to use for Maldon district highlighted. Cumulative rise to the end of each epoch is provided to aid total sea level increase calculations.[11]

[10] Government Guidance; Flood Risk Assessments and Climate Change Allowances (September 2020): https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-4 (Table 4)
[11] Government Guidance; Flood Risk Assessments and Climate Change Allowances (September 2020): https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-3 (Table 3)

2.7 Essex SuDS Design Guide (updated 2020)

2.7.1 In April 2015, as the Lead Local Flood Authority for Essex, Essex County Council (ECC) became a statutory consultee for surface water drainage on all major developments. ECC also comment on minor applications and discharge of conditions applications through Service Level Agreements with Local Planning Authorities.

2.7.2 Sustainable Drainage Systems (SuDS) are a range of site-specific measures that mimic natural processes. They aim to manage rainwater run-off from site to reduce the quantity and improve the quality of water entering the downstream surface water networks. Whilst providing this function they can also deliver a multitude of further benefits, especially around enhancing biodiversity and amenity. Features include swales, bioretention areas, green roofs, and ponds. They not only reduce pressure on local surface water sewers and networks, but also help wildlife thrive in urban environments.

2.7.3 To aid the incorporation of well designed, beneficial SuDS into developments and meet the requirements of the NPPF the Essex SuDS Design Guide (ESDG)[12] was created. This guide provides comprehensive information on the planning, design, and delivery of attractive and high-quality schemes that offer multiple benefits to the environment and communities.

2.7.4 The philosophy and concept contained within the ESDG is based upon those within the CIRIA Manual C753[13]. The guide seeks to complement the CIRIA Manual, and both should be used when designing SuDS for any development.

2.7.5 The ESDG provides detailed information on the standards and delivery of SuDS required in Essex and it will form the basis for all responses to applications ECC are consulted on. It is strongly recommended that the guide be used at the earliest opportunity to avoid unnecessary delays to planning applications, ultimately saving time and money for developers and the LPA.

2.7.6 The ESDG highlights that following drainage hierarchy should be followed:

a) Rainwater re-use (rainwater harvesting/greywater recycling)
b) An adequate soakaway or other infiltration system
c) Hybrid solution of infiltration and discharging to a surface water body
d) To a surface water body (e.g. an ordinary watercourse)
e) To a surface water sewer, highway drain, or other drainage system

[12] Essex SuDS Design Guide (2020): https://www.essexdesignguide.co.uk/suds
[13] The CIRIA SuDS Manual C753 https://www.ciria.org/ItemDetail?iProductCode=C753&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91

f) To a combined sewer

2.7.7 Therefore, first and foremost, rainwater reuse should be considered, if this is not viable or is to be used partially then a detailed site investigation should be undertaken to determine the suitability of discharging to ground via infiltration. This should be based on detailed infiltration testing and ground water monitoring in line with BRE365[14] and the methods outlined in the CIRIA Manual C753[15].

2.7.8 For all cases where infiltration is not possible and a positive outfall is required, the ESDG specifies that all greenfield sites should limit discharge rates to the 100% AEP (1 in 1 year) greenfield rates for all storm events up to and including the 1% AEP (1 in 100 year) (plus climate change) storm event. Alternatively, matched discharge rates can be used with the inclusion of long-term storage.

2.7.9 For brownfield sites the ESDG states that discharge rates should at first limited to the 100% AEP greenfield rate. Where this is proven not to be possible, discharge rates should be limited to as close as feasibly possible to the 100% AEP greenfield rate, with an absolute last resort being a 50% betterment on the 100% AEP brownfield rate.

2.7.10 In instances where the final discharge location is to a tidal estuary then it is accepted that discharge rates can be unrestricted. However, evidence should be provided to ensure that the surface water will be managed during a tide locking scenario. This should be demonstrated by showing that the surface water can be managed for a 1% AEP pluvial storm event plus climate change and a 5% AEP fluvial/tidal storm event coinciding. Likewise, when discharging to a main river, consideration should be given to a 5% AEP fluvial event coinciding with a 1% AEP pluvial event plus climate change at the development site.

2.7.11 For all sites, the ESDG asks that above ground green features are considered before proprietary devices. This is because they provide a large range of benefits such as enhancing biodiversity, amenity, surface water treatment, sustainability, and climate change mitigation.

[14] BRE365 (soakaway design)
[15] The CIRIA SuDS Manual C753 Chapter 25
https://www.ciria.org/ItemDetail?iProductCode=C753&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91

2.7.12 One benefit which above ground green features can be very proficient at is the provision of interception storage. As stated in the ESDG, interception storage should be provided for the first 5mm of rainfall as much as possible in order to closely mimic greenfield scenarios. Interception and evaporation can account for 15-50% of yearly precipitation. Interception should be utilised to closely reflect the greenfield runoff behaviour, and to decrease the risk of pollution downstream further.

2.7.13 The ESDG also states that when providing storage not only does it need to be able to provide storage for all storm events up to and including the 1% AEP plus climate change storm event (plus a 10% urban creep allowance if it is residential) but it also needs to the ability to cater for consecutive events. It should be shown that all storage features can half drain within 24 hours of a 3.33% AEP plus climate change storm event. Alternatively, it should be shown that all storage features have the capacity to store a 10% AEP storm event, 24 hours after a 3.33% AEP plus climate change storm event.

2.7.14 Another important feature in which the LLFA look for and in which the ESDG talks about, is the need for surface water treatment. It states that all surface water should be treated before leaving the site (and ideally before storage, in order to maintain capacities) in line with the Simple Index Approach found within the CIRIA Manual C753[16]. If proprietary devices are proposed, then their mitigation indices should be provided along with detailed information about the device. This can be provided from the manufacturer.

2.7.15 The SuDS features and philosophies contained within the ESDG have heavily influenced the basis of this appraisal to allow consistency with planning policies and ensure the appropriate consideration of SuDS for developments with the Causeway area.

2.7.16 It should be noted that due to the complexities with specific sites this appraisal does not cover every possible drainage scenario. To help identify potential issues and expedite the planning process it is strongly recommended that pre-application advice be sought from Maldon as LPA for all developments[17] and ECC for major developments[18].

2.7.17 For all cases where infiltration is not possible and a positive outfall is required, the ESDG specifies that all greenfield sites should limit discharge rates to the 100% AEP greenfield rates for all storm events up to and including the 100% AEP (plus climate change) storm event. Alternatively, matched discharge rates can be used with the inclusion of long-term storage.

2.8 Essex Green Infrastructure Strategy (2020)

2.8.1 The Essex Green Infrastructure Strategy[19], steered by the Essex Green Infrastructure Partnership, describes the need for green infrastructure in the county and sets a vision and objectives for the delivery of green infrastructure. This strategy provides a clear plan to guide the future planning and delivery of green infrastructure in Essex in light of increased development and population growth.

2.8.2 The Green Infrastructure Strategy[20] has the following vision:

"We will protect, develop and enhance a high quality connected green infrastructure network that extends from our city and town centres, and urban areas to the countryside and coast and which is self-sustaining and is designed for people and wildlife."

2.8.3 The Green Infrastructure Strategy aims to deliver its vision through the seven objectives below[21]:

- Protect existing green infrastructure, especially designed sites
- Improve existing infrastructure so it is better functioning for people and wildlife
- Create more high-quality multi-functional green infrastructure especially in areas of deficiency
- Improve the connectivity of green infrastructure for people and wildlife
- Increase use and inclusivity of green infrastructure across all user groups, social groups, and abilities
- Provide green infrastructure facilities to promote health and wellbeing
- Working with partners to build and secure funding, effective governance, and stewardship for new and existing green infrastructure to ensure their long-term sustainability.

[16] The CIRIA SuDS Manual C753 Chapter 26 https://www.ciria.org/ItemDetail?iProductCode=C753&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91
[17] Maldon District Council pre-application advice - https://www.maldon.gov.uk/info/20046/development_management/9227/planning_advice_and_information
[18] ECC SuDS Planning Advice for major developments: https://www.essexdesignguide.co.uk/suds/planning-advice/suds-planning-advice/
[19] The Essex Green Infrastructure Strategy 2020 https://www.placeservices.co.uk/resources/built-environment/essex-gi-strategy/
[20] The Essex Green Infrastructure Strategy 2020 Section 3.1
[21] The Essex Green Infrastructure Strategy 2020 Section 3.2

2.8.4 If considered at an early stage, the viability of using green infrastructure is increased and the easier it is to benefit from its inclusion. For example:

- Green infrastructure can make construction easier and more cost effective whilst additionally providing higher returns on properties.
- Green infrastructure can be multifunctional such as flood attenuation through SuDS, biodiversity enhancement, aesthetic and amenity value, public open spaces, etc.
- Can be cheaper than installing conventional grey infrastructure structures such as pipes and tanks for flood management

2.8.5 Section 8.1.1[22] of the Green Infrastructure Strategy states that green infrastructure can be incorporated on any scale and should be integral to planning the layout and design of new buildings and developments from the outset.

2.8.6 It is a common perception that the requirements for development sites to protect and enhance biodiversity, protect local landscapes, provide for informal recreation, and facilitate sustainable drainage, are all separate issues and therefore all incur additional costs. This is incorrect by combining these aspects together and using a multi-functional approach, such as through the delivery of SuDS, developers can reduce their costs whilst at the same time delivering a high-quality development.

2.9 Essex Local Flood Risk Management Strategy (2018)

2.9.1 The Local Flood Risk Management Strategy (LFRMS)[23] sets out a county-wide approach to the management of local flood risk, defined as the risk of flooding from surface water, groundwater, and ordinary watercourses.

2.9.2 An outcome of the LFRMS is the production of Surface Water Management Plans (SWMP's) which investigate local flood risk on smaller scales. This allows flooding processes to be better understood, highlighting potential mitigation measures and opportunities for joint working with partner Risk Management Authorities (RMA's).

[22] Essex Green Infrastructure Strategy (2020) Section 8.1
[23] Essex County Council Local Flood Risk Management Strategy (2018): https://flood.essex.gov.uk/our-strategies-and-responsibilities/our-local-flood-risk-management-strategy/

2.9.3 SWMP's identify Critical Drainage Areas (CDA's), which are sub-catchments within the wider SWMP study area at higher risk of surface water flooding. In Essex these are prioritised county-wide based on a range of factors to determine which are taken forward for further analysis and the potential provision of a flood alleviation scheme.

2.9.4 In Essex 12 SWMP's have been completed and a review was undertaken in 2019 to update and standardise all underlying modelling. A SWMP covering Maldon and Heybridge was completed in 2013 and updated in 2018, further information on this document, any relevant CDA's and schemes in relation to the Maldon Causeway study area can be found in Section 5.2.12.

2.10 Maldon District Local Development Plan (2014-2029)

2.10.1 The Maldon District Local Development Plan (LDP),[24] approved and adopted in July 2017, sets out the planning strategy for the future growth of Maldon over the plan period of 2014-29.

2.10.2 The LDP forms the method through which Maldon will deliver sustainable development and provides a strategy to meet the requirements of future employment, homes, retail, community facilities and infrastructure provision across the district.

2.10.3 The LDP sets out the scale and distribution of future development and the infrastructure needed to provide it and includes objectives and policies to ensure this is achieved.

2.10.4 Those policies relevant to either the study area or the purpose of this report are listed subsequently with summary information. Where policies relate to specific locations rather than applying district-wide the areas can be viewed using MDC's online interactive map tool[25].

Policy S1: Sustainable Development

2.10.5 When considering development proposals Maldon DC will take a positive approach that reflects the presumption in favour of sustainable development. Some key principles include:

- Enable and adapt to the effects of climate change by limiting greenhouse emissions through the efficient use of energy and renewable alternatives, coastal management, and mitigation against flooding

[24] The Maldon Local Plan https://www.maldon.gov.uk/homepage/7031/emerging_local_plan
[25] Maldon Interactive Map tool: https://publicaccess.maldon.gov.uk/online-applications/spatialDisplay.do?action=display&searchType=Application

- Ensure new development is either located away from high risk areas (Environment Agency Flood Zones 2 and 3) or is safe and flood resilient when it is not possible to avoid such areas.

Policy S4: Maldon and Heybridge Strategic Growth

2.10.6 The LDP specifically acknowledges the potential wider impacts of strategic developments on local drainage and flood risk, and states that they should include appropriate sustainable drainage systems and take account of the Maldon and Heybridge SWMP, and use the development as an opportunity to reduce flooding and divert surface water flows away from existing risk areas.

Policy S5: Maldon Central Area Policy

2.10.7 The Central Area incorporates the spatial areas of the Causeway Regeneration Area, Leisure Quarter and Maldon Central Area, and these three combined constitute the study area for this appraisal. The Central Area Masterplan has been created specifically to enact this policy (Section 2.12).

2.10.8 The Maldon and Heybridge Central Area is the main focus of the District's retail, employment, transport, leisure and community functions, and this policy sets out a strategy to retain the areas economic importance and tackle future issues.

2.10.9 The development and regeneration strategy for the policy area comprises the following aspects relevant to this study:

- Protect the sensitive environmental relationship between the Central Area and the adjacent environmentally designated areas including the River Blackwater and Chelmer and Blackwater Navigation.
- Minimise all forms of flood risk and ensure that flood infrastructure is effectively managed.

Policy D2: Climate Change and Environmental Impact of New Development

2.10.10 Climate change represents a significant and ongoing challenge to society, and mitigation and adaptation for all development is a key goal of the NPPF. Within the Maldon LDP the following is required to minimise the environmental impact of development:

- All non-residential development should achieve a minimum of BREEAM 'Very Good' rating or be supported by a bespoke assessment that demonstrates appropriate environmental performance results above current Building Regulation requirements.

- Green infrastructure should be incorporated as a way of adapting and mitigating for climate change through the management and enhancement of existing habitats and the creation of new ones to assist with species migration, to provide shade during higher temperatures and for flood mitigation. Negative impacts on ecology, landscape and green infrastructure should be minimised.
- Minimising all forms of possible pollution including air, land, water, odour, noise, and light. Any detrimental impacts and potential risks to the human and natural environment will need to be adequately addressed by appropriate avoidance, alleviation, and mitigation measures.
- Development must take into account the economic and other benefits or preserving the best and most versatile land. Where possible poor-quality land should be prioritised over higher quality land.

Policy D5: Flood Risk and Coastal Management

2.10.11 This policy states how proposals should be in line with the NPPF. National planning policy states that development should not increase flood risk elsewhere and should be located away from areas at highest risk of flooding. Where development is necessary in flood risk areas it should be designed accordingly to manage the risk. For further information see Section 2.1.

Policy N1: Green Infrastructure Network

2.10.12 This policy sets out a strategy with a presumption against any development which may lead to the loss, degradation, fragmentation, or isolation of existing or proposed blue/green infrastructure. Development that results in the creation, restoration, enhancement, protection, expansion, and interconnection of existing sites will be encouraged.

2.10.13 Within the study area multiple churches, parks and other public spaces exist along with river and canal corridors, and coastal and tidal areas.

2.10.14 Maldon District Council commissioned LUC to develop The Maldon District Green Infrastructure Strategy (Supplementary Planning Document)[26]. The purpose of the Maldon Green Infrastructure Strategy is to:

- Promote a long-term Vision for the sustainable development and management of green infrastructure across the District.
- Provide an opportunity map that demonstrates how distinct elements of the

[26] The Maldon District Infrastructure Strategy

green infrastructure network work together at a District level (and beyond, as appropriate).
- Create a set of principles and policies to underpin the creation and enhancement of the green infrastructure network.
- Identify and prioritise key projects, and identify potential partners and funding streams for their delivery.
- Provide an Action Plan for the delivery of key projects and interventions.

The Maldon District Infrastructure Strategy has identified 8 themes to help deliver this purpose. They are:

- Sustaining Productive Landscapes
- Nurturing Communities
- Supporting Economic Progress and Tourism
- Protecting and Enhancing Wildlife
- Celebrating Cultural Heritage
- Creating Resilient Water Environments
- Promoting Healthy Living
- Supporting Local Landscape Character

Policy N2: Natural Environment, Geodiversity and Biodiversity

2.10.15 Policy N2 ensures that developments have no detrimental impact or effect on conservation or biodiversity values of protected areas, priority habitat sites and/or protected or priority species, and those which help improve their condition will be encouraged.

2.11 The Causeway Development and Improvement Plan (2015)

2.11.1 Conducted by BBP in 2015, the aim of this study was to define a number of projects and initiatives that would lead to tangible benefits to the Causeway Regeneration Area and help the area achieve its economic potential.

2.11.2 A number of objectives were identified following consultation with local landowners, businesses, and developers:

- Taking steps to retain the larger employers.
- Supporting initiatives to encourage start-ups and micro businesses.
- Improving the quality of the business premises, reflecting trends towards high value employment activities.
- Improving the physical environment to retain and attract growing businesses.
- Maximising the economic potential of key sites.

2.11.3 In order to meet the strategic objectives listed above, the study concluded that several key interventions were required and prepared project plans to enable the delivery of these interventions:

- Business friendly initiatives and activities.
- Environmental improvements.
- Enterprise centre and business support provisions.
- Development briefs for key development sites.
- Flooding risk review

2.11.4 This flood risk appraisal advocates the use of sustainable flood-risk mitigation measures within the CRA to achieve environmental improvements and make the area more attractive for businesses to invest. This notion reinforces several of the strategic objectives highlighted by the Development and Improvement Plan (2015).

2.11.5 This appraisal also links well with the fifth strategic objective which suggests that the area's susceptibility to flooding is preventing further capital investment. This report assesses the CRA and provides a flood risk overview from; pluvial and coastal, surface water; and groundwater sources (see Section 5) as well as potential flood-risk mitigation options (Section 7) that could mitigate flooding and encourage new business investment.

2.12 Maldon and Heybridge Central Area Masterplan SPD (2017)

2.12.1 The Maldon and Heybridge Central Area Masterplan (CAMP)[27] has been created specifically to enact Policy S5 of the Local Development Plan (Section 2.10). This Policy specifically concerns the delivery of regeneration and enhancement of the Central Area, which constitutes the same spatial area covered by this document (Section 3).

2.12.2 A large number of studies have been undertaken in the Central Area which have informed Policy S5 and the CAMP. These highlight the importance of the area for employment and identify strategies to aid development and regeneration whilst improving amenity, green infrastructure, and connectivity, and reducing flood risk.

[27] Maldon and Heybridge Central Area Masterplan: Maldon and Heybridge central area masterplan | Maldon and Heybridge central area masterplan | Maldon District Council

2.12.3 The CAMP collates these studies into 10 key actions. Point 10 specifically concerns flooding and flood risk; 'Minimise all forms of flood risk and ensure that flood infrastructure is effectively managed'.

2.12.4 This Flood Risk Appraisal provides the latest flood risk information available and highlights costed options to support and aid decision making surrounding the enactment of the LDP and CAMP and all development or regeneration in the Central Area.

2.12.5 Several of the opportunity sites identified within the CAMP fall within flood risk hotpots identified by this report[28]. Further details on the specific risks in each area can be found in Section:

- Hotspot 1: Opportunity sites L and M
- Hotspot 2: Opportunity site K
- Hotspot 4: Opportunity site G
- Hotspot 5: Opportunity site E
- Hotspot 6: Opportunity sites C and D

2.12.6 To ensure the successful delivery of holistic development that meets the goals of the CAMP early stakeholder engagement is key. Contact with Maldon DC, Essex County Council SuDS Team, the Environment Agency, and Anglian Water should be undertaken early on in planning process to ensure site specific flood risk are appropriately addressed and opportunities for multifunctional spaces or wider improvements are identified.

2.13 North Quay Development Brief SPD (2020)[29]

2.13.1 The Development Brief is required as a Supplementary Planning Document (SPD) and sets out the expectations for any development or redevelopment in the North Quay Area. As such, it is a key document in the decision-making process for any subsequent planning application.

2.13.2 The Development Brief presents an ambitious framework to enable intensified employment led development and highlights unique opportunities to capitalise on the ample waterside frontages in the North Quay Area.

[28] Maldon and Heybridge CAMP pages 24 and 25
[29] North Quay Development Brief: North Quay Development Brief SPD | Other Local Plan Documents | Maldon District Council

2.13.3 Informed by both national and local planning policy, the Development Brief overlaps with the Maldon and Heybridge Central Area Masterplan SPD (2017, see Section 2.12), and specifically 5 Masterplan projects:

- Project 6: North Quay Regeneration
- Project 7: Heybridge Creek Connections
- Project 8: The Causeway Corridor
- Project 9: Heybridge Creek Improvements
- Project 12: The Causeway Strategic Flood Risk Review

2.13.4 The 5 Masterplan project objectives outlined in the Masterplan SPD ensure that all development within the North Quay Area considers:

- Flood resilience infrastructure,
- Delivery of improvements for access and connectivity between Maldon and Heybridge via walking, cycling and public transport,
- Public realm improvements and enhancements for the benefit of the community, employers, employees, and visitors.

2.13.5 The Development Brief outlines development opportunities for four ‘Opportunity Sites – C, D, E & F’ highlighted in the Masterplan SPD (2017) that are situated within the North Quay Area, as well as redundant sites that offer great potential for local enhancements through the achievement of the aforementioned objectives.

2.13.6 The North Quay Development Brief defined area falls within Hotspots 3, 5 & 6 of this Maldon Causeway Area Flood Risk Appraisal. As such, any new development will need to consider flood risk mitigation measures as part of their proposals and drainage strategy. This will include a detailed Flood Risk Assessment evaluating risk from surface water, ground water and tidal/coastal sources as well as demonstrating that any new development will not increase flood risk elsewhere.

2.13.7 Early engagement with key stakeholders: Maldon District Council, Essex County Council (LLFA) and the Environment Agency is essential to ensure flood risk is properly mitigated against, in line with the Masterplan project objectives, outlined in Section 2.12.

2.14 Maldon District Council Climate Change Statement (2021)

2.14.1 Maldon District Council herewith seeks to declare a Climate Emergency. In doing so we acknowledge the growing consensus that unless we significantly reduce UK and global greenhouse gas emissions, the consequences of climate change will be severe.

2.14.2 The District of Maldon is bounded by 70 miles of coastline and there are a number of areas around Mayland, Tollesbury and Goldhanger where sea defences are at risk of being below the acceptable level of protection, potentially causing flooding to valuable agricultural land.

2.14.3 Areas of air quality concern have also been identified within our District due to the use of older, more polluting heavy goods vehicles. With the prospect of greater development occurring across the District and the increased risk of sea levels and rising pollution, we will seek to identify ways to reduce carbon emissions across Maldon, by developing strong partnership links, improving transport initiatives, encouraging greener developments and supporting green infrastructure.

2.14.4 Our aspiration is:

- To develop a Climate Strategy with the aim to be a carbon neutral District Council by 2030 and ensure that all our strategic decisions, budgets and approaches to planning decisions are in line with a shift to net-zero carbon by 2030
- To support and work with all other relevant agencies towards making Maldon District and its parishes net-zero carbon within the same timescale
- To work with, influence and inspire partnerships across the District to help deliver the goals through all relevant strategies, plans and shared resources
- To seek to include young people in the process, ensuring that they have a voice in shaping the future

2.14.5 We make this declaration to show our commitment to making a positive change which we hope will benefit our residents and future generations.

3 STUDY AREA

3.0.1 The coverage of the study area is defined as The Causeway Regeneration Area, Maldon Central Area and Leisure Quarter as defined in the Maldon District Local Development Plan, shown in Figure 3.1 below:

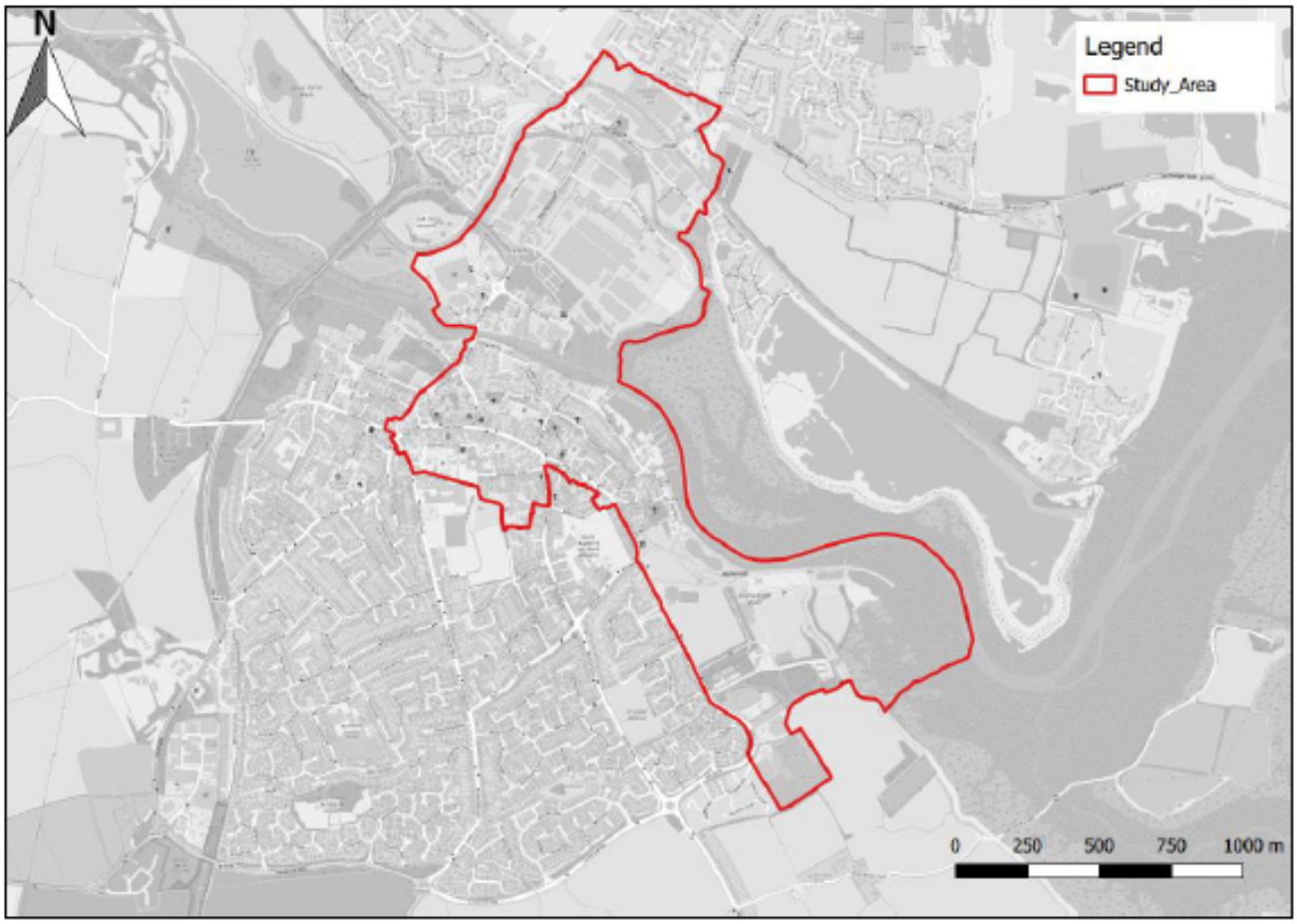

Figure 3.1: The Maldon Causeway study area

3.0.2 The study area is approximately 1.66km^2 (165ha) and ranges from the Maldon and Tiptree Football Club in the South; to Goldhanger Road (B1026) to the North.

3.0.3 Topographically, the study area is highly variable with the northern end of Maldon High Street and London Road situated at approximately 40.2m AOD whilst parts of the CRA are as low as 4.5m AOD.

3.0.4 In terms of local geology and hydrogeology, the majority of the CRA is situated on London Clay Formation – Clay, Silt and Sand[30], and the underlying soils are loamy and clayey floodplain soils with naturally high groundwater[31].

3.0.5 Consequently, infiltration measures as part of any drainage strategy may prove to be unviable. Nevertheless, any infiltration proposals would require Ground Investigations (GIs) that demonstrate the appropriateness and effectiveness of any before approval is granted.

3.0.6 Most of the study area is already developed so GIs would also be required prior to any new development to assess the suitability of the land and check for underground contamination. This is particularly important if underground storage or infiltration measures are being proposed as part of any site drainage strategy.

3.0.7 The study area is intersected by three main watercourses; the River Chelmer, the River Blackwater and the Chelmer and Blackwater Navigation and has been identified as a Critical Drainage Area (CDA) within Essex County Council's 'Maldon and Heybridge Surface Water Management Plan' (SWMP). More information can be found in Section 5.2.12.

3.0.8 The CRA is bounded to the east by the Heybridge Creek and, along with the Maldon Central Area (High Street), is the focus of the District's retail, employment, transport, leisure, and community functions. The area has many key assets and landmarks, as well as a strong sense of identity based on its heritage, riverside and coastal location.

3.0.9 As highlighted in the Local Development Plan (LDP), there is an emphasis on retaining the economic importance of this area that tackles key future needs and protects the existing, sensitive environmental designations. There is also a desire to enable development that preserves and enhances the historic character of the area and utilises the riverside setting to create a vibrant environment for the local community.

3.0.10 Following several discussions with Maldon District Council in relation to the desired outputs of this report, and taking into account economic importance and flood risk susceptibility, the study area has been refined to six flood risk 'hotspots' within the Causeway Regeneration Area and Heybridge, as illustrated in Figure 3.2:

[30] BGS geology viewer online mapping: http://mapapps.bgs.ac.uk/geologyofbritain/home.html
[31] Land Information Services online soilscapes viewer: http://www.landis.org.uk/soilscapes/

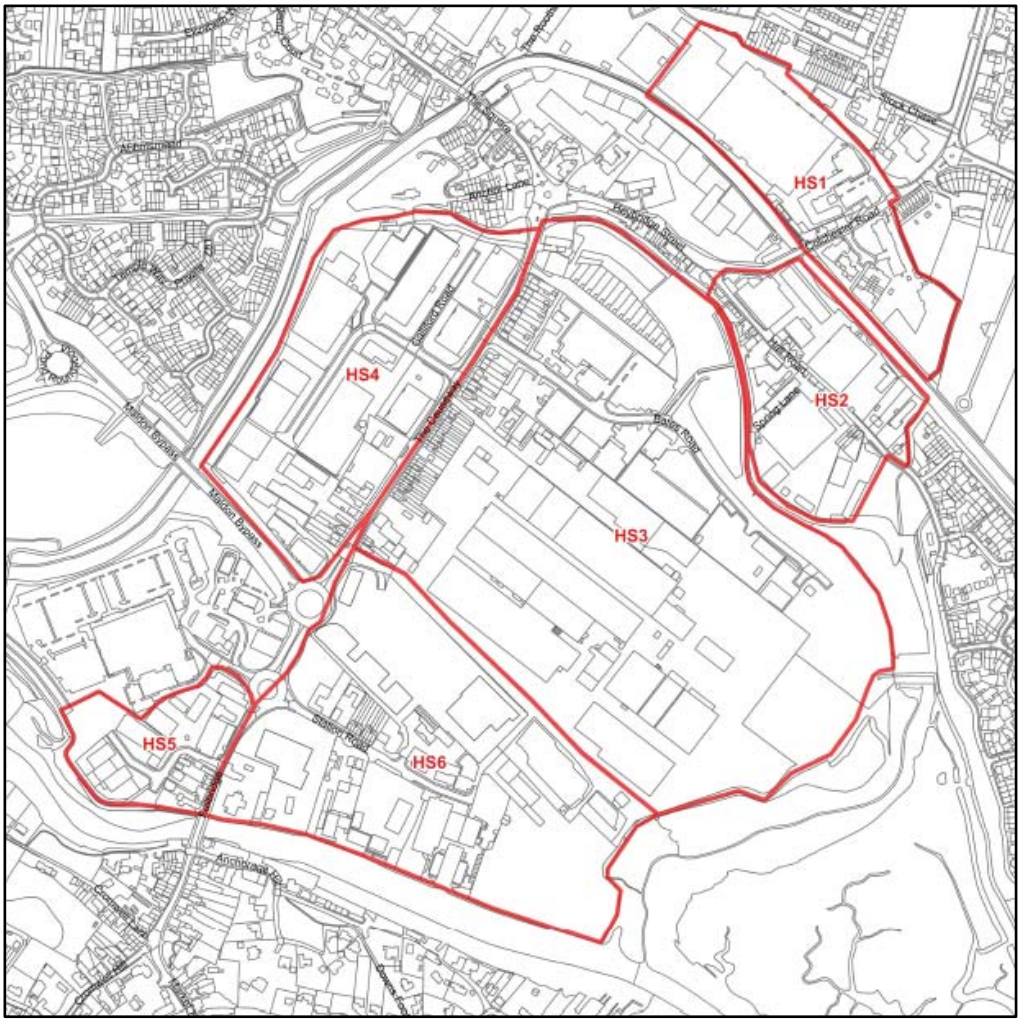

Figure 3.2: Flood risk hotspots

3.0.11 The flood risk hotspots have been identified following a detailed review and assessment of the available hydraulic modelling for surface water, pluvial and tidal sources.

3.0.12 A more detailed analysis of these six hotspots has determined that there are deliverable flood risk mitigation options that should be explored to reduce flood risk going forward. Further details of each flood risk hotspot and their flood risk mitigation options are detailed in Section 7.

4 FLOOD MODELLING REVIEW

4.0.1 This section provides further information on the role of computational modelling in outlining flood risk along with the key findings of a review into those covering the Causeway area. Where limitations have been identified, recommendations are provided to ensure potential shortcomings with existing models are accounted for should they be used or modified when determining flood risk for new developments.

4.0.2 No combined modelling has been undertaken due to the complexities and potential errors involved with integrating modelling from different flood sources.

4.1 Modelling and Flood Risk

4.1.1 Flooding is a natural and highly variable process influenced by a wide range of factors. These can include, but are not limited to, site aspects such as local topography, geology, and land use and, for surface water and river flooding, weather factors such as the intensity, duration, and location of rainfall. As such to gain a more complete picture and better understand these variations knowledge regarding flooding is heavily supported by computational modelling.

4.1.2 Due to the complexities of attempting to mimic the natural world models are built to represent single flood sources. Models only tend to be built or updated every 3-5 years, or unless there is a sudden improvement in technological capabilities or there is a requirement, such as significant land use change or infrastructure proposals.

4.1.3 It should be noted that when models are updated or rebuilt the underlying physical equations driving the model do not change, the amount of calculations increases resulting in a better representation of interactions and/or an increase in the resolution of the outputs.

4.1.4 The accuracy of models is limited by the quality of the data being fed into them and by their nature they are only ever an estimation of potential events. As such all work that relies on modelling must take full account of this and should use it only as guide whilst providing details of the modelling process and how the outputs have been used to ensure flood risk is fully and appropriately accounted for.

4.1.5 As the latest and most localised data the outputs of the surface water, fluvial and tidal flooding models listed below have all been used or have contributed to the national surface water and flood zone mapping datasets.

4.2 Maldon Causeway Area Models

4.2.1 Computation models covering the Maldon Causeway area exist for surface water flooding, fluvial flooding, and tidal flooding. Further details on the ownership, coverage and age of these models are shown in Table 4.1. The models have been provided for the purpose of this Appraisal by Essex County Council and the Environment Agency.

4.2.2 The Anglian Water (AW) model representing the foul and surface water network was unavailable for inclusion in the review. It should be noted that the surface water model listed includes the AW surface water sewer piped network, so these outputs take some account of local sewer capacities.

4.2.3 Localised models undertaken as part of site-specific Flood Risk Assessments (FRA) were not included in the review due to the complexities of adding them to wider models. Whilst these do better represent local factors, such as topography, most are based on modifications of the wider models reviewed.

4.2.4 Details regarding the construction and specific composition of the models reviewed are not covered by this report for brevity.

Flood Source	Area Covered	Latest Model	Model Owner
Surface Water	Maldon and Heybridge urban areas and upstream feeding catchments	Essex Pluvial Update Study (BMT WTM) (2018)	ECC
Fluvial	Heybridge Hall Ditch, Holloway Road Ditch and Langford Ditch	Heybridge Urban Flood Risk Mapping Study (Royal Haskoning, 2014)	EA
Tidal	Blackwater Estuary and tidal River Chelmer	Colne & Blackwater Coastal Model (JBA, 2018)	EA
Sewers	Covers foul and surface water sewer networks, specific details unknown as unavailable for assessment within the modelling review		AW

Table 4.1: Hydraulic models covering the Causeway Regeneration Area

4.3 Modelling Review

4.3.1 A review of existing hydraulic models was undertaken to achieve the following two main goals:

4.3.2 To identify any potential issues that could exist within the models themselves so that these can be taken account of if they are used to inform flood risk decisions or should the models themselves be modified as part of planning applications.

4.3.3 To identify hotspots (areas at increased risk of flooding) for each of the flood sources to allow further investigation and the targeted consideration of potential mitigation measures.

4.3.4 The report also considers the viability of creating a model integrating all flood sources. Such a model has not been created due to the significant costs and complexities involved.

4.3.5 Modelling tends to be updated every 5 years, or where there is a significant change planned, such as by development. It is recommended that checks are undertaken to ensure any modelling data used is the most up to date.

4.3.6 The review of existing modelling was undertaken by Jacobs[32], extracts and key findings of which are included in this section. The full report is provided as a supplementary document due to its size.

4.4 Key Findings and Recommendations

4.4.1 The following section outlines the key findings and limitations from reviewing each model that may impact the results and the future usage and impact the identification of hotpots. Where limitations have been observed recommendations are provided to allow mitigation to be implemented when using the models or outputs to determine flood risk.

Surface Water Flood Modelling

4.4.2 Several key issues were identified within the 2018 ECC surface water flooding model that may lead to an underestimation of flooding across the study area and for commercial buildings. Further information on the findings and measures to mitigate against them are outlined in Table 4.2.

[32] Hydraulic Model Review and Hotspot Identification Report (Jacobs) (2020)

Key Issue / Finding	Impact on Model and Outputs	Recommendation for Mitigation
In places road gullies have been duplicated or are in suspected incorrect positions	Flow leaving the surface and entering the drainage network is overestimated. This has wider implications where pipe capacities are shown to be exceeded	Gully numbers and positions are checked and amended where appropriate
Model results show flows entering piped networks to be higher than gully capacities	Flow leaving the surface and entering the drainage network is overestimated. This has wider implications where pipe capacities are shown to be exceeded	Gully flow parameters should be checked and amended where appropriate
Roads heights have been determined by lowering ground levels by 0.125m with building thresholds set as 0.3m above ground level	Commercial buildings tend to have lower thresholds and so flood risk to such buildings will be underestimated significantly	Commercial building thresholds should be amended. Site surveys should be undertaken to determine thresholds for FRA modelling
No account is taken for changes in water heights at pipe outlets, i.e. tidal ranges	As water is assumed to be able to discharge at all times flood risk in the vicinity of outfalls, where it may back up, is underestimated	Use an increased outfall water level to give a worse-case scenario and to account for tidal ranges and tide-locking

Table 4.2: Key findings and recommendations relating to the ECC surface water flooding model (2018)

Fluvial Flood Modelling

4.4.3 Several limitations were identified within the 2014 EA fluvial flooding model that may lead to an underestimation of flooding across the study area or reduced confidence in the model outputs. Further information on the findings and measures to mitigate against them are outlined in Table 4.3.

Key Issue / Finding	Impact on Model and Outputs	Recommendation for Mitigation
Sea level at the downstream boundary is assumed to be at the mean high-water spring tidal level	Flood risk in tidally influenced areas or where it may back up is underestimated	Use increased sea levels to give a worse-case scenario
Flood plain volume has been double counted in some locations where it is represented in the 1D and 2D model domains	Flood risk may be underestimated due to an increased storage capacity being used	Amend the relevant aspects of the model to ensure no duplication
The timesteps used (1s for 1D and 0.5s for 2D) are not within recommended guidelines	Using 1D timesteps higher than 2D can hide model instabilities and reduce confidence in outputs	Amend timesteps to meet recommended guidelines

Table 4.3: Key findings and recommendations relating to the EA fluvial flooding model (2014)

Tidal Flood Modelling

4.4.4 No potential issues or limitations were identified within the 2018 tidal flooding model that would impact its reliability of ability to be used to identify hotspots in the Causeway area.

4.5 Hotspot Identification

4.5.1 Hotspots have been identified for each source of flooding separately by manually assessing the areas of risk shown by the model outputs in combination with Ordnance Survey base maps.

4.5.2 The number of hotspots identified are listed in Table 4.4. As each source has been reviewed independently further details are provided where any hotspots overlap.

4.5.3 Further details on each hotspot can be found in the supplementary Hydraulic Model Review and Hotspot Identification Report[33].

Flood Source	Hotspots Identified	Further Information
Surface water	6	HS1 directly north of the Chelmer and Blackwater navigation is completely contained within fluvial hotspot HF1 HS2 directly south of the Navigation is completely within fluvial hotspot HF2. HS6 encompassing Mill Lane covers a similar extent to tidal hotspot HT1
Fluvial	2	HF1 contains surface water HS1 HF2 contains surface water hotspot HS2
Tidal	2	HT1 has similar extents to fluvial hotspot HS6 MT1 covers Promenade Park public open space and is outside of the Causeway area

Table 4.4: Number of identified hotspots along with any details regarding overlaps with other flood sources

[33] Hydraulic Model Review and Hotspot Identification Report (Jacobs) (2020), Section 3 and Table 4.1

4.5.4 Following the identification of hotspots an approach was made to Maldon DC to select a reduced number for further investigation into flood risk and the identification of potential of more targeted mitigation options. Of these the 6 surface water hotspots were chosen.

4.5.5 A summary of flood risk in the 6 hotspot areas can be found in Section 5 with further details on the hotspot areas and specific potential options in Section 7.

5 FLOOD RISK OVERVIEW

5.0.1 Parts of the study area are at varying degrees of flooding from one or more flood risk sources. This section will summarise the flood risk to the six identified ‘hotspots’ from each source and highlight pertinent Planning legislation that should be considered when determining any future Planning applications.

5.0.2 Table 5.1 below highlights the risk from Groundwater, Fluvial and Coastal, and Surface Water flood risk sources as well as any pertinent features within the six Hotspots that should be considered when assessing future flood risk.

5.0.3 Further details on flood risk from each source can be found further on in this section. This section has been informed by key stakeholders including Essex County Council, the Environment Agency, Anglian Water and Maldon District Council where relevant flood risk information pertaining to each flood risk source has been provided.

Area	District	Size (ha)	Fluvial FZ %			SW Flood Risk	GW Flood Risk	Flood risk comments
			1	2	3			
Hotspot 1	Causeway Regeneration Area / Heybridge. Bisected by Colchester Road, HS1 ranges from the end of the Heybridge Co-operative Academy playing fields in the south east, to the Wyndeham Heron industrial unit to the north west.	3.6	0	0	100	High	High	Entirety of the Hotspot situated within Flood Zone 3. Majority of the site (85%) highly susceptible to Groundwater flooding and situated within >=75% banding. Parts of the site highly susceptible to Surface Water flood risk (3.33% AEP) including the access route behind ASDA and the eastern part of the school playing fields. The school fields are also susceptible to flooding from the adjacent watercourse Chelmer and Blackwater Navigation.
Hotspot 2	Causeway Regeneration Area Ranging from the junction of Colchester Road, Heybridge Street and Hall Road to approximately 250m south east along Hall Road. Bordered on the north east by the Chelmer and Blackwater Navigation.	3.9	0	0	100	Medium	Medium	All of the site falls within FZ 3 and GW banding <=50% - <75%. Majority of the Hotspot falls within the low banding (0.1% AEP) for SW flood risk with isolated areas along Hall Road highly susceptible (3.33% AEP). Existing highway drainage within Hall Road, but consideration should be given to increased frequency and severity of flood events as a result of climate change. Non-residential properties along Hall Road with no raised thresholds likely to be affected by flood water.
Hotspot 3	Causeway Regeneration Area Majority of HS3 is occupied by warehouses, but there is a line of residential properties along The Causeway (B1018). Other notable features include Bates Road which travels west to east throughout HS3. The Hotspot is bordered to the east by the Heybridge Creek.	21.3	0	0	100	Low	Medium	Majority of the Hotspot (95%) situated within <=50% - <75% GW banding, 5% in <=75%. All of the Hotspot within FZ 3. Susceptibility to SW flood risk low apart from isolated areas on Bates Road at high risk (3.33% AEP). No defined SW flow path, but modelling shows pooling in low points across the Hotspot within roads between buildings. Non-residential buildings with no raised thresholds likely to be affected by flood water.

Hotspot 4	Causeway Regeneration Area HS4 is to the west of The Causeway (B1018) and includes Galliford Road. Bordered to the west by the Chelmer and Blackwater Navigation and to the north by the River Blackwater. Ranges from the River Blackwater to the Maldon bypass to the south. Overwhelming majority of the hotspot is commercial with <5% residential properties.	7.9	0	0	100	Medium	Medium	Entirety of the Hotspot situated within FZ 3. Majority of Hotspot (90%) within the <=50% - <75% GW banding, and 10% in <=75%. High risk of SW (3.33% AEP) within Galliford Road and all non-residential buildings with no raised threshold will be affected by flood water. Bounded by the Chelmer and Blackwater Navigation and the River Blackwater, consideration should also be given to the mitigation of flood risk from pluvial sources.
Hotspot 5	Causeway Regeneration Area Bordered by the River Chelmer to the south, HS5 consists of the Royal Mail Delivery Office as well as a few residential properties situated just off of Mill Lane. The hotspot is located adjacent to Fullbridge which borders the east.	2.2	0	0	100	Low	Medium	All of the Hotspot situated within FZ 3. Majority of the Hotspot (60%) situated within the <=50% - <75% GW banding and 40% within <=25% - <50% meaning medium probability of flooding from GW sources. Majority of site is at low risk from SW flooding, however increased risk of pooling at the end of Mill Lane and within the parcel of land just north of the Royal Mail offices.
Hotspot 6	Causeway Regeneration Area Bordered to the south by the River Chelmer and to the east by the Heybridge Creek, HS6 contains the recently developed Blackwater Retail Park. Also contains several businesses located off of Station Road including Jewsons and a Military Museum.	11.0	15	0	85	Medium	Medium	Majority of the Hotspot is within FZ 3 (85%), and 15% within FZ 1. All of site within the <=50% - <75% GW banding. Majority of Hotspot at low risk of flooding from SW, however higher susceptibility along Station Road and within the Jewson trading yard where pooling is expected. Other notable features include an existing attenuation pond along the north of the Hotspot which outfalls into the Heybridge Creek to the east.

Table 5.1: Flood Risk overview of Hotspots and flood risk sources

5.1 Fluvial and Coastal

5.1.1 Fluvial flood risk is defined as the risk of flooding from main rivers. It occurs when intense or prolonged rainfall is unable to be contained by drainage channels and water spills out onto adjacent areas. The risk of fluvial flooding is primarily determined by the rainfall duration, topography, proximity to a drainage channel and prior ground conditions.

5.1.2 Coastal flooding occurs when sea levels temporarily rise and flood adjacent land, most often due to low pressure weather systems, high tides, high winds, or a combination of all three. Risk is primarily determined by the proximity to the coast and height of the ground above sea level.

Flood Zone	Probability of Flooding	Definition
Flood Zone 1	Low	Land having a less than 0.1% annual probability of flooding from rivers or the sea. These areas are shown as being clear on the online flood mapping.
Flood Zone 2	Medium	Land having a 0.1 - 1% annual probability of flooding from rivers, or a 0.1 - 0.5% annual probability of flooding from the sea, estuaries, or tidal waters. This is shown as light blue on the online flood mapping.
Flood Zone 3a	High	Land having a greater than 1% annual probability of flooding from rivers, or a greater than 0.5% % annual probability of flooding from the sea, estuaries, or tidal waters. This is shown as dark blue on the online flood mapping.
Flood Zone 3b	The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map). An indicative value for this zone is land that is susceptible to a 5% or greater annual probability of flooding.

Table 5.2: Environment Agency Flood Zone definitions[34]

[34] Environment Agency Flood Zone definitions: https://www.gov.uk/guidance/flood-risk-and-coastal-change#flood-zone-and-flood-risk-tables

5.1.3 Fluvial and coastal flooding tends to involve high depths of water with high velocities near main river channels which decrease with distance. Water tends to rise and dissipate more slowly than other types of flooding and as such some measures can be taken to minimise its impact once it commences. Appropriate planning and development decisions, such as adjusting site layouts to accommodate flooding, can have a significant impact on who and what is impacted within a development.

5.1.4 Consequently, where fluvial or coastal flood risks exist within a site, if planning permission has not yet been granted a site-specific assessment should be undertaken as part of the planning application to fully understand how the risk may be altered across the site as a result of the development proposals.

5.1.5 Fluvial and coastal flood risk information is created and managed by the Environment Agency[35]. It should be noted that the zones are theoretically defined based on national modelling and have been revised in some areas where more refined modelling has been completed or errors have been found. The definition of each Flood Zone can be found in Table 5.2 below:

5.1.6 Figure 5.1 shows the six identified Hotspots and the associated risk of flooding from fluvial and coastal sources.

5.1.7 It should be noted that Hotspots 1-5 (HS1 – HS5) are situated completely within Flood Zone 3. The majority of HS6 also falls within Flood Zone 3 therefore it should be noted that any new development will require a site-specific flood risk assessment as part of any planning application.

5.1.8 Any planning application or proposed development should also seek early consultation and pre-application advice from the Environment Agency to discuss mitigation measures against the flood risk from this source.

[35] https://www.gov.uk/government/organisations/environment-agency

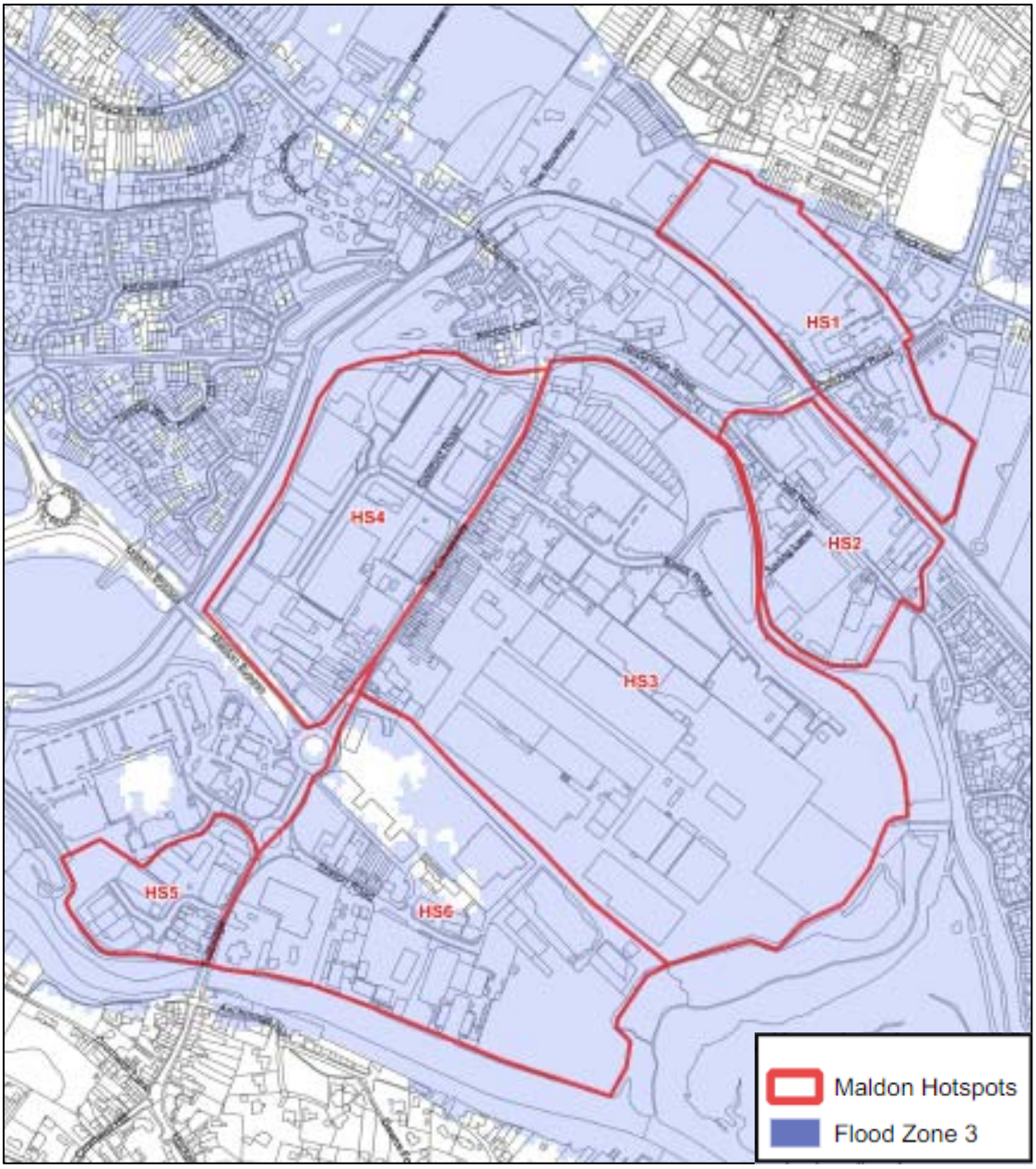

Figure 5.1: Flood risk hotspots with the EA extent of flooding from rivers and the sea

Fluvial Flood Defences

5.1.9 Climate change increases and their resultant flood depth increase have the potential to impact the standard of protection offered by defences and whether they may be overtopped.

5.1.10 All of the six Hotspots are shown as being protected by the existing fluvial flood defences[36]. The Environment Agency is responsible for the maintenance of fluvial defences and will restore/rebuild flood risk assets periodically depending on their condition and performance. To find out the level of protection offered for the CRA and for site-specific enquiries, please contact the Environment Agency.

Effects of Climate Change on Fluvial Flood Risk

5.1.11 The current guidance on fluvial climate change allowances states a 35% and 65% increase for the Anglian region over the next 50-100 years for the upper end scenarios, as shown in Table 2.1, in Section 2. This constitutes a significant increase from the previous 20% required by the superseded Planning Policy Statement 25 (PPS25).

5.1.12 As such predicted flow volumes and associated flood depths are greater, which increases risk and reduces usable space where potential developments contain or abut a main river.

5.1.13 In relation to the Hotspots, for sites yet to receive planning permission, a Flood Risk Assessment including updated or site-specific modelling will be required to support the submission to ensure climate change is appropriately considered and to deliver appropriate development, sustainability and the minimising of flood risk.

5.2 Surface Water

5.2.1 Surface water flooding occurs following intense or prolonged rainfall when the ground is unable to absorb it causing water to flow over the land surface. The risk of flooding is primarily determined by the rainfall intensity and duration, topography, surface types and prior ground conditions.

5.2.2 This type of flooding tends to involve lower depth but higher velocity flows which initiate and dissipate quickly. As such it is hard to stop surface water flooding once it commences and it is best mitigated through the prior installation of protective measures.

[36] https://flood-map-for-planning.service.gov.uk/confirm-location?easting=587176&northing=207085&placeOrPostcode=heybridge

5.2.3 Appropriate planning and development decisions, such as the implementation of SuDS and the layout of the development can have a significant impact on the depths, extents, and risks of surface water flooding.

5.2.4 Surface water flood risk is managed by LLFAs, however, to ensure standardised mapping nationwide the EA produced surface water flood risk mapping covering the entire UK. This used a national model updated in those areas where LLFAs had more accurate information to better take account of local topography and historic flood data.

5.2.5 As such, surface water flood risk is determined using the Environment Agency's Risk of Flooding from Surface Water (RoFSW) mapping. This mapping is available to interrogate through an online viewer or to use in GIS via a WMS layer.

Probability of Flooding	Definition
Very Low	Areas with a less than 0.1% chance of flooding each year
Low	Areas with a 0.1 - 1% chance of flooding each year
Medium	Areas with a 1 – 3.3% chance of flooding each year
High	Areas with a greater than 3.3% chance of flooding each year

Table 5.3: Environment Agency surface water flood risk area definitions[37]

5.2.6 The output map areas show overall risk of surface water flooding and include details on depths and velocities. Risks are categorised into four bands; Very High; High; Medium; and Low as detailed above in Table 5.3.

[37] Environment Agency Flood Zone definitions; https://www.gov.uk/guidance/flood-risk-and-coastal-change#flood-zone-and-flood-risk-tables

5.2.7 As with the mapping for fluvial flood zones, the areas shown are based on national modelling with a significant number of simplifications and assumptions. They cannot be used to determine the risk for individual properties and should only be used for spatial planning to assess whether an area is at risk and to what extent.

5.2.8 Figure 5.2 below illustrates the six flood risk Hotspots and the associated surface water flood risk using the Environment Agency's RoFSW maps.

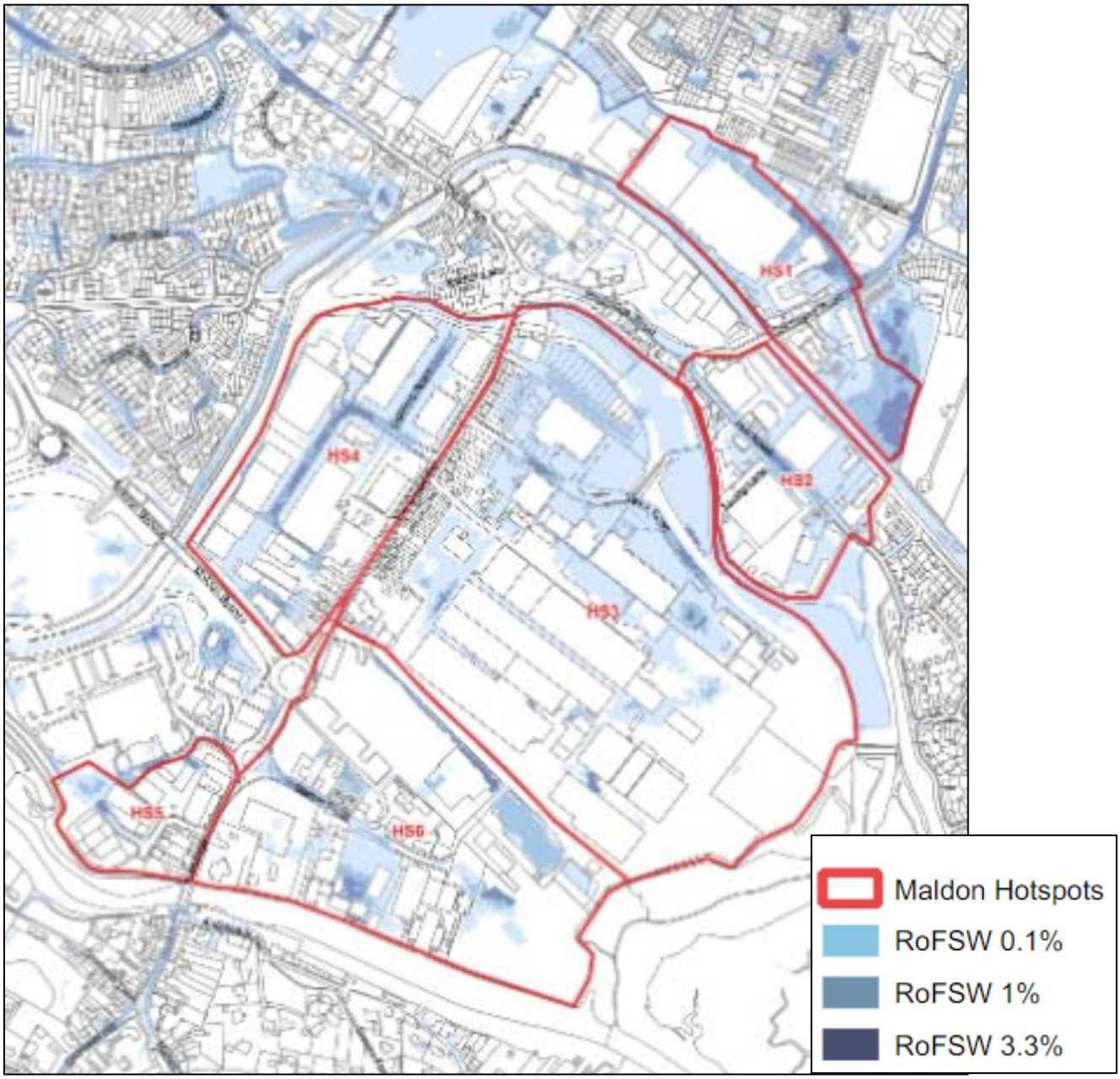

Figure 5.2: Hotspots and Risk of Flooding from Surface Water (RoFSW)

5.2.9 The surface water flood risk for each hotspot is summarised at the start of this section within Table 5.1.

5.2.10 There are no defined surface water flow paths throughout the study area or the six identified Hotspots but does include several localised low points which are shown to be at high risk of flooding from surface water (3.33% AEP).

5.2.11 The area's most susceptible to surface water flooding are generally confined to the highway; for example, within Bates Road, Hall Road, Station Road and Galliford Road. The other noticeable area shown as being highly susceptible is located at the end of the school fields within HS1.

5.2.12 More information about the potential flood mitigation measures for each Hotspot can be found in Section 7.

Surface Water Management Plans (SWMPs)

5.2.13 As discussed in Section 2.5, Essex County Council produced a SWMP for Maldon and Heybridge in 2013 as part of its Local Flood Risk Management Strategy. In 2018, this document was reviewed in line with updated hydraulic modelling. As part of the SWMP study, the Causeway Regeneration Area was found to be highly susceptible to surface water flood risk and was designated a Critical Drainage Area (CDA) with the reference MAL3 – The Causeway.

5.2.14 Despite the area's vulnerability to flooding from more than one flood risk source, much of the land use is commercial. Consequently, ECC has been unable to deliver a financially viable scheme within the Causeway Regeneration Area as its primary focus is to reduce flood risk to residential properties.

5.2.15 As the Causeway Regeneration Area falls within a CDA, the Lead Local Flood Authority (LLFA) should be consulted as part of any proposed new development to ensure surface water flood risk is mitigated against and that flood risk is not increased elsewhere.

5.2.16 More information relating to the management of surface water flood risk within Essex and the roles and responsibilities of ECC as the LLFA can be found on our website[38].

[38] https://flood.essex.gov.uk/

5.3 Groundwater

5.3.1 Groundwater flooding occurs when seasonal or very prolonged rainfall occurs causing the water table to rise above the ground surface. The risk of flooding from this source is primarily determined by the underlying geological conditions and existing groundwater levels. The British Geological Survey (BGS) have produced datasets to show risks across the country.

5.3.2 The Environment Agency utilised this data to create the Areas Susceptible to Groundwater Flooding (AStGWF) hazard maps which highlight the likelihood of groundwater flooding.

5.3.3 Groundwater flooding tends to involve lower depth, lower velocity flows which initiate and dissipate slowly. As such some measures can be taken once it commences, though due to the subsurface origin of the water, the specific occurrence of it can be hard to predict.

5.3.4 Groundwater flooding is rare in areas without porous bedrock, though the potential risks of it should be considered when designing and assessing developments as the influences of groundwater may impact the effectiveness of other flood mitigation measures.

5.3.5 Groundwater flood risk aligns directly with the underlying soils, geology and hydrogeological conditions and the British Geological Survey (BGS) have produced datasets to shows risks across the country. These can be found on their website[39].

5.3.6 Depending on the type of underlying soils and their drainage characteristics, consideration should also be given to any proposed flood mitigation measures. For example, should the data indicate lower permeability and impeded drainage into the soil then other means of attenuation or storage should be considered instead of infiltration.

5.3.7 As previously detailed in Section 3, the Land Information Services Soilscape viewer indicates that the underlying soils in the Causeway Regeneration Area are loamy and clayey floodplain soils with naturally high groundwater[40].

[39] BGS geology viewer online mapping: http://mapapps.bgs.ac.uk/geologyofbritain/home.html
[40] Land Information Services online soilscapes viewer: http://www.landis.org.uk/soilscapes/

5.3.8 Figure 5.3 below illustrates the six flood risk hotspots with the aforementioned AStGWF mapping. Due to the resolution of the model used to create the mapping (1km grids) and the assumptions it contains, this mapping cannot be used to determine flood risk to specific sites. As such it should be used only to highlight where groundwater flood risk may be relevant to a site and whether further investigations or specific mitigation measures may be required.

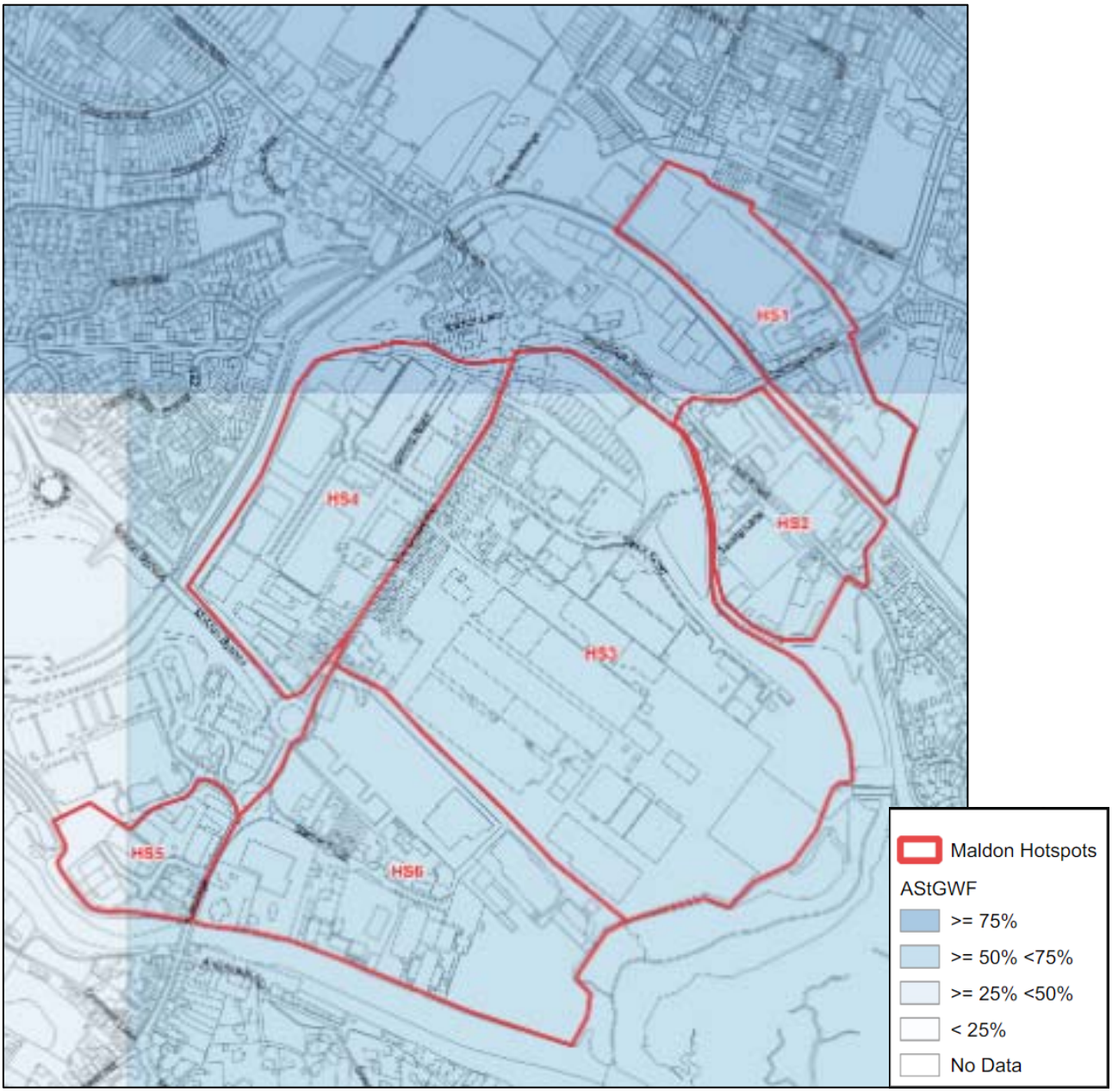

Figure 5.3: Six flood risk Hotspots with AStGWF mapping

5.3.9 The majority of the six Hotspots fall within the >=50% <75% GW banding and would be considered at medium risk of flooding from this source.

5.3.10 Hotspot 1 (HS1) is an exception with most of the area situated within the >=75% GW banding and should be considered at high risk of flooding from Groundwater sources. The suggested flood risk mitigation measures for HS1 and the other Hotspots can be found below.

5.3.11 In areas where ground water flood risk is present, the drainage strategy and features should be designed accordingly, and all finished floor levels should be set at appropriate heights above any anticipated ground water flooding. Further mitigation measures should be also be considered. For example, where possible below ground development such as basements should be avoided in order to prevent groundwater ingress and structural weakening.

5.3.12 The use of infiltration may not be suitable if high ground water level is present as a 1m gap is required between the base of all infiltration features and the highest annual ground water level.

5.3.13 If drainage features are constructed below the highest annual likely groundwater level, then the groundwater has the potential to enter the features and reduce their storage capacity. This where possible should be avoided and alternatives such as shallower wider features, raised features, or the incorporation of impermeable linings should be considered. Care should be given to the integrity of any lining as leakages can be problematic.

5.3.14 Flotation and structural design risks to storage structures such as tanks can also occur because of the extra loads imposed by the groundwater and the buoyancy of the tanks or liner. Therefore, it is important to keep storage and conveyance above maximum likely groundwater levels where possible. If this is not possible then mitigation should be provided to counter lateral loads on the sides of tanks and to provide counter force/anchorage to prevent floatation.

5.4 Sewers (Surface, Foul & Combined)

5.4.1 Essex County Council approached several stakeholders as part of this study to obtain pertinent data and modelling in relation to local flood risk assets. The aim was to create an integrated hydraulic model to fully assess flood risk in the Causeway Regeneration Area.

5.4.2 Anglian Water are responsible for the local sewer network and were approached for their modelling data, however they were unable to provide their data within the timescales required. As such, all enquiries relating to the local sewer network should be directed to Anglian Water.

5.4.3 There is a combined sewer present within Hotspot 1 underneath the playing fields of the Heybridge Co-operative Academy. The sewer then traverses the Chelmer and Blackwater Navigation before running underneath Hall Road in Hotspot 2 before out-falling into the Heybridge Creek.

5.4.4 Any proposed development that requires a downstream connection into the surface water sewer network would need permission from Anglian Water. This would include a s106 application that enables a connection into their sewer network and potentially an application to raise or lower and existing manhole chamber if appropriate.

5.5 Historic Flooding

5.5.1 In accordance with the General Data Protection Regulations (GDPR) we are unable to specify individual properties that have experienced internal flooding. With that said, we are aware of historic flood incidents that have occurred throughout the Causeway Regeneration Area and the flood risk Hotspots. These incidents are shown in Table 5.4 below:

5.5.2 Where properties have experienced sewer flooding, once they have informed their Local Water Authority, they are put on a register, known within the Water Industry as a DG5 register. This register is managed by water companies and audited periodically by the Water Services Regulation Authority (OFWAT).

5.5.3 Anglian Water have informed this Flood Risk Appraisal by making available their DG5 records for the Causeway Regeneration Area. More information relating to sewer flooding can be found on their website[41].

[41] https://www.anglianwater.co.uk/help-and-advice/sewage-flooding/

Hotspot	DG5 Record	Other Records
HS1	2	3
HS2	0	5
HS3	0	5
HS4	0	5
HS5	0	7
HS6	0	3

Table 5.4: Reported flood incidents within each hotspot

5.5.4 Water Companies are set a target by OFWAT every 5 years to remove properties from the DG5 registers and use this information when determining the location of any proposed works.

5.5.5 The 'Other records' highlighted within Table 5.4 are flood incidents reported to ECC directly, via Maldon District Council or where Essex Fire and Rescue have attended regarding flooding to a property.

5.5.6 It should be noted that the low number of recorded incidents could be as a result of the commercially dominated landscape and datasets and Risk Management Authorities (RMAs) tend to focus on recording flooding to residential properties.

5.5.7 Incidents resulting in flooding to the local road network are reported to Essex Highways and haven't been included in the figures in Table 5.4. More information about the roles and responsibilities of Essex Highways can be found on their website [42].

5.5.8 RMAs including ECC rely on the public and individuals to report their flood incidents therefore datasets might not show the full extent of any historic flooding. Moreover, flood incidents might not have been formally reported as a result of fears surrounding insurance or disclosing incidents in the eventuality of selling a property.

[42] Essex Highways | Essex County Council

5.6 Critical infrastructure

5.6.1 Critical Infrastructure can be defined as infrastructure that is essential for the continued delivery of goods and services and the maintaining of economic and social well-being. This includes, but is not limited to energy, transport, digital communications, and water.

5.6.2 Notable critical infrastructure at risk within the CRA and more specifically within the six flood risk Hotspots includes, but is not limited to: Royal Mail Delivery Office (HS5), Heybridge Co-operative Academy (HS1), Blackwater Retail Park (HS6), Rowland Pharmacy (HS1), Lidl Superstore (HS6).

5.6.3 Any new development within the CRA could explore the possibility of delivering wider-scale mitigation measures to reduce flood risk to the existing critical infrastructure within the Hotspots. Previously delivered schemes such as the Blackwater Retail Park, Canal Chunker and the Granaries have all enhanced flood resilience in the CRA (see Section 5.7).

5.6.4 The key sources of flood risk, potential mitigation options and their suggested locations are proposed for each of the Hotspots in Section 7 of this report. The delivery of these flood risk mitigation options will improve flood resilience within the CRA and reduce the overall risk to the existing critical infrastructure.

5.7 Flood Alleviation schemes

5.7.1 Despite the several sources of flood risk to the properties and development within the CRA, it should be emphasised that there are several mitigating options and measures available to potential developers looking to invest/build in the area.

5.7.2 Some of the mitigating measures are highlighted earlier within this section, however further options are explored in greater detail in Section 6.

5.7.3 Further to the above, there are several flood alleviation schemes that have been delivered within the CRA as part of new development which have mitigated flood risk as well as achieving wider socio-environmental benefits to the existing area.

5.7.4 A few of these schemes have been explored below:

The Granaries

5.7.5 In 2017, the Environment Agency carried out repairs to the existing flood defences along the River Chelmer at The Granaries. Located within Hotspot 6, the previous concrete flood wall was damaged and allowed excessive water to pass through it.

5.7.6 The 23-metre damaged section of the flood defence was restored by installing new sheet piling in front of the existing wall with a concrete infill section forming a strong composite flood wall structure.

Figure 5.4: Restored Flood Defence at The Granaries (right)

Langford Storage

5.7.7 Separating Hotspots 2 & 3 is a large tidal channel alongside the Langford Ditch, upstream of Sadds Dam Sluice. This channel can temporarily hold impounded levels of water when the tidal sluice downstream is closed.

5.7.8 Further upstream of the tidal channel and immediately upstream of the Canal Chunker is a flood storage area, otherwise known as the Regency Court Area Flood Alleviation Scheme (RCAFAS).

5.7.9 Further upstream of the tidal channel and immediately upstream of the Canal Chunker is a flood storage area, otherwise known as the Regency Court Area Flood Alleviation Scheme (RCAFAS).

5.7.10 The RCAFAS works in conjunction with another flood storage area further upstream at Langford Place to attenuate water and substantially reduce the peak flows that would otherwise cause flooding to Galliford Road industrial estate in Hotspot 4.

5.7.11 The Langford Place flood storage area is comprised of a small embankment along the eastern boundary of the site with a sluice-controlled concrete headwall used to regulate the flow of water through it. More information relating to this scheme can be obtained from the Environment Agency.

Blackwater Retail Park

5.7.12 As part of the delivery of the Blackwater Retail Park, Essex County Council were approached, in accordance with Section 23 of the Land Drainage Act, 1991 about the piping of the ditch on the northern boundary of Hotspot 6.

5.7.13 The piping of the 210m section of ditch was required in order to facilitate the construction of the associated car park for the six new retail units. Generally, the piping of a ditch is only permitted up to 20m in accordance with ECC's culvert policy. The piping of a ditch reduces the capacity of the local drainage system could increase flood risk to the area unless mitigated against.

5.7.14 To ensure flood risk was not increased elsewhere as a result of the piping of the ditch, the developer installed a 1050mm diameter pipe and lowered the outlet to the storage lagoon downstream by 600mm to provide additional storage in the local drainage network.

5.7.15 Further to the above, the works were not only required to mitigate against flood risk but had to also demonstrate that wider ecological enhancements had been achieved. Consequently, supplementary planting was delivered, and bird boxes and log piles constructed to improve biodiversity and create new habitats respectively.

5.7.16 This is yet another example of how new development within the CRA should be encouraged in order to realise wider socio-environmental benefits as well as flood risk mitigation.

Canal Chunker

5.7.17 In 2005, a partial collapse of the culvert running underneath The Chelmer and Blackwater Navigation at Heybridge meant that up to 230 properties upstream were at risk of flooding.

5.7.18 Known locally as ‘Chunkers’, the 35m section of culvert in question was, and still is, responsible for conveying flows from the Langford Ditch. The scheme not only repaired the partial collapse of the Chunker, but also significantly reduced the carbon footprint of the asset by using recycled steel sheet piles instead of concrete.

5.7.19 Completed by Royal Haskoning DHV in 2009, the project reduces flood risk to the local area and properties by increasing the size of the pipe conveying the water, improving capacity and flow under the watercourse.

Figure 5.5: Canal Chunker repairs

6 POTENTIAL OPTIONS

6.0.1 This section gives details on potential options that can be implemented to reduce or mitigate against flood risk. Options provided are based on site assessments of the 6 hotspots. It should be noted that the list is not exhaustive and is intended as a starting point when considering potential measures to reduce flood risk.

6.0.2 Key advantages and disadvantages are provided for each along with any relevant planning considerations.

6.0.3 Costs are also provided for each option to allow comparison and to provide a starting point for any Community Infrastructure Levy (CIL) or Section 106 discussions that may be undertaken as part of the planning process.

6.0.4 These are presented as ‘construction costs’, which constitute materials and labour only, and ‘total costs’, which include aspects relating to design and delivery to provide a more representative value of total project costs. Table 6.1 below provides a summary of these costs.

6.0.5 All costs are presented as a range with a simplified breakdown and key assumptions to give details on how they have been reached. It should be noted that all costs provided are high level assumptions and site-specific assessments should be undertaken where required to provide more accurate costings. Further details on the costing process and methodology can be found in Section 6.1.

6.0.6 Property Flood Resilience (PFR) measures have not been included as they are retrofit to buildings at risk and should be considered as a last resort as they do not address the causes of flooding. There are also significant complexities, variations and high costs associated with retrofitting PFR to commercial buildings.

6.0.7 It is strongly recommended that SuDS options are considered due to the significant wider benefits they have to ecology, biodiversity, amenity, and water quality as well as flood mitigation to both the site and the wider area. SuDS are also favoured by the planning processes in Essex and their inclusion within developments would likely expedite the planning process.

6.0.8 Where site limitations exist, such as restricted space, measures should be considered in combination to maximise wider benefits.

	Option	Sub-Option / Details	Construction Cost	Total Cost	Unit
1	Green roof	Fit to new build	£176 - £328	£286 - £531	per m^2
2	Rainwater re-use	Fit to new build	£3042 - £5650[43]	£4928 - £9153[34]	per m^2 of roof area
3	Bioretention area	Fit to new build	£119 - £221	£193 - £358	per m^2
4	Green wall	Fit to new build	£374 - £456	£449 - £834	per m^2
5	Permeable paving	Fit to new build	£108 - £200	£175 - £324	per m^2
6a 6b 6c	Downpipe measures	Downpipe planter Rainwater garden Water Butt	£571 - £1060 £305 - £566 £113 - £211	£924 - £1716 £493 - £916 £184 - £341	per downpipe
7a 7b	Non-return valve	Fit into existing chamber Fit into new chamber	£1390 - £2581 £612 - £1136	£2252 - £4181 £991 - £1841	per valve
8a 8b	Improve existing fluvial defences	Raising with earth bund Raising with wall	£255 - £474 £1872 - £3476	£413 - £768 £3032 - £5631	per m
9	New drainage connection	Installing into existing road or area of hardstanding	£185 - £343	£299 - £555	per m
10	Attenuation area	Creation of storage area with outlet connection Below ground storage areas only	£90 - £167 £111 - £206	£146 - £271 £180 - £334	per m^3 storage

Table 6.1: Summary of option and sub-option high-level average costs. The construction cost stated is for materials and installation only, total costs include aspects relating to design and delivery to give a better estimation of entire project costs.

6.1 Costing Process

6.1.1 Costs are presented for construction costs and total costs. Construction costs are those for materials and installation only.

[43] Note that costs are high as they include a large one-off payment for tank systems

6.1.2 The construction costs for all options have been calculated using Spon's Civil Engineering and Highways Work Price Book (2018)[44], Spon's External Works and Landscape Price Book (2018)[45], EA long term costing tools (2015)[46] in combination with costing information from flood alleviation works delivered by Essex County Council Flood Team between 2018 and 2020.

6.1.3 All construction costs determined using Spon's have had 20% added to the base costs whereas those determined using the EA long-term costing tools have had 30% added. Costs calculated using a combination of sources have had an appropriate value added based on the proportion of costings from the respective sources. The additions are included to reduce the potential for underestimations and to account for the ages of the respective sources. Information on the specific percentage increases are detailed in the relevant option sub-sections.

6.1.4 Costs presented as total costs also include aspects relating to design and delivery to provide a better representation of likely whole-project costs. These have been calculated by increasing the construction costs by a given percentage with these increase values based on information from Spon's and capital projects undertaken by Essex County Council (Table 6.2).

6.1.5 All costs are presented as a range. The lower and upper values of the ranges are calculated by increasing and decreasing the calculated construction and total costs respectively by 30%. A range is given to account for potential variation in the sourcing of materials, labour or other construction and delivery processes.

6.1.6 Estimated annual average maintenance costs are provided separately within each option sub-section. These are presented to give a complete representation of costs for the full lifetime of an option.

6.1.7 It should be noted that there is likely to be significant variation in such costs based on the design lifetime of options, the differing levels of maintenance that can be undertaken and variables associated with the delivery of specific projects. As such these are indicative only and should only be used as a guideline when considering the relative costs of multiple options.

[44] Spon's Civil Engineering and Highways Work Price Book 32nd Edition (2018)
[45] Spon's External Works and Landscape Price Book 37th Edition (2018)
[46] Environment Agency Long Term Costing Tools (March 2015): https://www.gov.uk/government/publications/long-term-costing-tool-for-flood-and-coastal-risk-management

6.1.8 It should be noted that there is likely to be significant variation in such costs based on the design lifetime of options, the differing levels of maintenance that can be undertaken and variables associated with the delivery of specific projects. As such these are indicative only and should only be used as a guideline when considering the relative costs of multiple options.

6.1.9 All costs provided are high-level estimations only. They should only be used as a starting point for further discussions regarding CIL or Section 106 contributions or as a factor when considering a range of potential options.

Aspect	Details	% Increase
Contingency Sum	A sum of money set aside to cover unforeseen circumstances and risks during construction	10%
General Site Provisions	Site set-up and removal, site compounds and welfare, site security	15%
Contractor Overheads	Including contractor profits	5%
Design Fees and Surveys	Consultant fees associated with creating design drawings and required site/building surveys	12%
Optimism Bias	A recommended increase based on evidence project appraisers are systematically optimistic[47]	20%
	TOTAL	**62%**

Table 6.2: Percentage increases applied to construction costs to give total costs

6.1.10 Any relevant assumptions and considerations associated with specific options are provided in the option sub-sections. It should be noted that the list of assumptions is not exhaustive and other factors may influence costs.

[47] UK Government Green Book supplementary guidance: optimism bias (Table 1) (April 2013): https://www.gov.uk/government/publications/green-book-supplementary-guidance-optimism-bias

6.1.11 Should any listed option be progressed it is recommended site investigations and detailed costings assessments be undertaken by appropriately trained professionals to provide more accurate and specific costs.

6.2 Green Roofs

6.2.1 Green roofs are areas of living vegetation on the roofs of buildings. They consist of several different layers of materials which aim to achieve the desired vegetative cover and drainage characteristics (Figure 6.1).

6.2.2 The design components vary depending on the type of green roof and site constraints however all green roofs provide significant benefits to both surface water flood mitigation and ecology.

6.2.3 There are two main types of green roofs: extensive and intensive. Extensive roofs have low substrate depths and loadings (growing medium of 20-150mm), simple planting and low maintenance. Intensive roofs have deeper substrates, higher loadings, and heavier maintenance. Some roofs can develop further into blue roofs, where they are explicitly designed to store larger quantities of water[48].

6.2.4 This appraisal recommends the use of extensive roofs.

6.2.5 The effect of a green roof on surface water management predominantly happens during frequent events. This occurs through the interception and retention of rainwater (on average the first 5mm). This rainwater is then either absorbed by the vegetation, lost to evapotranspiration, or discharged further along the surface water drainage network. During summer months, more rainfall is removed via evapotranspiration resulting in less surface water providing a strain on the drainage network. During the winter months the green roofs are more likely to be saturated for long periods of time. Therefore, losing interception storage and relying more on discharging to the surface water drainage network at a controlled rate. The green roofs can provide benefits in terms of reducing peak flow rates to drainage systems.[49]

6.2.6 In addition to the benefits on surface water management and controlling surface water flood risk, green roofs provide additional benefits. For example:

[48] The CIRIA SuDS Manual C753 Chapter 12 https://www.ciria.org/ItemDetail?iProductCode=C753&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91

[49] The CIRIA SuDS Manual C753 Chapter 12, section 12.4.2 https://www.ciria.org/ItemDetail?iProductCode=C753&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91

- Increased climate resilience i.e. reducing urban heat island effect and energy demands whilst increasing building thermal efficiency.
- Improved air and water quality.
- Providing acoustic dampening.
- Increased/enhanced biodiversity. They help to conserve valuable habitats and can provide an oasis of life in places which usually would be bare of life. In the wider scope of biodiversity, they can contribute to green clusters, networks, and corridors.[50]

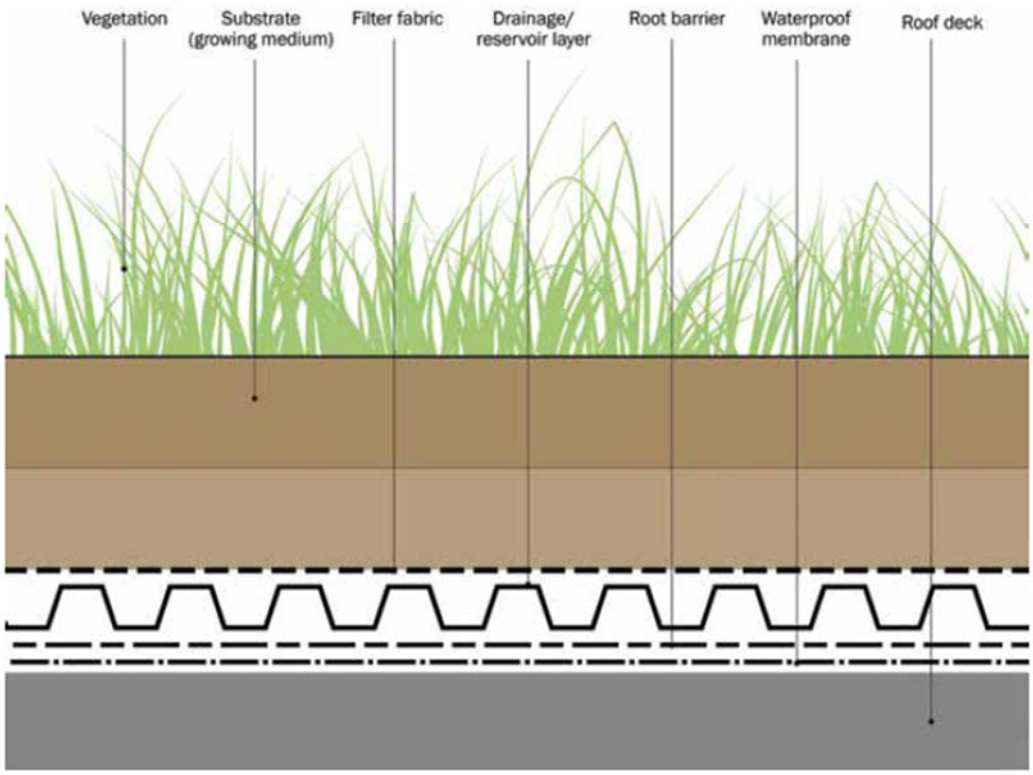

Figure 6.1: Section showing typical extensive green roof components[51]

The responsibility will be with the owner of the building unless a maintenance company is hired. This is usually decided at the planning stage.

[50] The CIRIA SuDS Manual C753 Chapter 12, section 12.4.7 https://www.ciria.org/ItemDetail?iProductCode=C753&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91

[51] Figure 12.1 CIRIA SuDS Manual C753 https://www.ciria.org/ItemDetail?iProductCode=C753&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91

Costs

6.2.7 The cost of green roofs can vary depending on the extent, complexity, and type of roofing proposed. For this appraisal an extensive roof was priced for a new build, and per m2 the cost would be £286 - £531.[52]

Material	Cost	Unit	Contingency range down (30%)	Contingency range up (30%)
Zinco Drainage Element Fixodrain XD20; 3L/m2 reservoir (drainage, water retention and protection mat with attached filter sheet 20mm thick)	£8.96	m^2		
Zinco system Substrate Growing medium 'Sedum Carpet'	£172.27	m^2		
Zinco Premium Sedum Carpet Mat	£28.73	m^2		
Total	£209.96	m^2	£147	£273
Plus construction costs adjustments (20%)	£252	m^2	£176	£328
Plus adjustments (62%)	£408	m^2	£286	£531

Table 6.3: Green roofs costings breakdown

6.2.8 Assumptions:

- The roof is structurally sound to host the green roof
- There are overflow pipes connecting into the surface water system
- They will be sufficiently maintained

Planning Considerations

6.2.9 Whilst green roofs provide a multitude of benefits for the development and surrounding areas, they are additionally a fantastic option when looking to meet planning requirements.

[52] SPONS: External Work and Landscaping Price Book (2018),

6.2.10 The Essex SuDS Design Guide[53] states that when putting together a drainage strategy, certain methods of surface water management should be considered first. These include above ground, green features, and those that provide interception storage. This is because not only do above ground green features such as green roofs provide a range of benefits, but they also aid in removing the first 5mm of rainfall from entering the downstream network, which is more in line with what would happen naturally. In addition to this, green roofs will help to reduce the discharge rates associated with the site to the 100% AEP greenfield rate without taking up any additional space. This is a key component when designing a surface water drainage scheme, as the Essex SuDS Design Guide 2020 states that all developments should restrict runoff to the 100% AEP greenfield rate where possible.

6.2.11 In addition to this, the NPPF (Section 2.1 of this report) states that where possible, all new development should include sustainable drainage systems and should ensure that flood risk is not increased, and water and air pollution is also not increased as a result. Green roofs are an easy to implement, beneficial example of a sustainable drainage system, whereby surface water can be treated and managed well.

6.2.12 The Green Infrastructure Strategy (Section 2.4 of this report) promotes and encourages the provision of green infrastructure and biodiversity. Green roofs are brilliant examples of features which can help to meet the Green Infrastructure Strategies seven objectives. This is because they can help to protect and improve an area's natural environment, whilst additionally creating new areas for biodiversity to thrive alongside a multitude of benefits such as flood resilience, climate resilience and amenity related benefits. Moreover, green roofs help to enhance biodiversity by increasing the connectivity of green spaces and ecosystems, whilst providing a cost effect, sustainable, aesthetic feature.

6.2.13 The Maldon District Local Development Plan, as mention previously, outlines a series of policies. The inclusion of green roofs within developments, through the benefits they provide, will assist in meeting the criteria outlined in policies S1, S4, S5, D2, D5, N1, N2. A standard roof would not provide this assistance or benefits and may result in further surface water storage and treatment being provided elsewhere within the site, consequently taking up space.

[53] The Essex SuDS Design Guide 2020 - https://www.essexdesignguide.co.uk/suds

Advantages and Disadvantages

6.2.14 Table 6.4 below provides a summary of key advantages and disadvantages associated with green roofs. It should be noted that this list is not exhaustive and is only provided to help aid decisions where this option is considered.

Benefits and Advantages	Risks and Disadvantages
Improved Water Quality	Buildings have to be structurally strong
Enhanced biodiversity and local amenity	Only suitable for flat, to shallow pitched roofs
Reduced heat island effect	Less proficient during winter months
Increased interception storage	More maintenance required than standard roofs
Evapotranspiration	Reduces proficiency of rainwater reuse systems
Remove strain on surface water networks	Maintenance requires good access
Flood mitigation and resilience	
Increased climate resilience	
Increased noise pollution through dampening	
Increased air quality	

Table 6.4: Advantages and disadvantages of Green roofs

6.3 Rainwater Re-use

6.3.1 Rainwater re-use or rainwater recycling is method of rainwater management which simultaneously helps to control discharge volumes and mitigate against water scarcity by reducing potable water demand. Rainwater can be collected from surfaces (predominantly rooftops) and used for things such as toilet flushing, cleaning and irrigation, and as Essex is predicted to have increased vulnerability to drought in the near future due to climate change, utilising rainwater for activities such as the aforementioned will help to reduce demand and strain supplies.[54]

[54] BS EN 16941-1:2018 - On-site non-potable water systems - Part 1: Systems for the use of rainwater.

6.3.2 Any rainwater re-use system should have 4 main elements: collection, treatment, storage, and distribution of water. Potential overflows should additionally be accounted for to ensure rainwater harvesting systems do not cause flooding by allowing excess water to be discharged either to infiltration systems or the surface water network[55].

6.3.3 There are a range of different types of rainwater reuse systems, for example, water butts, direct pumped systems (submersible or suction), indirect gravity systems, indirect pumped systems, gravity only systems[56]. Water butts are the most basic form and are used mainly for gardens, whilst submersible direct pumped systems are the most commonly used systems which provide water for indoor use such as toilet flushing.[46]

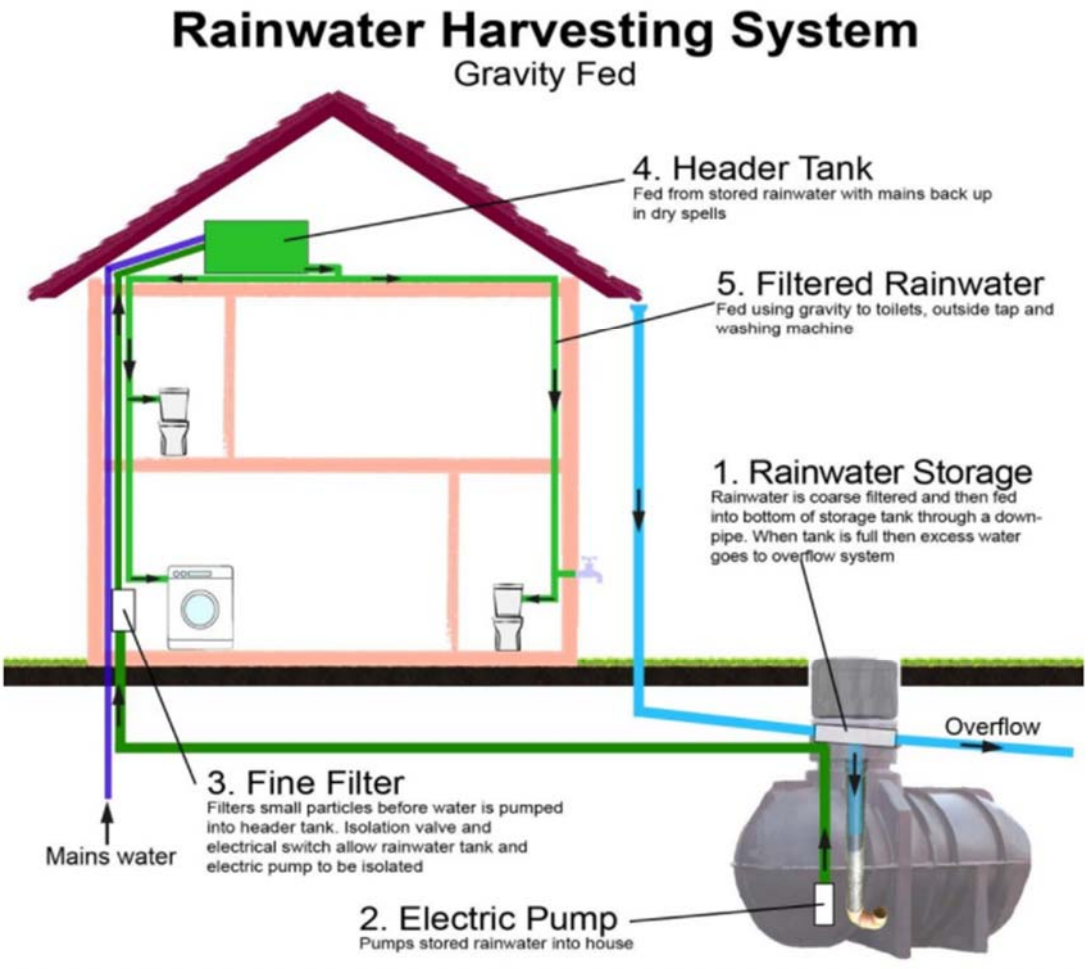

Figure 6.2: Typical arrangement of a domestic water re-use system[57]

[55] The Essex SuDS Design Guide 2020 - https://www.essexdesignguide.co.uk/suds
[56] www.rainharvesting.co.uk/types-of-rainwater-harvesting-systems/
[57] https://great-home.co.uk/rainwater-harvesting-systems/

6.3.4 The responsibility of maintaining any rainwater reuse system is typically the home/building owner or a maintenance company. This is usually decided at the planning stage whereby a maintenance plan highlighting the work that needs to be done, the frequency of the work, and who is to undertake the maintenance should be provided.

Costs

6.3.5 The cost of rainwater reuse systems can vary depending on the size of the catchment area, and the type of system used. For this appraisal the following system was costed. Table 6.5 shows that to prepare the area for the rainwater reuse tank it could cost between £77.85 and £144.60 per m3. It also shows that for a medium sized tank it could cost between £4,756.80 and £8,787.20.[58]

Activity/Item	Cost	Unit	Contingency range down (30%)	Contingency range up (30%)
Excavation for underground tank (max depth not exceeding 3m) - bucket volume 0.28m3	£7.29	m^3		
Disposal of soil – bucket volume 0.28m3	£32.80	m^3		
Type 1 granular fill base – PC £21.50/tonne (£43.70/m3 compacted) 150mm thick	£9.63	m3		
Backfilling to surround of rainwater tank	£7.49	m3		
Total	**£57.21**	**m3**	**£40.05**	**£74.40**
Plus construction costs adjustments (20%)	**£68.65**	**m2**	**£48.055**	**£89.25**
Plus adjustments (62%)	**£111.213**	**m2**	**£77.85**	**£144.60**
Rainwater harvesting tank (self-supporting) - max 1m cover, tank dome, pedestrian lid, submersible pump, filtration, pipes, filter, 6500litre (medium sized) 2.68x2.02x2.29	£3,389.09	Set price		
Downpipe for connection to roof down pipes – for roof areas up to 100m2	£106.49	Set price		
Total	**£3,495.58**		**£2,446.90**	**£4,544.25**
Plus construction costs adjustments (20%)	**£4,194.70**		**£2,936.30**	**£5,453.10**
Plus adjustments (62%)	**£6,795.40**		**£4,756.80**	**£8,787.20**

Table 6.5: Rainwater re-use cost breakdown and total costs summary

[58] SPONS: External Work and Landscaping Price Book (2018),

6.3.6 It is assumed that:

- The rainwater reuse system will be maintained sufficiently
- The roof area requires a medium sized rainwater reuse system

Planning Considerations

6.3.7 Rainwater reuse is becoming increasingly important when it comes to mitigating against the effects of climate change. It is therefore become a more predominant feature in planning requirements.

6.3.8 The Essex SuDS Design Guide 2020 has an updated drainage hierarchy which puts rainwater reuse at the very top. This means that for all new developments the LLFA will expect to see that rainwater reuse has been considered first and foremost in deciding how to manage the surface water runoff associated with the site. Not only does this reduce the strain on supply, helping in times of drought, but this will also provide an increasing in storage as well as reducing the strain on receiving surface water sewers/bodies. Furthermore the LLFA argue that, where sites struggle to meet the 100% AEP discharge rate, rainwater reuse can aid in bringing the surface water discharge rate and volume down. Doing so will help reduce the risk of surface water flood risk for the site and the surface water system.[59]

6.3.9 Sections 163 and 165 of the NPPF[60] (Section 2.1 of this report) state that where possible sites should incorporate sustainable drainage systems, and those which provide multifunctional benefits. Rainwater reuse systems are extremely beneficial, multifunctional features which are only going to have a growing importance as years progress on. They help provide much-needed mitigation to the hazards posed by climate change in terms of drought and surface water flooding.

[59] The Essex SuDS Design Guide 2020 - https://www.essexdesignguide.co.uk/suds
[60] The NPPF Sections 163-170

6.3.10 Similarly to green roofs, rainwater reuse systems additionally help meet a myriad of The Maldon District Local Development Plan's policies. Their inclusion will assist in meeting the criteria outlined in policies S1, S4, S5, D2, D5. This is because, as stated previously, they are a sustainable approach to combating the effects of climate change such as increased drought and increased rainfall and surface water runoff. Without their inclusion, it can be argued that the demand for non-potable will increase whilst the potential supply could decrease, increasing costs and the effects of drought. This will be specifically seen in the summer months.[61]

Advantages and Disadvantages

6.3.11 Table 6.6 below provides a summary of key advantages and disadvantages associated with rainwater re-use. It should be noted that this list is not exhaustive and is only provided to help aid decisions where this option is considered.

Benefits and Advantages	Risks and Disadvantages
Reduction in demand on water from providers	May not be demand for water use so not economically viable
Reduction on strain on surface water networks both giving and receiving	They require maintenance
Savings on water costs for owners	Can be initially expensive
Can be educational for schools	Certain roofs can seep chemicals/pollution so may require upstream treatment
Climate change effects mitigation i.e. drought	
Can help to reduce discharge rate, reducing flood risk	
Can provide more surface water storage	

Table 6.6: Key advantages and disadvantages associated with the installation or use of Rainwater re-use

[61] The Maldon District Local Plan

6.4 Ground Reprofiling and Bioretention Areas

6.4.1 Bioretention areas utilise engineered soils and vegetation to not only treat surface water runoff but also manage discharge volumes and rates. As stated in the CIRIA SuDS Manual C753[62] bioretention areas are effective in delivering interception storage, habitats and biodiversity, and cooling of the local microclimate through evapotranspiration.

6.4.2 Local areas of hardstanding can be reprofiled to direct surface water runoff to bioretention areas from walkways and roads. This runoff will pond on the surface. Any surface water that is then not lost through evapotranspiration and plant transpiration will slowly filter through the vegetation and soil where it is treated and eventually it will be collected via an underdrain system.

6.4.3 Bioretention areas can come in a range of forms, such as rain gardens, tree pits, swales, or trenches. As well reprofiling the ground they can also be designed to take surface water from roof tops. Bioretention areas are generally applied to small catchments and the maximum recommended area that should drain to a system is 0.8ha[63].

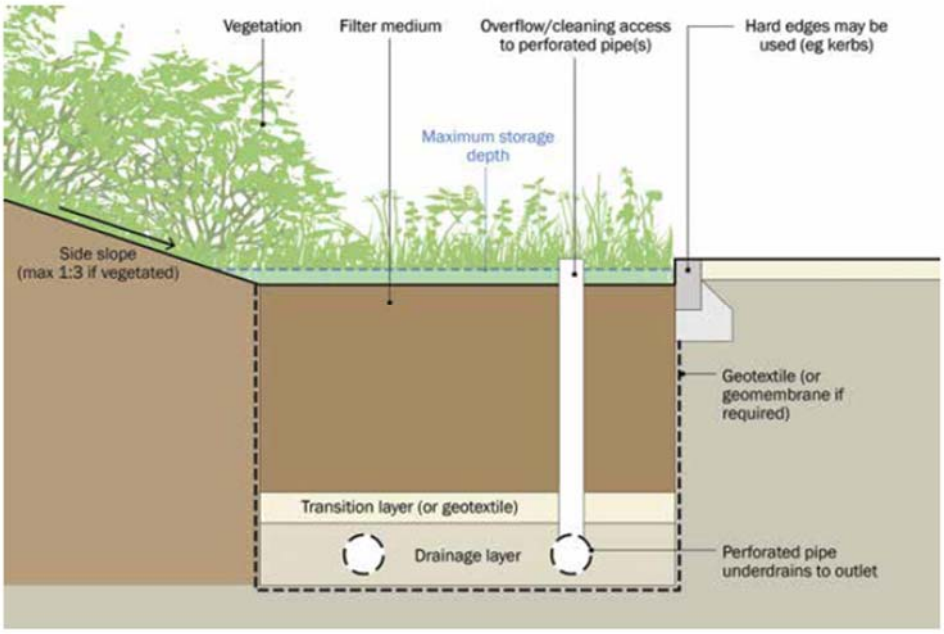

Figure 6.3: Components of a general bioretention system[64].

[62] The CIRIA SuDS Manual C753 Chapter 8
https://www.ciria.org/ItemDetail?iProductCode=C753&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91
[63] The CIRIA SuDS Manual C753 Section 8.2
https://www.ciria.org/ItemDetail?iProductCode=C753&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91
[64] The CIRIA SuDS Manual C753, Figure 18.1
https://www.ciria.org/ItemDetail?iProductCode=C753&Category=BOOK&WebsiteKey=3f18c87a-d62b-4eca-8ef4-9b09309c1c91

6.4.4 The responsibility of maintaining a bioretention system can vary. Dependent on the area that is being drained, they may have the potential to be adopted. However, is typically the home/building owner or an appointed maintenance company. This is usually decided at the planning stage whereby a maintenance plan highlighting the work that needs to be done, the frequency of the work, and who is to undertake the maintenance should be provided.

Costs

6.4.5 The cost of bioretention systems can vary depending on the size of the catchment area, the type of system used, if specific engineered soils are used, and what vegetation is used. For this appraisal the following system was costed between £192.65 and £357.75 per m3[65].

	Activity/Item	Cost	Unit	Contingency range down (30%)	Contingency range up (30%)
Prep	Excavation topsoil for preservation – depth 300mm, by machine	£11.80	m^3		
	Excavate trench for services – no deeper than 1m	£17.00	m		
	Disposal -excavated off site to tip, mechanically loaded 9JCB), inert material	£32.80	m^3		
	Earthwork Support – support to opposing faces of excavation, timber, no exceeding 500mm	£11.48	m		
Installation	Pipe perforated to trench – 800mm diameter	£1.33	m^3		
	Granular beds to trenches – drainage layer – gravel (estimate 300mm wide and 150mm thick	£8.53	m		
	Transition layer – sand – estimate 300mm wide and 150mm thick – coarse/sharp sand	£10.01	m		
	Topsoil/filter medium	£48.60	m^3		
	Vegetation/grass	Site specific/developments discretion			
	Total	**£141.55**	**m^3**	**£99.10**	**£184.00**
	Plus construction costs adjustments (20%)	**£169.85**	**m^3**	**£118.90**	**£220.80**
	Plus adjustments (62%)	**£275.20**	**m^3**	**£192.65**	**£357.75**

[65] SPONS: External Work and Landscaping Price Book (2018)

Table 6.7: Costings for bioretention systems

6.4.6 The costs have the following assumptions:

- That it is to be sufficiently maintained
- That there will be additional costing for seeding and vegetation of the developer's choice
- That there will be connections into the surface water drainage network
- That if necessary further treatment will be provided

Planning Considerations

6.4.7 Bioretention areas are another example of an above ground green feature which can manage and treat surface water runoff, whilst also promoting and enhancing habitats and biodiversity. In addition to this they are another example of how the effects of climate change can be additionally be mitigated. By doing so the consideration of bioretention areas also addresses planning policies and requirements.

6.4.8 The Essex SuDS Design Guide,[66] as previously stated highlights the importance of designing with interception in mind. Bioretention areas are very effective ways of delivering interception storage and if designed well, also are effective ways of controlling and managing surface water runoff from small localised areas. This will help bring discharge rates down, which is specifically important when trying to achieve the 100% AEP greenfield runoff rate for developments, as specified in the Essex SuDS Design Guide. In addition, bioretention areas perform very highly when it comes to surface water treatment and the Simple Index Approach, another key requirement outlined in the Essex SuDS Design Guide. This is due to the vegetation and engineered soil, which further provides fantastic habitats and biodiversity.

6.4.9 The NPPF[67] (see Section 2.1) states that where possible sites should incorporate sustainable drainage systems, and those which provide multifunctional benefits.

[66] The Essex SuDS Design Guide 2020 - https://www.essexdesignguide.co.uk/suds
[67] The NPPF sections 163 - 170

6.4.10 The NPPF also states that where possible surface water should promote biodiversity net gain and reduce the impacts of surface water pollution. Bioretention systems are extremely beneficial, multifunctional features which are only going to have a growing importance as years progress on. They provide localised cooling, enhancement of biodiversity, surface water treatment and management, air pollution treatment, and they additionally help to reduce the strain on surface water networks through interception storage and evapotranspiration. Thus helping to provide much-needed mitigation to the hazards posed by climate change.

6.4.11 The use of bioretention areas is supported by The Maldon District Local Development Plan's policies, specifically those mentioned earlier; Policies S1, S4, S5, D2, D5, N1 and N2. They are a sustainable approach to combating the effects of climate change as well as enhancing biodiversity. They can manage and treat surface water at source and from localised areas, and by doing so can reduce the risk posed by surface water flooding.[68]

6.4.12 The Green Infrastructure Strategy (Section 2.4 of this report) encourages the use of bioretention area as they are perfect examples of features which can help to meet the Green Infrastructure Strategies seven objectives. This is because they create new areas for biodiversity alongside other benefits such as surface water treatment and management, flood and climate resilience and amenity related benefits. Moreover, bioretention areas help to enhance biodiversity by increasing the connectivity of green spaces and ecosystems, whilst providing a cost effect, sustainable, aesthetic feature.[69]

Advantages and Disadvantages

6.4.13 Table 6.8 below provides a summary of key advantages and disadvantages associated with ground reprofiling and bioretention areas. It should be noted that this list is not exhaustive and is only provided to help aid decisions where this option is considered.

[68] The Maldon District Local Plan
[69] The Essex Green Infrastructure Strategy 2019

Benefits and Advantages	Risks and Disadvantages
Climate change effects mitigation	They require space
They can help to reduce runoff rates and volumes	They require maintenance - can be clogged easily without anyway maintenance
They can reduce on strain on surface water networks	Not suitable for areas with steep slopes
They treat and improve surface water quality	
They enhance biodiversity and local amenity	
They can provide localised cooling	

Table 6.8: Advantages and disadvantages for bioretention area

6.5 Living Walls

6.5.1 Living Walls are vertical structures that have different types of plants or greenery attached to them, generally planted in a growth medium consisting of soil, stone, or water. As the walls having living plants within them, they usually feature a built-in irrigation system.

6.5.2 An example of a Living Wall is shown below[70]

Figure 6.4: Example of a Living Wall and typical cross-section

[70] https://www.landud.co.uk/living-walls-reviving-the-urban-jungle-one-car-park-at-a-time/

6.5.3 Living Walls are more aesthetically pleasing than traditional walls and also provide several environmental benefits. As well as cooling the air, Living Walls improve air quality through the production of oxygen and will intercept and attenuate rainfall before it hits the ground. This not only reduces the pressure on the existing sewer network, but also improves the quality of water entering the piped systems.

6.5.4 An attractive design feature, Living Walls also insulate the building by directly shading the wall. They are suitable for a wide range of plants, usually herbaceous, though some small shrubs can be used as an alternative. The provision of light will also need to be considered when choosing its location, as well as the associated maintenance cost.

6.5.5 Living Walls are much easier to install on new development as opposed to retrofitting. Although possible, the structural integrity of building and walls should be checked before installation.

Costs

6.5.6 Living Walls can be expensive depending on the size of coverage and level of specification chosen. However, they can also be very affordable and remain effective through efficient design, choice of plant species, etc.

6.5.7 Despite the range of costs associated with Living Walls, they are becoming more common on new development and are considered to be a great way to achieve wider socio, economic and environmental benefits to the local community.

6.5.8 The costs provided below have been obtained from SPONS: External Work and Landscaping Price Book (2018), however different contractors and specialist companies should be explored considering the wide range of costs associated with this option.

6.5.9 Cost Assumptions:

- Prices below are for each m2 for area of installation assumed to be over 150m^2.
- Geotextile and soil-based system.
- Living Wall assumed to be self-contained and will include a vertical irrigation planting system.
- Assumed to be fully established upon installation with no establishment period required.

Details	Construction Cost	Total Cost	Unit
Simplified cost breakdown:			
System units 250 x 500 x 100mm overall; fixed to horizontal hanging rails on softwood batten and DPM; planting depth at 150mm; inclusive of dripline irrigation system and guttering with running outlets to drain;	£374.00	£374.00	m^2
OR as opposed to the dripline irrigation system; Fully automatic irrigation system to the above, comprising breaktank, station controller, soilnoid valves, plant feeders and dripline emitters	£8,525 (Optional)		each
*Maintenance costs (costs vary greatly depending on size of installation coverage - assumed 150m2) – includes regular visits to maintain planting systems; calibration of irrigation systems		Up to £11,000	annum

Table 6.9: Living Wall cost breakdown and total costs summary

6.5.10 Costs vary depending on the size of the Living Wall installation and range from £374 - £546.50 per m2 (SPONS, 2018). Optional costs include the provision of a fully automated irrigation system as well as maintenance costs associated with the regular upkeep of the walls and plants living within them (SPONS, 2018).

Planning Considerations

6.5.11 It is advised to contact the Local Planning Authority (LPA) when proposing the installation of Living Walls. Some may consider this type of feature to fall under Permitted Development (PD) whereby Planning Permission is not required. However, as the external appearance of the building is being altered, it should be looked at on a site-specific basis.

6.5.12 Should these features require Planning permission; the LPA should determine favourably as a result of the wider socio-economic and environmental benefits Living Walls provide. In cases of some developments, the installation of a Living Wall has been made a planning condition.

6.5.13 Reference should be made to the Essex SuDS Design Guide[71] which advocates the use of above-ground features and interception storage techniques to capture water before it reaches impermeable surfaces on the ground.

Advantages and Disadvantages

6.5.14 Table 6.10 below provides a summary of key advantages and disadvantages associated with Living Walls. It should be noted that this list is not exhaustive and is only provided to help aid decisions where this option is considered.

Benefits and Advantages	Risks and Disadvantages
Aesthetically pleasing – can transform the urban landscape	Can be costly to maintain
Intercepts and stores rainwater before it reaches impermeable surfaces on the ground	Planning permission may be required (Check with LPA on a case by case basis)
Provides wider socio-economic and environmental benefits including, but not limited to; better mental well-being, improved air quality, increased wildlife, and biodiversity.	
Reduces the pressure on the local sewer network through water attenuation and regulation	
Can be used extensively for great effectiveness	

Table 6.10: Key advantages and disadvantages associated with the installation or use of Living Walls

6.6 Permeable Paving

6.6.1 Permeable paving is a specific type of pavement with high porosity that allows rainwater to pass through it into the sub-surface. By doing so, permeable paving mimics natural processes and reduces surface water run-off by enabling water to percolate into the ground.

[71] https://www.essexdesignguide.co.uk/suds

6.6.2 A typical cross section of permeable paving is shown below.[72]

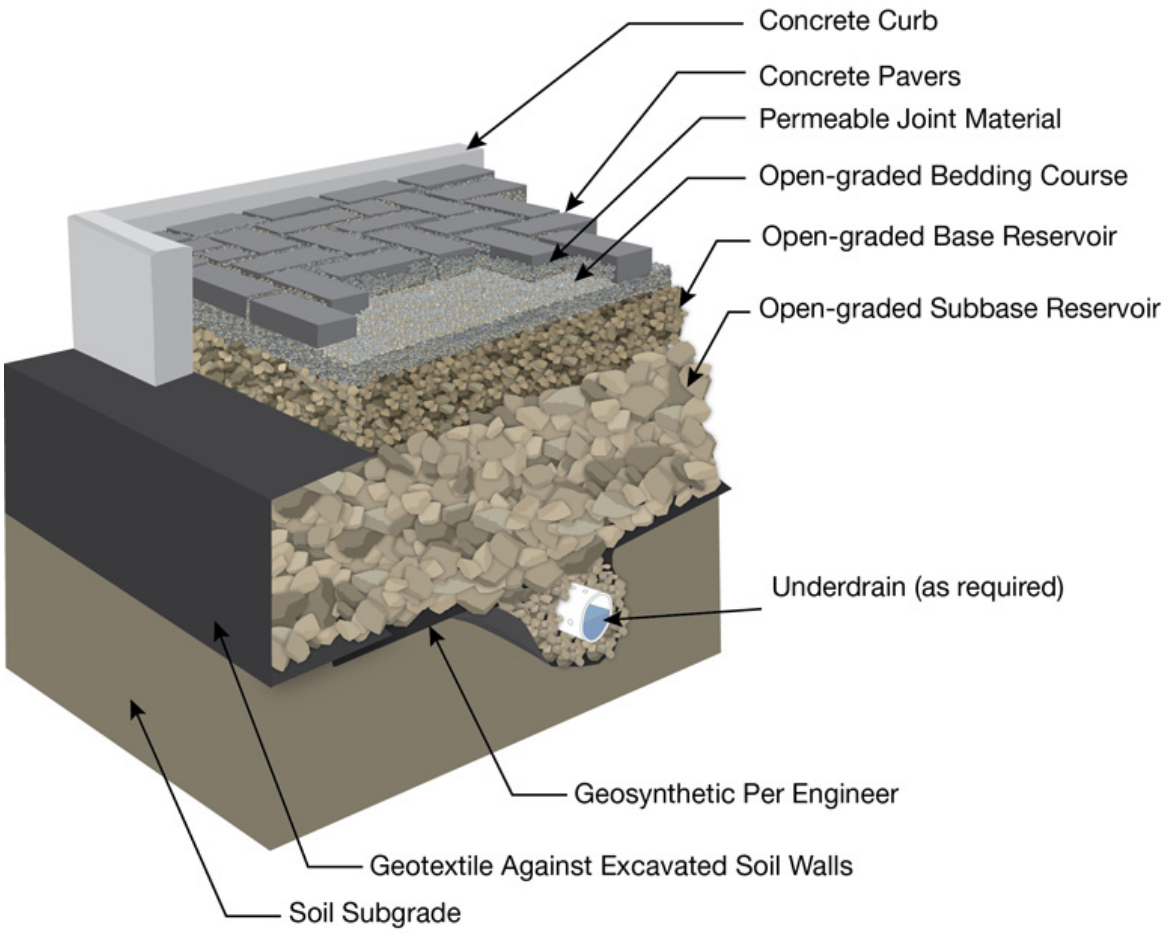

Figure 6.5: Typical permeable paving cross-section

6.6.3 It is designed so that any suspended solids or pollutants are trapped within the paving which in turn reduces pollution downstream and in underground water sources.

6.6.4 Permeable paving is much easier to install on a new development as opposed to retrofitting, but consideration should be made to this option where possible, especially in urbanised environments where there is limited permeable surfaces.

[72] http://www.permeabledesignpro.com/features.aspx

6.6.5 Cyclical maintenance is required for all types of permeable paving to prevent suspended solids and pollutants blocking the pavement pores. Failure to clear any blockages will result in the paving assuming the traits of an impermeable surface.

Costs

6.6.6 Permeable paving is arguably a cost-effective alternative to traditional highway that eliminates surface water run-off and the need for underground piping and storm drains.

6.6.7 The costs provided below have been obtained from SPONS: External Work and Landscaping Price Book (2018), however different contractors and specialist companies should be explored considering the wide range of costs associated with this option.

6.6.8 Cost assumptions:

- Pre-installation Ground Investigations (GIs) are not included within the costings and will vary depending on contractor and area surveyed.
- Costs are associated with the installation of permeable paving to new development and do not include costs for retrofit.

Details	Construction Cost	Total Cost	Unit
Simplified cost breakdown:			
Subbase replacement system for SuDS paving; Geocellular, interlocking, high strength; high void capacity (95%); typically a 4:1 ratio; allows for water storage to be confined at a shallow depth within the subbase layer; inclusive of connection; not inclusive of encapsulation in geotextile/ geomembrane	£80.12		m^2
Encapsulation of geomembrane geofabric or combination of both filtration and attenuation of water; 150mm thick systems	£19.94		m^2
Permatex 300 Geotextile	£21.23		m^2
Permafilter pollution control geotextile	£7.10		m^2
		£128.39	m^2
	20% VAT	£154.07	m^2

Table 6.11: Permeable paving cost breakdown and total costs summary

6.6.9 It should be noted that the costs within Table 6.11 should be used only as guidance and will vary depending on the specification of product chosen.

Planning Considerations

6.6.10 Planning permission is not required for any new or replacement driveway of any size that uses permeable surfacing which allows water to drain through. This is the case for both residential and non-residential premises. As such, any installation of permeable paving can be done under Permitted Development and will not require a planning application.

6.6.11 Reference should be made to the Essex SuDS Design Guide[73] which advocates the use of above-ground features and interception storage techniques to capture water before it reaches impermeable surfaces on the ground.

Advantages and Disadvantages

6.6.12 Table 6.12 below provides a summary of key advantages and disadvantages associated with permeable paving. It should be noted that this list is not exhaustive and is only provided to help aid decisions where this option is considered.

Benefits and Advantages	Risks and Disadvantages
Aesthetically pleasing – can transform the urban landscape	Requires cyclical maintenance to clear any blockages and ensure the paving remains permeable and effective
Can be installed under Permitted Development	
Improves water quality by filtering out suspended solids and pollutants	
Reduces the pressure on the local sewer network through water attenuation and regulation	
Can be used extensively for great effectiveness	

Table 6.12: Key advantages and disadvantages associated with the installation or use of permeable paving

[73] https://www.essexdesignguide.co.uk/suds

6.7 Downpipe Measures (Planters, Rain Gardens and Water Butts)

6.7.1 As a result of climate change and the need to combat the increase in frequency and severity of rainfall, there has been a big rise in the use of Sustainable Drainage Systems (SuDS).

6.7.2 Downpipe planter, Water butt and Rain garden arrangement shown below in Figure 6.7.

Figure 6.6: Examples of Downpipe planters, Water butts, and Rain gardens

6.7.3 In 2012, the National Planning Policy Framework (NPPF) made the incorporation of SuDS a mandatory requirement for all new major developments. This approach encourages water to be attenuated on site and released into the downstream drainage system at a controlled rate so as not to increase flood risk elsewhere.

6.7.4 SuDS are above-ground features used to delay the entry of rainwater into piped drainage systems. Features such as: water butts, swales, rain gardens and planters will collect, store and re-use water and reduce the risk of sewer surcharge.

6.7.5 SuDS also provide wider socio-environmental benefits including, but not limited to cooling the urban landscape, improving water quality, increasing biodiversity.

Costs

6.7.6 SuDS are a cheap, effective measure that can be installed on both residential and non-residential premises to reduce flood risk and achieve wider sustainable benefits.

6.7.7 The costs provided below are indicative for each product and should be used as a guide only. The costs for downpipe planter and rain garden have been obtained from SPONS: External Work and Landscaping Price Book (2018), however different contractors and specialist companies should be explored considering the wide range of costs associated with this option.

Details	Construction Cost	Total Cost	Unit
Simplified cost breakdown:			
Breaking out existing hardstanding, excavation of trench down to required depth, not exceeding 1m. Assumed concrete 100 - 200mm thick	£23.85		m^2
Removal, re-shape existing material up to 450mm deep (depending on application and ground conditions). Excavate in hard material; using scraper and ripper bulldozer; tarmacadam	£14.96		m^3
Disposal of acceptable material excluding Class 5A using 10 tonne capacity tipping lorry on site or off-site use not exceeding 1km; ADD per further km haul - m3/km - £2.26	£4.52		m^3
Support to opposing faces of excavation, timber, not exceeding 500mm	£11.48		m
Subbase 150mm thick gravel	£6.38		m^2
Terram synthetic fibre fabric as a geotextile membrane - Terram 1000; 0.70mm thick; mean water flow 50 l/m2/s	£2.18		m^2
Flexible plastic perforated pipe for connection into existing highway / surface water network, if appropriate, to a minimum depth of 450mm. Pipe size: 100mm dia; available in 100mm coil.	£226.19		100m
Boughton Loam; screened topsoil 10mm	£72.90		m^3
Total		**£362.46**	
Total (plus VAT)	**20% VAT**	**£434.95**	

Table 6.13: Rain garden cost breakdown and total costs summary

Details	Construction Cost	Total Cost	Unit
Simplified cost breakdown:			
Garden planter; plastic; 900mm x 600mm	£229.00		nr
Terram synthetic fibre fabric as a geotextile membrane - Terram 1000; 0.70mm thick; mean water flow 50 l/m2/s	£2.18		m^2
Flexible plastic perforated pipe for connection into existing highway / surface water network, if appropriate, to a minimum depth of 450mm. Pipe size: 100mm dia; available in 100mm coil.	£226.19		100m
Herbaceous planting including forming planting holes in appropriate soil and backfilling; average 4 plants per m2; 500mm centres	£9.58		m^2
Topsoil	£40.50		
Installation Cost (EA Costing tool)	£172.47		
Total		**£679.92**	
Total (plus VAT)	**20% VAT**	**£815.90**	

Table: 6.14: Downpipe planter cost breakdown and total costs summary

Details	Construction Cost	Total Cost	Unit
Simplified cost breakdown:			
250 litre Water Butt	£50.00		nr
Rain diverter kit	£5.00		nr
Water butt base	£50.00		nr
Installation - Connecting components to existing pipework and drainage system	£30.00		
Total		**£135.00**	
Total (plus VAT)	**20% VAT**	**£162.00**	

Table 6.15: Water butt cost breakdown and total costs summary

Planning Considerations

6.7.8 The installation of water butts will not require planning permission. Similarly, the installation of downpipe planters is unlikely to require planning permission and can generally be completed under permitted development.

6.7.9 Depending on the location and scale of the proposed rain garden, planning permission might need to be sought, however if within the curtilage of a property, then can be installed under Permitted Development. As such, consideration should be given to contacting the LPA for further advice.

6.7.10 Should the proposals require the alteration or disconnection of sections of pipework or sewers, then permissions from the landowner or water authority respectively would need to be obtained prior to the works.

Advantages and Disadvantages

6.7.11 Table 6.16 below provides a summary of key advantages and disadvantages associated with Downpipe planters, Rain gardens and Water butts. It should be noted that this list is not exhaustive and is only provided to help aid decisions where these features are considered.

Benefits and Advantages	Risks and Disadvantages
Aesthetically pleasing – can transform the urban landscape	Rain gardens require maintenance to prevent the spread of weeds
Can be installed under Permitted Development (check with LPA)	Water butts need to be regularly emptied to ensure water is being collected
Improves water quality by filtering out suspended solids and pollutants	Water butts and downpipe planters needs to be installed on a large scale to be really effective
Reduces the pressure on the local sewer network through water attenuation and regulation	
Can be used extensively for great effectiveness	
Water saving efficiencies	
Increase and improvements in biodiversity and habitat creation	
Cheap and effective features to install – can be installed on a large scale	

Table 6.16: Key advantages and disadvantages associated with the installation or use of Downpipe planters, Rain gardens, Water butts

6.8 Non-Return Valves

6.8.1 Non return valves (NRVs) are devices fitted inside pipework that only allow the flow of water in a single direction. They provide flood protection by preventing water or sewerage backing up towards a property or into a building.

Figure 6.7: An example of an in-pipe non-return valve[74] demonstrating how flows are only able to pass in one direction

6.8.2 NRV's are usually only installed in pipework where backflows pose a risk. Such risks are often linked to wider issues with sewer capacity or properties being on a low point in a sewer network, so it is strongly recommended further investigations be undertaken and conversations held with local sewerage providers where flooding occurs due to backflows or surcharging pipework.

6.8.3 A property own can install an NRV on drainage under their ownership at their discretion. Sewerage providers often install NRVs on adopted public sewers in areas where frequent flooding occurs due to sewers surcharging. Consideration for NRV's or wider risk reduction works are often driven by historic issues which are recorded on sewerage providers DG5 registers.

[74] http://www.kessel.com/index.php?id=produktsuche_en&han=72100R

6.8.4 NRVs are typically installed where private foul and surface water drainage pipework from a property meets an adopted public sewer. This position allows the pipe network between the NRV and entry points within the property to act as storage whilst the valve is closed, reducing the risk of flooding due systems being unable to accept incoming flows.

6.8.5 Pipe backflow protection options such as NRVs form part of wider suite of measures that can be fitted to a property to reduce flood risk, termed Property Flood Resilience (PFR). Other PFR measures include airbrick covers, demountable barriers and waterproof doors.

6.8.6 Wider PFR measures are not covered by this appraisal due to the wide range of measures available and significant variability in different options based on the age and size of the property being applied to. It should be noted that it is typically more difficult and expensive to fit PFR to commercial buildings than residential properties.

6.8.7 PFR measures are retrofit to existing properties at risk of flooding and should be considered as a last resort as they only provide protection and do not attempt to address the source of flooding. All new development should have any flood risks mitigated as part of the design and planning process through the incorporation of appropriate SuDS[75] (NPPF, Para 163c, 2019).

Costs

6.8.8 NRV's should be fitted into a manhole chamber to allow access for inspection and maintenance. Estimated costs are provided separately for both fitting to an existing chamber and where a new chamber needs to be constructed.

6.8.9 Cost Assumptions:

- Does not include costs associated with any consents, design requirements or inspections should the NRV be installed on an adopted sewer
- NRV is installed onto a 600mm diameter pipe
- Chamber is made of 1200mm diameter pre-cast concrete rings

75 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf

Details	Construction Cost	Total Cost	Unit
Simplified cost breakdown:			
Manhole construction	£854.84		each
Non-return valve	£500.00		each
Non-return valve installation	£172.47		each
New manhole chamber constructed:	£1390 - £2580	£2250 - £4180	per valve
Retrofit to existing manhole chamber:	£610 - £1140	£990 - £1840	per valve

Table 6.17: Non-return valve simplified cost breakdown and total costs summary

Planning Considerations

6.8.10 The installation of a non-return valve is unlikely to require planning permission unless a new manhole chamber needs to be constructed to accommodate it. It is recommended that an approach be made to the Local Planning Authority prior to any works being undertaken to ensure the appropriate permissions are sought.

6.8.11 Should planning permission be required it is recommended that other measures be considered in combination with the fitting of an NRV due to the lack of wider non-flood risk benefits the option provides.

6.8.12 Where an NRV is considered for installation it is also recommended that conversation be held with the relevant sewerage provider due to the potential links to wider network issues. Discussions may highlight other measures that could be undertaken to protect a wider area, or those that could be undertaken in partnership.

Advantages and Disadvantages

6.8.13 Table 6.18 below provides a summary of key advantages and disadvantages associated with non-return valves. It should be noted that this list is not exhaustive and is only provided to help aid decisions where this option is considered.

Benefits and Advantages	Risks and Disadvantages
Valves operate automatically	Require regular checks and maintenance to function as designed
Can be fitted horizontally or vertically and fit a wide range of pipe diameters	Function by shutting off the outlet to a pipe connection so can increase flood risk on the upstream network
Highly effective at reducing flooding where foul and/or surface water sewers surcharge	Can increase flood risk to a site depending on the capacity upstream of the valve
No visual impact once constructed	No wider benefits to amenity, ecology, or biodiversity

Table 6.18: Key advantages and disadvantages associated with the installation or use of non-return valves

6.9 Raising of Existing Fluvial Defences

6.9.1 This option constitutes increasing the height of existing flood defences to offer a higher level of protection from fluvial and coastal flooding.

6.9.2 The existing defences are primarily formed from earth embankments or sheet piled walls and provide flood protection by creating a raised barrier between properties and local rivers, estuaries, and the sea.

6.9.3 Within the study area defences exist alongside the River Chelmer and River Blackwater. These provide protection up to a 1%AEP fluvial flooding event and/or a 0.5%AEP tidal flooding event.

6.9.4 The provision and maintenance of fluvial and tidal flood defences falls under the responsibility of the Environment Agency.

6.9.5 A Shoreline Management Plan (SMP) is a strategic document that divides the coastline into policy units. Each unit details the levels and extents of intervention and is used to determine which areas of the coast are protected, and to what level, and whether existing defences are maintained, allowed to naturally deteriorate, or are removed.

Figure 6.8: View from Upstream of the Sadd's Dam Embankment that is within the Causeway Regeneration Area

6.9.6 Maldon falls within the East of England SMP (2010)[76], Management Unit F (Blackwater Estuary), Policy Unit F7[77] which has a policy of 'Hold the Line'. This designation means that the existing position of defences will be retained with the current standard of protection either maintained or upgraded.

6.9.7 The existing 2010 SMP is currently under review to update the contents to align with the upcoming epoch change (2025). It should be noted that policies regarding the levels of intervention are unlikely to change but may also be influenced by proposed or further developments in the Causeway area.

[76] Essex and South Suffolk Shoreline Management Plan (2010): http://www.eacg.org.uk/smp8.asp
[77] Essex and South Suffolk SMP, Section 4.7 (pages 174 to 191)

6.9.8 No works are currently planned to increase the heights of existing defences. Due to the high costs for fluvial defences and funding application processes future schemes are unlikely to be fully funded and as such contributions from those benefitting would likely be sought.

6.9.9 The amount of height increase used to undertake the cost calculations is 570mm, which constitutes the total sea level rise from the current 2020 level until 2075 (for further details, see Section 2.5). A 55-year timeframe has been used as this comprises of the average lifetime of commercial developments when seeking planning permission (50 years), plus 5 years to ensure the value remains relevant into the future.

Costs

6.9.10 Costs have been calculated for increasing the height of existing defences using clay/earth material and by constructing a wall. All costs have been reached by averaging costs from completed EA fluvial flood defence works[78]. An increase of 40% has been applied to account for the age of the sourcing documentation.

6.9.11 Earth embankment raising involves increasing the height by adding additional clay material. Surfaces receiving new material would have to be excavated to a small depth first to create a foundation for the new material to be keyed into. Clay would then be added and compacted to the required height.

6.9.12 Raising defences using a wall involves increasing the height by creating either a concrete or brick structure. Surfaces receiving a wall would require appropriate foundations to take the weight of the structure, manage the forces associated with flood conditions and to prevent any flows where they join.

6.9.13 Cost Assumptions:

- The earth embankment consists of imported clay material
- The new clay is keyed into the existing earth bund and mechanically compacted with no internal piling or other reinforcement
- The wall costs presented are an average value for concrete and brick structures
- As the majority of existing defences consist of earth embankments wall costs include the installation of sheet piling to create appropriate foundations

[78] Environment Agency Long Term Costing Tool: https://www.gov.uk/government/publications/long-term-costing-tool-for-flood-and-coastal-risk-management

Details	Construction Cost	Total Cost	Unit
Simplified cost breakdown:			
Earth bund raising	£260.40		per m
Wall construction	£1910.00		per m
Sheet piling	£481.00		per m
Earth bund raising:	£260 - £470	£410 - £770	per m
Wall construction:	£1870 - £3480	£3030 - £5630	per m

Table 6.19: Increasing existing fluvial defence height simplified cost breakdown and total costs summary

Planning Considerations

6.9.14 Any increase to the height of existing flood defences would require planning permission to be sought. Applications would need to be supported by a robust Flood Risk Assessment showing flood extents before and after the works, with details on changes due to additional water being displaced by the increased heights. Information should also be provided on the risks and processes or overtopping.

6.9.15 The Environment Agency would need to lead on the planning application for any works involving changes to existing fluvial and tidal flood defences. Due to their size, any proposals would involve consultations with local residents and businesses.

Advantages and Disadvantages

6.9.16 Table 6.20 below provides advantages and disadvantages associated with raising existing fluvial flood defences. It should be noted that this list is not exhaustive and is only provided to help aid decisions where this option is considered.

Benefits and Advantages	Risks and Disadvantages
Would be constructed on top of existing defences so new land would not be required	Very disruptive to construct
Provides protection to very large areas	Minimal biodiversity improvements
Can be used as an opportunity to provide improved local amenity such as through the creation of footpaths	Has a long design and construction timeframe due to the need for modelling and consultations
Very effective at providing protection up to the design level	Has very high total project costs due to the large scale of fluvial flood schemes
	Has a very high visual impact

Table 6.20: Key advantages and disadvantages associated with increasing the height of existing fluvial flood defences

6.10 New Drainage Connections

6.10.1 A new drainage connection involves installing a new pipe between building or areas at risk of flooding and an appropriate outlet such as an existing attenuation area, river or the sea.

6.10.2 Drainage connections reduce flood risk by increasing capacity and removing more water away from areas at risk more quickly. To operate successfully the water must be able to discharge from the system freely or pipes be oversized to allow water to be stored below ground.

6.10.3 The design on new piped systems would need to take account of existing drainage and other below ground services.

6.10.4 To maximise benefits pipework can be oversized (made bigger than the maximum flows it is required to take) to create storage. This allows water to be captured and held below the ground, reducing the impact on surface areas.

6.10.5 The routing of piped systems, size of pipes and locations of manholes can all be designed to take account of wider development and additional connections that may need to be made in the future.

6.10.6 If the constructors of a new piped drainage system are proposing that it be adopted, Anglian Water must be consulted at the earliest opportunity to ensure compliance with the required building standards and designs.

6.10.7 As piped systems are primarily below ground there are minimal opportunities for water to be lost via evaporation or absorbed by plants when compared to other options. Losses help alleviate flood risk further by increasing capacity and reducing pressures on existing systems so it is strongly recommended that where new pipework is considered it is done so in conjunction with other measures, such as green roofs, downpipe planter and/or bioretention areas to maximise benefits

6.10.8 It should also be noted that pipework only moves water from one area to another and therefore consideration must be given to the downstream systems new pipework is being connected into to ensure that flood risk is not purely moved from one location to another.

Costs

6.10.9 The costs provided are estimates based on retrofitting new pipework under an existing road. It should be noted that costs may be cheaper for delivering pipework as part of a development as construction can be combined with wider ground and surfacing works.

6.10.10 Costs have been calculated for 100m of pipework and averaged to give a per metre value. Due to the costing methodology it should be noted that shorter sections of pipework will have lower total project values but higher average costs per metre.

6.10.11 Construction costs include the following:

- A manhole chamber at the start and end of the run and one at every 50m interval (3 total for 100m of pipework)
- A pair of gullies (one for each side of the road) at the start and end of the run and a further pair at every 20m interval (12 total for 100m of pipework)
- One headwall with a non-return valve at the downstream end of the system

6.10.12 Cost Assumptions:

- The costings assume the new pipe will be laid underneath a road surface
- No costs have been included for the locating or re-routing of existing underground services
- Manholes have assumed to be installed at 50m intervals; more may be necessary where multiple changes in direction are required
- It has been assumed that the new system will outfall to an attenuation area, river or the sea, so includes a headwall and flap valve. Connections to existing systems may only require a chamber so will have lower costs

Details	Construction Cost	Total Cost	Unit
Simplified cost breakdown:			
Site preparation and pipe laying	£85.68		per m
Headwall construction	£450.00		per m
NRV and installation	£672.47		each
Chamber construction	£854.84		each
Gully construction	£645.12		each
Restoration works and resurfacing	£19.71		per m
New drainage system:	£185 - £340	£300 - £560	per m

Table 6.21: New piped drainage system simplified cost breakdown and total costs summary

Planning Considerations

6.10.13 Planning permission is likely to be required for new drainage systems and appropriate approaches should be made to the Local Planning Authority. When laying underneath an adopted road, road closure and work permits should also be sought from the relevant highway authority.

6.10.14 It should be noted that whilst such works do not contradict any of the planning policies listed in Section 2, drainage and flood mitigation measures involving SuDS will be preferred by planners and should be explored first.

6.10.15 Where a new pipe system discharges into a watercourse permission should be sought from the landowner. This is to ensure there is understanding of the potential impacts the new discharge will have on the downstream system and appropriate measures can be undertaken to mitigate against any erosion or increases to flood risk.

6.10.16 Connections into an existing system will require consent to be sought from the relevant sewerage provider.

6.10.17 For discharges to a main river the Environment Agency must be consulted, and any necessary Consents sought. Discharges to tidal waters or the sea need no formal permissions, but it is recommended that the EA be consulted on proposals where this occurs so that the impacts of tidal variations and tide-locking of systems can be appropriately accounted for.

6.10.18 It should be noted that discharge and connection permissions are entirely separate to any planning permissions that may be required, and all required permissions must be agreed and in place before works can commence.

6.10.19 Where it is proposed for new drainage systems to be adopted conversations should be held with the relevant sewerage provider at the earliest opportunity to ensure their requirements are met.

Other Considerations

6.10.20 Pipework is primarily installed under roads or paved areas to provide the best access to the system when required. As such retrofitting to existing areas may cause disruption to traffic, parking, or site operations, which must be taken account for.

6.10.21 Other services are installed under roads and paved areas for the same access reasons so appropriate investigations must be undertaken to identify and locate these during the design phase of any new drainage systems. It should be noted that where such services need to be moved to facilitate pipework then significant time and costs will be added to a project.

6.10.22 As such it is preferable to install pipework during new developments to allow all services to be installed at the same time whilst taking account of potential future needs so the potential for future works is minimised.

6.10.23 Table 6.22 below provides key advantages and disadvantages associated with installing a new drainage connection. It should be noted that this list is not exhaustive and is only provided to help aid decisions where this option is considered.

Benefits and Advantages	Risks and Disadvantages
New pipework can alleviate pressure on existing drainage networks	Disruptive to construct as requires digging up roads and areas of hard surfacing
Pipework can be designed to accommodate future development	Potential for clashes with other services when installed within roads
Pipework can be oversized to provide below ground storage	Minimal opportunity for improvements to ecology, biodiversity, and amenity
Minimal visual impact once constructed as the majority of features are below ground	Pipework only moves water from one area to another and does not provide opportunities for losses (absorption, evaporation) compared to other greener options
	As water can flow quickly through pipes serious consideration must be given to the downstream connections and areas to ensure flood risk is not just moved
	The efficiency of piped systems to reduce flood risk depends on the number, position, size and cleanliness of gullies and other inputs feeding water into it
	As systems are primarily below ground specialist maintenance, such as jetting, and CCTV surveys are required to ensure effective operation
	Consents and permissions may need to be sought from multiple organisations

Table 6.22: Key advantages and disadvantages associated with installing a new drainage connection

6.11 Attenuation Areas

6.11.1 Attenuation areas or flood storage areas are open features where surface water flows are captured and stored. Storage can be delivered as above or below ground. Above ground features involve creating a barrier, generally on a slope, to capture water behind it. Below ground features involve digging below the existing ground level and removing earth to create an area for water to be held.

6.11.2 Flood benefits are provided by capturing and holding surface water flows upstream of people or properties at risk. Attenuation areas generally have a restricted outlet to help promote the storage of water, which slowly releases flow after a rainfall event occurs, further reducing risk by decreasing the volume and peak flows of water entering the wider drainage network.

Figure 6.9: A grassed; below-ground detention basin created as part of the ECC Brickhouse Farm flood alleviation scheme in Maldon

6.11.3 Storage areas are highly flexible features and can be designed to fit into the space available. Areas can be dry under normal conditions or have a permanent water at the base to create a pond and they can be grassed or vegetated to provide wider ecology or amenity benefits. Side slopes are generally shallow to allow safe access and egress

6.11.4 Due to their nature storage areas require larger amounts of space to deliver and the benefits provided are directly linked to the amount of water able to be stored. However, due to their flexibility they can be accommodated well into developments based on the space available and also operate as multifunctional spaces that only activate and provide flood alleviation benefits during more extreme rainfall events.

Costs

6.11.5 The costs presented have been determined by averaging costs of completed flood alleviation schemes involving attenuation areas. These schemes constitute 8 EA and 8 ECC flood alleviation schemes.

6.11.6 EA scheme costings have been sourced from the EA Long Term Costing Tool (2008)[79] Only schemes with storage less than 50,000m^3 storage have been incorporated due to the significant footprint required to provide storage above this level. An increase of 30% has been applied to all costs due to the age of the information and lack of detail on the schemes.

6.11.7 ECC scheme costings have been calculated using costs from flood alleviation schemes delivered between 2017 and 2020 and involving the provision of both above and below ground storage or a combination of both. In calculating costs these schemes have been given a weighting of 2 relative to the EA schemes as specific details are known regarding the nature of the works and costs involved.

6.11.8 It should be noted that significant cost differences exist between attenuation works based on whether storage is provided above and below ground. Below ground schemes are more expensive due to the requirement to dig out, transport and dispose of spoil.

[79] https://www.gov.uk/government/publications/long-term-costing-tool-for-flood-and-coastal-risk-management

6.11.9 Due to the flatter nature of the Causeway study area it is anticipated that any attenuation schemes considered would be likely to require the provision of below ground storage. As such separate costs are provided based on the average of the 5 ECC flood schemes where below ground storage was created.

6.11.10 Cost Assumptions:

- Attenuation costs are provided from an average of above and below ground storage. It would be expected above ground storage to be cheaper and below ground to be more expensive than the figures provided
- Due to the lack of details regarding the EA schemes they have been given a lower weighting (1) than the ECC schemes (2)
- All ECC schemes include the costs of an outlet headwall and trash screen, an average of 20m of pipework, and a connection into an existing sewer network via the creation of a new manhole chamber
- All ECC schemes include costs for grassed attenuation areas with compensatory planting

Details	Construction Cost	Total Cost	Unit
Simplified cost breakdown:			
ECC flood schemes (average of 8)	£115.90		per m^3 storage
Average of all schemes (8 EA, 8 ECC)	£128.71		per m^3 storage
ECC flood schemes – below ground only (average of 5)	£158.42		per m^3 storage
Attenuation Area:	£90 - £170	£150 - £270	per m^3 storage
Attenuation area (below ground):	£110 - £200	£180 - £330	per m^3 storage

Table 6.23: Attenuation area simplified cost breakdown and total costs summary

Planning Considerations

6.11.11 The creation of an attenuation area would require planning permission from the Local planning Authority. Sites over 1ha will require a Flood Risk Assessment to be completed and for sites below this it is recommended a detailed assessment of the existing flood risk and improvements being provided are included within the application to aid justification. Overflow/spillway route details need to be provided, should follow existing flow paths so as not to exacerbate risk in areas without it already.

Advantages and Disadvantages

6.11.12 Table 6.24 below provides key advantages and disadvantages associated with creating an attenuation area. It should be noted that this list is not exhaustive and is only provided to help aid decisions where this option is considered.

Benefits and Advantages	Risks and Disadvantages
Provide significant benefits for biodiversity, ecology, and amenity	Requires space to create and storage is limited by the size available areas
Dry attenuation areas can have multiple uses (recreation space, amphitheatre/education space)	Prevent areas for having future development (may also be a benefit)
Designs are highly flexible and can be adapted to the space available	Can be disruptive to create due to the machinery required
Can have a permanent pond and/or include planting to maximise ecology and amenity benefits	Storage requiring spoil disposal is more disruptive and costly to install
Most cost-effective way to provide larger flood storage volumes	

Table 6.24: Key advantages and disadvantages associated with the creation of attenuation areas

Planning Policy

6.11.13 Planning policies exist to ensure flood risk is appropriately mitigated for during the planning process. Due to the high risks in the Causeway regeneration area, specific or tailored policies that exceed existing policies could be implemented to require maximum flood risk benefits or other betterments.

6.11.14 The implementation of such policies would need to be achieved via the direct inclusion of such policies into the Local Development Plan, or through the creation of a specific supplementary planning policy document.

6.11.15 The benefit of implementing such policies are that they would be holistic and provide standardisations that can go over and above measures that are investigated and implemented on a site by site basis. By being implemented at a strategic level such measures would have a significant impact on flood risk reduction, mitigation and awareness as well as best allowing future development and wide-scale flood risk to be accounted for.

6.11.16 For example policies could be implemented that:

- Require sites to provide storage and or benefits greater than those required by the NPPF
- Require runoff rates for brownfield sites be improved further than those required within the ECC SuDS Design Guide
- Require new developments to use green roofs and/or grey water recycling as a priority
- Apply ECC SuDS Design Guide requirements to all sites (as currently ECC are only consulted on major developments)

6.11.17 The above is provided purely as potential examples to prompt discussion and consideration of this option as a measure to reduce flood risk. No detailed or specific policy examples are provided within this appraisal as implementation would need to be discussed and assessed by local planners to take full account of wider planning policies, potential future site specific or strategic development, and consider how to implement them to ensure they are as effective as possible.

Advantages and Disadvantages

6.11.18 Table 6.25 below provides key advantages and disadvantages associated with reducing flood risk through changing planning policy. It should be noted that this list is not exhaustive and is only provided to help aid decisions where this option is considered.

Benefits and Advantages	Risks and Disadvantages
Holistic as would be applicable to all types and sizes of new developments	Would need to be implemented strategically and align with all other planning documentation and policies
Flexibility to have different policies or conditions associated with different spatial areas or types/scales of development	Potentially longer time frames for implementation as would require consultations and political approval
Clear policies provide standardisation surrounding flooding and drainage mitigation and could reduce application consultation times	
Would be an innovative way to strategically approach the way in which flood risk is addressed, both at a site level and at wider scales	

Table 6.25: Key advantages and disadvantages associated with mitigating flood risk through changes to planning policy

7 HOTSPOTS

7.0.1 The six flood risk Hotspots have been identified following a detailed assessment of the initial study area and the associated hydraulic modelling from each flood risk sources.

7.0.2 This section summarises the main sources of flood risk for each Hotspot and identifies where each risk occurs. It should be noted that no specific details are provided around locations of flooding from adopted sewers.

7.0.3 The potential options listed in Section 6 that are best suited to reducing risk in the area are outlined with potential areas to install or retrofit to provide a starting point when considering flood mitigation in the area.

7.0.4 Table 7.1 below summarises the key flood risks and potential options for each hotspot

Potential Option	Hotspot					
	1	2	3	4	5	6
Green Roofs	x	x	x	x	x	x
Rainwater re-use	x	x	x	x	x	x
Reprofiling and Bioretention Areas	x	x	x	x	x	x
Living Walls	x	x	x	x	x	x
Permeable Paving	x	x	x	x	x	x
Downpipe Measures	x	x	x	x	x	x
NRVs	x	x	x	x	x	x
Raising Existing Defences	x	x	x	x	x	x
New Drainage Connection		x	x	x	x	x
Attenuation Areas	x				x	x
Planning Policy	x	x	x	x	x	x

Table 7.1: Summary of key flood risks and potential options for each hotspot. Preferred options (those which are most favourable mitigation measures through planning and provide wider benefits) are highlighted.

7.1 Hotspot 1: Area around The Street

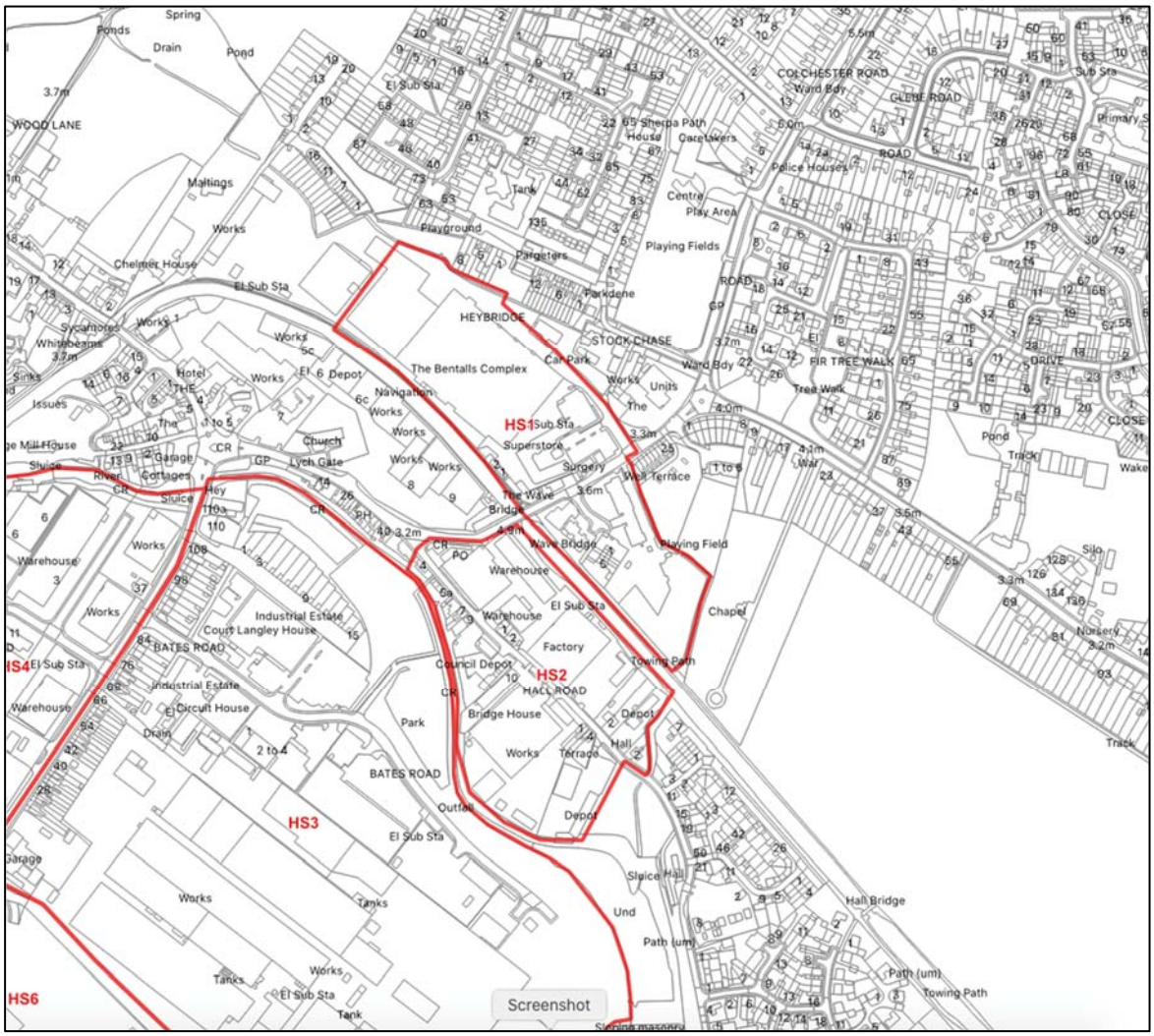

Figure 7.1: Hotspots 1 and 2

7.1.1 Hotspot 1 lies in Heybridge and covers the area immediately north-east of the Chelmer and Blackwater Navigation, north and south of The Street. It includes the Bentalls Estate and Heybridge Co-operative Academy.

7.1.2 The area is highly developed with commercial buildings in the Bentalls Estate and some residential properties and the Academy south of the Street. The only significant area of undeveloped green space forms the play area within the Academy.

7.1.3 The high point is located centrally at roughly 7.9m AOD, it then falls towards to the Chelmer and Blackwater Navigation both to the north west (4.8m AOD) and south east (5.2mAOD)[80].

7.1.4 The area has a bedrock of London Clay Formation, Clay, Silt and Sand. This is overlain by River Terrace Deposits, 1; Sand and Gravel[81].

Key Flood Risks and Locations

7.1.5 The area has the Chelmer and Blackwater Navigation along its south-western boundary and contains the Heybridge Hall Ditch which follows close to the north-eastern boundary.

7.1.6 Table 7.2 summarises the specific key area/s at risk from each source of flooding.

Flood Source	Key Risk Areas
Surface Water	Parts of the site are highly susceptible to Surface Water flood risk (3.33% AEP), mainly the North, North-eastern and South-eastern parts of the site. This is including the access route behind ASDA and the eastern part of the school playing fields
Fluvial	Hotspot 1 is entirely in Flood Zone 3 and the school fields are also susceptible to flooding from the adjacent watercourse Chelmer and Blackwater Navigation.
Tidal	Area is protected to 0.5% AEP events by existing flood defences
Groundwater	85% of the hotspot is susceptible to groundwater flooding (75% chance of groundwater flooding). This is the highest of all the hotspots.

Table 7.2: Hotspot 1 main areas at risk from each flood source

Possible Options

7.1.7 Table 7.3 outlines the potential options that could be implemented in the area and provides further details on potential locations. Total costs are also included for new build options to aid comparison.

7.1.8 It should be noted that options listed, and the locations stated, are not exhaustive and are provided purely as a starting point for discussions surrounding the mitigation of flood risk.

[80] Topographic mapping tool; https://en-gb.topographic-map.com/maps/d6y/Maldon/
[81] BGS online mapping tool; http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Potential Option	Location	Type	Newbuild Total Costs
Green roofs	On all new builds Retrofit on flat roofed buildings if structurally sound	Retrofit and new build	£286 - £531 per m^2
Rainwater reuse	Within all new builds if there is demand Retrofit into school Retrofit into Asda Retrofit into other industrial buildings if there is demand	Retrofit and new build	£4928 - £9153 per m^2
Bioretention areas	Ground reprofiling and areas in Asda car parking areas, in car parking opposite Asda, Where appropriate in new builds Direct towards bioretention areas.	Retrofit and new build	£193 - £358 per m^2
Green wall	Retrofit within school or on industrial buildings Where appropriate on new builds	Retrofit and new build	£449 - £834 per m^2
Permeable paving	Retrofit in all areas of car parking (subject to loading requirements) Where appropriate on new builds	Retrofit and new build	£175 - £324 per m^2
Downpipe measures (planters, raingardens, waterbutts)	Retrofit into all downpipe areas, especially Asda and the school. Where appropriate on new builds	Retrofit and new build	Planter: £924 - £1716 Rain Garden: £493 - £916 Water Butt: £184 - £341
Non-Return Valve	For all new and existing connections where there is a risk of backflows causing flooding	Retrofit and new build	£2252 - £4181 per valve (retrofit: £991 - £1841 per valve)
Improve existing Fluvial Defences	South east playing field for school bund or wall	Retrofit	Earth bund: £413 - £768 per m Wall: £3032 - £5631 per m
Attenuation Area	Where appropriate for new builds	New builds	Above ground: £146 - £271 per m^3 of storage Below ground: £180 - £334 per m^3 of storage

Table 7.3: Hotspot 1 potential options and locations

7.2 Hotspot 2: Area around Hall Road

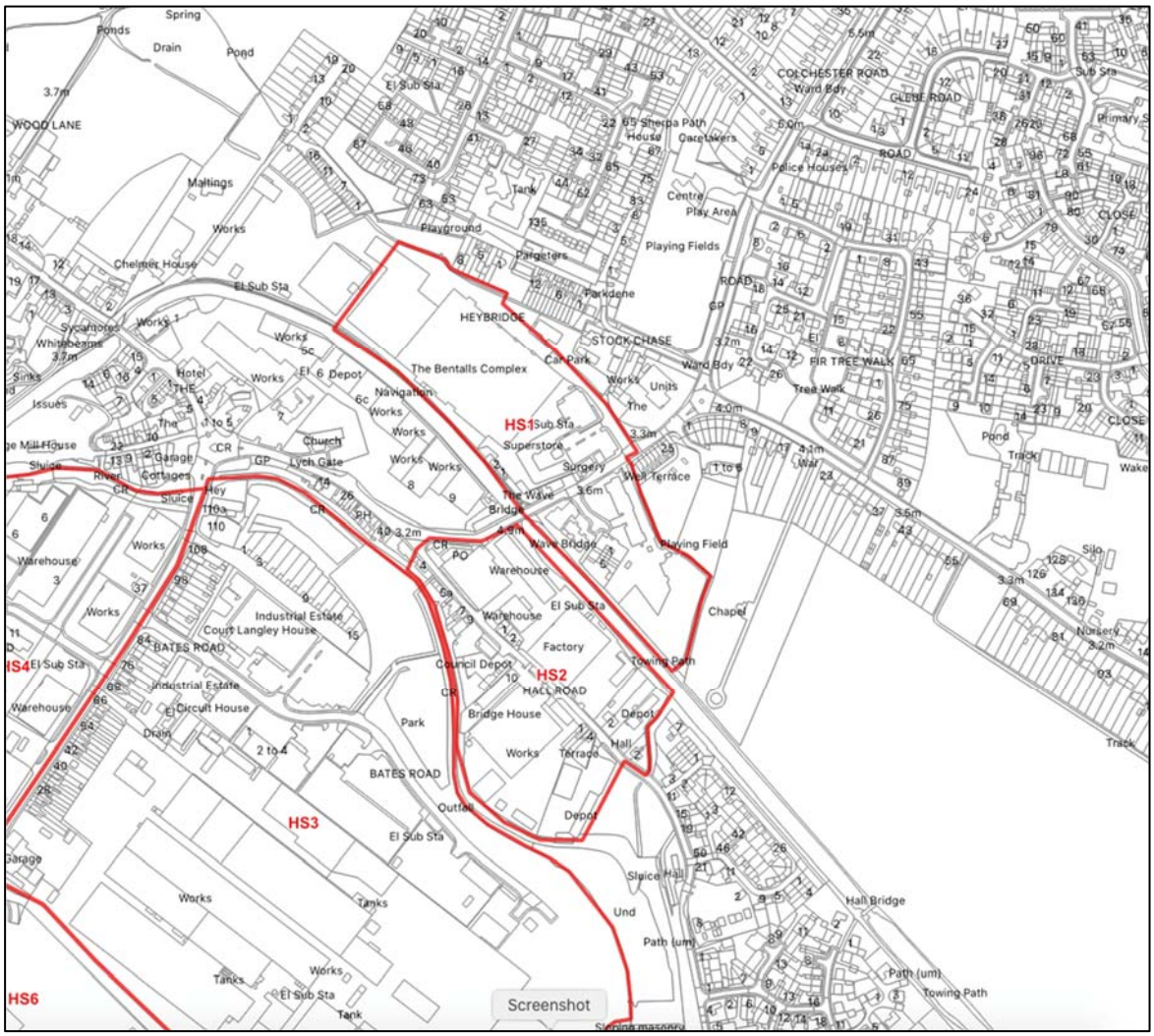

Figure 7.2: Hotspots 1 and 2

7.2.1 Hotspot 2 lies in Heybridge and covers the area of Hall road south of The Street between the Chelmer and Blackwater Navigation to the north-east and the River Blackwater to the south and west.

7.2.2 The area is currently completely developed with commercial buildings with no notable open or green spaces. A notable landmark is the former Bentall's Warehouse, a listed building, located adjacent the Chelmer & Blackwater Navigation.

7.2.3 Hotspot 2 is very flat with localised low points along Hall Road itself. The ground is generally only 1-2m higher than the tidal River Blackwater.

7.2.4 The area is protected from fluvial flooding by an earth embankment and attenuation areas on the north bank of the River Blackwater and downstream end of the Heybridge Hall Ditch respectively.

Key Flood Risks and Locations

7.2.5 The area has the Chelmer and Blackwater Navigation along its north-eastern boundary and the River Blackwater to its southern and western boundaries. The Heybridge Hall Ditch forms the south-eastern boundary which outfalls into an attenuation area immediately outside of the hotspot.

7.2.6 Table 7.4 summarises the specific key area/s at risk from each source of flooding.

Flood Source	Key Risk Areas
Surface Water	Localised flooding to Hall Road from all events, some flooding to car parks and paved areas surrounding commercial buildings during extreme events (0.1% AEP)
Fluvial	Entire hotspot is within Flood Zone 3
Tidal	Area is protected to 0.5% AEP events by existing flood defences
Groundwater	The entire hotspot falls within a 50-75% risk banding

Table 7.4: Hotspot 2 main areas at risk from each flood source

Possible Options

7.2.7 Table 7.5 outlines the potential options that could be implemented in the area and provides further details on potential locations. Total costs are also included for new build options to aid comparison.

7.2.8 It should be noted that options listed, and the locations stated, are not exhaustive and are provided purely as a starting point for discussions surrounding the mitigation of flood risk.

Potential Option	Location	Type	Newbuild Total Costs
Green roofs	On all new builds Retrofit on flat roofed buildings if structurally sound	Retrofit and new build	£286 - £531 per m^2
Rainwater reuse	Within all new builds if there is demand Retrofit into existing commercial buildings if there is demand	Retrofit and new build	£4928 - £9153 per m^2
Bioretention areas	Ground reprofiling and areas alongside Hall Road and within paved areas surrounding commercial buildings	Retrofit and new build	£193 - £358 per m^2
Green wall	Retrofit adjacent to existing commercial buildings Where appropriate on new builds	Retrofit and new build	£449 - £834 per m^2
Permeable paving	Retrofit in all areas of car parking (subject to loading requirements) Where appropriate on new builds	Retrofit and new build	£175 - £324 per m^2
Downpipe measures (planters, raingardens, waterbutts)	Retrofit into all downpipe areas, especially existing commercial buildings with larger roof areas Where appropriate on new builds	Retrofit and new build	Planter: £924 - £1716 Rain Garden: £493 - £916 Water Butt: £184 - £341
Non-Return Valve	For all new and existing connections where there is a risk of backflows causing flooding	Retrofit and new build	£2252 - £4181 per valve (retrofit: £991 - £1841 per valve)
Improve existing Fluvial Defences	Defences along the northern bank of the River Blackwater	Retrofit	Earth bund: £413 - £768 per m Wall: £3032 - £5631 per m
New Drainage Connection	Retrofit to Hall Road connecting into the existing attenuation area to the east	Retrofit	£299 - £555 per m

Table 7.5: Hotspot 2 potential options and locations

7.3 Hotspot 3: Area West of the Heybridge Creek

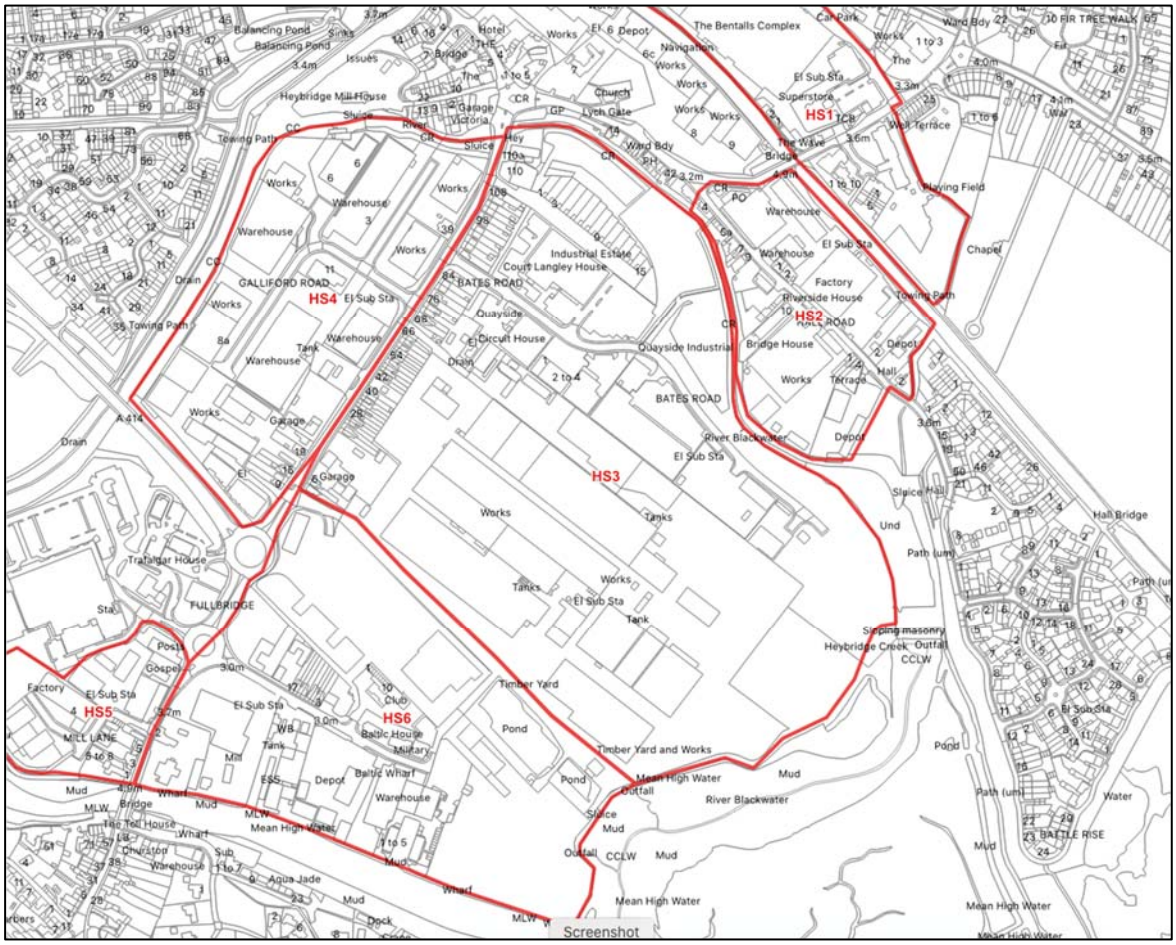

Figure 7.3: Hotspots 3 and 4

7.3.1 Hotspot 3 is situated immediately to the west of the Heybridge Creek and is comprised mainly of warehouses and non-residential buildings. The hotspot includes the residential buildings that front onto The Causeway (B1018).

7.3.2 The hotspot is bisected by Bates Road and includes an existing green space to the north which lies immediately south of the River Blackwater.

7.3.3 Generally, hotspot 3 is low-lying and is ranges from 3m AOD in the south east to 4m AOD in the north west[82].

[82] https://en-gb.topographic-map.com/maps/d6y/Maldon/

7.3.4 Hotspot 3 has a bedrock of London Clay Formation, Clay, Silt and Sand. This is overlain by River Terrace Deposits, 1; Sand and Gravel.[83]

Key Flood Risks and Locations

7.3.5 Hotspot 3 has the River Blackwater to the north and the Heybridge Creek along its eastern boundary. The entirety of the hotspot is situated in FZ3 and is protected by existing fluvial defences, maintained by the Environment Agency.

7.3.6 Table 7.6 below summarises the specific key area/s at risk from each source of flooding.

Flood Source	Key Risk Areas
Surface Water	Parts of the site are highly susceptible to Surface Water flood risk (3.33% AEP), mainly localised low points within Bates Road. There are, however, several low points across the hotspot that are also highly susceptible to surface water flooding.
Fluvial	Hotspot 3 is entirely situated in Flood Zone 3 but is protected by fluvial defences along the River Blackwater and Heybridge Creek.
Tidal	Area is protected to 0.5% AEP events by existing flood defences
Groundwater	Majority of the Hotspot (95%) situated within <=50% - <75% GW banding, 5% in <=75%.

Table 7.6: Hotspot 3 - Main areas at risk from each flood source

Possible Options

7.3.7 Table 7.7 below outlines the potential options that could be implemented in hotspot 3 and provides further details on potential locations. Total costs are also included for new build options to aid comparison.

7.3.8 It should be noted that options listed, and the locations stated, are not exhaustive and are provided purely as a starting point for discussions surrounding the mitigation of flood risk.

[83] BGS online mapping tool; http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Potential Option	Location	Type	Newbuild Total Costs
Green roofs	On all new builds. Retrofit on flat roofed non-residential buildings if structurally sound.	Retrofit and new build	£286 - £531 per m^2
Rainwater reuse	Within all new builds if there is demand. Retrofit onto other industrial buildings if there is demand. Retrofit onto existing car wash and dealership fronting onto The Causeway (B1018).	Retrofit and new build	£4928 - £9153 per m^2
Bioretention areas	Ground reprofiling and areas along Bates Road and within the existing green space immediately south of the River Blackwater. Where appropriate in new builds. Direct towards bioretention areas.	Retrofit and new build	£193 - £358 per m^2
Living/Green wall	Retrofit onto non-residential buildings if structurally sound. Where appropriate on new builds.	Retrofit and new build	£449 - £834 per m^2
Permeable paving	Retrofit in all areas of car parking (subject to loading requirements) Where appropriate on new build development.	Retrofit and new build	£175 - £324 per m^2
Downpipe measures (planters, raingardens, waterbutts)	Retrofit into all downpipe areas, specifically the non-residential buildings across the hotspot and buildings along Bates Road. Where appropriate on new builds. Retrofit where possible onto residential buildings fronting the B1018.	Retrofit and new build	Planter: £924 - £1716 Rain Garden: £493 - £916 Water Butt: £184 - £341
Non-Return Valve	For all new and existing connections where there is a risk of backflows causing flooding	Retrofit and new build	£2252 - £4181 per valve (retrofit: £991 - £1841 per valve)
Improve Existing Defences	Raise existing earth bund alongside Heybridge Creek	Retrofit	Earth bund: £413 - £768 per m Wall: £3032 - £5631 per m
New Drainage Connection	New pipe connection(s) into the existing attenuation area south of HS3 and north of HS6 or new pipe from Bates Road into the River Blackwater or Heybridge Creek	Retrofit	£299 - £555 per m

Table 7.7: Hotspot 3 potential options and locations

7.4 Hotspot 4: Area West of the Causeway, including Galliford Road

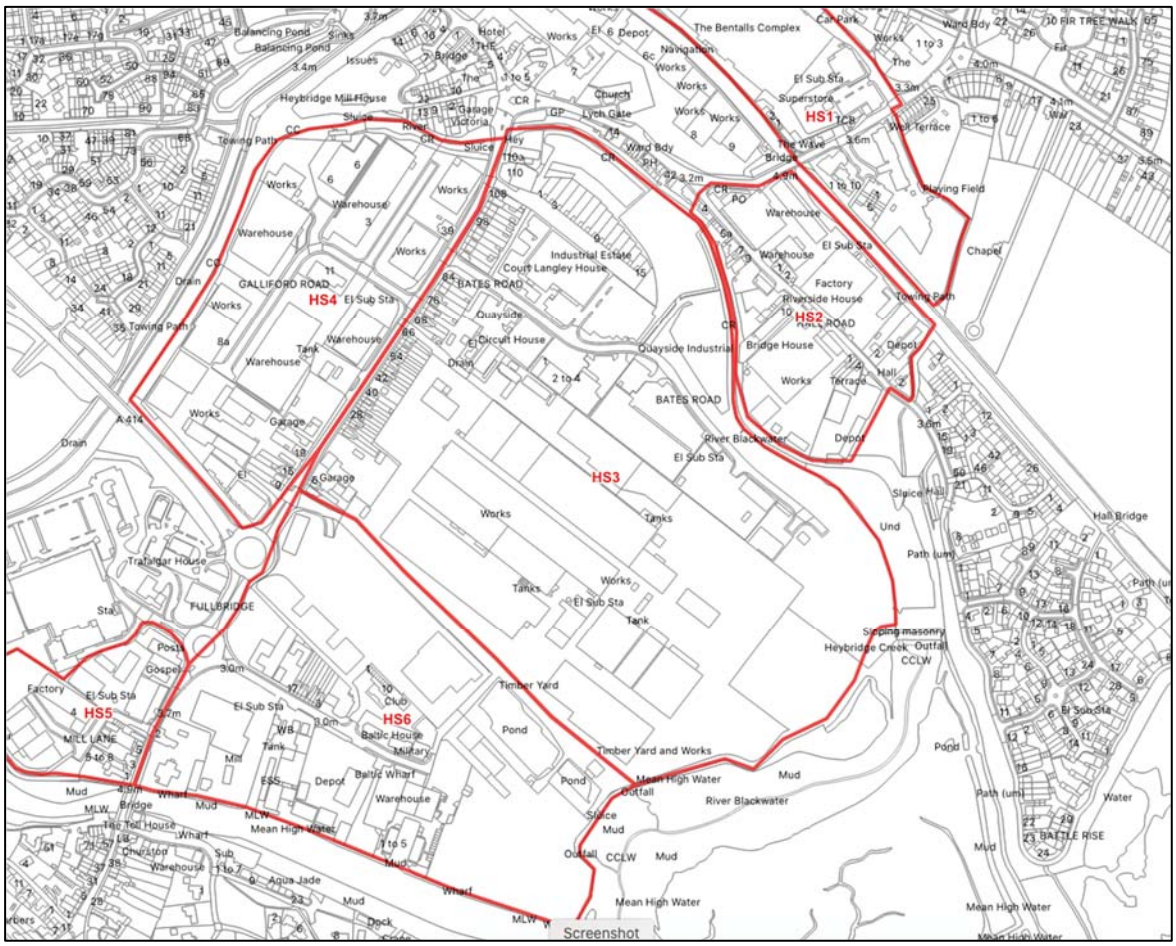

Figure 7.4: Hotspots 3 and 4

7.4.1 Hotspot 4 is to the west of The Causeway (B1018) and includes Galliford Road. It is bordered to the west by the Chelmer and Blackwater Navigation and to the north by the River Blackwater. The majority of this Hotspot is commercial with <5% being residential properties.

7.4.2 Hotspot 4 consists of a multitude of commercial properties, such a car dealership, carwashes, Travis Perkins, Dantech Electronic Engineering and Lemon Worldwide. There are no significant greenfield areas within Hotspot 4, therefore all development will either be brownfield new build or retrofitting.

7.4.3 Hotspot 4 is reasonably flat in terms of topography, ranging from 4.3m AOD in the East to 3m AOD in the West. The slight fall is towards the Chelmer and Blackwater Navigation.[84]

7.4.4 Hotspot 4 has a bedrock of London Clay Formation, Clay, Silt and Sand. This is overlain by superficial deposits of Alluvium; Clay, Silt, Sand and Gravel.[85]

7.4.5 Table 7.8 summarises the specific key area/s at risk from each source of flooding.

Flood Source	Key Risk Areas
Surface Water	Parts of the site are highly susceptible to Surface Water flood risk (3.33% AEP). This is mainly the within Galliford Road. The rest of the ground level hardstanding is at risk of 0.1% AEP surface water flooding
Fluvial	Hotspot 4 is entirely in Flood Zone 3
Tidal	Area is protected to 0.5% AEP events by existing flood defences
Groundwater	90% of the hotspot is susceptible to a 50% chance of groundwater flooding 10% of the hotspot is susceptible to a 75% chance of groundwater flooding

Table 7.8: Hotspot 4 main areas at risk from each flood source

Possible Options

7.4.6 Table 7.9 outlines the potential options that could be implemented in the area and provides further details on potential locations. Total costs are also included for new build options to aid comparison.

7.4.7 It should be noted that options listed, and the locations stated, are not exhaustive and are provided purely as a starting point for discussions surrounding the mitigation of flood risk.

[84] Topography Mapping tool : https://en-gb.topographic-map.com/maps/d6y/Maldon/
[85] BGS online mapping tool; http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Potential Option	Location	Type	Newbuild Total Costs
Green roofs	On all new builds Retrofit on flat roofed buildings if structurally sound	Retrofit and new build	£286 - £531 per m^2
Rainwater reuse	Within all new builds if there is demand Retrofit within car dealerships and carwashes as there should be demand Retrofit into other industrial buildings if there is demand	Retrofit and new build	£4928 - £9153 per m^2
Bioretention areas	Ground reprofiling and areas in Galliford Road and in car parking areas, direct towards bioretention areas. Where appropriate in new builds	Retrofit and new build	£193 - £358 per m^2
Green wall	Retrofit on industrial/commercial buildings where appropriate Where appropriate on new builds	Retrofit and new build	£449 - £834 per m^2
Permeable paving	Retrofit in all areas of car parking (subject to loading requirements) Where appropriate on new builds	Retrofit and new build	£175 - £324 per m^2
Downpipe measures (planters, raingardens, waterbutts)	Retrofit into all downpipe areas where appropriate – i.e building frontages Where appropriate on new builds	Retrofit and new build	Planter: £924 - £1716 Rain Garden: £493 - £916 Water Butt: £184 - £341
Non-Return Valve	For all new and existing connections into the Chelmer and Blackwater Navigation	Retrofit and new build	£2252 - £4181 per valve (retrofit: £991 - £1841 per valve)
Improve Existing Defences	Alongside Chelmer and Blackwater Navigation border	Retrofit	Earth bund: £413 - £768 per m Wall: £3032 - £5631 per m
New Drainage Connection	Under Galliford Road and/or The Causeway connecting into the Chelmer and Blackwater Navigation	Retrofit	£299 - £555 per m

Table 7.9: Hotspot 4 potential options and locations

7.5 Hotspot 5: Area North of River Chelmer and West of Fullbridge

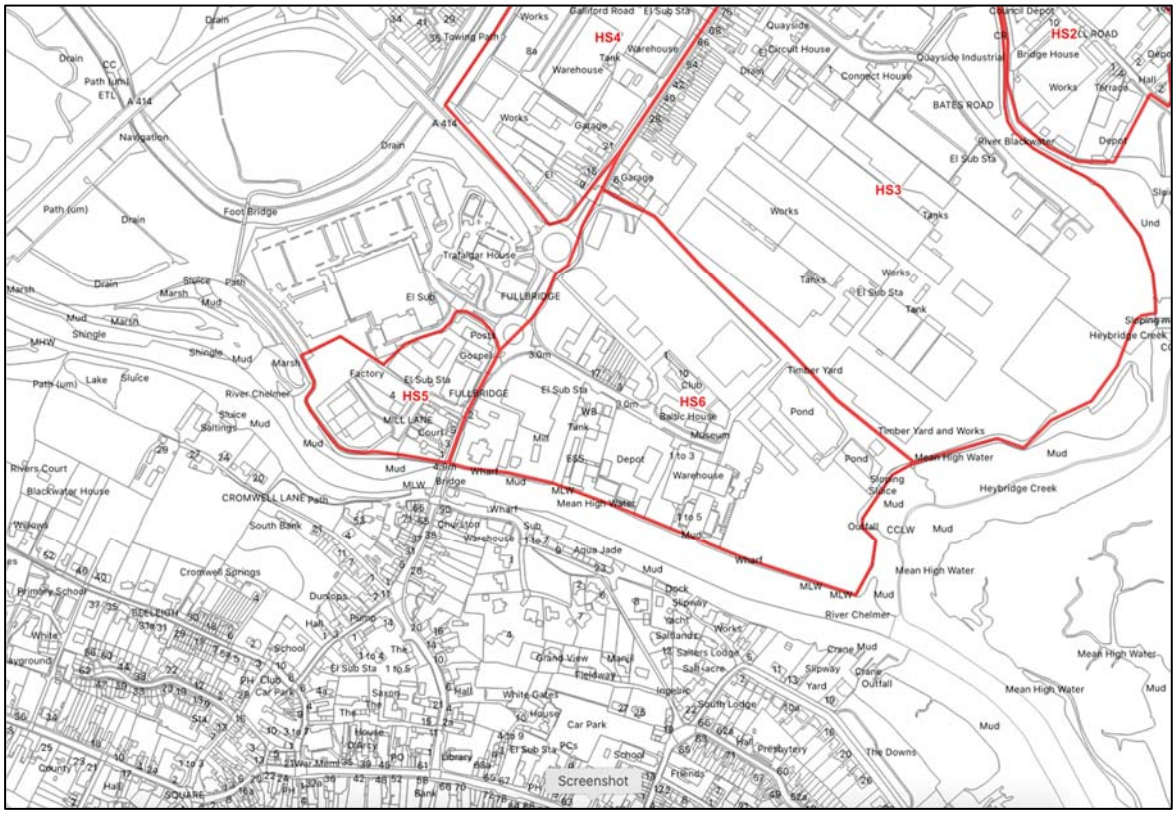

Figure 7.5: Hotspots 5 and 6

7.5.1 Hotspot 5 is the smallest hotspot located in the south west of the Causeway Regeneration Area. It is located immediately north of the River Chelmer and south of Tesco.

7.5.2 The hotspot is intersected by Mill Lane and notable landmarks include the Royal Mail Delivery Office, Fullbridge Church and the Sunny Sailor Public House located riverside along the Chelmer. There are notable listed buildings adjacent the bridge crossing at Fullbridge relating to the former Port of Maldon and the grain storage and milling processes in the Victorian era.

7.5.3 Hotspot 5 ranges from 1-4m AOD which include low points along Mill Lane and within the existing unused land to the north of the Royal Mail Delivery Office.

7.5.4 The hotspot has a bedrock of London Clay Formation, Clay, Silt and Sand. This is overlain by Alluvium – Clay, Silt Sand and Gravel.[86]

Key Flood Risks and Locations

7.5.5 Hotspot 5 is situated adjacent the River Chelmer to the south. The entirety of the hotspot is situated in FZ3 and is protected by existing fluvial defences, maintained by the Environment Agency.

7.5.6 Table 7.10 below summarises the specific key area/s at risk in Hotspot 5 from each source of flooding.

Flood Source	Key Risk Areas
Surface Water	Parts of the site are highly susceptible to Surface Water flood risk (3.33% AEP), mainly localised low points within Mill Lane and the existing unused land north of the Royal Mail Delivery Office. The rest of the hotspot is not susceptible to SW flooding.
Fluvial	Hotspot 5 is entirely situated in Flood Zone 3 but is protected by fluvial defences along the River Chelmer.
Tidal	Area is protected to 0.5% AEP events by existing flood defences
Groundwater	Majority of the Hotspot (60%) situated within the <=50% - <75% GW banding and 40% within <=25% - <50% meaning medium probability of flooding from GW sources.

Table 7.10: Hotspot 5 - Main areas at risk from each flood source

[86] BGS online mapping tool; http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Possible Options

7.5.7 Table 7.11 below outlines the potential options that could be implemented in the area and provides further details on potential locations. Total costs are also included for new build options to aid comparison.

7.5.8 It should be noted that options listed, and the locations stated, are not exhaustive and are provided purely as a starting point for discussions surrounding the mitigation of flood risk.

Potential Option	Location	Type	Newbuild Total Costs
Green roofs	On all new builds. Retrofit on flat roofed non-residential buildings if structurally sound.	Retrofit and new build	£286 - £531 per m^2
Rainwater reuse	Within all new builds if there is demand. Retrofit onto other industrial buildings if there is demand.	Retrofit and new build	£4928 - £9153 per m^2
Bioretention areas	Ground reprofiling and areas along Mill Lane and within the existing unused land north of the Royal Mail Delivery Office. Where appropriate on new builds development.	Retrofit and new build	£193 - £358 per m^2
Living/Green wall	Retrofit onto non-residential buildings if structurally sound. Where appropriate on new builds development.	Retrofit and new build	£449 - £834 per m^2
Permeable paving	Retrofit in all areas of car parking (subject to loading requirements) – Royal Mail Office, Fullbridge Church. Where appropriate on new build development.	Retrofit and new build	£175 - £324 per m^2
Downpipe measures (planters, raingardens, waterbutts)	Retrofit into all downpipe areas, specifically the non-residential buildings across the hotspot and buildings along Mill Lane. Where appropriate on new builds. Retrofit where possible onto residential buildings in hotspot.	Retrofit and new build	Planter: £924 - £1716 Rain Garden: £493 - £916 Water Butt: £184 - £341
Non-Return Valve	For all new and existing connections where there is a risk of backflows causing flooding	Retrofit and new build	£2252 - £4181 per valve (retrofit: £991 - £1841 per valve)
Improve Existing Defences	Improve defences alongside the River Chelmer	Retrofit	Earth bund: £413 - £768 per m Wall: £3032 - £5631 per m
New Drainage Connection	New pipe(s) from hotspot into the River Chelmer to the South	Retrofit	£299 - £555 per m
Attenuation Area	Where appropriate for new build development. Could look to formalise the existing unused land north of the Royal Mail Delivery Office into an attenuation area if appropriate. Downstream connection direct into the River Chelmer.	New builds	Above ground: £146 - £271 per m^3 of storage Below ground: £180 - £334 per m^3 of storage

Table 7.11: Hotspot 5 potential options and location

7.6 Hotspot 6: Area around Station Road

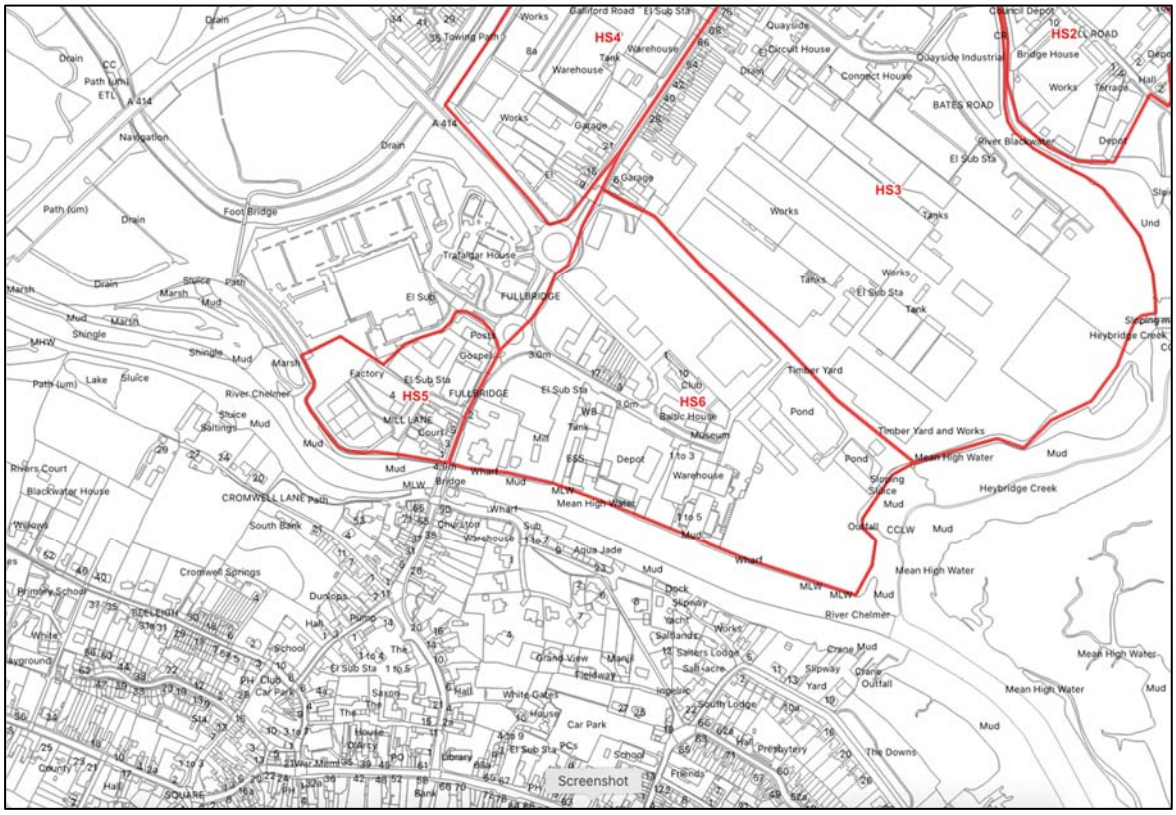

Figure 7.6: Hotspots 5 and 6

7.6.1 Hotspot 6 lies in Heybridge and covers the area east of Fullbridge and The Causeway with the River Chelmer to the south and the Heybridge Creek to the east. The northern boundary follows the industrial road between Brooks Bros and the Blackwater Retail Park.

7.6.2 The area is currently heavily developed with commercial buildings though some residential properties exist on Station Road and between Station Road and the River Chelmer. There is a currently undeveloped area of land to the east of Station Road adjacent to the River Chelmer and Heybridge Creek. The area has a number of listed buildings relating to the Victorian industrial era including Maldon East Railway Station, the former Ironworks, grain storage and the milling processes. The North Quay is within the Maldon Conservation Area.

7.6.3 Hotspot 6 is primarily flat with localised low points along Station Road and the industrial road. The ground is generally only 1-2m higher than the tidal River Chelmer and Heybridge Creek.

7.6.4 The area is protected from fluvial flooding by an earth embankment alongside Heybridge Creek and raised ground adjacent to the River Chelmer.

Key Flood Risks and Locations

7.6.5 Hotspot 6 has the River Chelmer and Heybridge Creek alongside its southern and eastern boundaries respectively. There is also an existing attenuation area south of the industrial road and east of the Blackwater Retail Park.

7.6.6 Table 7.12 summarises the specific key area/s at risk from each source of flooding.

Flood Source	Key Risk Areas
Surface Water	Localised flooding to Station Road and the Jewson hardstanding areas and the industrial road during more frequent (3.33% AEP events). Flooding to other areas surrounding commercial buildings during more extreme (0.1% AEP events)
Fluvial	Entire hotspot is within Flood Zone 3
Tidal	Area is protected to 0.5% AEP events by existing flood defences
Groundwater	The entire hotspot falls within a 50-75% risk banding

Table 7.12: Hotspot 6 main areas at risk from each flood source

Possible Options

7.6.7 Table 7.13 outlines the potential options that could be implemented in the area and provides further details on potential locations. Total costs are also included for new build options to aid comparison.

7.6.8 It should be noted that options listed, and the locations stated, are not exhaustive and are provided purely as a starting point for discussions surrounding the mitigation of flood risk.

Potential Option	Location	Type	£286 - £531 per m^2
Green roofs	On all new builds Retrofit on flat roofed buildings if structurally sound	Retrofit and new build	£4928 - £9153 per m^2
Rainwater reuse	Within all new builds if there is demand Retrofit into existing commercial buildings if there is demand	Retrofit and new build	£193 - £358 per m^2
Bioretention areas	Ground reprofiling and areas alongside Station Road and the industrial road and within paved areas surrounding commercial buildings	Retrofit and new build	£449 - £834 per m^2
Green wall	Retrofit adjacent to existing commercial buildings and w Where appropriate on new builds	Retrofit and new build	£175 - £324 per m^2
Permeable paving	Retrofit in all areas of car parking (subject to loading requirements) Where appropriate on new builds	Retrofit and new build	Planter: £924 - £1716 Rain Garden: £493 - £916 Water Butt: £184 - £341
Downpipe measures (planters, raingardens, waterbutts)	Retrofit into all downpipe areas, especially existing commercial buildings with larger roof areas Where appropriate on new builds	Retrofit and new build	£2252 - £4181 per valve (retrofit: £991 - £1841 per valve)
Non-Return Valve	For all new and existing connections where there is a risk of backflows causing flooding	Retrofit and new build	Earth bund: £413 - £768 per m Wall: £3032 - £5631 per m
New Drainage Connection	Retrofit to Station Road connecting to the River Chelmer and/or retrofit to industrial road connection into the existing attenuation area	Retrofit	£299 - £555 per m
Improve existing Fluvial Defences	Defences along the northern bank of the River Chelmer and western bank of Heybridge Creek	Retrofit	Above ground: £146 - £271 per m^3 of storage Below ground: £180 - £334 per m^3 of storage
Attenuation Area	New storage could be created within the currently unused land east of Station Road		£286 - £531 per m^2

Table 7.13: Hotspot 6 potential options and locations

8 APPENDICES

Appendix 1: List of partner contact details

Organisation	Website	email
Anglian Water (Assets and Flooding)	https://www.anglianwater.co.uk/services/sewers-and-drains/flooding/	
Anglian Water (Planning)	https://www.anglianwater.co.uk/developing/planning--capacity/planning-and-capacity/	planningliaison@anglianwater.co.uk
Environment Agency (Assets)	https://environment.data.gov.uk/asset-management/index.html	enquiries@environment-agency.gov.uk
Environment Agency (Flooding and Planning)	https://www.gov.uk/government/organisations/environment-agency	enquiries@environment-agency.gov.uk
Essex County Council (Environment)	https://www.essex.gov.uk/protecting-environment	environment@essex.gov.uk
Essex County Council (Assets and Flooding)	https://flood.essex.gov.uk/	floods@essex.gov.uk
Essex County Council (Highways)	https://www.essexhighways.org/roads-and-pavements/drainage-and-flooding.aspx	
Essex County Council (Planning and SuDS)	https://flood.essex.gov.uk/new-development-advice/apply-for-suds-advice/	suds@essex.gov.uk
Maldon DC (Flooding)	https://www.maldon.gov.uk/info/20093/flooding_and_drainage	
Maldon DC (Planning)	https://www.maldon.gov.uk/info/20046/development_management	