Loughton, Buckhurst Hill and Theydon Bois

Surface Water Management Plan

Final Report

June 2016

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RELATED DOCUMENTS

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	Essex Local Flood Risk Management Strategy	Capita Symonds	2013	03
	Thames Catchment Flood Management Plan	Environment Agency	2008	-

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- Environment Agency (EA)
- Thames Water (TW)
- British Geological Survey (BGS)
- Essex Highways (EH)
- Epping Forest District Council (EFDC)

Executive Summary

This document forms the Surface Water Management Plan (SWMP) for the towns of Loughton, Buckhurst Hill and Theydon Bois in the Epping Forest District of Essex. The report outlines the predicted risk and preferred surface water management strategy for Loughton, Buckhurst Hill and Theydon Bois. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall. A four phase approach has been undertaken in line with Defra's SWMP technical guidance documentation (2010).

Phase 1 work involved the collection and review of surface water information from key stakeholders and the building of partnerships between key stakeholders responsible for local flood risk management. The Phase 2 risk assessment consisted of a desktop investigation of available data and computer modelling of direct rainfall that falls within the study area under different rainfall scenarios. The areas identified to be at more significant risk have been delineated into Critical Drainage Areas (CDAs) representing the contributing catchment area and features that influence the predicted flood extent.

Within the study area a total of seven CDAs have been identified and are presented in the figure below. The dominant mechanisms for flooding can be broadly divided into the following categories: historical watercourse valleys; topographical low lying areas and low points; road and rail embankments; sewer flood risk; and fluvial / tidal flood risk. Based on historic flooding information the identified CDAs have experienced significant surface water flooding. Therefore, the next phase of work focussed on development of planning policy, small scale interventions as well as larger scale capital management options to manage flood risk, reflecting potential short, medium and long term intervention options.

Phase 3 (Options Assessment) identified a number of opportunities for measures to be implemented across the catchment to reduce the impact of surface water flooding. Ongoing maintenance of the drainage network and small scale improvements are already undertaken as part of normal operation within the study area. It is important to recognise that flooding within the catchment is not confined to just the CDAs, and therefore, there are opportunities for wider-scale measures to be implemented through the establishment of a policy position on issues including the widespread use of sustainable drainage systems (SuDS) measures such as water butts and rainwater harvesting, swales, permeable paving, bioretention / rain gardens and green roofs. In addition, there are study area wide opportunities to raise community awareness and change behaviour.

For each of the CDAs identified within the study area, site-specific measures have been identified that could be considered to help reduce the risk of surface water flooding. These measures were subsequently short listed to identify potential preferred options for each CDA. It is recommended that in the short to medium term ECC and EFDC:

- Engage with residents regarding the flood risk in their areas, to make them aware of their responsibilities for property drainage (especially in the CDAs) and steps that can be taken to improve flood resilience;
- Provide information to residents, to inform them of measures that can be taken to mitigate surface water flooding to / around their property;
- Prepare and implement a communication strategy to effectively communicate and raise awareness of surface water flood risk to different audiences; and
- Improve maintenance regimes to target those areas identified to regularly flood or known to have blocked gullies / culverts / watercourses.

Phase 4 establishes a long-term Action Plan for ECC, EFDC and other Risk Management Authorities to assist in their roles under the Flood and Water Management Act 2010 (FWMA 2010) to lead in the effective management of surface water flood risk across the catchment.

The purpose of the Action Plan is to:

- Outline the actions required to implement the preferred options identified in Phase 3;
- Identify the partners or stakeholders responsible for implementing the action; and
- Provide an indication of the priority of the actions and a timescale for delivery.

The SWMP Action Plan is a 'living' document, and as such, should be reviewed and updated regularly. Other triggers for update could include the occurrence of a significant surface water flood event, when / if additional data or modelling becomes available, following the outcome of investment decisions by partners and following any additional major development or changes in the catchment which may influence the surface water flood risk within the plan area . ECC is responsible for maintaining and updating the SWMP and related Action Plan.

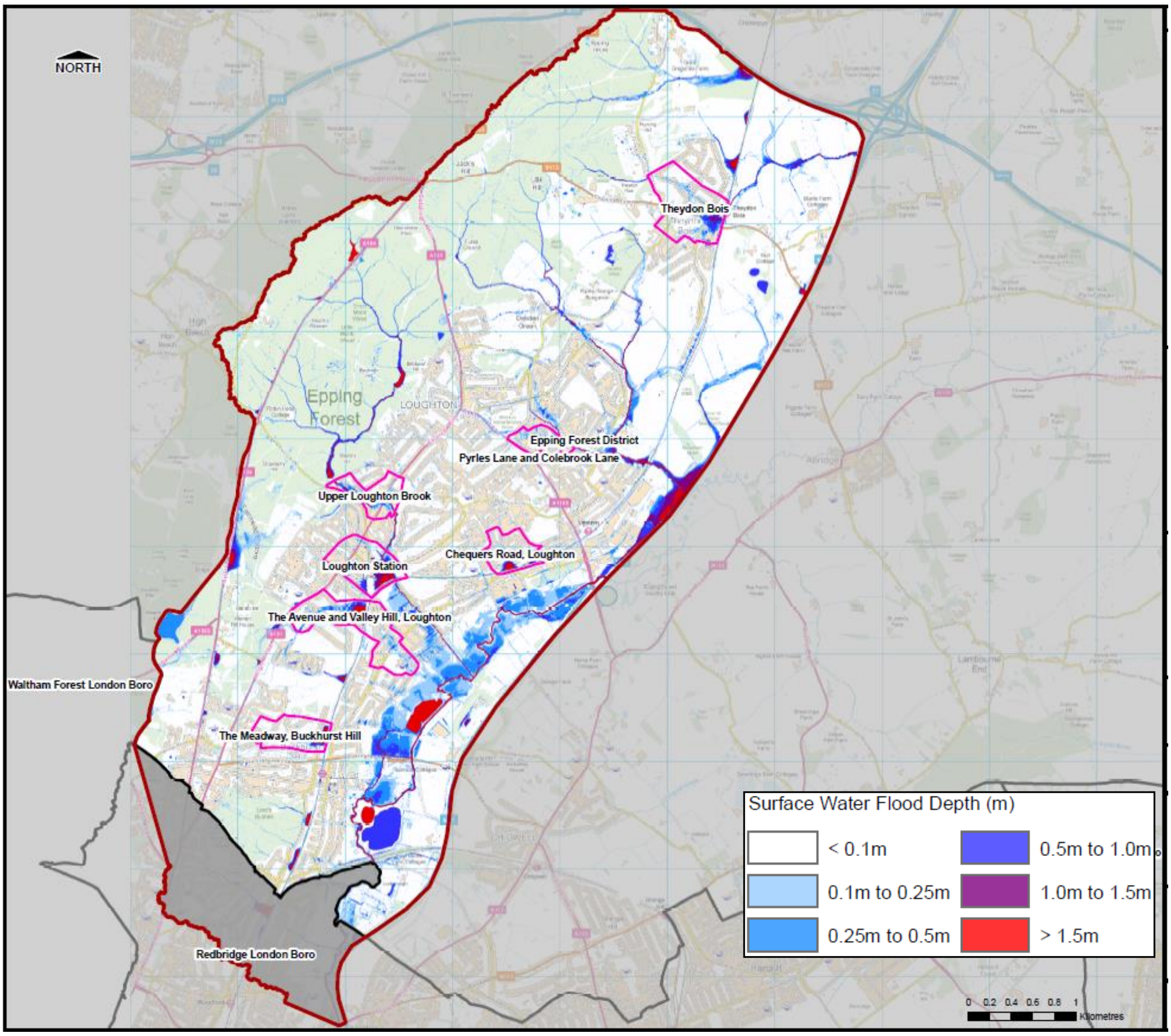

Figure i: Critical Drainage Area (CDA) with Predicted 1 in 100 year Surface Water Flood Event Depths

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1 Introduction

Capita Property and infrastructure (Capita) has been commissioned by Essex County Council (ECC) and Epping Forest District Council (EFDC) to prepare a Surface Water Management Plan (SWMP) which covers Phases 1, 2, 3 and 4 of the Defra guidance for the towns of Loughton, Buckhurst Hill and Theydon Bois, within the EFDC administrative area. Further references to these areas within the report will be abbreviated to LBT.

Epping Forest District is situated within the Metropolitan Green Belt, abutting the north-east edge of London, in the south west corner of Essex. It is comprised of the towns of Loughton/Buckhurst Hill (population 41,000), Waltham Abbey (pop. 20,400), Chigwell (pop. 12,500), Epping (pop. 11,000) and Chipping Ongar (pop. 6,000) together with villages, the largest of which are Theydon Bois, North Weald Bassett, Roydon and Nazeing.

Defra's National Rank Order of Settlements Susceptible to Surface Water Flooding (Defra, 2009) indicates that the Loughton area is vulnerable to surface water flooding and is ranked 313th out of 4,215 settlements in England, with an estimated 1,000 properties at risk of flooding. The Defra document did not contain any information regarding the vulnerability or flood risk rank for the other towns included in this study. Though consultation of EFDC these adjacent areas had experienced historical flooding, therefore it was decided to assess them as part of the SWMP.

ECC's Preliminary Flood Risk Assessment (PFRA), produced in January 2011, indicated that 43% of the recorded flood event occurred in Epping Forest; although differences between council authorities in recording and storing flood event data mean this cannot be taken as a reliable representation of the range in frequency or severity of flood risk within the district. The PFRA identified the Loughton area as a Tier 1 at risk area.

As part of the duties created by the Flood and Water Management Act (FWMA) 2010, Risk Management Authorities (RMA) are required to cooperate or manage the risk of local flooding – including surface water and groundwater. Under the Act ECC is classed as a Lead Local Flood Authority (LFRA) with the responsibility of managing the risk of flooding from local sources. As it has been previously identified that the LBT area is susceptible to surface water flooding, this SWMP will provide a basis for more effective management of surface water.

1.1 What is a Surface Water Management Plan?

A SWMP is a study to understand the flood risk that arises from local flooding, which is defined by the Flood and Water Management Act 2010 as flooding from surface runoff, groundwater and ordinary watercourses.

This SWMP study has been undertaken by ECC, the LLFA, in partnership with key local stakeholders responsible for surface water management and drainage in the LBT area including EFDC, Thames Water (TW) and the Environment Agency (EA).

The purpose of a SWMP is to identify what the local flood risk issues are, what damage may be caused, what options there may be to prevent them and who should take these options forward. This is presented in an action plan which lists the partners who are responsible for taking the various options forward. The action plan, which will be reviewed periodically, is agreed by all project partners to tackle the flood risks that are identified.

1.2 SWMP Process

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

1. Preparation: Identify the need for a SWMP, establish a partnership with the relevant stakeholders and scope SWMP (refer to Section 1);
2. Risk Assessment: Select an appropriate level risk assessment and complete it – a Level 2 Intermediate assessment was selected for this study (refer to Sections 2 and 3);
3. Options: Identify options/measures (with stakeholder engagement) which seek to alleviate the surface water flood risk within the study area (refer to Section 4); and
4. Implementation and Review: Prepare Action Plan and implement the monitoring and review process for these actions (refer to Appendix B).

1.3 Objectives

The objectives of the SWMP are to:

- Develop a thorough understanding of surface water flood risk in and around the study area, taking into account the implications of climate change, population and demographic change and increasing urbanisation in and around the LBT area;
- Identify, define and prioritise CDAs, including further definition of existing local flood risk zones and mapping new areas of potential flood risk;
- Make recommendations for holistic and integrated management of surface water management which improve emergency and land use planning, and support better flood risk and drainage infrastructure investments;
- Establish and consolidate partnerships between key stakeholders to facilitate a collaborative culture, promoting openness and sharing of data, skills, resource and learning, and encouraging improved coordination and collaborative working;
- Engage with stakeholders to raise awareness of surface water flooding, identify flood risks and assets, and agree mitigation measures and actions; and
- Deliver outputs to enable practical improvements or change where partners and stakeholders take ownership of their flood risk and commit to delivering and maintaining the recommended measures and actions.

1.4 Study Area

The study area comprises the towns of Loughton, Buckhurst Hill and Theydon Bois in Epping Forest District within the County of Essex. This area is predominantly urban with the main town of Loughton located in the centre, along with Theydon Bois to the north and Buckhurst Hill to the south. Epping Forest borders the study area to the north and west.

Loughton covers an area of 15 km^2 and is located on the south west edge of the County of Essex. Theydon Bois lies to the north of Loughton and occupies an area of approximately 7 km^2 and is located 2.2km south of Epping Forest. Buckhurst Hill covers an area of 2.7 km^2 and lies to the south of Loughton. The LBT study area is located next to the M11 corridor.

The spatial extent of the study area within this SWMP is focussed on the urban areas in and around Loughton, including Theydon Bois to the North and Buckhurst Hill to the South and is approximately 31 km^2. The study area is shown in Figure 1-1.

1.4.1 Major Rivers and Waterways within the Study Area

The Environment Agency Detailed River Network (DRN) dataset was used to identify watercourses within the study area. The study area falls within the River Roding catchment.

Three primary rivers flow through the model area before feeding into the River Roding:

1. An unnamed watercourse that flows from Theydon Bois eastwards before flowing south towards the Roding;
2. Loughton Hall Farm Ditch / Pyrles Brook which flow to the east of Loughton and is comprised of two smaller tributaries that join near Debden Park High School and St John Fisher Primary School; and
3. Loughton Brook, which flows through the centre of Loughton.

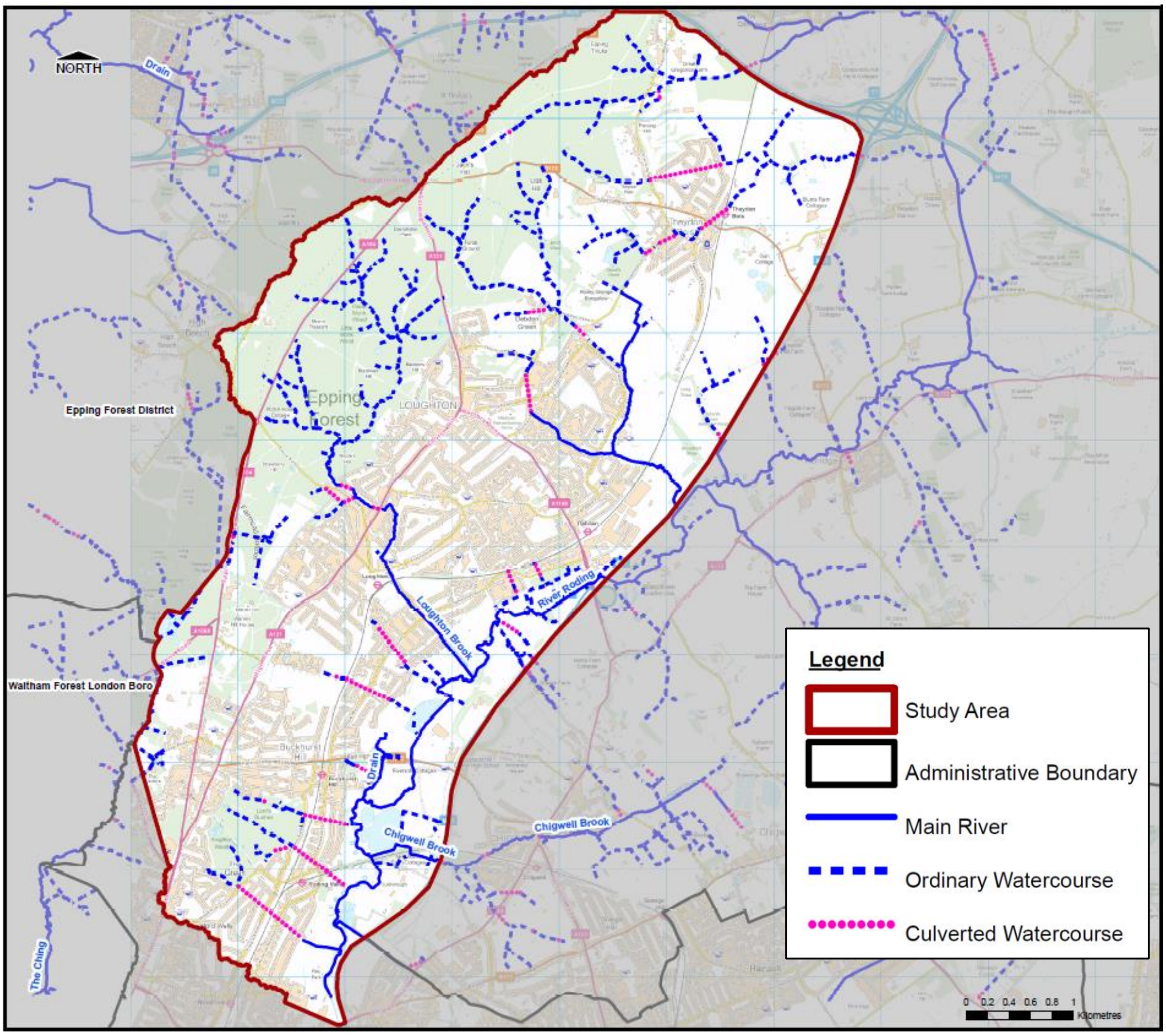


Figure 1-1 LBT Study Area

1.4.2 Location and Characteristics

The study area is comprised of the town of Loughton in the centre, Buckhurst Hill to the south and Theydon Bois to the north. The site is bounded by Epping Forest to the west and the M11 corridor to the east. The River Roding dominates the catchment running down the east of the study boundary from north east to south east. Loughton Brook flows from Epping Forest in the west through the south west of Loughton to join the River Roding in the south east of the study area.

Figure 1-2 (and Figures 2.0 – 2.5, within Appendix C), overleaf, provides an overview of the land uses within the study area.

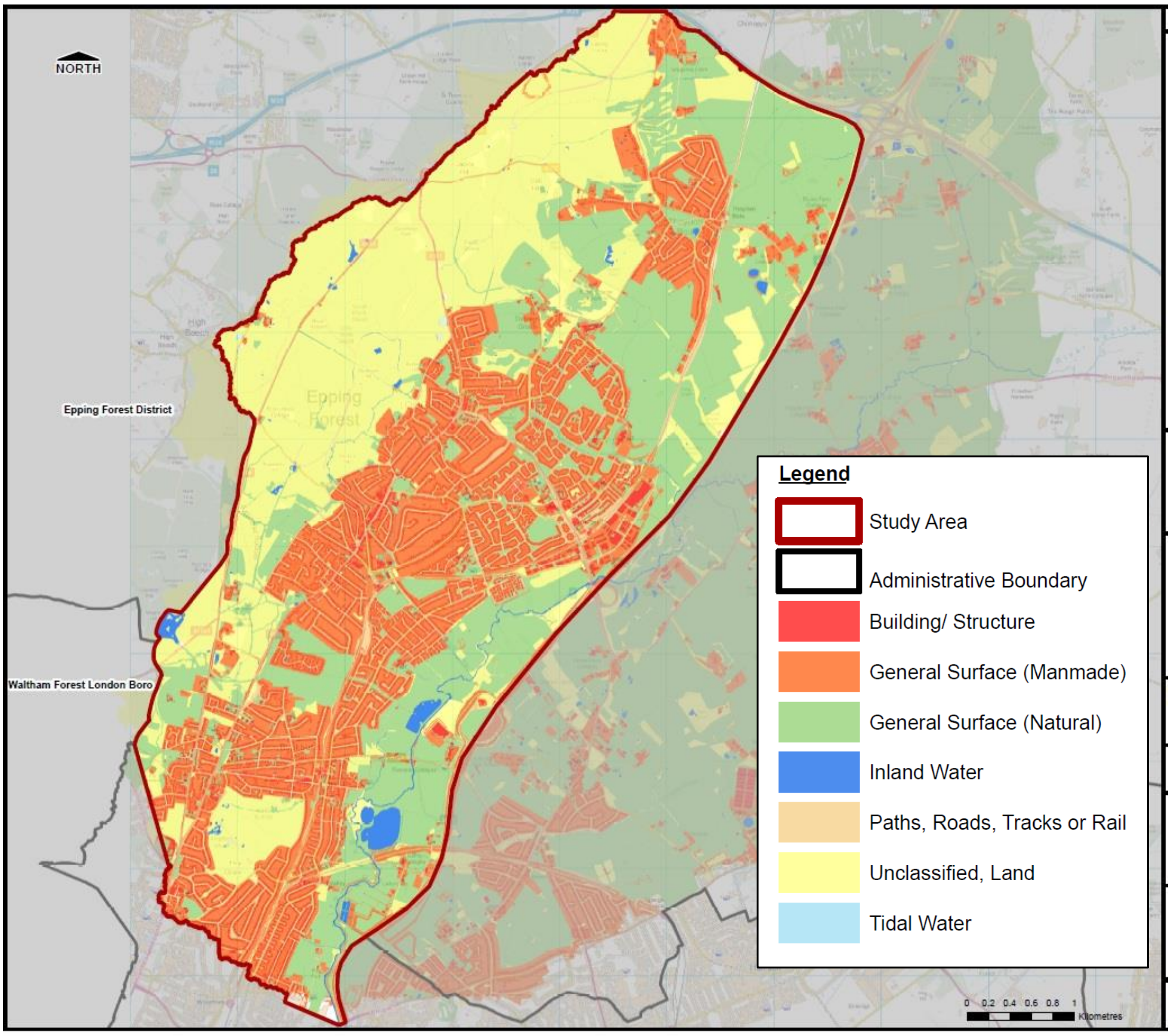


Figure 1-2 Land Uses within LBT

1.4.3 Topography and Geology

Figure 1-3 identifies the general topography of the study area. This figure highlights that the topography of the Loughton town catchment varies between 117mAOD- 7mAOD. High ground is located in the north and west of the study area with lower areas located in the south and east.

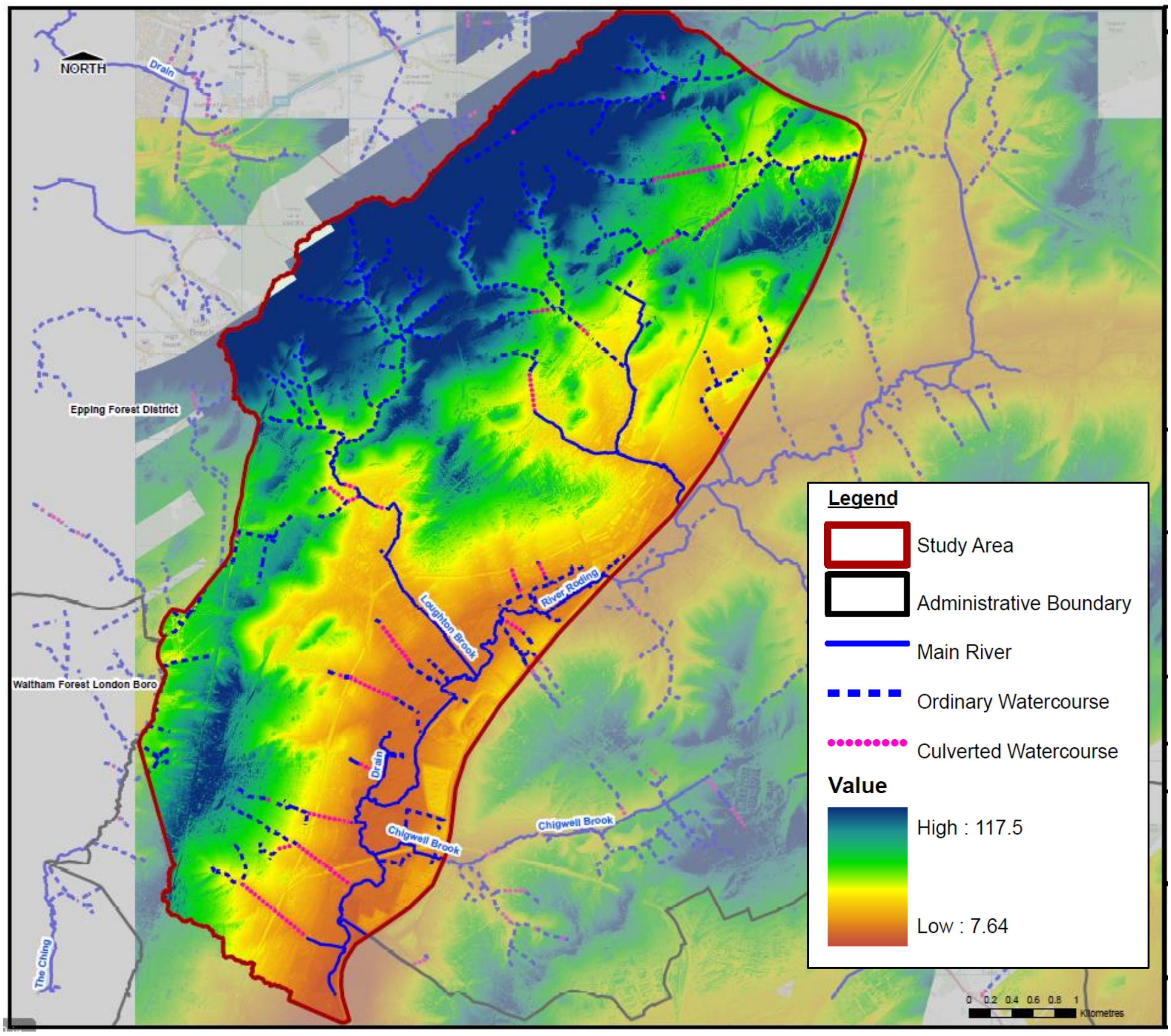


Figure 1-3 DTM Representation of the Topography within LBT

The geology of LBT is illustrated in Figure 1-4 overleaf. The solid geology of the area is dominated by London Clay Formation. In the North West, covering the Epping Forest area, the predominant bedrock is Claygate with the addition of Bagshot. The bedrock is overlain by superficial deposits of Stanmore Gravel (sand and gravel) in the topographic highs. The River Roding and Loughton Brook flow through alluvium deposits consisting of clay, silt, sand and gravel.

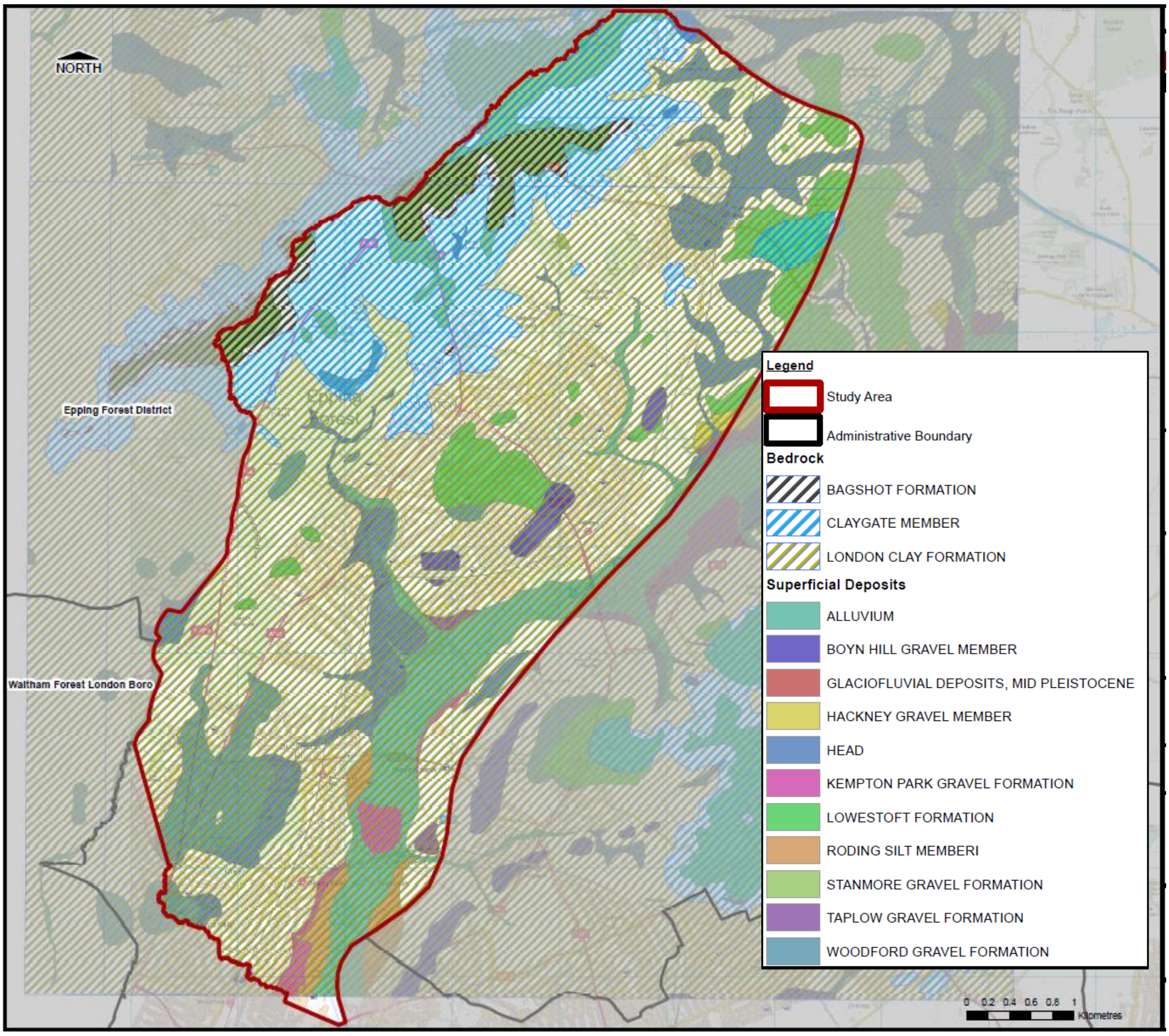


Figure 1-4 Geology of LBT

1.5 Key Stakeholders

In order to provide an integrated approach to surface water management, it is important that key stakeholders with responsibility for different flood mechanisms are able to work together in a coordinated effort. To this end, key stakeholders have been engaged throughout the duration of this study as illustrated in Figure 1-5. These groups have been consulted throughout the SWMP process and have provided key input at a number of stages of the study.

The study area also falls within the zone of responsibility for Thames Regional Flood and Coastal Committee (RFCC). This committee replaced the previous Regional Flood and Coastal Defence (RFCD) committee that existed until 31 March 2011 as part of national changes initiated by the FWMA 2010. The ECC representative on the RFCC are formed of elected members.

Figure 1-5 Key stakeholders engaged in the SWMP process

1.6 Significant Future Development Plans

EFDC is currently preparing a new Local Plan to replace the existing 1998 Local Plan. This new plan will guide the development in the district up to 2033. The plan will set out how and where homes, jobs, community facilities, shops and infrastructure will be delivered and the type of places and environments EFDC wants to create. It will also identify land to be protected from development, such as open space.

Public consultation on Issues and Options for the Epping Forest Local Plan took place in October 2012 and a further round of Local Plan consultation will take place in October 2016 for Epping's Preferred Approach. It is expected that adoption of the Local Plan will take place in summer 2018.

1.7 Links with Other Studies

It is important that the SWMP is not viewed as an isolated document, but one that connects with other strategic and local plans. It is also important that it fits in with other studies and plans and does not duplicate existing work.

Figure 1-6, overleaf, shows an interpretation of the drivers behind the LBT SWMP, the evidence base and how the SWMP supports the delivery of other key planning and investment processes.

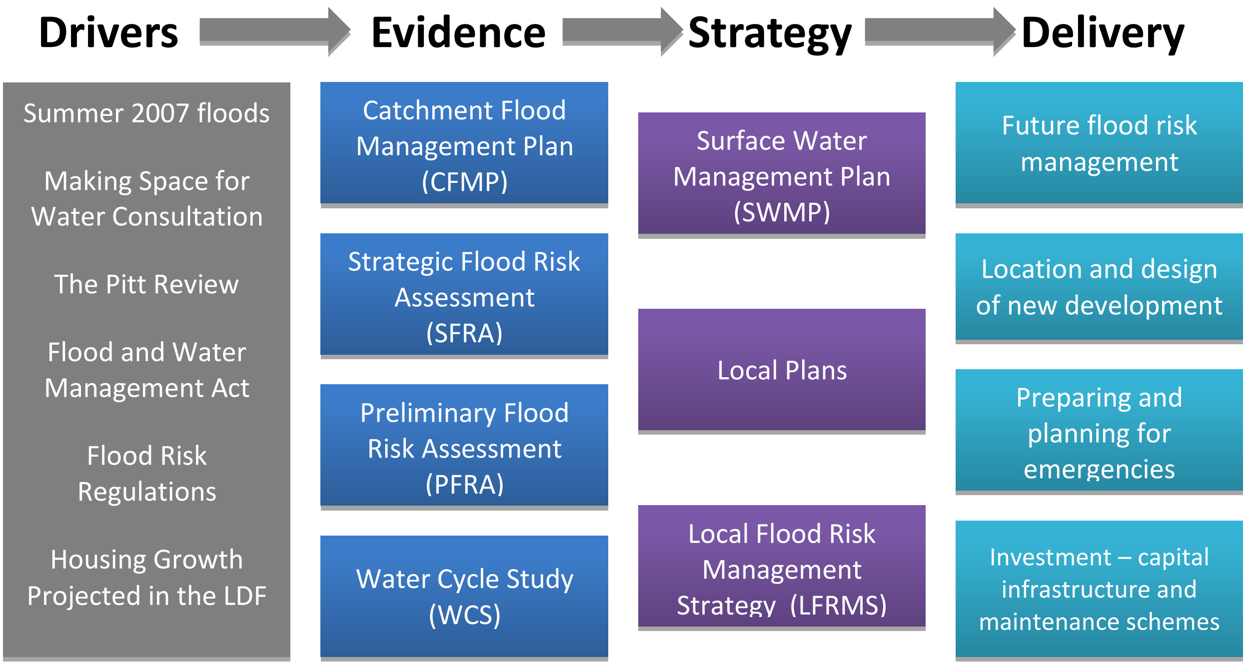


Figure 1-6 Where SWMPs fit in with Policy and Other Strategic Documents

Figure 1–6 highlights reports compiling evidence on flood risk (CFMP, SFRA, PFRA and WCS) and strategy documents (SWMP and LFRMS). The number of these reports and their nature running parallel to each other has primarily been driven by the timings of their production and data availability; however, the creation and existence of numerous different documents can be confusing. Some key details for these different studies and plans and how they are relevant to the study area are included below:

- Thames Catchment Flood Management Plan (2009) and Summary Report (2009) considers all types of inland flooding except flooding directly from the sea within the Thames catchment area;
- Essex County Council Preliminary Flood Risk Assessment - The PFRA process provides a consistent high level overview of the potential risk of flooding from local sources such as surface water, groundwater and ordinary water courses. The outputs from this SWMP will be able to inform future PFRA cycles, which will benefit from an increased level of information and understanding relating to surface water flood risk in LBT; and
- Essex County Council Flood Risk Management Strategy - The FWMA (2010) requires each LLFA to produce a Local Flood Risk Management Strategy for their administrative area. This SWMP will help support future updates of the LFRMS.

1.8 Partnership

As an LLFA, ECC is responsible for leading local flood risk management including establishing effective partnerships with stakeholders such as the EA, Local Authorities and Thames Water Utilities Ltd (TW) as well as others; achieved through Essex Flood Partnership Board. Ideally these working arrangements should be formalised to ensure clear lines of communication, mutual co-operation and management through the provision of Level of Service Agreements or Memoranda of Understanding.

As mentioned in Section1.5, the study area falls within the Thames RFCC. EFDC participate in the Essex Flood Risk Management Groups which currently includes departmental representatives from Development Management, Spatial Policy and Technical Services, in recognition of the cross-department input required on managing local flood risk.

Members of the public may also have valuable information to contribute to the SWMP and to an improved understanding and management of local flood risk within the study area. Public engagement can afford significant benefits to local flood risk management including building trust, gaining access to additional local knowledge and increasing the chances of stakeholder acceptance of options and decisions proposed in future flood risk management plans.

1.9 Level of Assessment

SWMPs can function at different geographical scales and as a result of this differing levels of detail may be necessary. Table 1-1 defines the levels of assessment that can be used within a SWMP.

Table 1-1: Level of assessment (adapted from Defra SWMP Guidance, March 2010)

Level of Assessment	Appropriate Scale	Outputs
Strategic Assessment	County or large conurbation (e.g. Essex county area)	• Broad understanding of locations that are more vulnerable to surface water flooding. • Prioritised list for further assessment. • Outline maps to inform spatial and emergency planning.
Intermediate Assessment	Large town or city (e.g. Loughton)	• Identify flood hotspots which might require further analysis through detailed assessment. • Identify immediate mitigation measures which can be implemented. • Inform spatial and emergency planning.
Detailed Assessment	Known flooding hotspots (e.g.CDAs)	• Detailed assessment of cause and consequences of flooding. • Use to understand the mechanisms and test potential mitigation measures.

Intermediate Assessment

As shown in Table 1-1, an intermediate assessment is applicable across a large town or city. Discussions with the Steering Group concluded that an intermediate assessment is considered to be an appropriate level of assessment to further quantify the risks within LBT and area.

The purpose of the intermediate assessment will be to further identify areas within LBT that are likely to be at greatest risk of surface water flooding and which may require further analysis through more detailed assessment.

The outputs from this assessment should be used to inform spatial and emergency planning. The outputs can also be used to identify potential mitigation measures which can be implemented in order to reduce surface water flood risk. These may include quick win measures such as improving maintenance and clearing blockages / obstructions from within the drainage network.

1.10 Data Collection

Data was collected from each of the following organisations:

- Essex County Council;
- British Geological Survey;
- Environment Agency;
- River Roding Flood Risk management Strategy (2012);
- Essex Highways;
- Thames Water; and
- Epping Forest District Council

Appendix E provides a summary of the data sources obtained from the organisations listed above, provides a description of each dataset and how the data was used in preparing the SWMP. Key datasets are summarised in the next section.

1.11 Data Review

1.11.1 Historic Records of Local Flooding

The most significant data gap across the study area relates to records of past 'local' flooding incidents. This is a common issue across the UK as record keeping of past floods has historically focussed on flooding from rivers or the sea, or has incorrectly attributed flooding to these sources. Records of past incidents of surface water, sewer, groundwater or ordinary watercourse flooding have been sporadic. ECC and EFDC have provided all available historic records that were accessible at the time of request. Where possible, these have been digitised into GIS form, however there is very little information on the probability, hazard or consequence of flooding.

TW has also provided postcode linked data on records of sewer flooding (known as the DG5 register).Detailed information regarding the exact location and cause of sewer flooding is not currently available.

1.11.2 Groundwater Records

Groundwater flooding is dependent on local variations in topography, geology and soils. The causes of groundwater flooding are generally understood; however it is difficult to predict the actual location, timing and extent of groundwater flooding without comprehensive datasets.

There is a lack of reliable measured datasets to undertake flood frequency analysis and even with datasets, this analysis is complicated due to the non-independence of groundwater level data. Surface water flooding incidents are sometimes mistaken for groundwater flooding incidents, such as where runoff via infiltration seeps from an embankment, rather than locally high groundwater levels.

1.11.3 Flooding Consequences

The National Receptors Database (NRD), version NRD 2011, data set was provided by the EA to allow property counts to be undertaken for this SWMP.

1.11.4 Topographic / Elevation Data

Topographic data has been provided by the EA in the form of 1m resolution LiDAR data. The EA have confirmed that this was flown in March 2009. The EA has also provided 0.5m resolution LiDAR data for the study, which covers the entire study area. The 0.5m LiDAR is more recent (it was flown in 2014) and is considered a good representation of the local topography therefore this was the dataset used to build the model.

1.11.5 Sewer Network Data

TW has provided GIS layers of the sewer network pipes and manholes within the study area (data were provided in July 2015). The GIS layers provide limited information on the sewer network. A review of the dataset highlighted missing invert levels for pipes and manholes as well as missing sizes / dimensions.

Essex Highways (EH) has provided a GIS layer of gullies within the study area. The layer provides gully locations only –no information has been provided on invert levels, dimensions or gully type. TW has provided post code-linked data (DG5 register) on records of sewer flooding up to approximately 20 years ago for use in this SWMP. Figure 7 in Appendix F provides a graphical representation of the DG5 data provided by TW.

2 Flooding

2.1 Risk Overview

The following sources of flooding are assessed and discussed in detail in the following sections of this report:

- Pluvial (surface water) flooding: runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or a watercourse.
- Flooding from ordinary watercourses: flooding which occurs as a result of the capacity of the watercourse being exceeded resulting in out of bank flow (water coming back out of rivers and streams).
- Sewer flooding: Flooding which occurs when the capacity of the underground drainage system is exceeded, resulting in flooding inside and outside of buildings. Normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters as a result of wet weather conditions.
- Flooding from groundwater sources: Occurs when the water level within the groundwater aquifer rises to the surface.

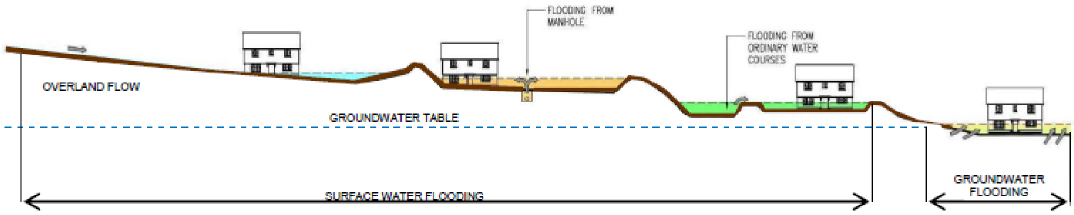


Figure 2-2-1 Illustration of Flood Sources[1]

The identification of areas at risk of flooding has been dominated by the assessment of pluvial flooding as these sources are expected to result in the greatest consequence (risk to life and damage to property), as well as by the quality of the information available for informing the assessment.

2.1.1 Historical Flooding

Past records of surface water flooding within the study area have been provided by various stakeholders. A breakdown of the incident data provided for the SWMP can be located within Appendix F, Figure 6.

The EA identifies historic flooding located along the River Roding in the south east of the study area. ECC flood incident reports record 11 points of flooding, two of which were from surface water, however the source(s) of flooding are unknown. The TW DG5 register for the EFDC identifies 130 properties flooded in the last 10 years, however some of these incidents may not be related to rainfall events. These recorded incidents have been reported to TW by the property owner. Figure 6 within Appendix F identifies the number of sewer flooding records reported per 5 digit postcode area over a 10 year period.

A review of historical flood records identifies the majority of the flood incidents recorded are located throughout the low lying urban areas within this study boundary.

[1] Adapted from Thatcham Surface Water Management Plan Volume One

Recorded flood data has also been used to verify areas which are identified as being at risk of flooding from previous known flood events, and to highlight any areas that may not have been picked up in previous studies.

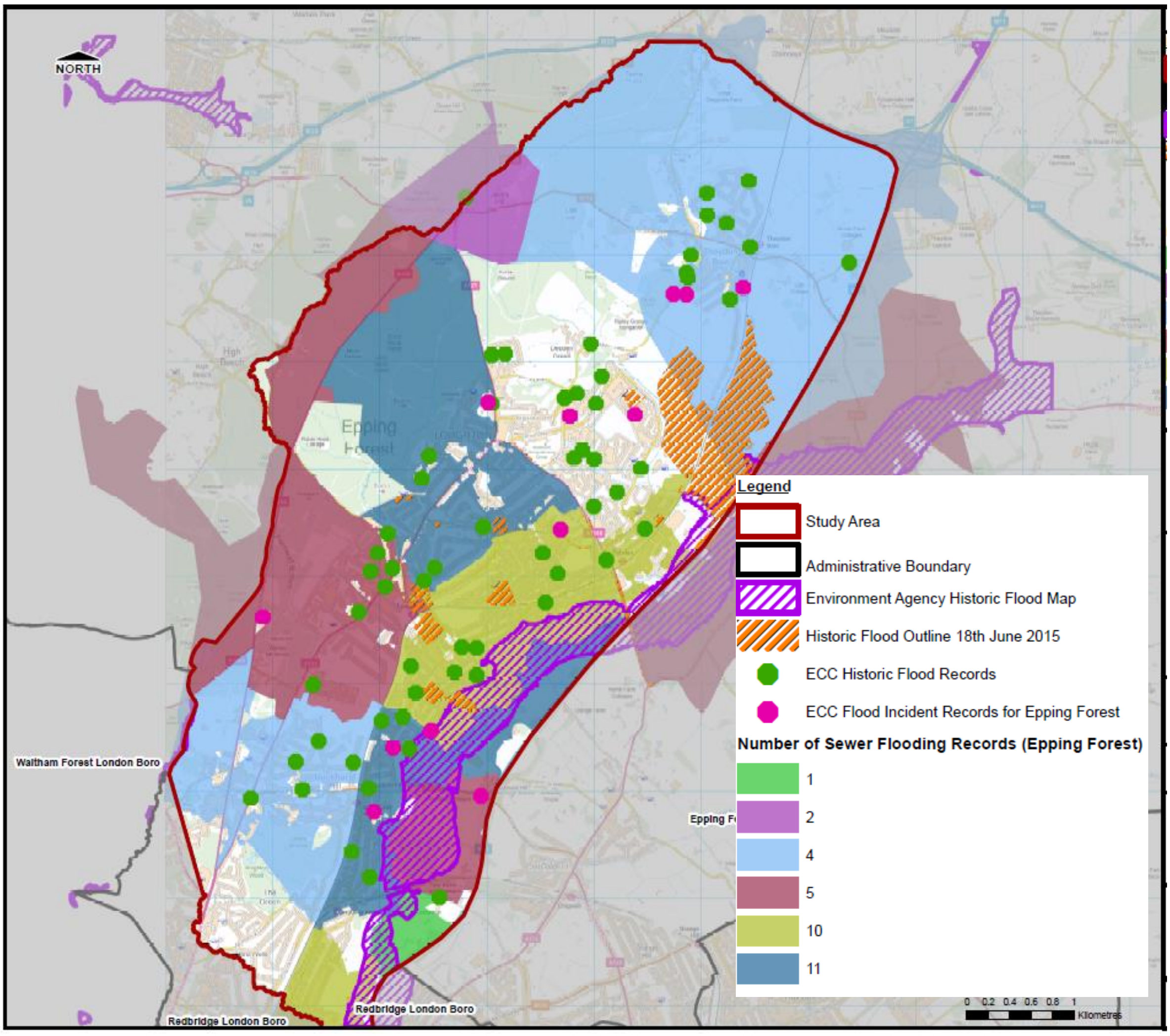


Figure 2-2 Historical Flood Events within LBT study area

2.2 Pluvial Flooding

2.2.1 Description

Pluvial flooding is most likely to occur when soils are saturated (or baked hard) such that they cannot infiltrate any additional water, or in urban areas where buildings, tarmac and concrete prevent water soaking into the ground. The excess water can pond (collect) in low points and result in the development of flow overland pathways, often along roads but also through built up areas and open spaces. This type of flooding is usually short lived and associated with heavy downpours of rain. Pluvial flooding can be exacerbated when the drainage network has insufficient capacity to manage the additional flow.

The potential volume of surface runoff in catchments is directly related to the size and shape of the catchment to that point. The amount of runoff is also a function of geology, hydrogeology, slope, climate, rainfall, saturation, soil type, urbanisation and vegetation.

2.2.2 Methodology for Assessment of Pluvial Flooding

Modelling Overview

Detailed hydraulic modelling has been undertaken for a range of rainfall event probabilities in order to further understand the causes and consequences of surface water flooding. The purpose of this modelling is to provide additional information where local knowledge is lacking and forms a basis for future detailed assessments in areas identified as high risk.

The selected rainfall event return periods were chosen through consultation with ECC. Table 2-1 provides details of the return periods that have been selected and the suggested uses of the various modelling outputs.

Table 2-1: Selected return periods and suggested use of outputs

Modelled Return Period	Suggested Use
1 in 10 year event *(0.1% AEP)*	Used to check the performance of the SuDS implemented in the area.
1 in 20 year event *(5% AEP)*	TW utilised the 1 in 20 year to identify properties that might be at risk of flooding. The identification of flooding from this scenario is also required for populating the Flood and Coastal Risk Management Grant in Aid (FCRM GiA) funding applications as it assists with highlighting areas at a very significant risk of flooding.
1 in 30 year event *(3.33% AEP)*	TW sewers are typically designed to accommodate rainfall events with a 1 in 30 year return period or less. This layer will identify areas that are prone to regular flooding and could be used by highway teams to inform maintenance regimes.
1 in 75 year event (1.3% AEP)	In areas where the likelihood of flooding is 1 in 75 years or greater, insurers may not guarantee to provide cover to property if it is affected by flooding. This layer should be used to inform spatial planning as if property cannot be guaranteed insurance, the development may not be viable. Based on the new (January 2013) National Flood Risk Assessment (NaFRA) proposals by the EA, this return period event is considered to border the 'significant' flood likelihood band – results from this event will help provide an audit trail as flood likelihood bands change or some processes are slow to change.
1 in 100 year event *(1% AEP)*	Can be overlaid with Environment Agency Flood Zone 3 layer to show areas at risk under the same return period event from surface water and main river flooding. Can be used to advise planning teams – please note that the pluvial 1 in 100 year event may differ from the fluvial event due to methods in runoff and routing calculations.
1 in 100 year event (plus climate change)	National Planning Policy Framework (NPPF) requires that the impact of climate change is fully assessed. Reference should be made to this flood outline by the spatial planning teams to assess the sustainability of developments.
1 in 200 year event *(0.5% AEP)*	To be used by emergency planning teams when formulating emergency evacuation plans from areas at risk of flooding. The new NaFRA banding indicates that this event is also required by Cabinet Office policy for determining the risk and resilience of critical infrastructure.

As part of this study, maps of maximum water depth and hazard for each of the return periods above have been prepared and are presented in Appendix F of this report. Additionally, ASCII grids and ESRI Shape files have been created and distributed to EFDC and ECC for use within their in-house GIS systems. When viewing the maps, it is important that the limitations of the modelling are considered – refer to key assumptions and uncertainties discussed later in this report.

The figures presented in Appendix F indicate that water is predicted to pond over a number of roads and residential properties. These generally occur at low points in the topography or where water is confined behind an obstruction or embankment. Some of the records of surface water flooding shown in Figure 2-2 have been used to verify the modelling results. Discussions with Council technical officers have also provided anecdotal support for several of the locations identified as being susceptible to flooding. The results of the assessment have been used to identify CDAs across the study area.

Appendix D provides a full methodology of the hydraulic modelling undertaken, including details of model parameters, hydrology and modelling assumptions.

2.2.3 Uncertainty in flood risk assessment – Surface Water Modelling

The surface water modelling provides the most detailed information to date on the mechanisms, extent and hazard which may result from high intensity rainfall across the study area. However, due to the strategic nature of this study and the limitations of some data sets, there are limitations and uncertainties in the assessment approach of which the reader should be aware.

There is a lack of reliable measured datasets and the estimation of the return period (probability) for flood events is therefore difficult to verify. The broad scale mapping provides an initial guide to areas that may be at risk; however there are a number of limitations to using the information:

- The mapping should not be used in a scale to identify individual properties at risk of surface water flooding. It can only be used as a general indication of areas potentially at risk.
- Whilst modelled rainfall input has been modified to reflect the possible impacts of climate change it should be acknowledged that this type of flooding scenario is uncertain and likely to be very site specific. More intense short duration rainfall and higher volume more prolonged winter rainfall are likely to exacerbate flooding in the future.

2.2.4 Model Verification

It is important to ensure that the outputs from the modelling process are as reliable as possible. To this end, a number of actions and data sources have been used to check the validity of the model outputs, including the following:

Ground-truth model

This stage of verification involved reviewing the hydraulic model outputs against the initial site inspections / assessment to ensure that the predictions were realistic and considered local topography and identified drainage patterns. Where previous site inspection data did not provide sufficient information on a specific area within the study, the model outputs were assessed against aerial photography from third party sources to assist in the model verification.

EA national surface water mapping

The EA has produced two national surface water datasets using a coarse scale national methodology:

- Areas Susceptible to Surface Water Flooding (AStSWF); and
- Updated Flood Map for Surface Water (UFMfSW).

As a method of validation, the outputs from these datasets have been compared to the SWMP modelling outputs to ensure similar flood depths and extents have been predicted. There are slight variations, due to the more accurate methodology used in the SWMP risk assessment, but generally the outputs with relation to ponding locations and flow paths are very similar. The extent of the depths was noticed to vary slightly, as shown in the example in Figure 2-3.

This observation provides confidence in the final model outputs as the variation in the results is concluded as being related to the more refined DTM (used within this study) and the catchment specific critical durations (as the EA uFMfSW maps utilised a single duration to represent runoff throughout England) defined in this report.

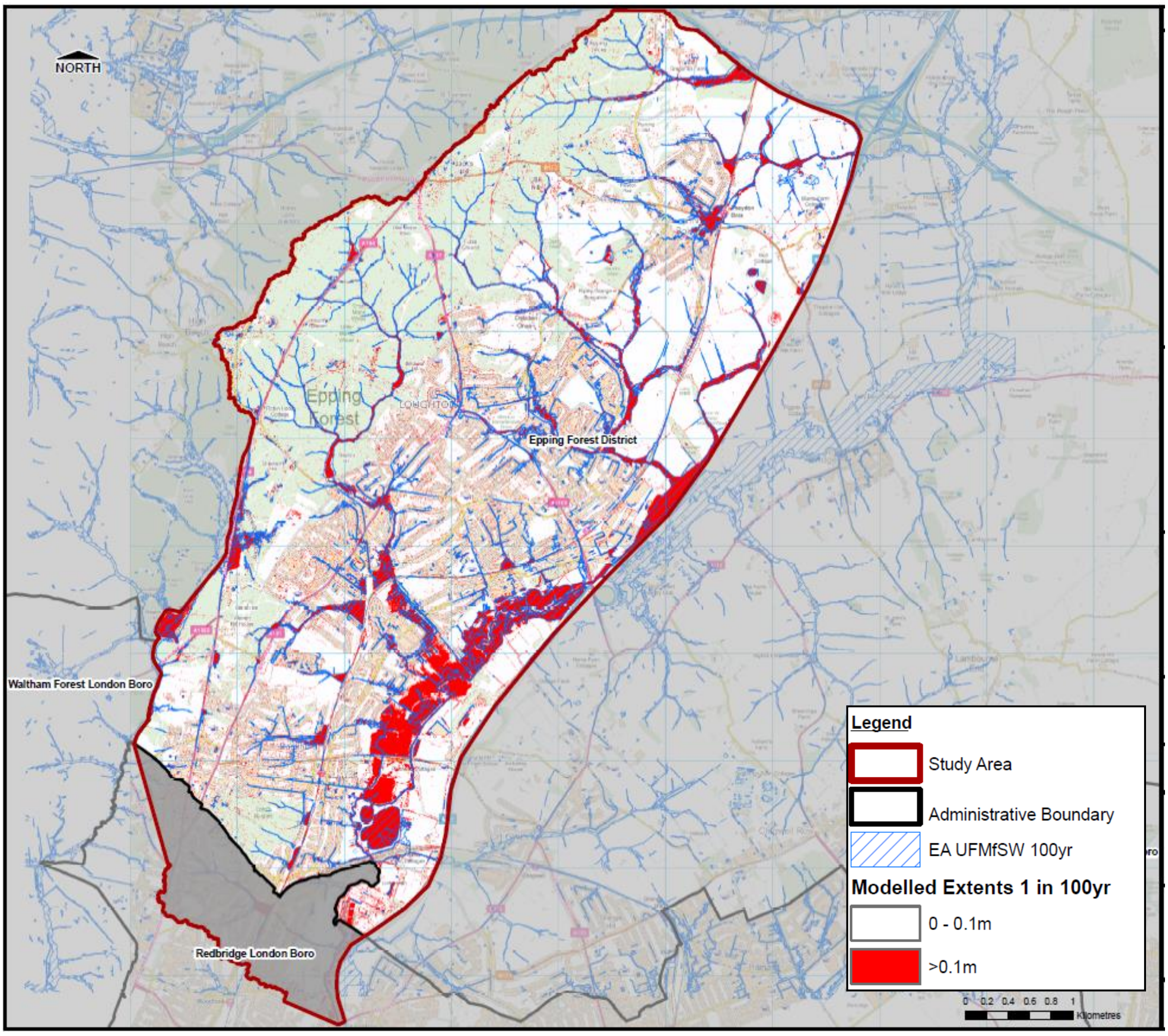


Figure 2-3 Example comparison between uFMfSW and SWMP model outputs

Flood history and local knowledge

Recorded flood history has also been used to verify areas which are identified as being at risk of flooding with previous known flood events. As discussed in Section 2.1.1, information on historical flood events was collected from a number of sources.

The use of a direct consultation with TW and Council officers was also an effective way to validate the model outputs. Officers were invited to examine the modelling outputs and were able to provided anecdotal information on past flooding which confirmed several of the predicted areas of ponding.

2.3 Sewer Flooding

2.3.1 Description

Flooding which occurs when the capacity of the underground drainage network is exceeded, resulting in the surcharging of water into the nearby environment (or within internal and external building drainage networks) or when there is an infrastructure failure. The discharge of the drainage network into waterways and rivers can also be affected if high water levels in receiving waters obstruct the drainage network outfalls. In the study area, the sewer network is comprised of mainly a separated surface water and foul system.

2.3.2 Sewer Flooding Responsibilities

EH, as the Highways Authority, is responsible for maintaining an effective highway drainage system including kerbs, road gullies and the pipes which connect the gullies to the trunk sewers and soakaways. EH is also the Highways Authority for all roads except trunk roads. The sewerage undertaker, in this case TW, is responsible for maintaining all of the public sewer network including the trunk sewers, plus pipes and networks coming under the definition of the Water Industry (Schemes for Adoption of Private Sewers), Regulations 2011 that came into force in October 2011.

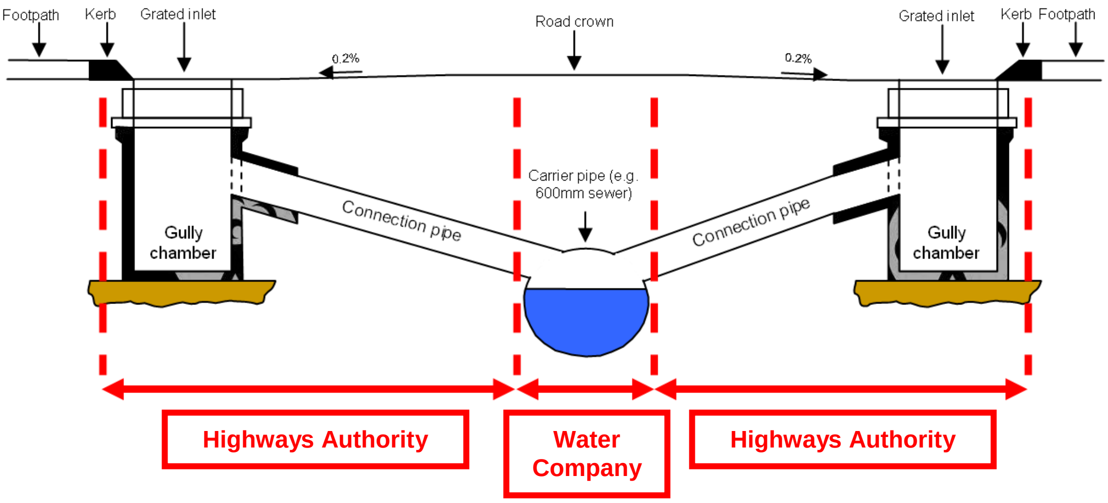


Figure 2-4 Surface water sewer responsibility

The Thames Water Revised Draft Water Resources Management Plan (2015-2040) indicates that Experian's "headline" projections (i.e. the most likely scenarios) show the total population of the

TW supply area increasing from 9,043,407 in 2011/2012 to 11,698,517 in 2039/2040. This marks an increase of 2,655,110 (29.35%) over 28 years, an average annual increase of 1.04%.

Experian's projections (most likely scenario) show the number of households in the TW supply area increasing from 3,407,100 to 3,850,320 between 2011/2012 and 2039/2040, an annual average of 0.41% increase.

2.3.3 Drainage Network

TW has provided GIS layers of the sewer network pipes and manholes within LBT (data was provided in July 2015). The GIS layers provide limited information on the sewer network. A review of the dataset highlighted missing invert levels for pipes and manholes as well as missing sizes / dimensions.

EH has provided a GIS layer of gullies within the study area. The layer provides gully locations only –no information has been provided on invert levels, dimensions or gully type. A review of this information indicated that the sewer network in the study area which is primarily separate.

2.3.4 Methodology for Drainage Network Modelling

In consultation with the client steering group, it was concluded that the all surface water network pipes, equal to and greater than 300mm in diameter, would be included within the hydraulic model to account for the benefit of the system during the model storm events. If a detailed assessment of any CDA (or sub-catchment) is undertaken, it is recommended that all drainage pipes are included within the hydraulic model, as this may improve the capacity and conveyance within the local area and could indicate a reduced risk of surface water flooding.

Gullies have been represented in the model based on the information provided by EH. Gullies in LBT were found to be fairly evenly distributed across the drainage network, with an average of four gullies per manhole, and have been represented accordingly in the model. Gully type in the model was determined based on a site inspection in which average dimensions and grate type at various locations across the town were observed. This data was used to specify a depth-discharge relationship for water into the network, better representing the exchange of water between the floodplain and the drainage network.

Appendix D provides a full methodology of the hydraulic modelling undertaken, including details of model parameters, hydrology and modelling assumptions. The appropriate modelling assumptions were used to fill any identified gaps in the drainage data sets.

These include:

- Only pipes >=300mm were included in the model;
- For the manholes missing invert levels the levels were determined based on the levels of the connecting pipes. In the case where invert levels are missing from connecting pipe data, the cover level was dropped by a specific level determined by looking at the height of the surrounding manholes;
- For the manholes with missing chamber dimensions it was assumed that they are similar to the surrounding manholes;
- For manholes with missing cover levels the values were extracted from the LiDAR;
- For the pipes with missing shape it was assumed that the pipes are circular;
- For the pipes with unknown dimensions, the dimensions were derived by integrating the dimensions of the connecting pipes upstream and downstream. It was also assumed that the pipes downstream are of the same or larger size;
- For the pipes with missing upstream invert levels the level was derived from the adjoining pipes, assuming that the upstream invert level of the outgoing pipe is the same as the

downstream invert level of the incoming pipe. For the pipes with missing levels and where levels cannot be taken from the connecting pipes, the levels were extracted from the manhole information, either using the original data or using the assumptions discussed above.

2.4 Groundwater Flooding

2.4.1 Description

Groundwater flooding is water originating from sub-surface permeable strata which emerges from the ground, either at a specific point (such as a spring) or over a wide diffuse location, and inundates low lying areas. A groundwater flood event results from a rise in groundwater level sufficient for the water table to intersect the ground surface and inundate low lying land.

The actual flooding can occur some distance from the emergence zone, with increased flows in local streams resulting in flooding at downstream constrictions / obstructions. This can make groundwater flooding difficult to categorise. Flooding from groundwater tends to be long in duration, developing over weeks or months and continuing for days or weeks. In general terms, groundwater flooding rarely poses a risk to life.

2.4.2 Groundwater Flooding Risk Assessment

Figure 2-5 shows the EA's Areas Susceptible to Groundwater Flooding Map (EA, 2012). The map uses underlying geological information to infer groundwater flood susceptibility over an area of 1km^2. Table 2-2 summarises the content of the map, and how it was used within the risk assessment. No historical groundwater flooding records were highlighted within the data provided for this assessment.

The basis for the groundwater flood risk assessment for this study is predominantly the EA Areas Susceptible to Groundwater Flooding Map. This map uses underlying geological information to infer groundwater flood susceptibility.

Table 2-2: Review of Available Groundwater Information

Source	Summary	Risk Assessment Application
EA Areas Susceptible to Groundwater Flooding (AStGWF) Map	This data has used the top two susceptibility bands of the BGS 1:50,000 Groundwater Flood Susceptibility Map. It shows the proportion of each 1km grid square where geological and hydrogeological conditions show that groundwater might emerge.	This provides an overview of proportional area that is at high or very high risk of groundwater flooding. The categories are as follows: <25% (low) ≥25%<50%(moderate) ≥ 50% <75% (high) ≤75% (very high)

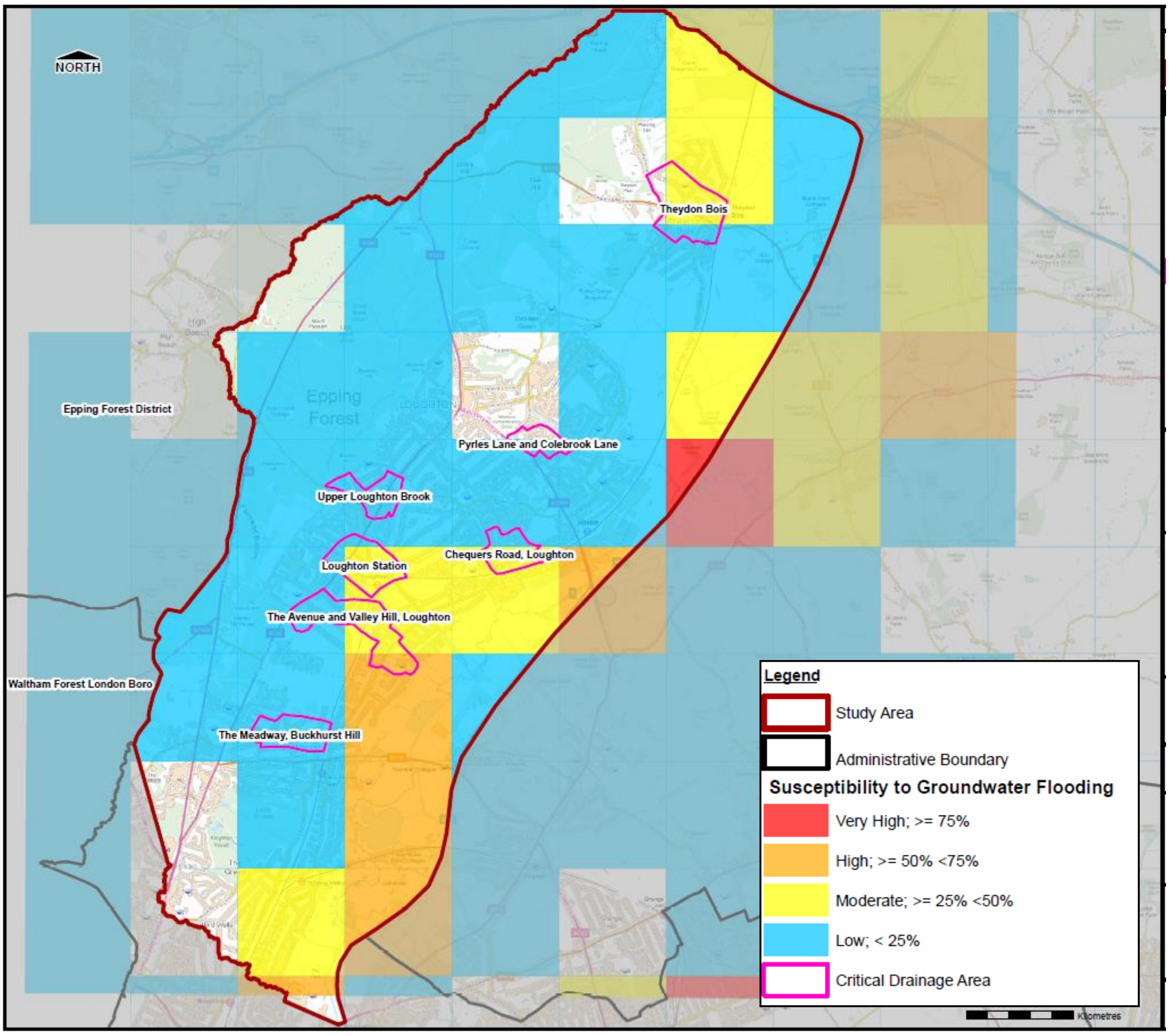


Figure 2-5 Environment Agency Areas Susceptible to Groundwater Flooding

Groundwater flooding is often highly localised and complex. As can be seen from Figure 3-5 the CDA's are mainly located into low (<25%) to moderate (>=25%<50%) susceptibility to ground water flooding.

2.5 Ordinary Watercourse Flooding

2.5.1 Description

All watercourses in England and Wales are classified as either 'Main Rivers' or 'ordinary watercourses'. The difference between the two classifications is based largely on the perceived importance of a watercourse, and in particular it's potential to cause significant and widespread flooding. However, this is not to say watercourses classified as ordinary watercourses cannot cause significant localised flooding. The FWMA (2010) defines any watercourse that is not a Main River an ordinary watercourse – including ditches, dykes, rivers, streams and drains (as in 'land drains') but not public sewers.

The EA has duties and powers in relation to Main Rivers. Local Authorities, or in some cases Internal Drainage Boards, have powers and duties in relation to ordinary watercourses. Flooding from ordinary watercourses occurs when water levels in the stream or river channel rise beyond the capacity of the channel, causing floodwater to spill over the banks of the watercourse and onto the adjacent land.

2.5.2 Watercourses within the Study Area

The EA Detailed River Network (DRN) indicates that there are two Main Rivers in the study area, the River Roding and Loughton Brook. The River Roding has several recorded incidents of ordinary watercourse flooding. There are several known recorded incidents of ordinary watercourse flooding within the historic data provided.

2.6 Main River Fluvial and Tidal Flooding

Interactions between surface water and fluvial flooding are generally a result of watercourses unable to receive and convey excess surface water runoff. Where the watercourse in question is defended, surface water can pond behind defences. This may be exacerbated in situations where high water levels in the watercourse prevent discharge via flap valves through defence walls.

Main Rivers have been considered in the surface water modelling. An initial review of the hydrology and the 'time to peak' showed that short duration peak rainfall on Loughton Brook catchment would fall before River Roding begins to rise. Therefore the three rivers will be represented in the Integrated Urban Drainage (IUD) model as bank full. Some structures such as weirs, culverts and bridges have been explicitly modelled. For more information refer to the modelling report in Appendix D. In general fluvial risk in the tributaries of the Roding is minimal, predominantly in bank. An overland flow route exists on the Loughton Brook in the Roding Gardens / Valley Close area but only in the modelled 1 in 1000 year event.

Figure 2-6 below identifies the EA's Flood Zones and defences along the River Roding. As can be seen in the Figure, areas along the Roding are classified as Flood Zone 2 and Flood Zone 3. Defences can be identified in the south eastern corner of the study area.

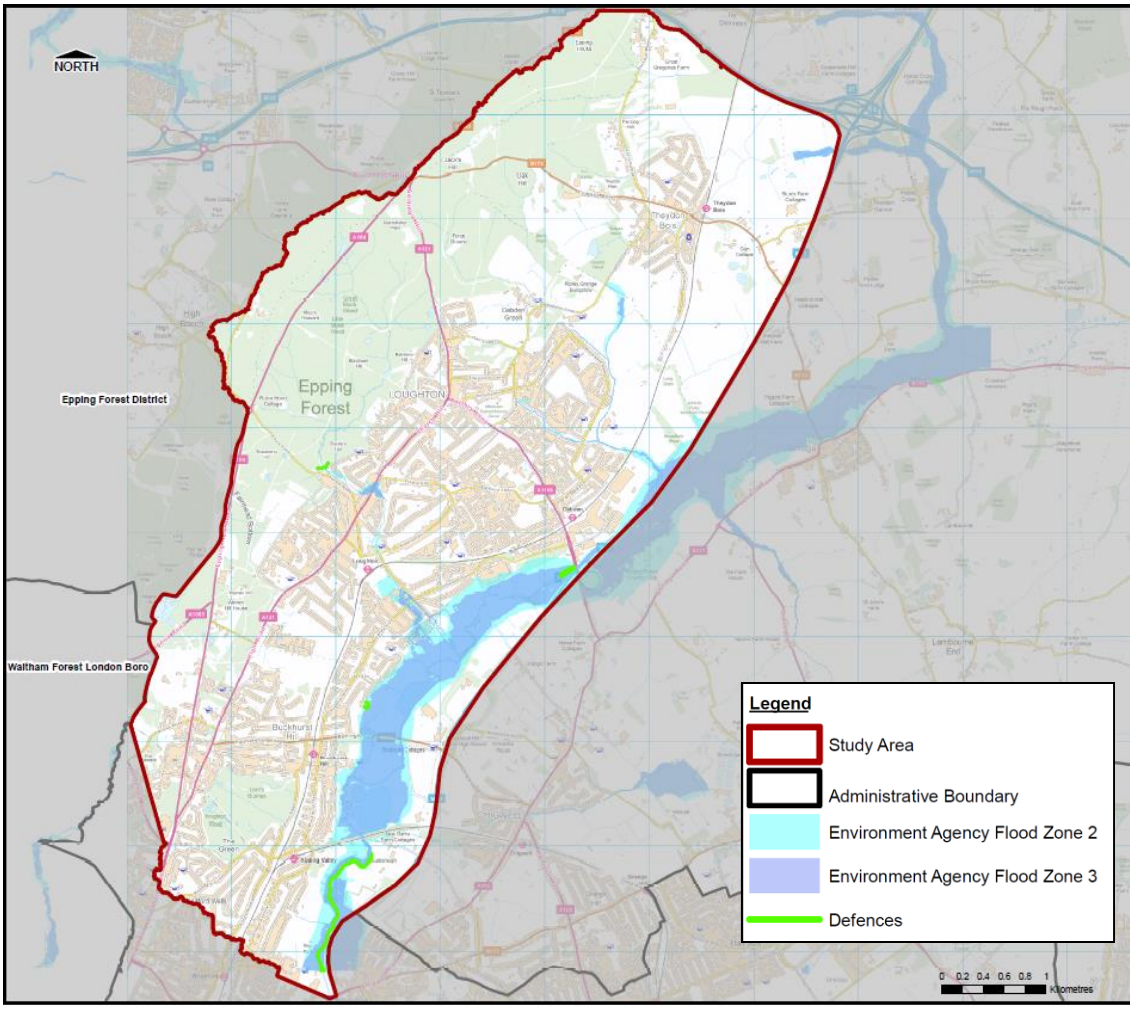


Figure 2-6 Flood Zones and Defence Locations within LBT

3 Pluvial Flood Risk Assessment

3.1 Critical Drainage Areas (CDAs)

An initial assessment of flood risk identified seventeen (17) CDAs within the LBT study area. Consultation with ECC and EFDC refined the number of CDAs to seven (7) high priority areas for the purpose of this report. Figure 3-3 (below) identifies the location of these high priority CDAs within Loughton, Buckhurst Hill and Theydon Bois.

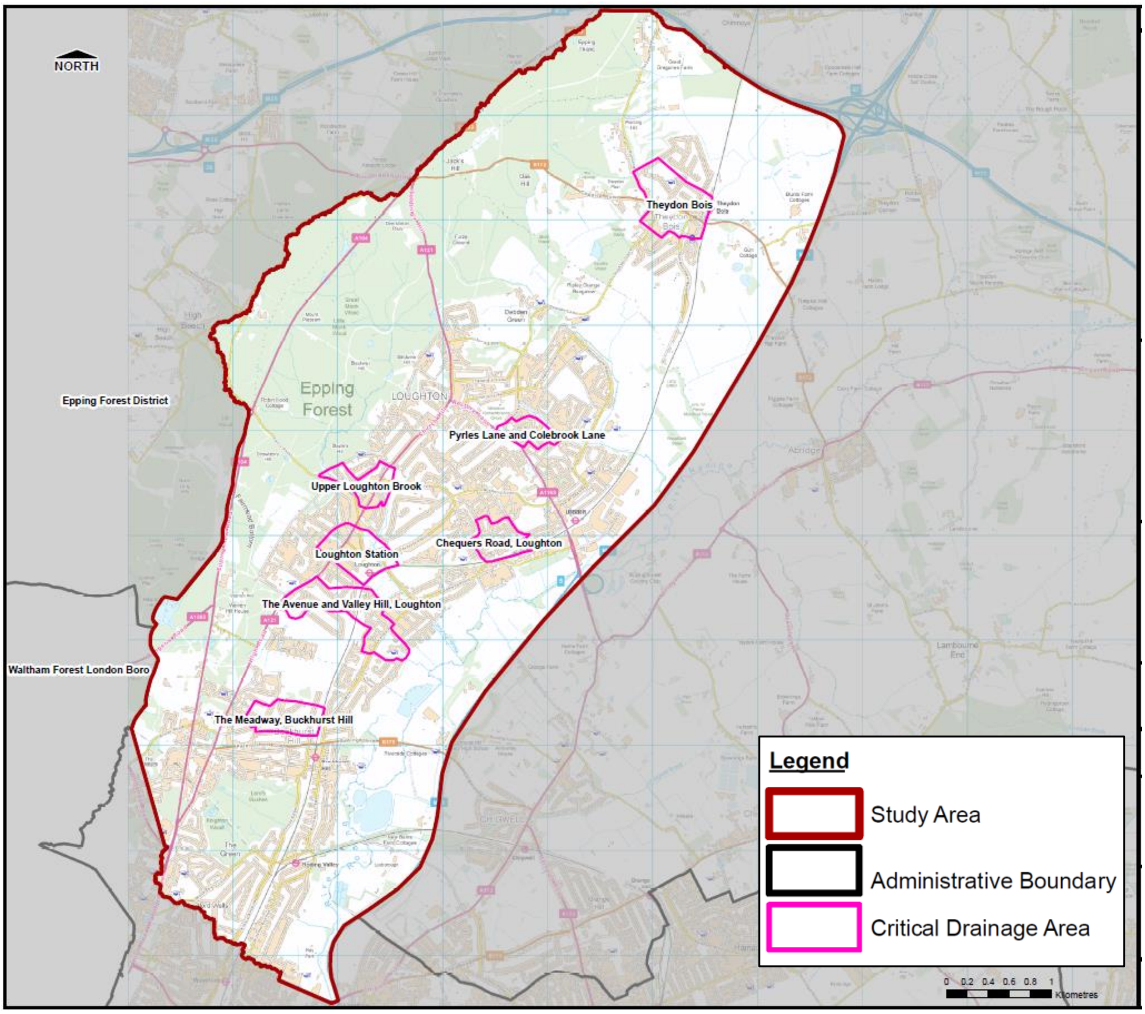


Figure 3-3 Critical Drainage Areas within LBT

In order to quantify the risk across the CDAs an assessment has been carried out to determine the number of properties and critical infrastructure at risk from surface water flooding during a range of flood events. Details on this assessment are included in the following sections.

CDA 01 – Theydon Bois

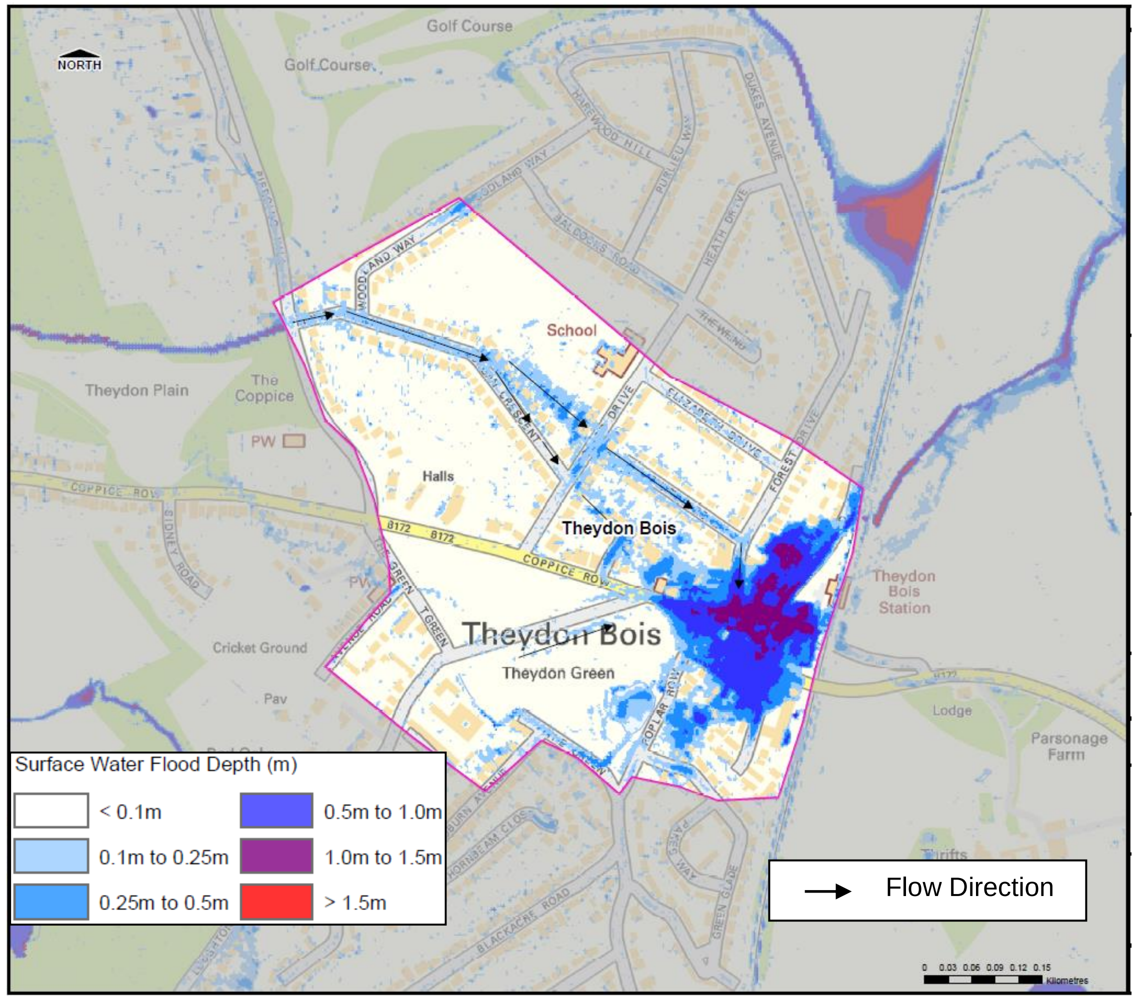


Figure 3-1 CDA 01 - 1 in 100 year Depth Results

Summary of risk:

1. Theydon Bois

This CDA is located in the north eastern portion of the study area.

Surface water is predicted to flow generally from west to east towards the River Roding. The pluvial modelling indicates predicted surface water flooding across various locations of the CDA (as a result of the topography and water being trapped behind raised building pads). Water flows from the upper catchment in an easterly direction where it appears to flow along Coppice Row and Piercing Hill and ponds to depths of up to 1.5m at its eastern extremity. The entire pipe network in the area is flowing at full capacity.

Table 3-1 Summary of local flood risk within CDA 01

Flood Classification/ Type	Source	Pathway	Receptor
Overland flow	In extreme rainfall events surface water runoff from predominantly urban areas are conveyed as overland sheet flow via what appears to be a lost watercourse.	Runoff from the local catchment is conveyed through properties, roads and the drainage network.	Car park at Theydon Bois Railway Station and properties around Slade End.
Ponding of surface water (within topographic low spots and behind obstruction)	Topographic low points and obstructions to overland flow.	Ponding within car park of Theydon Bois Railway Station.	Car park at Theydon Bois Railway Station and properties around Slade End.
Hazard	'Significant' hazard is predicted in the Theydon Bois Train Station car park and nearby residential properties along Slade End. Moderate risk is identified along the flow path along Morgan Crescent to the west of the CDA.		
Sewer	The drainage network within the CDA is a separate drainage system.		
Validation	No historic events have been identified within the CDA.		
Groundwater	The EA identifies the majority of the CDA as 'moderate' susceptibility to ground water flooding. The south of the CDA is at 'low' susceptibility to groundwater flooding.		
Fluvial	The CDA is located in Flood Zone 1 and is therefore considered to be at low risk of fluvial flooding.		

CDA 02 – Pyrles Lane and Colebrook Lane

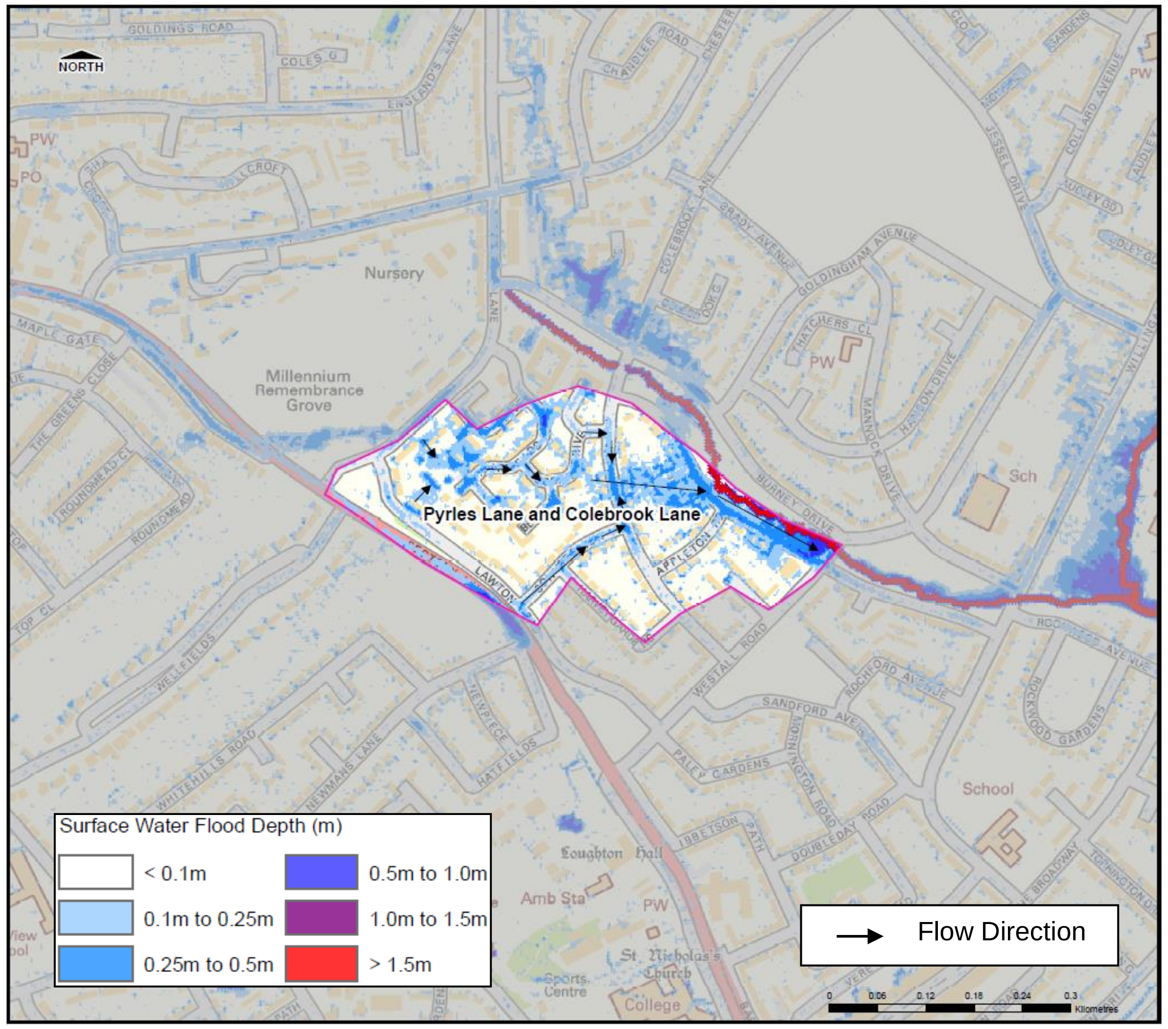


Figure 3-2 CDA 02 - 1 in 100 year Depth Results

Summary of risk:

2. Pyrles Lane and Colebrook Lane

There are four flow paths for surface water within this CDA all off which exit the CDA to the east joining Loughton Brook. Surface water follows the road network with flood depth between 0.25-0.5m. Along the north eastern boundary of the CDA, there is a very high risk of surface water flooding due to the location of Pyrles Brook and a lower elevation of land.

Table 3-2 Summary of local flood risk within CDA 02

Flood Classification/ Type	Source	Pathway	Receptor
Overland flow	In extreme rainfall events surface water runoff is conveyed as overland sheet flow via the road network or other topographic low paths.	Runoff from the local catchment is conveyed through properties, roads and the drainage network.	Properties along the main flow path and mainly the Pyrles Lane and Beech Close area.
Ponding of surface water (within topographic low spots and behind obstruction)	Topographic low points and obstructions to flow.	Ponding occurring along Etheridge Road along the north east of the CDA.	Properties along the main flow path and mainly the Pyrles Lane and Beech Close area.
Hazard	Predominantly 'moderate' with 'Significant' hazards being predicted along the Etheridge Road and Appleton Road area. 'Extreme' hazards identified along the north eastern boundary where Loughton Brook is located.		
Sewer	The drainage network within the CDA is a separate drainage system.		
Validation	Historic flood events have been identified within the CDA.		
Groundwater	The CDA is considered to be at 'low' susceptibility to groundwater flooding by the EA data set. EA data is missing for the northern portion of the CDA.		
Fluvial	The CDA is located in Flood Zone 1, however the north east boundary of the site is located along Loughton Brook which is in Flood Zones 2 and 3. However the majority of the CDA is considered to be at low risk form fluvial flooding.		

CDA 03 – Upper Loughton Brook

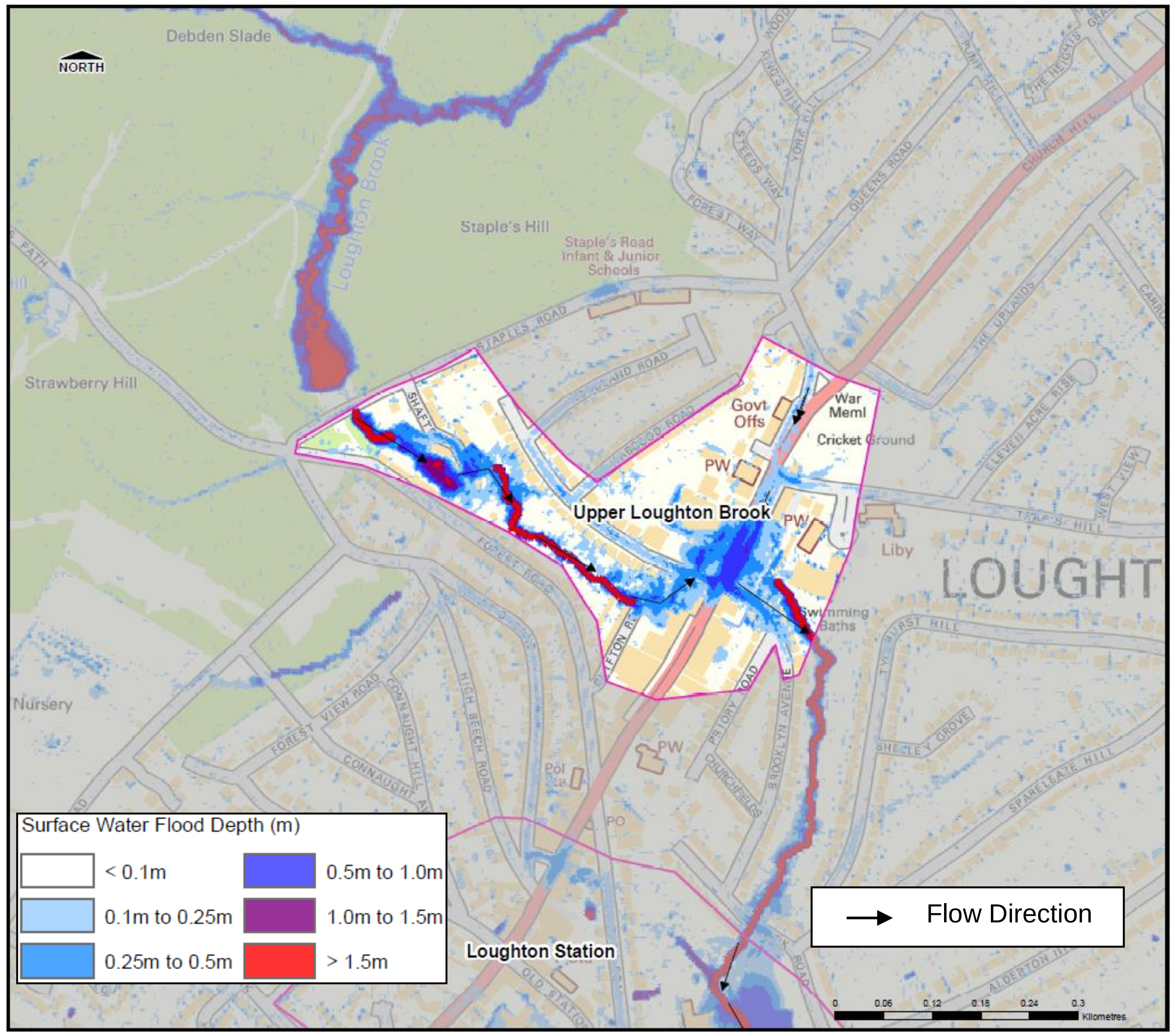


Figure 3-3 CDA 03 - 1 in 100 year Depth Results

Summary of risk:

3. Upper Loughton Brook

This CDA is located in the centre of the study area. There is a high risk of surface water flooding in the entire of the CDA in the vicinity of the High Road/Brooklyn Parade in this CDA due to Loughton Brook flowing through the area. Ponding can be seen across Church Hill road where the land height is lower. The pipe network in this area is predicted to be running at full capacity.

Table 3-3 Summary of local flood risk within CDA 03

Flood Classification/ Type	Source	Pathway	Receptor
Overland flow	In extreme rainfall events surface water runoff is conveyed as overland sheet flow via the road network or other topographic low paths.	Runoff from the local catchment is conveyed through properties, roads and the drainage network.	Along High Road at the junction with The Drive and around southeast of the supermarket car park
Ponding of surface water (within topographic low spots and behind obstruction)	Topographic low points and obstructions to flow.	Main pathway is from the Loughton Brook and along High Road.	Ponding around High Road and south east of supermarket.
Hazard	'Significant' to 'Extreme' hazard identified along Loughton Brook to the north of Forest Road. 'Significant' hazard also predicted to the south east of the supermarket on High Road.		
Sewer	The drainage network within the CDA is a separate drainage system.		
Validation	Historic flood events have been identified within the CDA.		
Groundwater	The CDA is considered to be at 'low' susceptibility to groundwater flooding by the EA data set.		
Fluvial	The CDA is at risk of fluvial flooding due to the location of Loughton Brook running through the CDA. The area to the east located around the junction of The Drive, High Road and Brooklyn Avenue is located in Flood Zone 3. The area in the west of the CDA, between Shaftesbury and Forest Drive, is located in Flood Zone 2.		

CDA 04 – Loughton Station

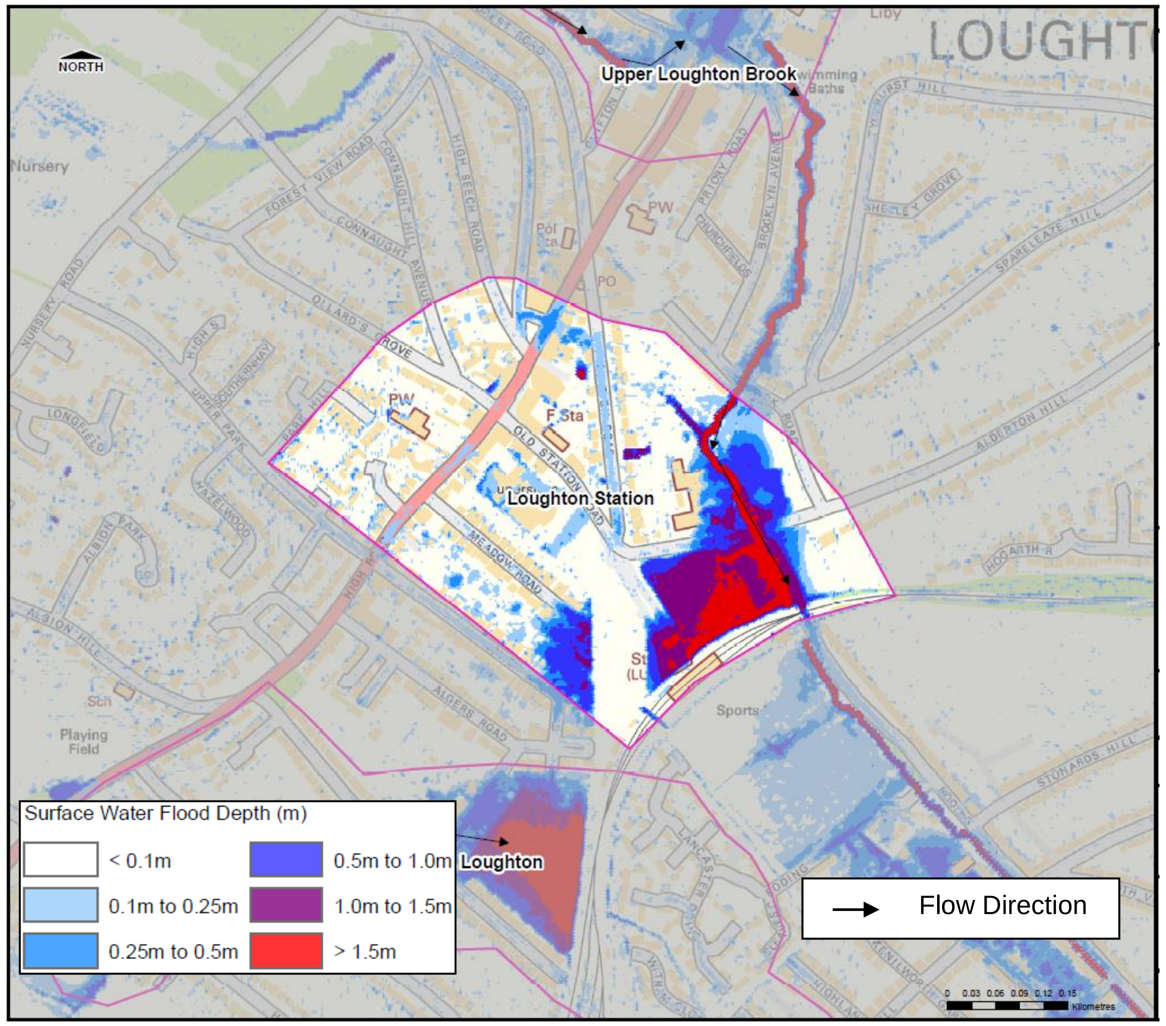


Figure 3-4 CDA 04 - 1 in 100 year Depth Results

Summary of risk:

4. Loughton station

This CDA is located to the south of the study area. Surface water flooding depth is high in the west of the CDA, surrounding Loughton Brook. The area north of the railway is predicted to be at significant risk as is Roding Valley High school. The flow path runs through the school and ponds to the north of the railway station.

Table 3-4 Summary of local flood risk within CDA 04

Flood Classification/ Type	Source	Pathway	Receptor
Overland flow	In extreme rainfall events surface water runoff from predominantly urban areas are conveyed as overland sheet flow along the entire CDA.	Surface water runoff from the local catchment is conveyed along properties located west of. Brook Road and Roding Road.	Roding Valley High School.
Ponding of surface water (within topographic low spots and behind obstruction)	Topographic low points and obstructions to flow.	Quite a few areas of ponding along the entire CDA.	Ponding near railway.
Hazard	Predominantly ‘Significant’ hazard is predicted in the eastern portion of the CDA. ‘Extreme’ hazard is also predicted along Loughton Brook entering the CDA to the north and flowing south past Roding Valley High School, and passed railway line.		
Sewer	The drainage network within the CDA is a separate drainage system.		
Validation	Historic events have been identified within the CDA (ECC,TW).		
Groundwater	The EA data set identifies the majority of the CDA as having ‘moderate’ susceptibility to ground water flooding, with ‘low’ susceptibility in the eastern portion of the CDA.		
Fluvial	The majority of the CDA is located in Flood Zone 1 and therefore considered to be at low risk of fluvial flooding. The area in the east of the CDA around Loughton Brook is located in Flood Zone 2 and considered at moderate risk.		

CDA 05 – The Meadway, Buckhurst Hill

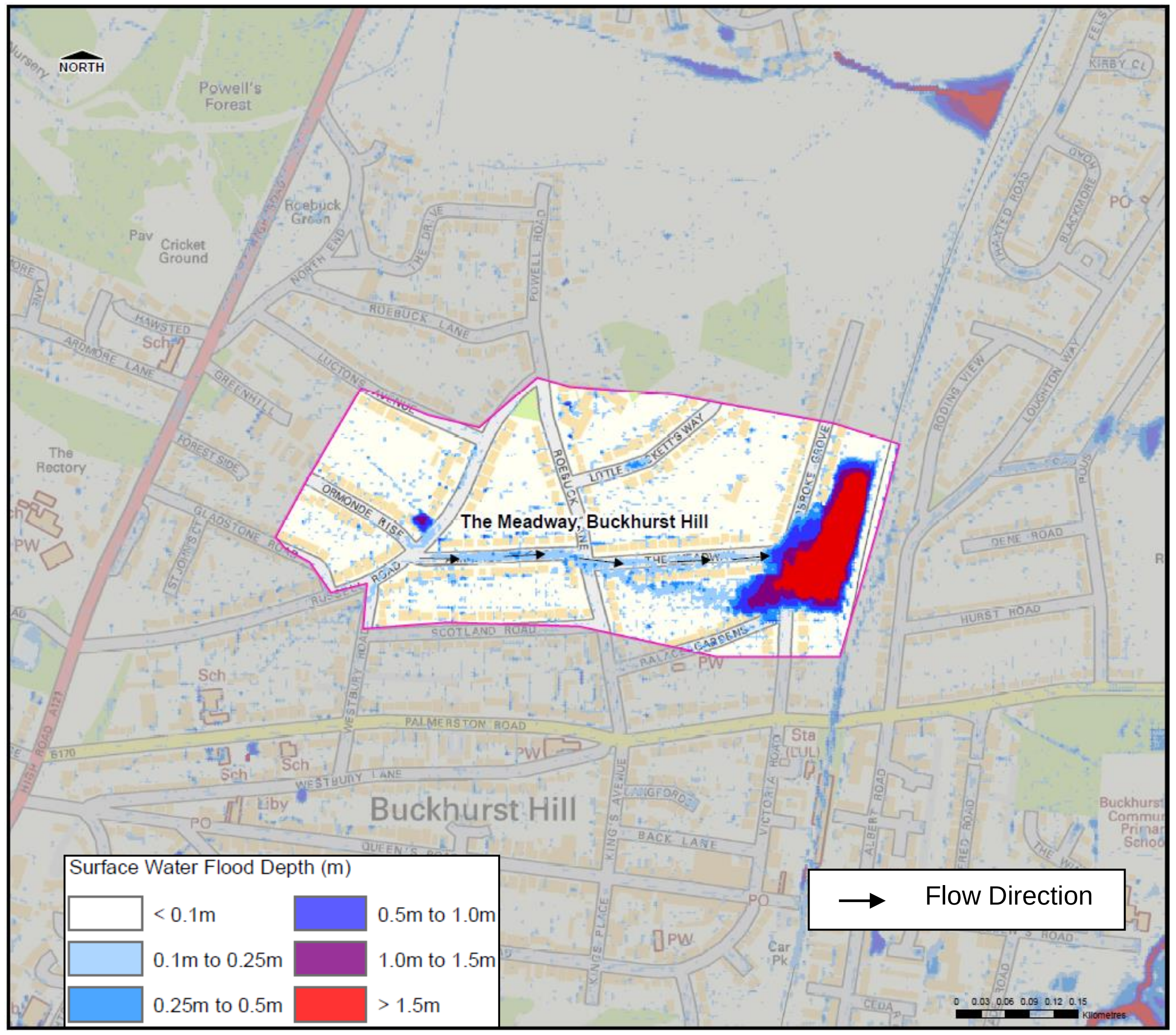


Figure 3-5 CDA 05 - 1 in 100 year Depth Results

Summary of risk:

5. The Meadway, Buckhurst Hill

This CDA is the southernmost one located within the study area. The east of the CDA is predicted to be at significant risk of surface water flooding with estimated depths of over 1.5m. The majority of the drainage network is running near or at full capacity (from 75-100%). The surface water flows along The Meadway from west to east across a largely residential area.

Table 3-5 Summary of local flood risk within CDA 05

Flood Classification/ Type	Source	Pathway	Receptor
Overland flow	In extreme rainfall events surface water runoff from predominantly urban areas are conveyed as overland sheet flow along the entire CDA.	Surface water runoff from the local catchment is conveyed along properties located at the end of The Meadway and to the east of Stradbroke Grove.	Residential properties located along the eastern end of The Meadway and at Stradbroke Grove.
Ponding of surface water (within topographic low spots and behind obstruction)	Topographic low points and obstructions to flow.	Ponding west of the railway.	Residential properties.
Hazard	Predominantly ‘Significant’ hazard predicted in the east of the CDA. ‘Extreme’ hazard is predicted to the west of the rail way (within the CDA boundary).		
Sewer	The drainage network within the CDA is a separate drainage system.		
Validation	Historic events have been identified within the CDA (ECC,TW).		
Groundwater	The CDA is predicted to have a ‘low’ susceptibility to groundwater flooding from the EA data set.		
Fluvial	The CDA is located entirely in Flood Zone 1 and is considered to be at low risk of fluvial flooding.		

CDA 06 – Chequers Road, Loughton

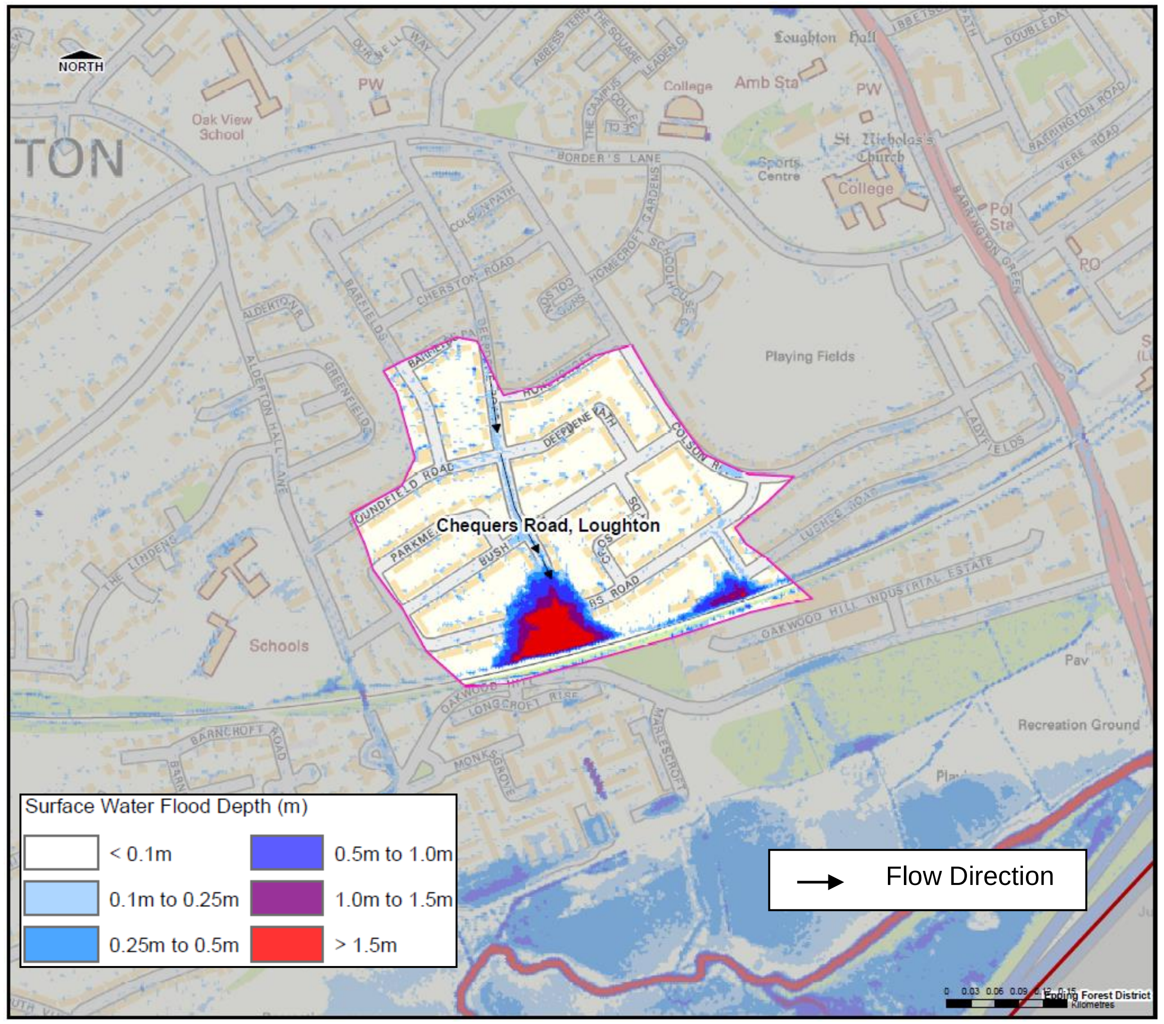


Figure 3-6 CDA 06 - 1 in 100 year Depth Results

Summary of risk:

6. Chequers Road, Loughton

This CDA is located within the eastern portion of the study area. Significant surface water depths are expected in the south around Chequers Road and the railway line where the land elevation is lowest (approximately 26m AOD). According to the model the main flow path is down the centre of the CDA running north to south through Deepdene Road. In this area the pipe network is running at medium capacity, however at the area of greatest risk of surface water flooding the pipe capacity is at full.

Table 3-6 Summary of local flood risk within CDA 06

Flood Classification/ Type	Source	Pathway	Receptor
Overland flow	In extreme rainfall events surface water runoff from predominantly urban areas are conveyed as overland sheet flow along the entire CDA.	Surface water runoff from the local catchment is conveyed along Deepdene Road.	Properties at the base of Deepdene Road and along Chequers Road.
Ponding of surface water (within topographic low spots and behind obstruction)	Topographic low points and obstructions to flow.	Ponding significant at bottom of Deepdene Road north of railway line. Additional ponding can be seen at Lushes Road.	Properties at the base of Deepdene Road and along Chequers Road.
Hazard	‘Significant’ hazard is predicted at the base of Deepdene Road, along with an area predicted to be at ‘Extreme’ hazard near the railway line, where surface water sewer passes beneath the railway embankment.		
Sewer	The drainage network within the CDA is a separate drainage system.		
Validation	Historic events have been identified within the CDA (EH, TW)		
Groundwater	The EA data set indicates the CDA is at ‘moderate’ susceptibility to groundwater flooding in the southern portion of the CDA.		
Fluvial	The CDA is located entirely in Flood Zone 1 and therefore considered to be at low risk of fluvial flooding.		

CDA 07 – The Avenue and Valley Hill, Loughton

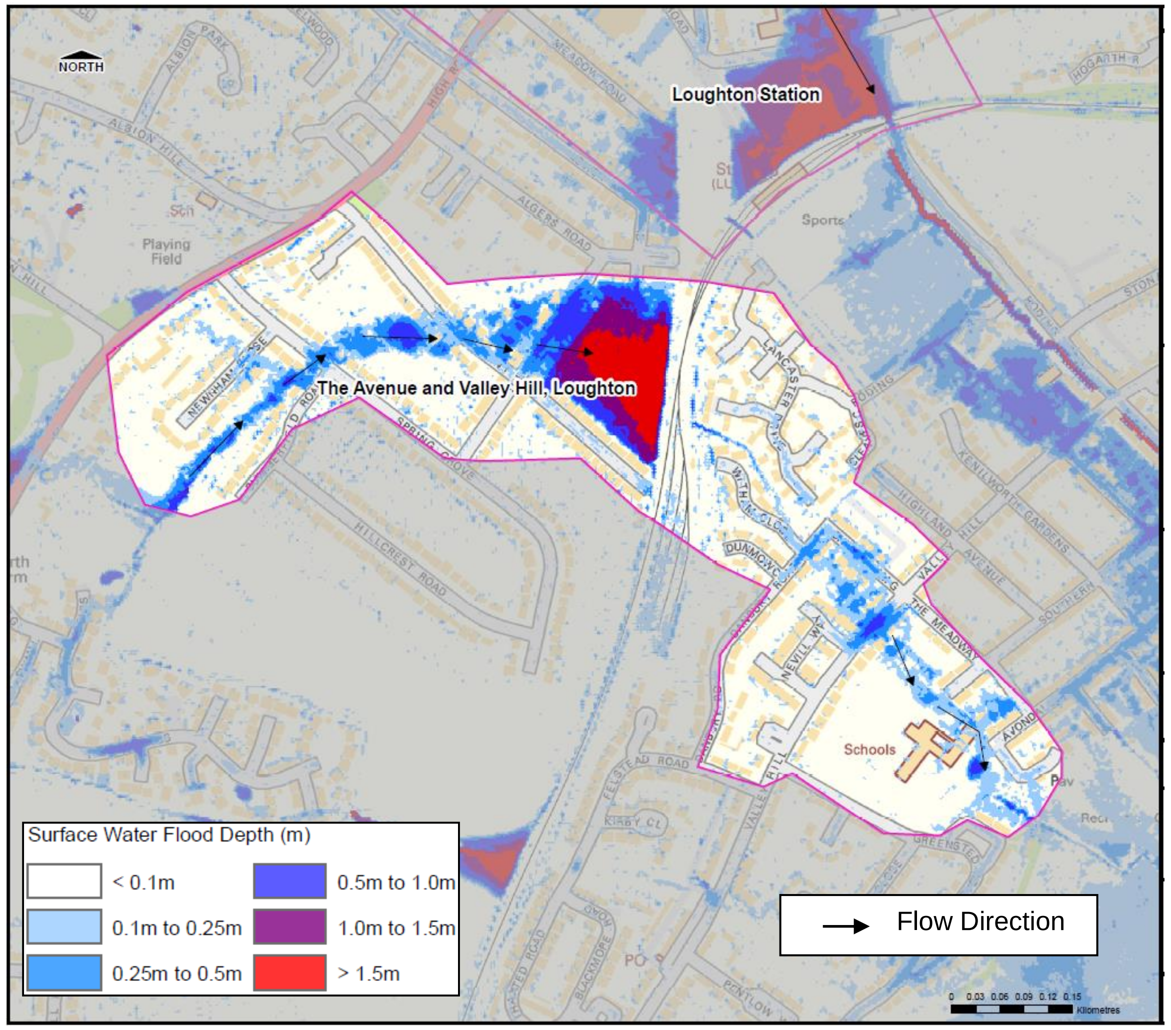


Figure 3-7 CDA 07 - 1 in 100 year Depth Results

Summary of risk:

7. The Avenue and Valley Hill, Loughton

This CDA is located to the south of CDA 04 – Loughton Station. The model predicts significant surface water ponding to the west of the railway line around The Avenue, the Crescent and Lower Park Road junction where the land is low lying.

Table 3-7 Summary of local flood risk within CDA 07

Flood Classification/ Type	Source	Pathway	Receptor
Overland flow	In extreme rainfall events surface water runoff is conveyed as overland sheet flow via the road network or other topographic low paths.	Pathway enters CDA in the west and flows just north of Summerfield Road, across Spring Grove down towards The Avenue.	Residential properties to south of The Avenue and north of The Crescent.
Ponding of surface water (within topographic low spots and behind obstruction)	Topographic low points and obstructions to flow.	Ponding to west of railway around residential area on Lower Park Road and area to north of the Crescent.	Residential properties.
Hazard	'Significant' hazards are predicted along properties to the south of The Avenue and north of The Crescent. Areas classified at an 'Extreme' hazard are also identified near the railway line. 'Significant' hazard also identified to the north of Summerfield Road across Spring Grove and down to the Avenue.		
Sewer	The drainage network within the CDA is a separate drainage system.		
Validation	Historic events have been identified within the CDA (TW, EH, and EFDC).		
Groundwater	The EA's data identifies this CDA to have a mixed ground water susceptibility. The western portion of the CDA is classified as having 'low' susceptibility to groundwater flooding, the centre at 'moderate' groundwater flood risk and south east at 'high' susceptibility.		
Fluvial	The CDA is located entirely in Flood Zone 1 and therefore considered to be at low risk of fluvial flooding.		

3.2 Flood Risk Summary

3.2.1 Overview of Flood Risk

The results of the risk assessment, combined with site visits and a detailed review of existing data and historical flood records, indicate that there is a low risk of groundwater flooding in LBT. The risk assessment indicated a moderate to high risk to LBT from surface water and sewer flooding[2] – particularly as rainfall intensities increase with climate change. The results indicate that the flood risk is widely dispersed across the study area with areas at low elevations and/ or adjacent to obstructions to flow (such as raised roads and rail embankments) being at the greatest risk.

In general, flooding across the study area is low to moderate in the lower order rainfall events (such as the modelled 1 in 10 year event) and is predicted to experience greater levels of flooding across the study area during higher order events (such as a 1 in 100 year event). This is reflected in the analysis of risk to properties, businesses and infrastructure that is discussed below.

3.2.2 Predicted Risk to Existing Properties & Infrastructure

Maps of predicted flood depths and extents which have been generated from the surface water modelling results are included in Appendix F. In order to provide a quantitative indication of potential risks, building footprints (taken from the OS MasterMap dataset) and the National Receptor Dataset (NRD) have been overlaid onto the modelling outputs to estimate the number of properties at risk within the study area. The NRD is not entirely comprehensive and may not include all known or recent properties.

Properties with basements have not been identified using the NRD dataset.

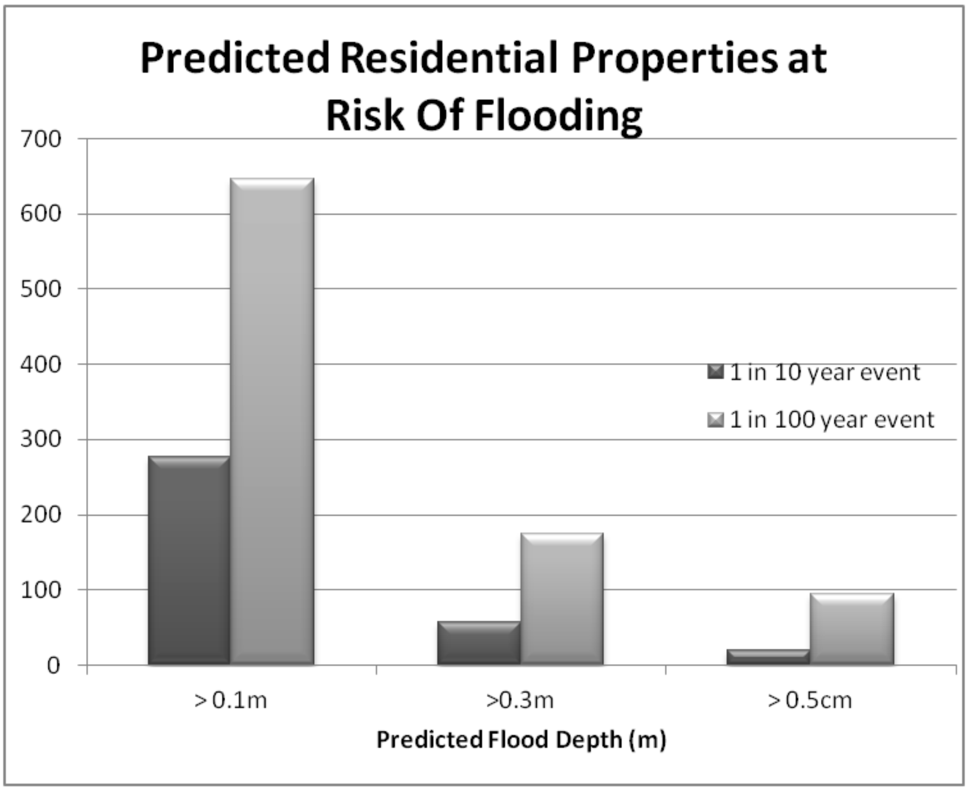


Figure 3-8 Comparison of Predicted Flooded Properties for the 1 in 10 year and 1 in 100 year Rainfall Event

[2] Methodology and limitations relating to each source of flooding can be located within Section 2.

As would be expected, the number of properties at risk of shallow flooding (>0.1m) is greater than the number at risk of deeper flooding (>0.3m). The number of properties at risk increases with lower probability surface water flood events due to the increased volume of rainfall for these events.

3.2.3 Risk to Future Development

As discussed in Section 1.6, EFDC is currently preparing a new Local Plan to guide the development in the district up to 2033. It is therefore important that surface water flood risk identified within this study should be a consideration in the site allocation process as their locations could either assist or exacerbate the risk to existing properties within LBT. It is recommended that these developments adhere to specific policy relating to surface water management in this document in addition to the requirements of NPPF.

4 Flood Mitigation Assessment

4.1 Overview

The following section indicates what options are generally available for reducing flood risk within LBT. A high level options assessment was undertaken, which involved identifying a range of structural and non-structural options for alleviating flood risk in the study area, and assessing the feasibility of these options. As well as surface water, consideration was given to other sources of flooding and their interactions with surface water flooding, with particular focus on options which will provide flood alleviation from combined flood sources.

CDAs delineate the areas where the impact of surface water flooding is expected to be greatest, it is acknowledged that the CDAs do not account for all the areas that could be affected by surface water flooding. It is therefore recommended that ECC and EFDC implement policies that will reduce the risk from surface water flooding throughout the whole study area (refer to Appendix B SWMP Action Plan for further details). Both authorities are also encouraged to promote the implementation of SuDS and other Best Management Practices to reduce of surface water runoff volumes.

4.2 Methodology

4.2.1 Source-Pathway-Receptor Model

Surface water flooding is often highly localised and complex. There are few solutions which will provide benefits in all locations, and therefore, its management is largely dependent upon the characteristics of the CDA. This section outlines potential measures which have been considered for mitigating the surface water flood risk within LBT.

The SWMP Plan Technical Guidance (Defra 2010) identifies the concept of Source, Pathway and Receptor as an appropriate basis for understanding and managing flood risk. Figure 4-1 identifies the relationship between these different components, and how some components can be considered within more than one category.

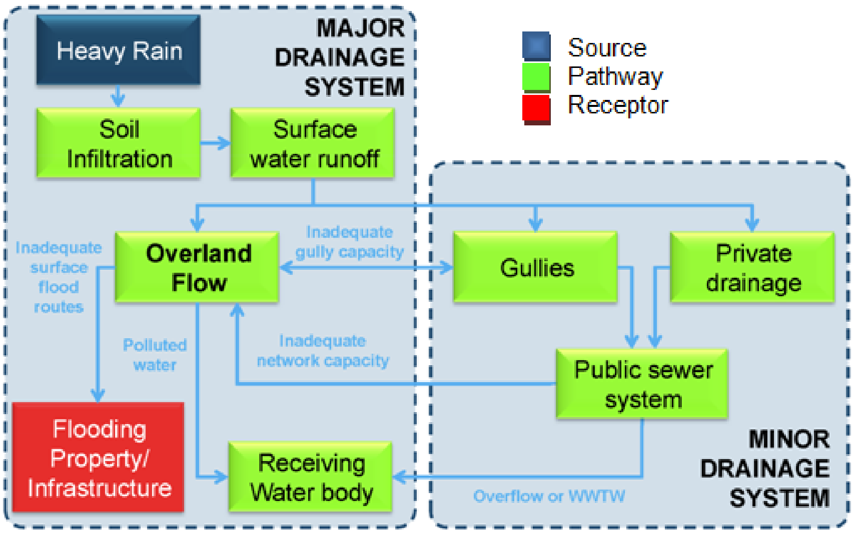


Figure 4-1 Diagram of Sources, Pathways & Receptors

When identifying potential measures, it is useful to consider the source, pathway, receptor approach (refer to Figure 4-1 and Figure 4-2). Both structural and non-structural measures should be considered in the optioneering exercise undertaken. Structural measures can be considered as those which require fixed or permanent assets to mitigate flood risk, such as a detention basin or increased capacity pipe networks. Non-structural measures may not involve fixed or permanent facilities, and the benefits to of flood risk reduction is likely to occur through influencing behaviour , such as through education and awareness campaigns with residents and businesses to inform them of flood risk and possible flood resilience measures, planning policies.

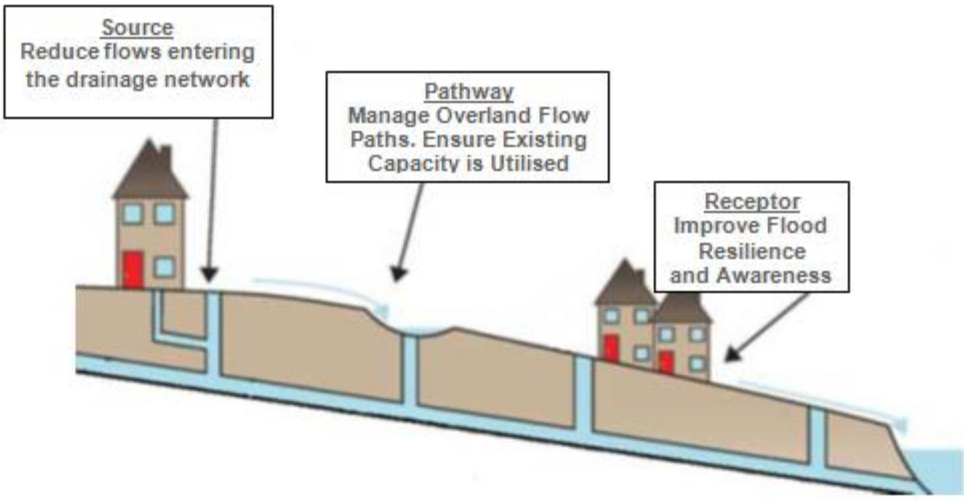


Figure 4-2 Source, Pathway and Receptor Model
(adapted from Defra SWMP Technical Guidance, 2010)

Methods for managing surface water flooding can be divided into methods which influence the Source, Pathway or Receptor, as described below:

- **Source Control:** Source control measures aim to reduce the rate and volume of surface water runoff through increasing infiltration or storage, and hence reduce the impact on receiving drainage systems. Examples include retrofitting SuDS (e.g. bioretention basins, wetlands, green roofs etc) and other methods for reducing flow rates and volumes;

- **Pathway Management:** These measures seek to manage the overland and underground flow pathways of water in the urban environment, and include increasing capacity in drainage systems and separation of foul and surface water sewers;

- **Receptor Management:** These measures involve changes to communities, property and the environment that are affected by flooding. Mitigation measures to reduce the impact of flood risk on receptors may include improved warning and education or flood resilience measures.

4.2.2 Scale of Assessment

Flood risk management activities should be undertaken at a variety of scales – generally from strategic planning policy down to site specific mitigation solutions. This approach is reflected in the options assessment by use of three scales:

- **Study Area Wide:** Recommended flood mitigation measures and policies that should be considered for the entire study area;

- **Policy Areas:** Defined areas where specific planning policy should be implemented to manage future development; and

- **Opportunity Areas:** 'Sub-catchments' (as defined in Section 3.1) within the study area where potential site specific flood mitigation solutions are proposed.

4.3 Study Area Wide Options

- **Adaptation of spatial planning policy:** It is recommended that emphasis is placed on the requirement for appropriate measures to reduce surface water runoff, and the requirements for Flood Risk Assessments (FRAs) to inform the detailed design of new development. Proposed planning policies are detailed in the Action Plan (refer to Appendix B);

- **Improve maintenance of the drainage network:** It is recommended that a risk-based approach is applied so that drainage infrastructure in key areas is kept clear and maintained;

- **Improve drainage network capacity:** A key recommendation of this study is to look at improving the drainage network capacity across the study area, especially within areas that may have capacity issues;

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

- **Rainwater harvesting and water-butts:** Improving the resilience of local communities to flooding can be achieved through raising awareness of simple measures and systems that can be installed at their homes;

- **Preferential overland flowpaths (Urban Blue Corridors):** This concept aims to manage the conveyance of surface water across an area of the catchment through the long term redesign of the urban landscape to create specific pathways to convey surface water;

- **Raising community awareness:** Communicating the risk of flooding and raising awareness within local communities across the town can be implemented in the short-term and provides a 'quick win' measure to surface water management.

4.4 Critical Drainage Area Options

4.4.1 Recommendations for all Critical Drainage Areas

It is recommended that a community flood plan should be created for all CDAs. This document should advise residents and site users of the risk of flooding and appropriate techniques for flood risk management.

The following recommendations are proposed:

- Initial consultation:
    - Discussions with residents / land owners to confirm flooding history (if any);
    - Internal discussions with EFDC and ECC teams; and

    - Discussions with the EA and TW to determine if any synergies can be provided within any proposed schemes and determine potential for funding (FDGiA funding, Local Levy Funding, AMP 5 / 6, and other funding opportunities).
- Undertake a detailed feasibility study which includes:
    - Asset investigations (e.g. Inspection / CCTV of existing infrastructure to confirm condition, size and connectivity);
    - Detailed modelling of the CDA (i.e. refined model grid size, include all pipes and gullies);
    - Initial underground service investigations (obtain and review relevant service plans);
    - Confirmation on land ownership issues; and
    - Conceptual sizing and locating of proposed measures / options based on updated data and constraints.

It is further recommended that all CDAs, including the lower priority CDAs not assessed in this report, be considered when undertaking a review of planning policies to mitigate flood risk within the LBT study area. Other initiatives, including raising community awareness and other non-structural options should be applied as appropriate.

4.4.2 Critical Drainage Areas Specific Options

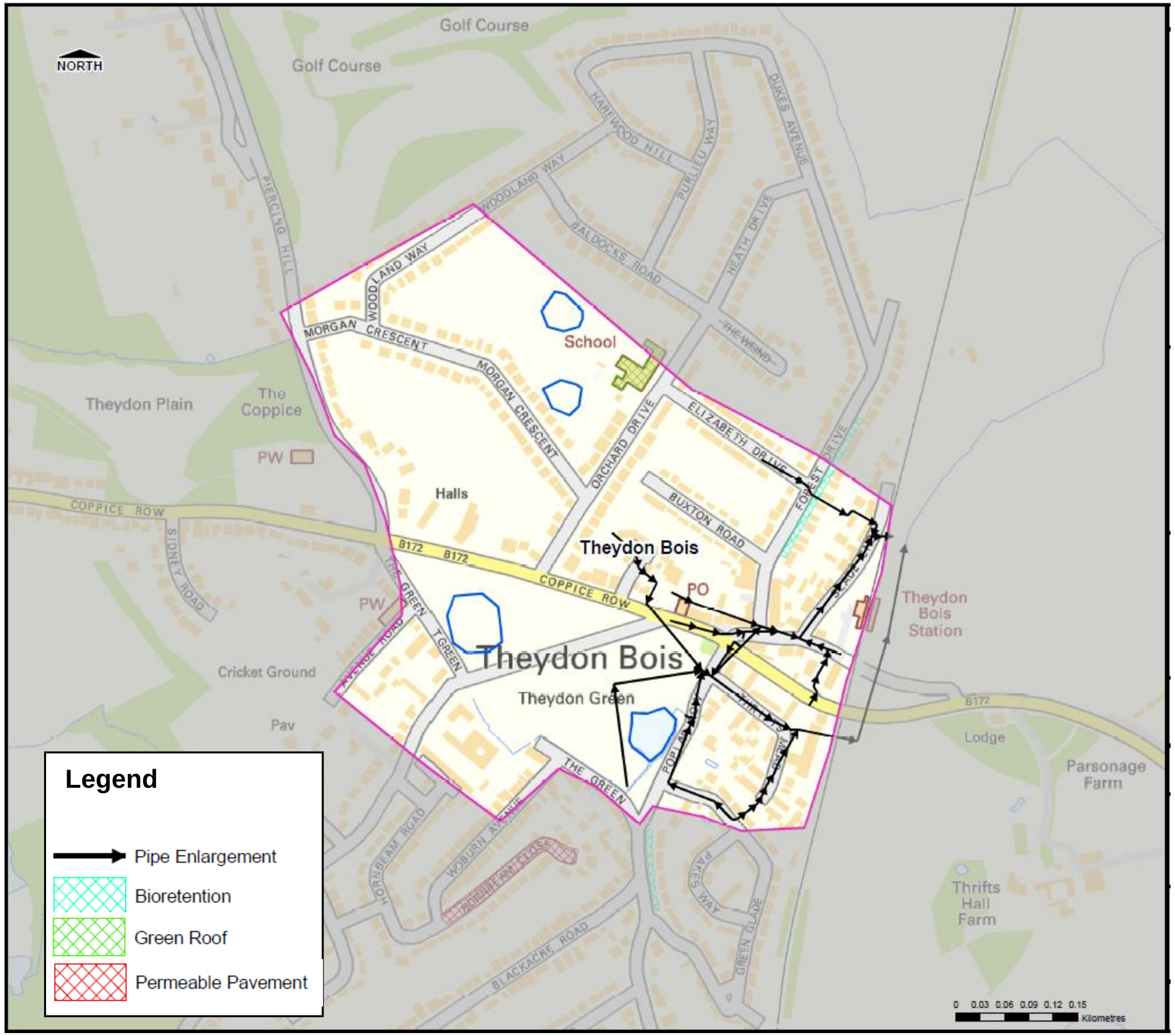
This section discusses the preferred options identified for each CDA based on a review of available measures for mitigating surface water flood risk. These options have been identified for the purpose of providing ECC, EFDC and other stakeholders with potential means of mitigating surface water flood risk for further investigation. Further information on options considered are outlined in Appendix C.

Conceptual option appraisal assessments were undertaken on a range of options for each CDA. Issues relating to feasibility, land ownership and conflicts with other services should be assessed before these conceptual options are progressed further. Further details on the options appraisal process are included in Appendix C.

CDA 01 – Theydon Bois

Preferred Modelled Options:

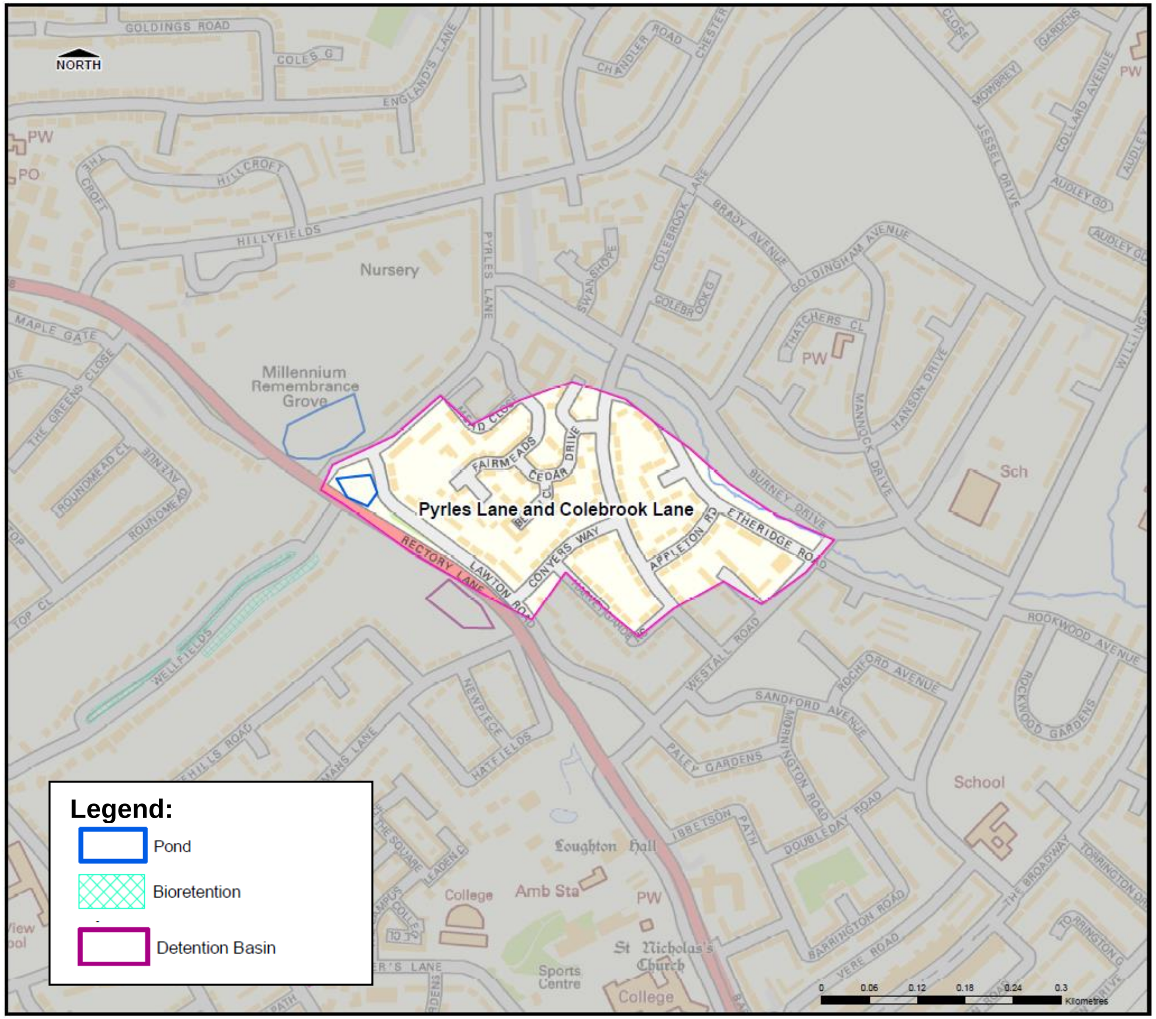
- Four ponds suggested to intercept the flow path within the CDA.
- Two ponds have been located within the Theydon Bois County School grounds. Two additional ponds have been assessed in the east and western portions of Theydon Bois Green.
- A green roof has been located on top of the School building.
- Pipe enlargement has been assessed in the east of the CDA around Coppice Row as the pipes are running at full capacity in this location.
- The model has positioned permeable paving along Hornbeam Close, just to the south of the CDA to help intercept surface water along the flow path into the CDA.
- Bioretention has been situated just to the south east of CDA along Theydon Park Road and in the north east of the CDA along Forest Drive.



CDA 02 – Pyrles Lane and Colebrook Lane

Preferred Modelled Options:

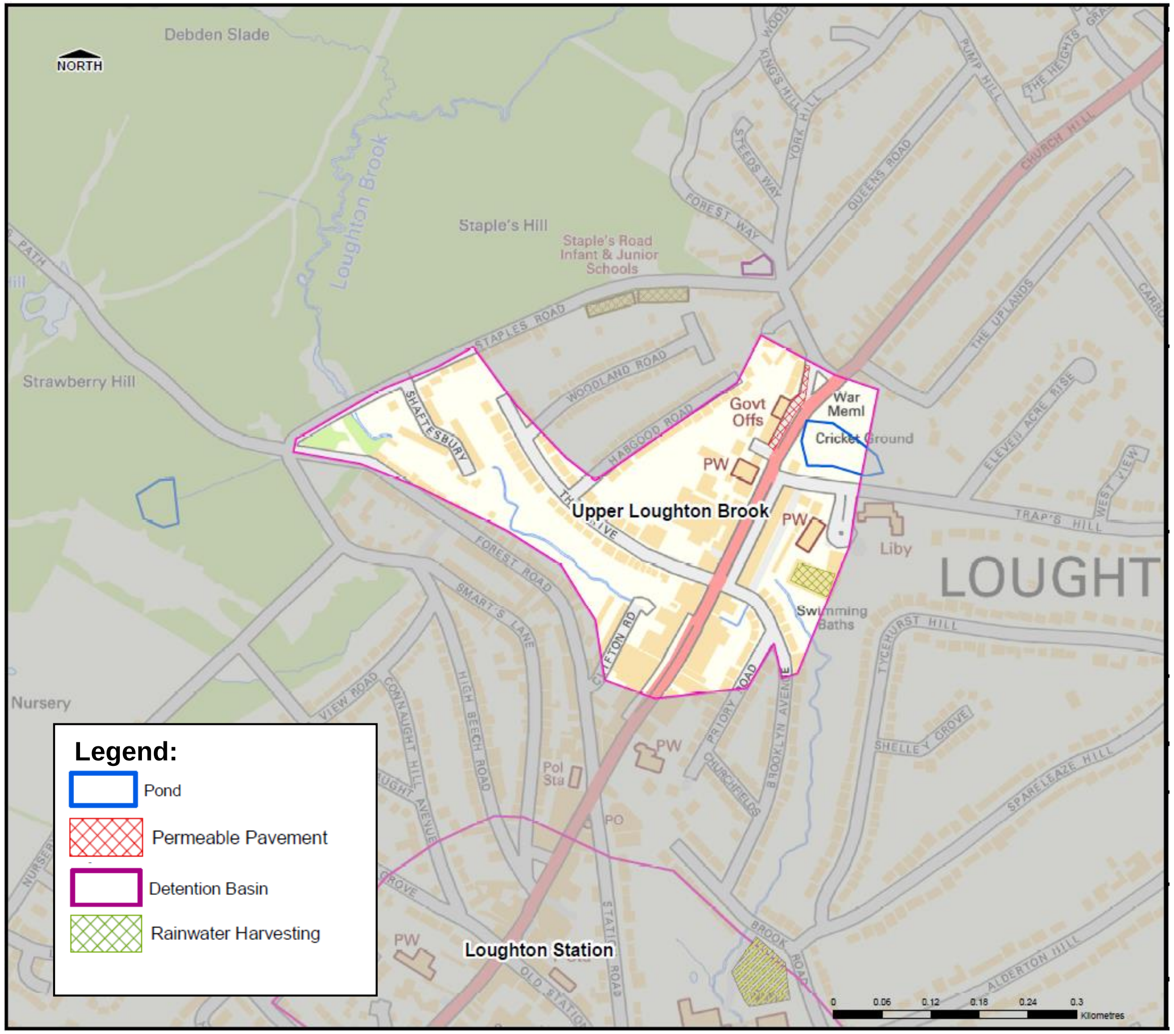
- The model has examined ponds to the west of the CDA in Millennium Remembrance Grove and one in the western corner of the CDA to intercept the main surface water flow path into the CDA.
- A detention basin has been placed to the south west of the CDA on the south side of Rectory Lane.
- Bioretention has been examined along Westfields.



CDA 03 – Upper Loughton Brook

Preferred Modelled Options:

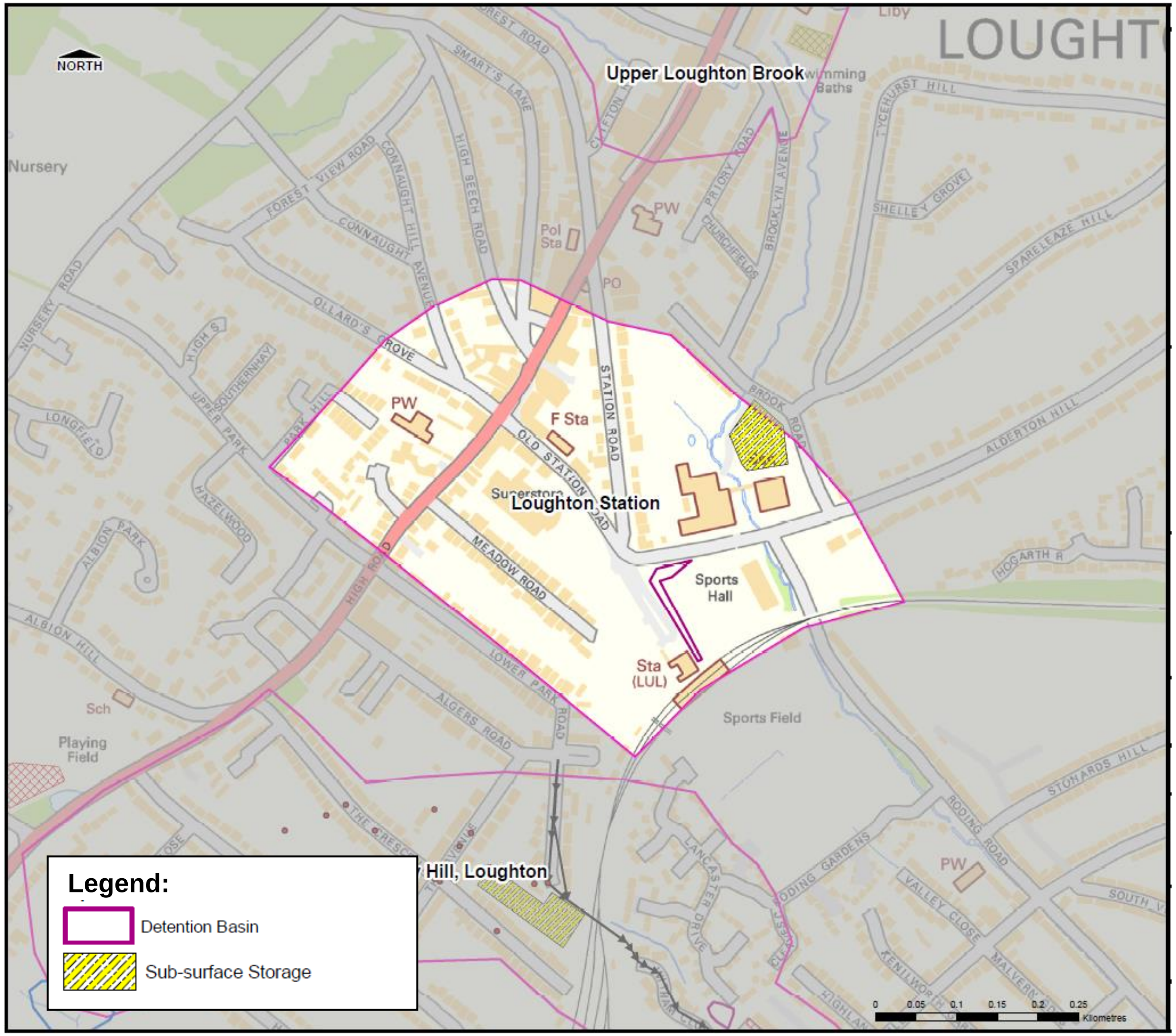
- A pond has been situated within the cricket ground in the eastern part of the CDA. An additional pond could potentially be located to the west of the CDA at the start of a tributary to Loughton Brook.
- The use of rainwater harvesting has been assessed for a school building north of the CDA (along the southern side of Staples Road) and at a leisure centre along the eastern boundary of the CDA.
- Permeable paving has been placed along King's Green in the north east of the CDA.
- A detention basin has been located near the intersection of Forest Way and Staples Road.



CDA 04 – Loughton Station

Preferred Modelled Options:

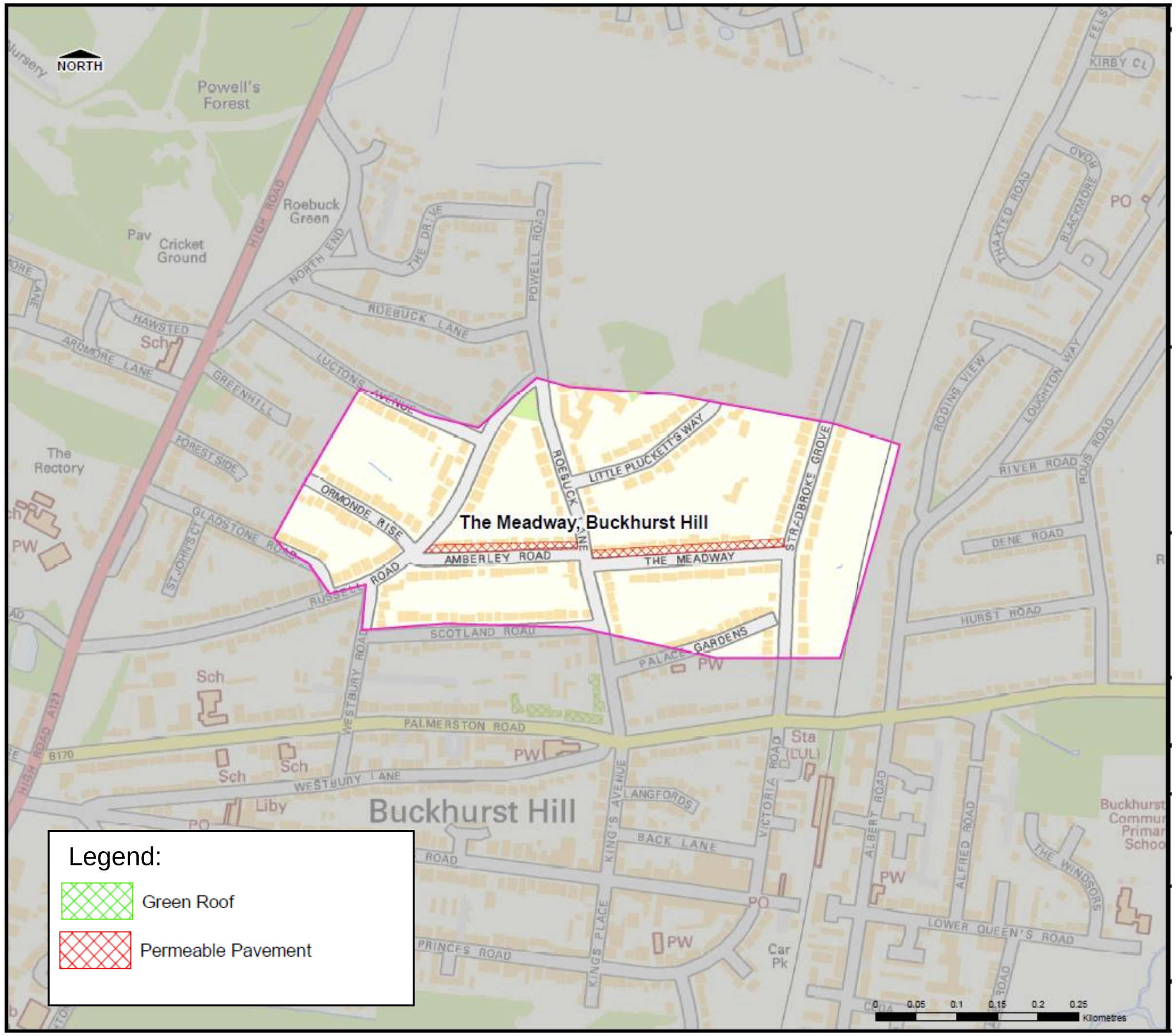
- The use of sub surface storage was assessed using an area of land to the north of Roding Valley High School.
- A detention basin was examined in a small strip of land east of an existing sports field (north of Loughton Station).



CDA 05 – The Meadway Buckhurst Hill

Preferred Modelled Options:

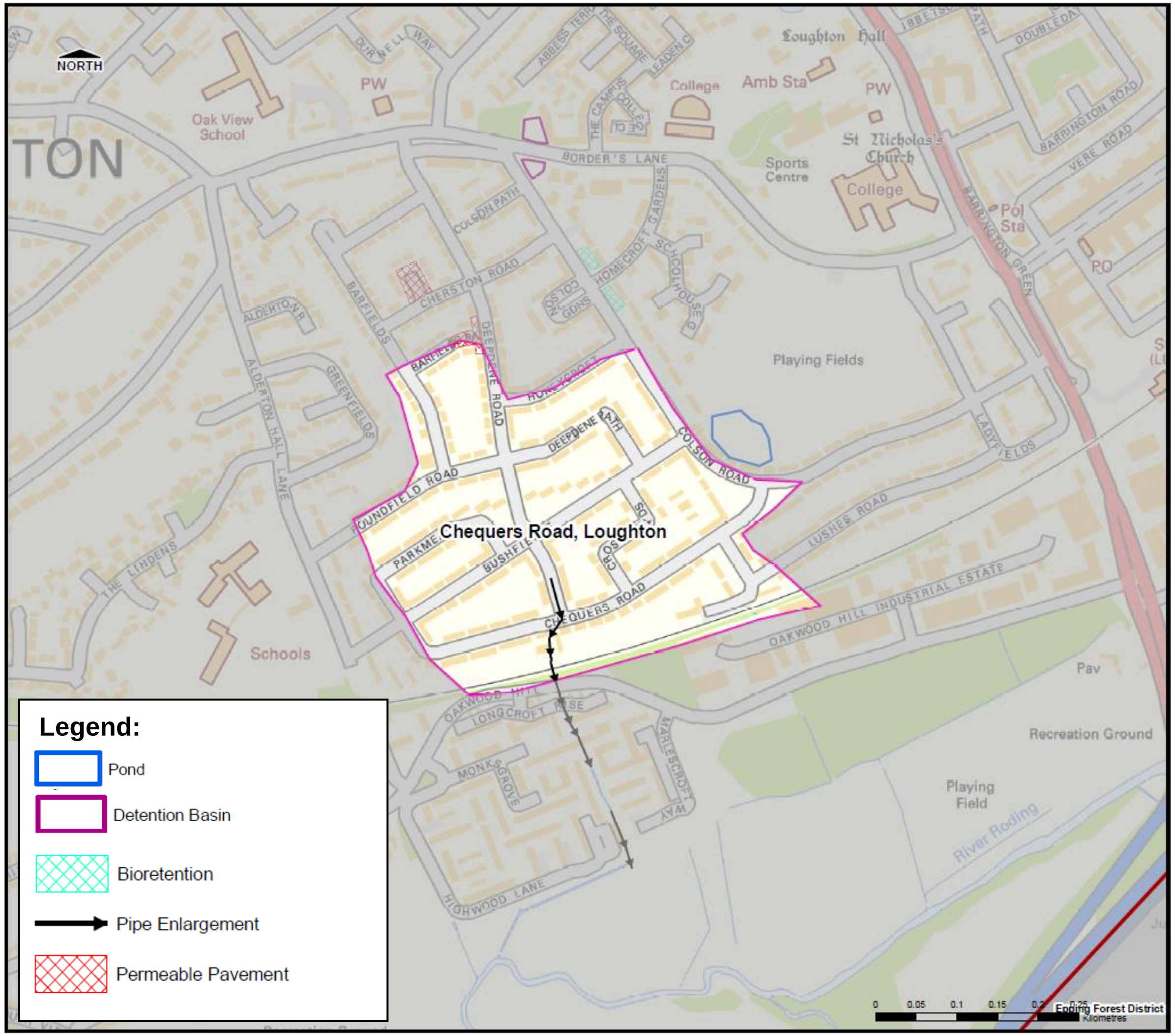
- Permeable paving was positioned along Amberley Road and The Meadway to intercept surface water along this flowpath.
- Green roofs were assessed on existing high rise apartment buildings south of the CDA (at the junction of Palmerston Road and Roebuck Lane)



CDA 06- Chequers Road, Loughton

Preferred Modelled Options:

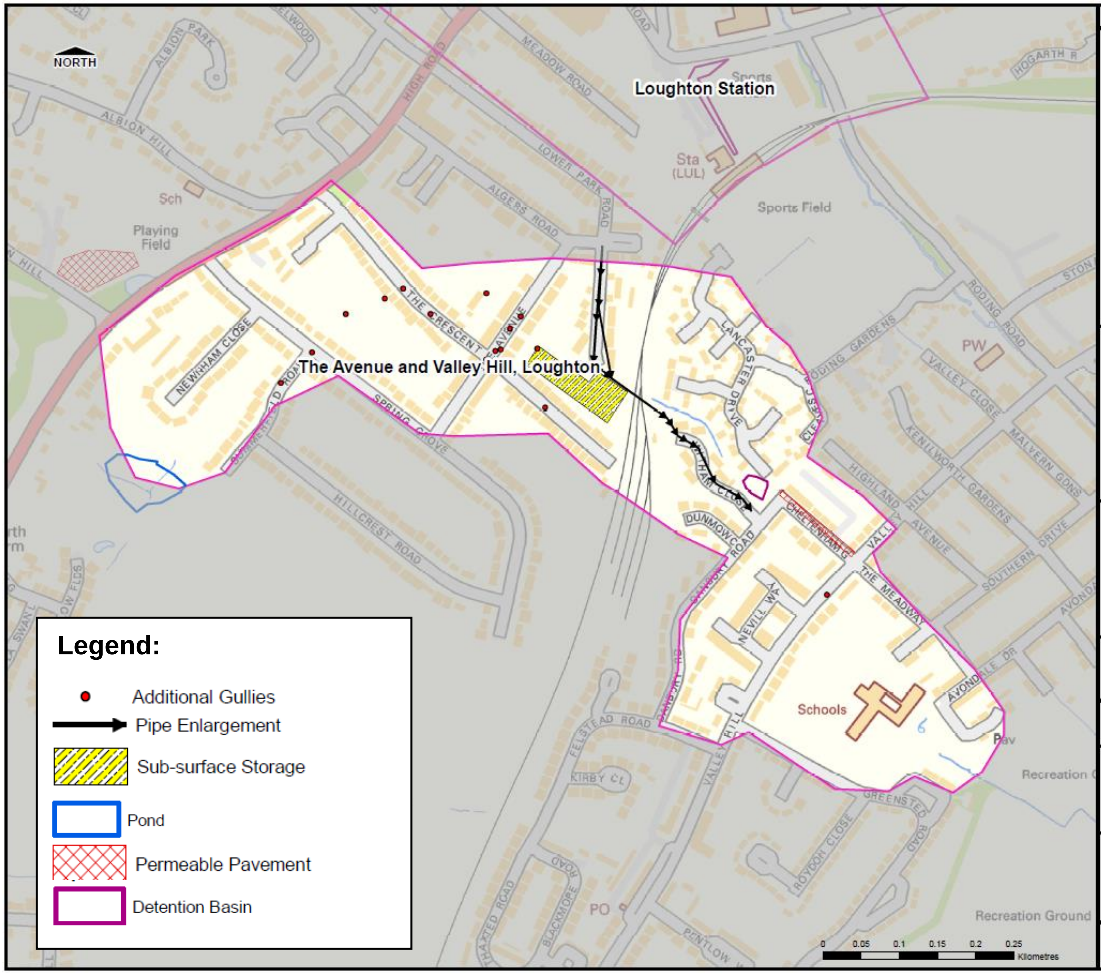
- Pipe enlargement situated along the bottom of Deepdene Road and Chequers Road and underneath the Railway line to improve the drainage from the CDA to reduce ponding in this area.
- Permeable paving placed to the north west of the CDA at the eastern end of Barfields Path.
- Permeable paving has also been assessed in the carpark to the north of Cherston Road.
- Bioretention has been sited along Colston Road either side of Homecroft Gardens.
- Detention basins have been located north of the CDA either side of Border's Lane.
- A pond has been placed within the playing fields east of Colson Road.



CDA 07-The Avenue and Valley Hill, Loughton

Preferred Modelled Options:

- The model has placed permeable paving to the west of the CDA at Oaklands School. Permeable paving has also been modelled along Cheltenham Gardens.
- A detention basin has been placed in the green area to the north of Cheltenham Gardens.
- Sub-surface storage has been located at the Tennis Club.
- Along Lower Park Road and under the Railway line and along Witham Close, pipe enlargement has been sited.
- Additional gullies have been located in a number of areas specifically around Summerfields Road, The Crescent and along The Avenue.
- A pond has been modelled on the western boundary of the CDA, south west of Newham Close and Summerfield Road.



The options indicated above were modelled to assess their potential impact on surface water flood risk within the LBT study area. Two scenarios were investigated using the model: one with the options only, and one with the options plus property level protection (PLP). PLP was assessed in the areas identified in the figures above for to protect properties from depths of surface water ponding up to 0.6m. The potential flood mitigation benefits of implementing the options and the options + PLP were assessed through counts of the number of properties with modelled depths greater than 0.1m. Table 4-1 below shows the number of properties which are predicted to flood during the 100 year event under the baseline, options and options + PLP scenarios.

Table 4-1: Number of Flooded Properties under Baseline and Options scenarios for the 1 in 100 year probability event

Critical Drainage Area	Number of Properties with Modelled Depths Greater Than 0.1m		
	Baseline	Options Implemented	Options + PLP Implemented
CDA 01 – Theydon Bois	31	31	31
CDA 02 – Pyrles Lane and Colebrook	44	44	41
CDA 03 – Upper Loughton Brook	45	27	24
CDA 04 – Loughton Station	75	38	38
CDA 05 – The Meadway, Buckhurst Hill	38	29	29
CDA 06 – Chequers Road, Loughton	117	100	72
CDA 07 – The Avenue and Valley Hill, Loughton	62	60	55

5 Action Plan

5.1 Structure and Content

The Action Plan outlines a range of recommended measures to manage surface water within LBT more effectively. The Action Plan has been developed to outline the responsibilities and implications of both structural and non-structural options discussed in Phase 3 of the SWMP. The Action Plan details the methods, timescale and responsibility of each proposed action.

Within the Action Plan there are details of general measures that could be implemented across LBT. The general actions are non-structural and encourage improved surface water management through planning policy and public education and awareness.

The Action Plan should be read in conjunction with details the referenced relevant sections of this SWMP document. The Action Plan is included in Appendix B of this report.

This Action Plan is a simple summary spreadsheet that has been formulated by reviewing the previous phases of the SWMP in order to create a useful set of actions relating to the management and investigation of surface water flooding going forward. It is the intention that the Action Plan is a live document, maintained and regularly updated by ECC (the LLFA) and EFDC as actions are progressed and investigated. New actions may be identified by the LLFA and EFDC, or may be required by changing legislation and guidance over time.

5.2 Implementation and Review

Following the completion of the SWMP, the actions detailed in the Action Plan will need to be implemented. This will require continued work within the ECC and their delivery partners to ensure all partners are involved in the implementation and ongoing maintenance and performance measures.

ECC should coordinate with relevant internal and external partners in order to ensure a holistic approach to the implementation of outputs and actions from the SWMP. Key internal Council partners include emergency planners, the highways department, spatial planning and the environment departments. Key external partners include EFDC development and regeneration services, environmental health, emergency planning and leisure and public spaces; TW, and the EA.

6 Review and Update

6.1 Review Timeframe and Responsibilities

This SWMP and Action Plan identify the relevant internal departments and external partnerships that should be consulted and asked to participate when addressing an action. After an action has been addressed, it is recommended that the department responsible for completing the action should review the Action Plan and update it to reflect any issues (communication or stakeholder participation) which arose during the completion of an action and whether or not additional actions are required. It is recommended that the Action Plan is regularly reviewed and updated to reflect any necessary amendments.

6.2 Ongoing Monitoring

It is intended that the working arrangements established as part of the SWMP process, will continue beyond the completion of the SWMP in order to facilitate the implementation of the proposed actions, review opportunities for operational efficiency and to review any legislative changes.

Examples of something which would be likely to trigger an Action Plan review include:

- Occurrence of a surface water flood event;
- Additional data or modelling becoming available, which may alter the understanding of risk within the study area;
- Outcome of investment decisions by partners which may require a revision to the action plan; and
- Additional (major) development or other changes in the catchment which may affect the surface water flood risk.

It is in the interest of ECC, EFDC and the residents of the catchment that the SWMP Action Plan remains current and up-to-date. To help facilitate this, the EFDC and ECC should liaise with other flood risk management authorities and monitor progress.

7 References

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Appendix A: Glossary and Abbreviations

Term	Definition
AEP	Annual Exceedance Probability (represented as a %) is the chance or probability of a rainfall or flooding event occurring annually.
Aquifer	A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water.
AMP	Asset Management Plan, see below
Asset Management Plan	A plan for managing water and sewerage company (WaSC) infrastructure and other assets in order to deliver an agreed standard of service.
AStGWF	Areas Susceptible to GroundWater Flooding. A national data set held by the Environment Agency identifying the risk of groundwater emergence within an area.
Bank Full	The flow stage of a watercourse in which the stream completely fills its channel and the elevation of the water surface coincides with the top of the watercourses banks.
CDA	Critical Drainage Area, see below.
Critical Drainage Area	A discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure.
Catchment Flood Management Plan (CFMP)	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
CFMP	Catchment Flood Management Plan, see entry above.
CIRIA	Construction Industry Research and Information Association.
Civil Contingencies Act	This UK Parliamentary Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums have a duty to put into place emergency plans for a range of circumstances including flooding.
CLG	Government Department for Communities and Local Government.
Climate Change	Long term variations in global temperature and weather patterns caused by natural and human actions.
Culvert	A channel or pipe that carries water below the level of the ground.
Defra	Government Department for Environment, Food and Rural Affairs.
DEM	Digital Elevation Model: a topographic model consisting of terrain elevations for ground positions at regularly spaced horizontal intervals. DEM is often used as a global term to describe DSMs (Digital Surface Model) and DTMs (Digital Terrain Models).
Dendritic	Irregular stream branching, with tributaries joining the main stream at all angles e.g. drainage networks converge into larger trunk sewers and finally one outfall.
DG5 Register	A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 20 years.
DSM	Digital Surface Model: a topographic model of the bare earth/underlying terrain of the earth's surface including objects such as vegetation and buildings.
DTM	Digital Terrain Model: a topographic model of the bare earth/underlying terrain of the earth's surface excluding objects such as vegetation and buildings. DTMs are usually derived from DSMs.
EA	Environment Agency, Government Agency reporting to Defra charged with protecting the Environment and managing flood risk in England.
ECC	Essex County Council. The Lead Local Flood Authority in the area.
EFDC	Epping Forest District Council.

Term	Definition
FCERM	Flood and Coastal Erosion Risk Management Strategy. Prepared by the Environment Agency in partnership with Defra. The strategy is required under the Flood and Water Management Act 2010 and will describe what needs to be done by all involved in flood and coastal risk management to reduce the risk of flooding and coastal erosion, and to manage its consequences.
Flood defence	Infrastructure used to protect an area against floods such as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Flood Risk Area	See entry under Indicative Flood Risk Areas.
Flood Risk Regulations	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.
Flood and Water Management Act	An Act of Parliament which forms part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England. The Act was passed in 2010 and is currently being enacted.
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a watercourse (river or stream). In this report the term Fluvial Flooding generally refers to flooding from Main Rivers (see later definition).
FRR	Flood Risk Regulations, see above.
Hyetograph	A graphical representation of the variation of rainfall depth or intensity with time.
IDB	Internal Drainage Board, see below.
Internal Drainage Boards	Internal Drainage Board. An independent body with powers and duties for land drainage and flood control within a specific geographical area, usually an area reliant on active pumping of water for its drainage.
Indicative Flood Risk Areas	Areas determined by the Environment Agency as potentially having a significant flood risk, based on guidance published by Defra and WAG and the use of certain national datasets. These indicative areas are intended to provide a starting point for the determination of Flood Risk Areas by LLFAs.
IUD	Integrated Urban Drainage, a concept which aims to integrate different methods and techniques, including sustainable drainage, to effectively manage surface water within the urban environment.
LBT	Loughton, Buckhurst Hill and Theydon Bois.
LDF	Local Development Framework is the spatial planning strategy introduced in England and Wales by the Planning and Compulsory Purchase Act 2004 and given detail in Planning Policy Statements 12. These documents typically set out a framework for future development and redevelopment within a local planning authority.
Lead Local Flood Authority	Local Authority responsible for taking the lead on local flood risk management. The duties of LLFAs are set out in the Floods and Water Management Act.
LiDAR	Light Detection and Ranging, a technique to measure ground and building levels remotely from the air, LiDAR data is used to develop DTMs and DEMs (see definitions above).
LLFA	Lead Local Flood Authority, see above.
Local Resilience Forum	A multi-agency forum, bringing together all the organisations that have a duty to cooperate under the Civil Contingencies Act, and those involved in responding to emergencies. They prepare emergency plans in a co-ordinated manner and respond in an emergency. Roles and Responsibilities are defined under the Civil Contingencies Act.
LPA	Local Planning Authority, see below.
Local Planning Authority	The local authority or Council that is empowered by law to exercise planning functions for a particular area. This is typically the local borough or district Council.

Term	Definition
LRF	Local Resilience Forum, see above.
Main River	Main rivers are a statutory type of watercourse in England and Wales, usually larger streams and rivers, but also include some smaller watercourses. A main river is defined as a watercourse marked as such on a main river map, and can include any structure or appliance for controlling or regulating the flow of water in, into or out of a main river. The Environment Agency's powers to carry out flood defence works apply to main rivers only.
NPPF	National Planning Policy Framework (replaces PPS25).
NRD	National Receptor Dataset – a collection of risk receptors produced by the Environment Agency. A receptor could include essential infrastructure such as power infrastructure and vulnerable property such as schools and health clinics.
Ordinary Watercourse	All watercourses that are not designated Main River, and which are the responsibility of Local Authorities or, where they exist, IDBs are termed Ordinary Watercourses.
Partner	A person or organisation with responsibility for the decision or actions that need to be taken.
PFRA	Preliminary Flood Risk Assessment, see below.
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.
Pluvial Flooding	Flooding from water flowing over the surface of the ground; often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow.
Preliminary Flood Risk Assessment	Assessment required by the EU Floods Directive which summarises flood risk in a geographical area. Led by LLFAs.
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Return Period	The return period is defined as the average period of time expected to elapse between occurrences of events at a certain location.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, combined with the consequence of the flood.
Risk Management Authority	As defined by the Floods and Water Management Act. These can be (a) the Environment Agency, (b) a lead local flood authority, (c) a district council for an area for which there is no unitary authority, (d) an internal drainage board, (e) a water company, and (f) a highway authority.
RMA	Risk Management Authority, see above.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
SFRA	Strategic Flood Risk Assessment, see below.
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
Strategic Flood Risk Assessment	SFRAs (SFCAs in Wales) are prepared by local planning authorities (in consultation with the Environment Agency) to help guide local planning. They allow them to understand the local risk of flooding from all sources (including surface water and groundwater). They include analysis and maps of the impact of climate change on the extent of future floods. You can find these documents on the website of your local planning authority.
SuDS	Sustainable Drainage Systems, see below.
Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques. Includes swales, wetlands, bioretention devices and ponds.

Term	Definition
Surface water runoff	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.
SWMP	Surface Water Management Plan.
Thames Water	The Water Authority for this area.
UFMfSW	Updated Flood Map for Surface Water. A national data set held by the Environment Agency showing areas where surface water would be expected to flow or pond, as a result of three different chances of rainfall event, the 1 in 30yr, 1 in 100yr and 1 in 1000 year events.
UKCIP	The UK Climate Impacts Programme. Established in 1997 to assist in the co-ordination of research into the impacts of climate change. UKCIP publishes climate change information on behalf of the UK Government and is largely funded by Defra.
WaSC	Water and Sewerage Company.

Appendix B: SWMP Action Plan

Appendix C: Options Assessment

Appendix D: Modelling Details

Appendix E: Data Collection

Appendix F: Maps and Figures

Limitations

Capita Property and Infrastructure Ltd ("Capita") has prepared this Report for the sole use of **Essex County Council** ("Client") in accordance with the Agreement under which our services were performed. No other warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by Capita. This Report is confidential and may not be disclosed by the Client nor relied upon by any other party without the prior and express written agreement of Capita.

The conclusions and recommendations contained in this Report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by Capita has not been independently verified by Capita, unless otherwise stated in the Report.

The methodology adopted and the sources of information used by Capita in providing its services are outlined in this Report. The work described in this Report was undertaken between **October 2013** and **April 2015** and is based on the conditions encountered and the information available during the said period of time. The scope of this Report and the services are accordingly factually limited by these circumstances.

Where assessments of works or costs identified in this Report are made, such assessments are based upon the information available at the time and where appropriate are subject to further investigations or information which may become available.

Capita disclaim any undertaking or obligation to advise any person of any change in any matter affecting the Report, which may come or be brought to Capita's attention after the date of the Report.

Certain statements made in the Report that are not historical facts may constitute estimates, projections or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the Report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. Capita specifically does not guarantee or warrant any estimate or projections contained in this Report.

Unless otherwise stated in this Report, the assessments made assume that the sites and facilities will continue to be used for their current purpose without significant changes.

Costs may vary outside the ranges quoted. Whilst cost estimates are provided for individual issues in this Report these are based upon information at the time which can be incomplete. Cost estimates for such issues may therefore vary from those provided. Where costs are supplied, these estimates should be considered in aggregate only. No reliance should be made in relation to any division of aggregate costs, including in relation to any issue, site or other subdivision.

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