LUTON BOROUGH COUNCIL

SURFACE WATER MANAGEMENT PLAN

2012

Quality Management

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RELATED DOCUMENTS

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- Thames Water
- Anglian Water
- Bedfordshire Fire Brigade
- British Geological Survey

Executive Summary

This document forms the Surface Water Management Plan (SWMP) for Luton. The report outlines the preferred surface water management strategy for the borough and for the part of the contributing hydrological catchment that lies within Central Bedfordshire. 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). These are:

- Phase 1 – Preparation;
- Phase 2 – Risk Assessment;
- Phase 3 – Options; and
- Phase 4 – Implementation and Review.

Phase 1: Preparation

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.

Phase 2: Risk Assessment

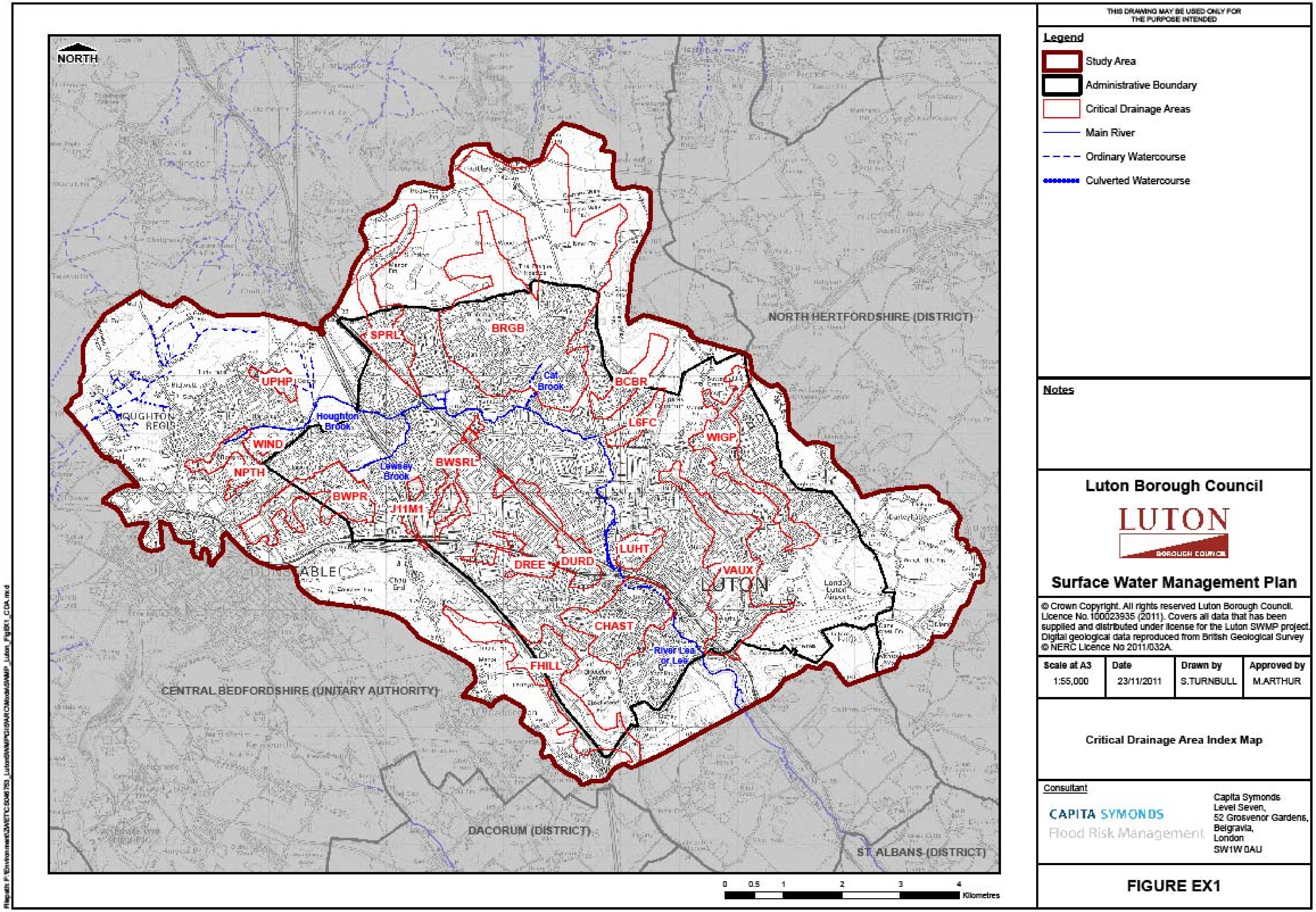
As part of the Phase 2 Risk Assessment, direct rainfall modelling has been undertaken across the study area for five rainfall event return periods. The results of this modelling have been used to identify Local Flood Risk Zones (LFRZs) where surface water flooding affects houses, businesses and/or infrastructure. Those areas identified to be at more significant risk have been delineated into Critical Drainage Areas (CDAs) representing one or several LFRZs as well as the contributing catchment area and features that influence the predicted flood extent.

As a result of this process 17 CDAs have been identified within the study area and are presented in the figure below. The dominant mechanisms for flooding can be broadly divided into the following categories:

- River Valleys (current and historic) - across the study area, the areas particularly susceptible to overland flow are formed by narrow corridors associated with topographical valleys which represent the routes of 'lost' watercourses;
- Topographical Low Lying Areas - areas such as underpasses, subways and lowered roads beneath railway lines are more susceptible to surface water flooding;
- Railway Cuttings - stretches of railway track in cuttings are susceptible to surface water flooding and, if flooded, will impact on services;

- Railway Embankments - discrete surface water flooding locations along the upstream side of the raised rail embankment;
- Topographical Low Points - areas which are at topographical low points throughout the borough which result in small, discrete areas of deep surface water ponding;
- Sewer Flood Risk - areas where extensive and deep surface water flooding is likely to be the influence of sewer flooding mechanisms alongside pluvial and groundwater sources; and
- Fluvial Flood Risk - areas where extensive and deep surface water flooding is likely to be the influence of fluvial flooding mechanisms (alongside pluvial, groundwater and sewer flooding sources).

Figure EX1: Critical Drainage Areas within the Study Area



Analysis of the number of properties at risk of flooding has been undertaken for the rainfall event with a 1 in 100 probability of occurrence in any given year. A review of the results demonstrate that 6,085 properties in the study area could be at risk of surface water flooding of a depth greater than 0.1m during a 100 year rainfall event (above an assumed 0.1m building threshold). In terms of administrative areas within the study area, the properties are distributed as shown in Table EX1 below.

Administrative Area	Infrastructure	Households		Commercial / Industrial	Other (Unclassified Landuse)	Total
		Non-Deprived	Deprived			
Central Bedfordshire	2	441	25	33	78	**579**
Luton	32	3140	1429	331	568	**5500**
North Hertfordshire	0	4	0	0	2	**6**
Total	**34**	**3585**	**1454**	**364**	**648**	**6085**

Table EX1: Flooded Properties Summary

Phase 3 Options Assessment

There are 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 operations 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 generic measures to be implemented through the establishment of a policy position on issues including the widespread use of water conservation measures such as water butts and rainwater harvesting technology, use of soakaways, permeable paving, bioretention car park pods and green roofs. In addition, there are study-area-wide opportunities to raise community awareness.

For each of the CDAs identified within the study area, site-specific measures have been identified that could be considered to help alleviate surface water flooding. These measures were subsequently short listed to identify a potential preferred option for each CDA.

Pluvial modelling undertaken as part of the SWMP study has identified that flooding is heavily influenced by existing and historic river valleys, and impacts a number of regionally important infrastructure assets. It is recommended that in the short-to-medium term Luton Borough and Central Bedfordshire Councils:

- 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 they can take to improve flood resilience;
- Inform residents of measures that they can take to mitigate surface water flooding to/around their property;
- Prepare and implement a communication strategy to effectively communicate with different audiences to raise awareness of surface water flood risk using a clearly defined process for internal and external communication with stakeholders and the public; and
- Improve maintenance regimes, and target those areas identified to regularly flood or known to have blocked gullies.

Phase 4 Implementation & Review
Phase 4 establishes a long-term Action Plan for LBC to assist in their role as the Lead Local Flood Authority (LLFA) under the FWMA 2010 to lead in the 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;
- Provide an indication of the priority of the actions and a timescale for delivery; and
- Outline actions required to meet the requirements of LBC as the LLFA under the FWMA 2010.

The SWMP Action Plan is a 'living' document, and as such, should be reviewed and updated regularly, particularly i) following the occurrence of a surface water flood event, ii) when additional data or modelling becomes available, iii) following the outcome of investment decisions by partners and iv) following any additional major development or changes in the catchment which may influence the surface water flood risk within the borough.

Glossary

Term	Definition
AEP	Annual Exceedance Probability
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 (AMP)	A plan for managing water and sewerage company (WaSC) infrastructure and other assets in order to deliver an agreed standard of service.
AStSWF	Areas Susceptible to Surface Water Flooding. A national data set held by the Environment Agency and based on high level modelling which shows areas potentially at risk of surface water flooding.
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.
CBC	Central Bedfordshire Council
CDA	Critical Drainage Area, see below.
Critical Drainage Area (CDA)	A discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer and/or main river) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property and/or local infrastructure.
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 ground level.
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 Models) and DTMs (Digital Terrain Models).
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.

Term	Definition
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.
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.
National FCERM Strategy	National 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.
FMfSW	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 two different chances of rainfall event, the 1 in 30yr and 1 in 200yr events.
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 (FRR)	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.
Floods & Water Management Act (FWMA 2010)	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.
IDB	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.
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.
LBC	Luton Borough Council

Term	Definition
LDF	Local Development Framework. The spatial planning strategy introduced in England and Wales by the Planning and Compulsory Purchase Act 2004 and given detail in Planning Policy Statement 12. These documents typically set out a framework for future development and redevelopment within a local planning authority (will be replaced by new Local Plan).
LFRZ	Local Flood Risk Zone, see below.
Local Flood Risk Zone (LFRZ)	Local Flood Risk Zones are defined as discrete areas of flooding that do not exceed the national criteria for a ‘Flood Risk Area’ but still affect houses, businesses or infrastructure. A LFRZ is defined as the actual spatial extent of predicted flooding in a single location (and see CDA above).
Local FCERM Strategy	A local strategy required by the FWMA 2010 that must specify: (a) the risk management authorities in the authority’s area, (b) the flood and coastal erosion risk management functions that may be exercised by those authorities in relation to the area, (c) the objectives for managing local flood risk (including any objectives included in the authority’s flood risk management plan prepared in accordance with the Flood Risk Regulations 2009), (d) the measures proposed to achieve those objectives, (e) how and when the measures are expected to be implemented, (f) the costs and benefits of those measures, and how they are to be paid for, (g) the assessment of local flood risk for the purpose of the strategy, (h) how and when the strategy is to be reviewed, and (i) how the strategy contributes to the achievement of wider environmental objectives.
Lead Local Flood Authority (LLFA)	Local Authority responsible for taking the lead on local flood risk management (Luton Borough Council is the LLFA for Luton). The duties of LLFAs are set out in the FWMA 2010.
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 (LRF)	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. The local authority or Council that is empowered by law to exercise planning functions for a particular area (LBC is the LPA for Luton and CBC is the LPA for Central Beds.).
LRF	Local Resilience Forum, see above.

Term	Definition
Main River	Main Rivers are a statutory type of watercourse in England and Wales and are usually larger streams and rivers, but may 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
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 properties 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 designated Ordinary Watercourses.
PA	Policy Area, see below.
Partner	A person or organisation with responsibility for a decision or action that needs 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 the additional flow.
Policy Area (PA)	One or more Critical Drainage Areas linked together to provide a planning policy tool. Primarily defined on a hydrological basis, but can also accommodate geological concerns where these significantly influence the implementation of SuDS.
PPS25	Planning and Policy Statement 25: Development and Flood Risk (now subsumed into the NPPF - see definition above).
Preliminary Flood Risk Assessment (PFRA)	Assessment required by the EU Floods Directive which summarises flood risk in a geographical area. Led by Local Authorities.
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical sockets and appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, combined with the consequence of or the hazard posed by the flood.
Risk Management Authority (RMA)	Defined by the Floods and Water Management Act as “the Environment Agency, a lead local flood authority, a district council for an area for which there is no unitary authority, an internal drainage board, a water company, and a highway authority”.

Term	Definition
RMA	Risk Management Authority, see above.
Sewer flooding	Flooding caused by a blockage in or overflowing from a sewer or urban drainage system.
SFRA	Strategic Flood Risk Assessment, see below.
Stakeholder	A person or organisation affected by a problem or its solution, or interested in the problem or solution. They can be individuals or organisations, and includes the public and communities.
SSSA	Strategic Site Specific Allocation (refer Luton and Central Bedfordshire Core Strategy Document – www.shapeyourfuture.org.uk)
Strategic Flood Risk Assessment (SFRA)	A strategic framework for the consideration of flood risk when making planning decisions at local level.
SuDS	Sustainable Drainage Systems, see below.
Sustainable Drainage Systems (SuDS)	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than conventional techniques that Includes permeable surfaces, swales, wetlands and ponds.
Surface water	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.
SWMP	Surface Water Management Plan.
TWUL	Thames Water Utilities Ltd.
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.

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1 Introduction

1.1 *What is a Surface Water Management Plan?*

1.1.1 A Surface Water Management Plan (SWMP) is a plan produced by the Lead Local Flood Authority (LLFA) (in this case LBC) which outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small water courses and ditches that occurs as a result of heavy rainfall.

1.1.2 This SWMP study has been undertaken in partnership with key local stakeholders who are responsible for surface water management and drainage in the Luton area – including Thames Water, Anglian Water and the Environment Agency. The Partners have worked together to understand the causes and effects of surface water flooding and agree the most cost effective way of managing surface water flood risk for the long term.

1.1.3 This document also establishes a long-term action plan to manage surface water and will influence future capital investment, maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

1.2 *Background*

1.2.1 Defra's National Rank Order of Settlements Susceptible to Surface Water Flooding (Defra, 2009) indicates that the Luton area is vulnerable to surface water flooding and is ranked 33rd out of 4,200 settlements in England. However, there is a general lack of comprehensive knowledge regarding the location, frequency and magnitude of existing surface water flood risk in Luton, primarily due to the management of different elements of the drainage system by different stakeholders, resulting in the lack of a strategic overview by one body.

1.2.2 Previous studies have indicated that surface water flood risk is a particular problem for Luton and the areas surrounding Lewsey Brook and Houghton Brook, including Lewsey and Limbury in Luton, and Parkside in Houghton Regis. This is thought to be due to the rapid expansion of Luton to the north from the 1950s to the 1980s without a related upgrade of the downstream sewer system. The problem is further compounded by the local topography, which routes surface water generally toward the centre of Luton, and by some reliance on pumped drainage which can become overwhelmed during heavy rain.

1.2.3 As part of the duties created by the Floods and Water Management Act 2010, local authorities are responsible for management of local flood risk – including surface water and groundwater. As it has been previously identified that the

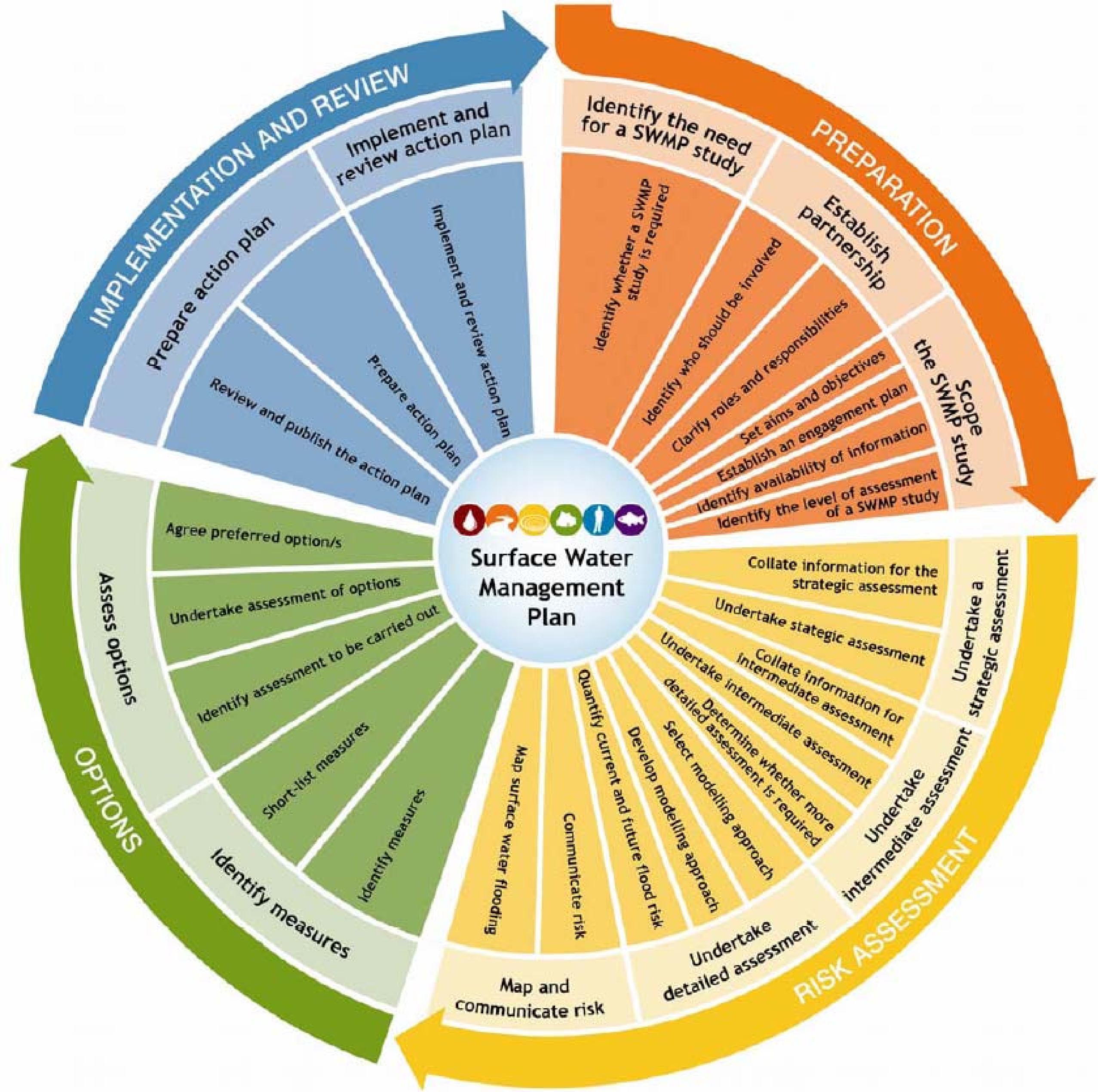
Luton area is susceptible to surface water flooding, this SWMP will provide a basis for more effective management of surface water within it and the risk of flooding from it.

1.3 SWMP Process

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

1. Preparation: Identify the need for a SWMP, establish a partnership with the relevant stakeholders and scope the SWMP (refer to Chapter 2);
2. Risk Assessment: Select an appropriate risk assessment level and complete the assessment – a Level 2 Intermediate assessment was selected for this study (refer to Chapter 3);
3. Options: Identify options/measures (with stakeholder engagement) which seek to alleviate the surface water flood risk within the study area (refer to Chapter 4); and
4. Implementation and Review: Prepare Action Plan and implement the monitoring and review process for these actions (refer to Chapter 5).

1.3.2 The scope of this study includes elements of all phases of the process.



Recommended Defra SWMP Process (Source Defra 2010)

1.4 Objectives

1.4.1 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 Luton;
- Identify, define and prioritise Critical Drainage Areas, 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 planning 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, resources 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;
- 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.

1.5 Study Area

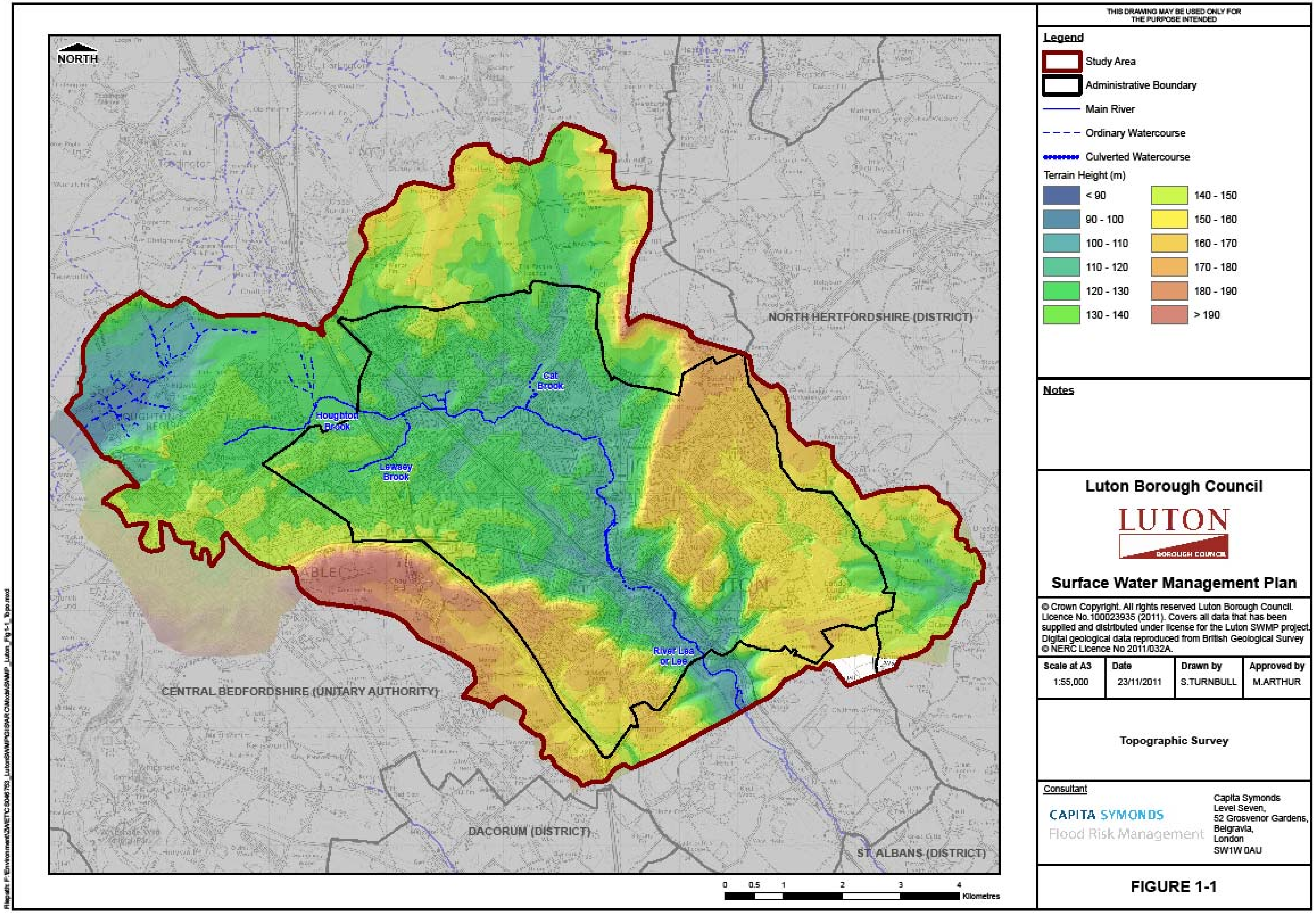
Location, Extent and Topography

1.5.1 Luton is a large town located 30 miles north of London in southern Bedfordshire, bounded by the local authority areas of Central Bedfordshire to the north and west, Dacorum and St Albans to the south and North Hertfordshire to the east.

1.5.2 The 'Study Area' has been defined to include the entire hydrological catchment for Luton and to incorporate areas identified for future growth (Houghton Regis and others – refer paragraph 1.5.18). As a result of this, the study area encompasses the entire LBC Administrative Area along with parts of Central Bedfordshire and North Hertfordshire.

1.5.3 The topography of the study area generally slopes towards the River Lea which runs in a south easterly direction through the centre of Luton. The highest elevations are in the north west and the lowest in the south east. Figure 1-1 shows a topographic survey of the study area derived from LiDAR data.

Figure 1-1 Topographic Survey



Key Stakeholders / Study Area Governance

1.5.4 LBC is a ‘Unitary Authority’ and therefore takes the role of the LLFA for their administrative area as defined by the FWMA 2010. LBC covers the majority of the study area and is therefore responsible for management of local sources of flood risk. LBC is the lead partner in this SWMP study.

1.5.5 Central Bedfordshire Council (CBC) is also a Unitary Authority and LLFA. LBC and CBC are working together to manage and coordinate development in their adjacent areas. In the context of the SWMP, the study area extent has been defined to include the North Houghton Regis Strategic Site Specific Allocation (SSSA) to support this partnership – even though a large portion of this area does not contribute runoff to the LBC area. Similarly, the area immediately to the north of LBC was also included in the study area as runoff from this area does enter the borough and may be influenced in the future by the North Luton SSSA.

1.5.6 The eastern border of the study area overlaps into North Hertfordshire District Council and Hertfordshire County Council administrative areas. The study area was extended beyond the LBC boundary in this area to ensure the runoff towards LBC from the ridgeline immediately to the east was included in the overall assessment. The study area was also extended to include the East of Luton Airport Employment SSSA to ensure that the impacts of any changes in the upstream catchment could be easily assessed in the future.

1.5.7 The Environment Agency (EA) is responsible for flood risk and water quality management of the River Lea and its associated Main River tributaries within the study area. These rivers and brooks receive a large proportion of the surface water runoff in this study area, and the EA are thus an essential partner for flood risk management.

1.5.8 Thames Water is the sewerage undertaker within the LBC area, but Anglian Water manages the areas of Dunstable and Houghton Regis immediately to the north and west with some interconnection to the Thames Water system in Luton.

1.5.9 The study area also falls within the zone of responsibility for the Thames Regional Flood and Coastal Committee (RFCC). This committee replaced the previous Regional Flood and Coastal Defence Committee that existed until 31 March 2011 as part of national changes initiated by the FWMA 2010. LBC is part of a constituent authority group along with Buckinghamshire County Council, Slough Borough Council and CBC. This group is represented on the RFCC by a single elected member from the authorities listed above.

Land Use Characteristics

1.5.10 Figure 1-2A shows the land use within the study area based upon Ordnance Survey 'Master Map' information. The study area is predominantly residential land use interspersed with industrial / commercial estates. Luton town centre is the largest single commercial area within the study area.

1.5.11 The Victorian expansion of Luton focused on areas close to the existing town centre and railways. In the 1920s and 1930s growth typically was through absorbing neighbouring villages and hamlets, with infill construction in between. After World War II there were several estates and developments constructed both by the local authority such as Farley Hill and Marsh Farm, or privately such as Bushmead. This has resulted in the main industrial / commercial areas being developed around the main road and rail corridors with a mixed distribution of residential land use as typical of similar sized conurbations in the UK.

1.5.12 Luton Airport is also a key feature of the land use in the south-east of the study area. The airport was built over a historic landfill area and was opened in 1938. Since then, the airport has grown into a major transport hub servicing not only the local area, but also becoming a significant feeder for the Greater London area.

1.5.13 The study area contains the following notable features and significant infrastructure:

- 24 Grade I and Grade II listed buildings
- Wauluds Bank – Scheduled Monument
- Wardown Park – Registered Park and Garden
- Plaiters Lea and Town Centre Conservation Areas
- Three railway stations (Leagrave, Luton Central and Luton Parkway)
- Main rail line connecting Bedford and London St Pancras
- M1 Motorway and several trunk and other major 'A' roads
- Luton Airport

1.5.14 Figure 1-2B shows the location of each of these items of infrastructure and notable features within the study area.

Main Rivers and Ordinary Watercourses

1.5.15 The River Lea originates in the Luton area from a natural spring at Leagrave in the north of the borough and includes the Houghton Brook, Lewsey Brook and Catbrook tributaries. The main urban areas of Houghton Regis and Dunstable are also served by small Ordinary Watercourses that generally originate in the surrounding farmland. The only Ordinary Watercourse in Luton is Riddy Brook which rises west of the junction of New Bedford and Barton Roads and is a tributary of the River Lea.

1.5.16 These drainage features influence the behaviour of surface water flooding within the study area by providing an outlet for runoff – or a restriction on flows if water levels are sufficiently high. Figure 1-1 shows the locations of these watercourses within the borough.

Geology

1.5.17 The geology of the study area consists of Chalk within the Lambeth Group along the north east and south west sides of the borough and Glaciofluvial Deposits along the river. This underlying geology creates a highly variable environment for possible runoff infiltration and related groundwater flooding, and is shown on Figure 1-3.

Figure 1-2A Land Use Areas

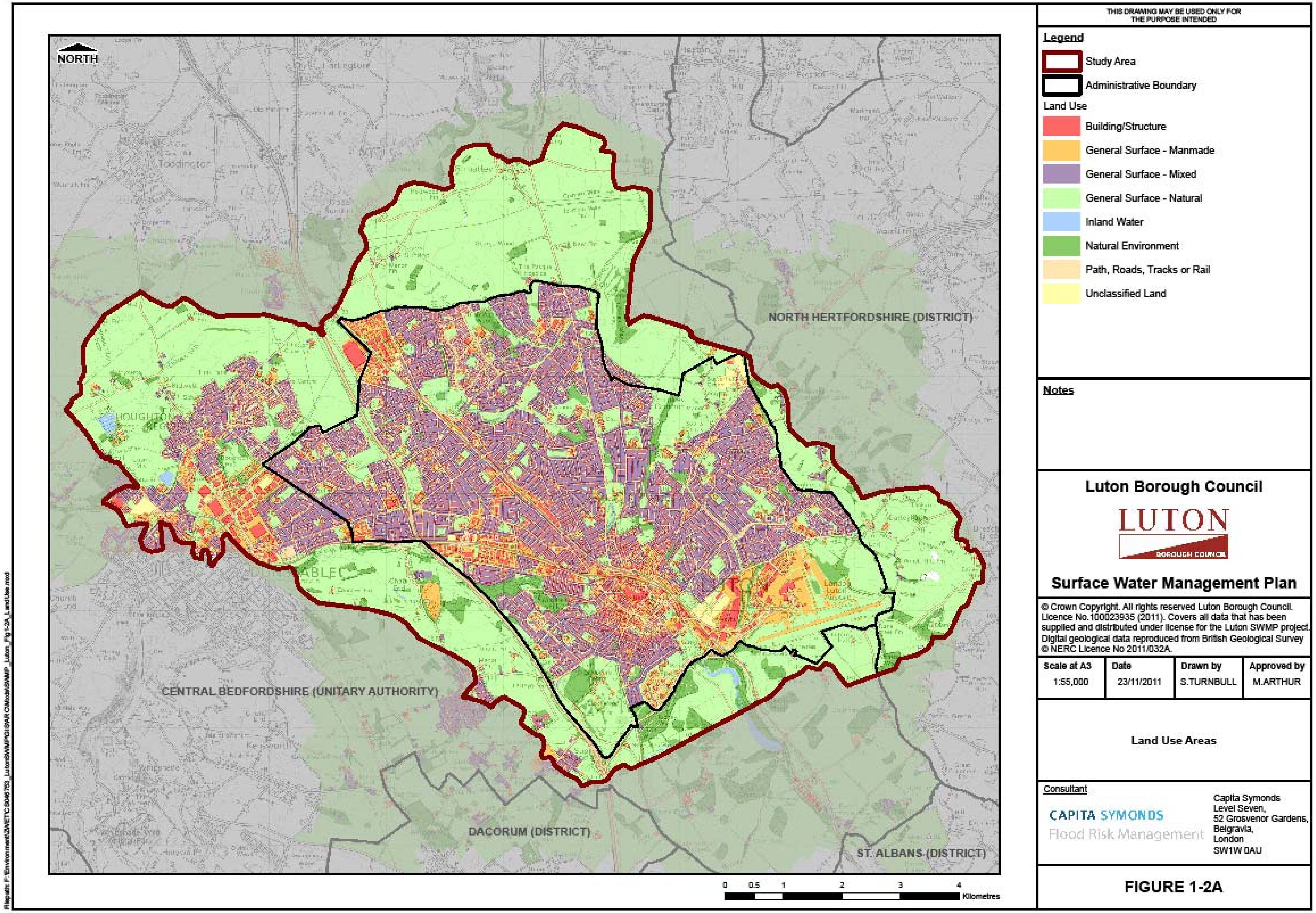


Figure 1-2B Infrastructure and Key Features

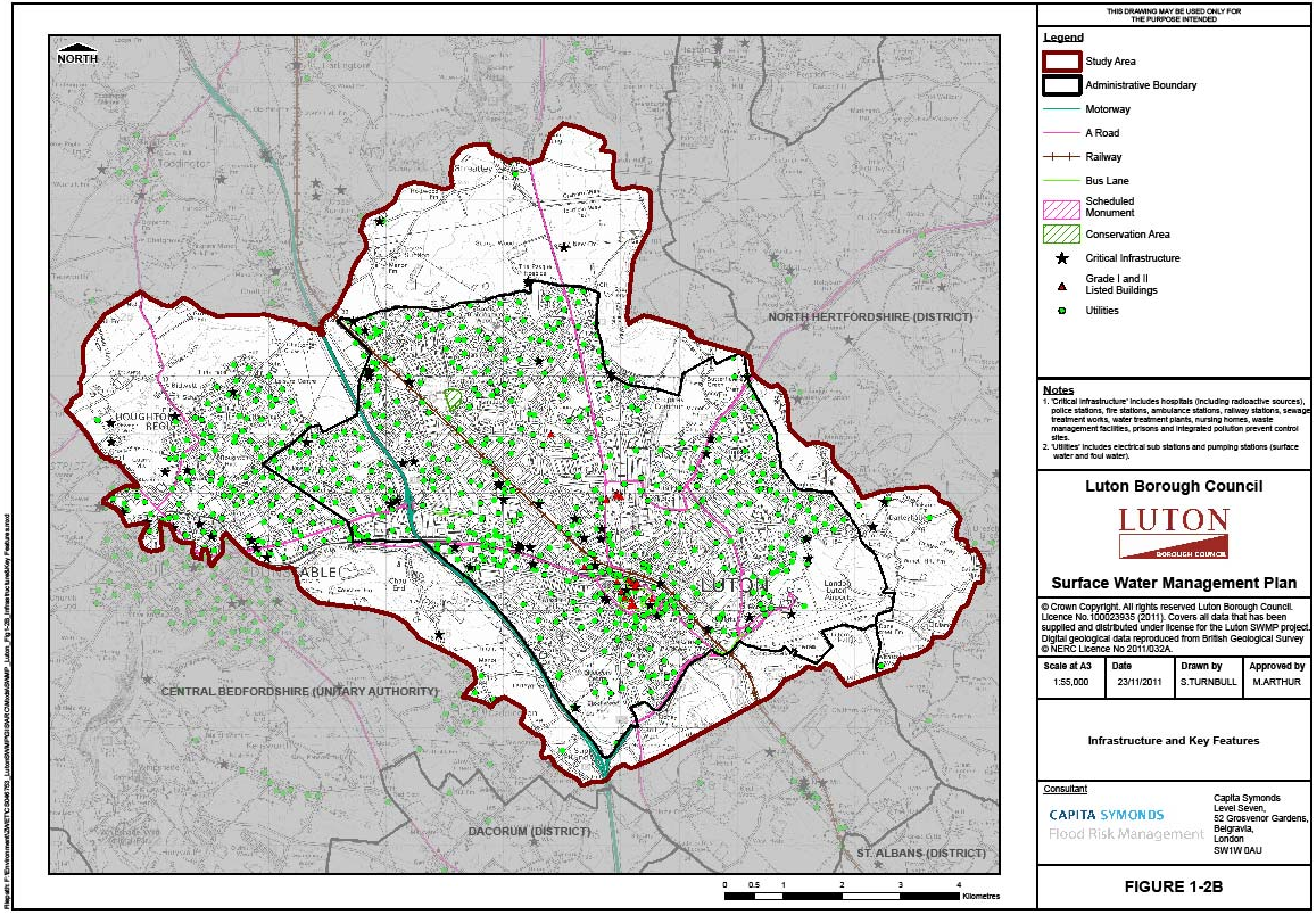
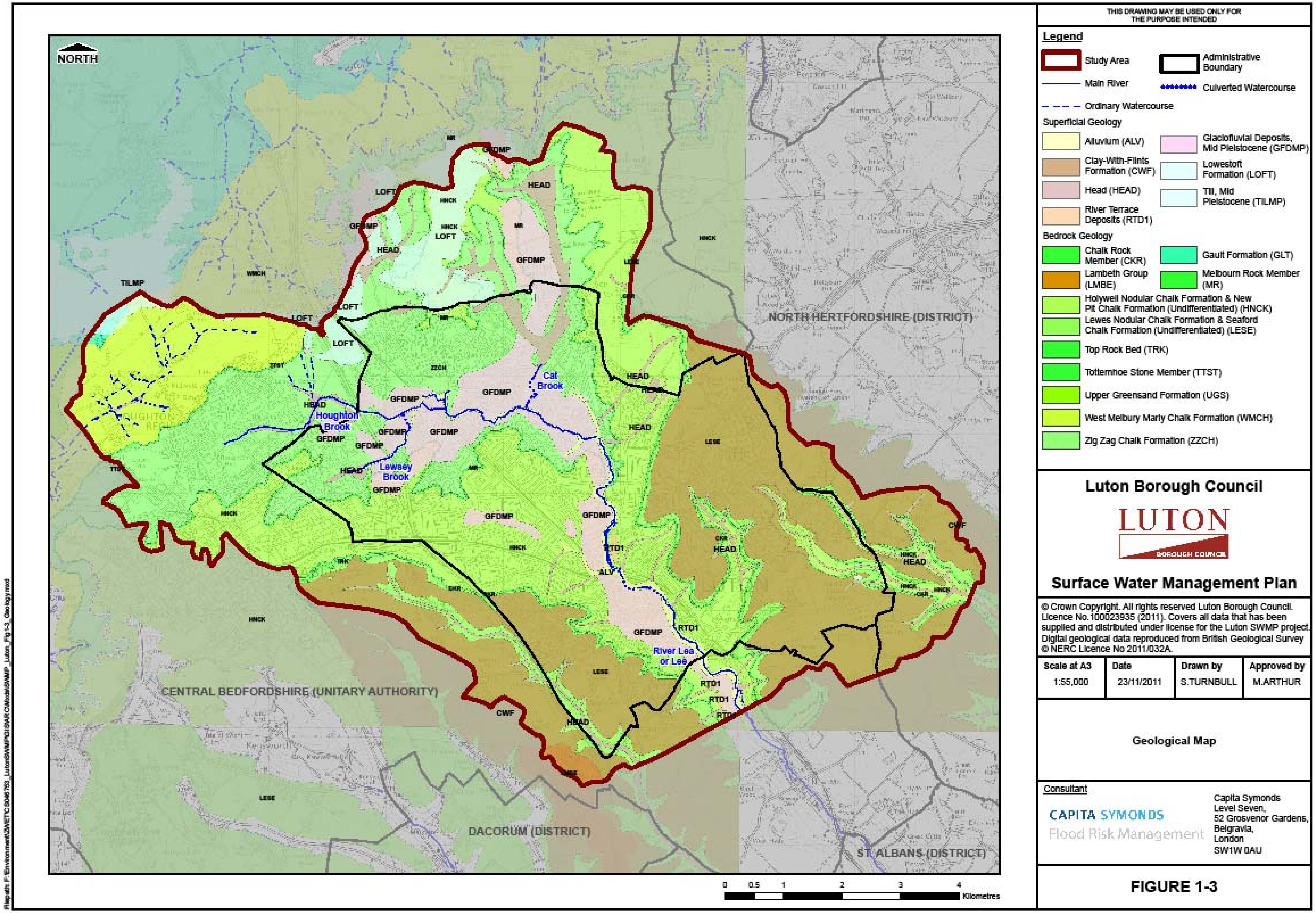


Figure 1-3 Geology



Significant future development plans

1.5.18 The Local Development Framework (LDF) Core Strategy for Luton and Southern Bedfordshire identified two 'sustainable urban extension' areas and one employment area around the periphery of the LBC area. While these potential development areas are not specifically within the Luton boundary, they will still influence surface water flooding within the Luton area. The potential development areas are identified as:

- North Luton Strategic Site Specific Allocation (Undeveloped area to north of Marsh Farm and Bramingham Park)
- North Houghton Regis Strategic Site Specific Allocation (Undeveloped area to north of Houghton Park and Houghton Regis)
- East of London Luton Airport (potential employment area).

1.5.19 In each instance an Area Action Plan will be produced to provide further guidance on how development should be brought forward.

1.5.20 These potential developments, along with planned regeneration of the Luton Town Centre area, offer the opportunity to reduce flood risk in 'critical drainage areas' identified in this document, as well as the potential to exacerbate existing problems.

1.6 Flooding Interactions

1.6.1 The SWMP technical guidance (Defra 2010) identifies four primary sources of surface water flooding that need to be taken into consideration within a SWMP as described below:

- **Pluvial flooding**: High intensity storms (often with a short duration) are sometimes unable to infiltrate into the ground or be drained by formal drainage systems since the capacity of the collection systems is not large enough to convey runoff to the underground pipe systems (which in turn might already be full). The pathway for surface water flooding can include blockages, restrictions of flow (elevated ground), overflows of the drainage system and failures of sluice outfalls and pump systems.
- **Sewer flooding**: 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). The discharge of the drainage network into waterways and rivers can also occur if high water levels in receiving waters obstruct the drainage network outfalls.
- **Ordinary Watercourses**: Flooding from small open channels and culverted urban watercourses (which receive most of their flow from the urban areas) can be caused by either flows in excess of the capacity of the waterways, creating localised flooding of an area, or by obstruction (through debris or

illegal obstruction), creating localised out of bank flooding of nearby low lying areas.

- **Groundwater flooding:** Flooding occurs when the water level within the groundwater aquifer rises to the surface. In very wet winters these rising water levels may lead to flooding of areas that are normally dry. This can also lead to streams that only flow for part of the year being reactivated. These intermittent streams are typically known as 'bournes'. Water levels below the ground can rise during winter (dependant on rainfall) and fall during drier summer months as water discharges from the saturated ground into nearby watercourses.

1.6.2 Figure 1-4 provides an illustration of these flood sources. Each of these sources of flood risk are futher explained within Chapter 3 of this report.

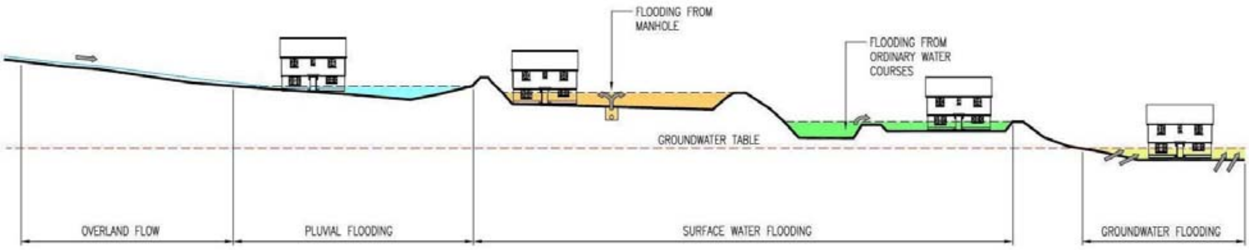


Figure 1-4 Illustration of Flood Sources (source: WSP - 2010)

1.7 Linkages with Other Plans

1.7.1 The increased focus on flood risk over recent years is an important element of adaptation to climate change. The clarification of the role of Unitary Authorities and County Councils as LLFA is welcomed. However, the creation of a number of new documents can at times be confusing. This section aims to link together previous documents relating to flood risk and set a framework of how developing and future documents will relate to each other:

Regional Flood Risk Appraisal (RFRA)

1.7.2 The East of England RFRA was produced in 2009 by the East of England Regional Assembly (EERA). As of 31 March 2010, the EERA was dissolved as an organisation and much of their work is now undertaken by the East of England Local Government Association (East of England LGA). Nevertheless, the RFRA still exists as a document and provides a summary of flood risk in the region with the aim of informing Strategic Flood Risk Assessments and other local development plans. With the introduction of the new National Planning Policy Framework to replace the current Planning Policy Statements, the RFRA is unlikely to be revised in future.

Strategic Flood Risk Assessment (SFRA)

1.7.3 Each local planning authority was required to produce a SFRA under Planning Policy Statement 25 (PPS25). This requirement has been carried forward into the National Planning Policy Framework and provides an important tool to guide planning policies and land use decisions. Current SFRAs have a strong emphasis on flooding from main rivers and the sea and are relatively weak (due to past priorities and a lack of data) in evaluating flooding from other local sources including surface water, groundwater and Ordinary Watercourses. The information from the Luton SWMP will improve this understanding.

1.7.4 A Level 1 SFRA was produced by LBC and the former South Bedfordshire District Council in 2008. The intention is that it will be updated periodically to reflect flood risk information. This document can be obtained from Luton's Shape your future website - http://www.shapeyourfuture.org.uk

Thames Catchment Flood Management Plan (CFMP)

1.7.5 The Thames Catchment Flood Management Plan (CFMP) was published in 2008 by the Environment Agency and sets out policies for the sustainable management of flood risk across the whole of the Thames catchment over the long-term (50 to 100 years) taking climate change into account. More detailed flood risk management strategies for individual rivers or sections of river may sit under these.

1.7.6 The CFMP emphasises the role of the floodplain as an important asset for the management of flood risk, the crucial opportunities provided by new development and regeneration to manage risk, and the need to re-create functioning river corridors so that rivers can flow and flood more naturally.

1.7.7 This CFMP will be periodically reviewed, approximately six years from when it was published, to ensure that it continues to reflect any changes in the catchment. There are links to this SWMP where there are known interactions between surface water and fluvial flooding.

Preliminary Flood Risk Assessment (PFRA)

1.7.8 These are required as part of the Flood Risk Regulations which implement the requirements of the European Floods Directive. The purpose of the PFRA is to give an overview of all local sources of flood risk. The Luton PFRA was produced and delivered to the EA in June 2011, and must be reviewed every six years. The Luton PFRA can be obtained from the LBC website – http://www.luton.gov.uk/internet/community_and_living/accidents_emergencies_and_safety/luton's%20preliminary%20flood%20risk%20assessment

Surface Water Management Plans (SWMP)

1.7.9 A SWMP (this document) provides detailed information on the potential for surface water flooding, based on probabilistic 2-dimensional hydraulic modelling. This information improves greatly on data which has previously been provided at a national scale by the Environment Agency. In addition this SWMP contains an Action Plan that has been developed in conjunction with both the Borough and other relevant Risk Management Authorities. This data and actions and associated policy interventions will feed directly into the operational level of the Borough across many departments, in particular into spatial and emergency planning policies and designations and into the management of local authority controlled land.

Local Development Documents (LDD)

1.7.10 LDDs including the Core Strategy and relevant Area Action Plans (AAPs) will need to reflect the results from this study. This may include policies for the whole study area (Policy Areas) or for specific parts of the study area (Critical Drainage Areas). There may also be a need to review Area Action Plans where surface water flood risk is a particular issue.

National Flood and Coastal Erosion Risk Management Strategy (National FCERM Strategy)

1.7.11 The FWMA 2010 requires the EA to produce a national strategy to inform and guide local flood risk management strategies. This NFRMS document was consulted upon in early 2011 and became law on 19 July 2011. The strategy's overall aim is to ensure that flooding and coastal erosion risks are well-managed and co-ordinated, so that their impacts are minimised.

1.7.12 The National FCERM Strategy for England stresses the need for risk to be managed in a co-ordinated way across river catchments and along the coast, embracing the full range of practical options and helping local decision-making.

Local Flood Risk Management Strategy (LFRMS)

1.7.13 The FWMA 2010 requires each LLFA to produce a Local Flood Risk Management Strategy. Whilst this study will not directly deliver a LFRMS, the SWMP, PFRA, SFRA and the associated risk maps will provide the necessary evidence base to support the development of an LFRMS. It is anticipated that no, or only limited, new modelling or detailed investigation will be necessary to produce this strategy.

Summary of Documents

1.7.14 The schematic diagram (Figure 1-5 below) illustrates how the CFMP, PFRA, SWMP and SFRA link to and underpin the development of a Local Flood Risk Management Strategy.

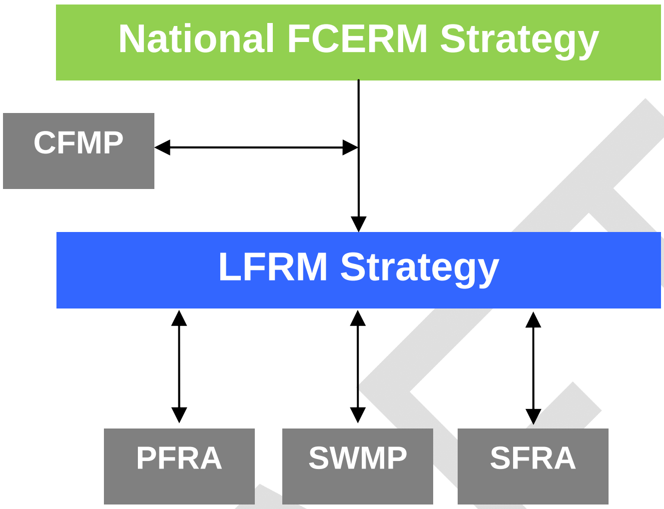


Figure 1-5 Linkages of Flood Risk Management Documents

1.8 Existing Legislation

1.8.1 The FWMA 2010 presents a number of challenges for policy makers and the flood and coastal risk management authorities identified to co-ordinate and deliver local flood risk management (surface water, groundwater and flooding from ordinary water courses). 'Upper Tier' local authorities have been empowered to manage local flood risk through new responsibilities for flooding from surface and groundwater.

1.8.2 The FWMA 2010 reinforces the need to manage flooding holistically and in a sustainable manner. This has grown from the key principles within Making Space for Water (Defra, 2005) and was further reinforced by the summer 2007 floods and the Pitt Review (Cabinet Office, 2008). It implements several key recommendations of Sir Michael Pitt's Review of the Summer 2007 floods, whilst also protecting water supplies to consumers and protecting community groups from excessive charges for surface water drainage.

1.8.3 The FWMA 2010 must also be considered in the context of the EU Floods Directive, which was transposed into law by the Flood Risk Regulations 2009 (the Regulations) on 10 December 2009. The Regulations require three main types of assessment / plan to be produced:

a) Preliminary Flood Risk Assessments (maps and reports for Sea, Main River and Reservoirs flooding) to be completed by LLFA and the

Environment Agency by the 22 December 2011. Flood Risk Areas, at potentially significant risk of flooding, must also be identified. Maps and management plans will be developed on the basis of these flood risk areas.

b) Flood Hazard Maps and Flood Risk Maps. The Environment Agency and LLFA are required to produce Hazard and Risk maps for Sea, Main River and Reservoir flooding as well as 'other' relevant sources by 22 December 2013.

c) Flood Risk Management Plans. The Environment Agency and LLFA are required to produce Flood Risk Management Plans for Sea, Main River and Reservoir flooding as well as 'other' relevant sources by 22 December 2015.

1.8.4 *It should be noted that only (a) above is compulsory for all LLFAs. Where an LLFA is not located within a nationally defined 'Flood Risk Area', then (b) and (c) above are not required. LBC is not within a Flood Risk Area and therefore is only required to complete (a) and then review the document every six years.*

1.8.5 Figure 1-6 below illustrates how this SWMP fits into the delivery of local flood and coastal risk management, and where the responsibilities for this lie.

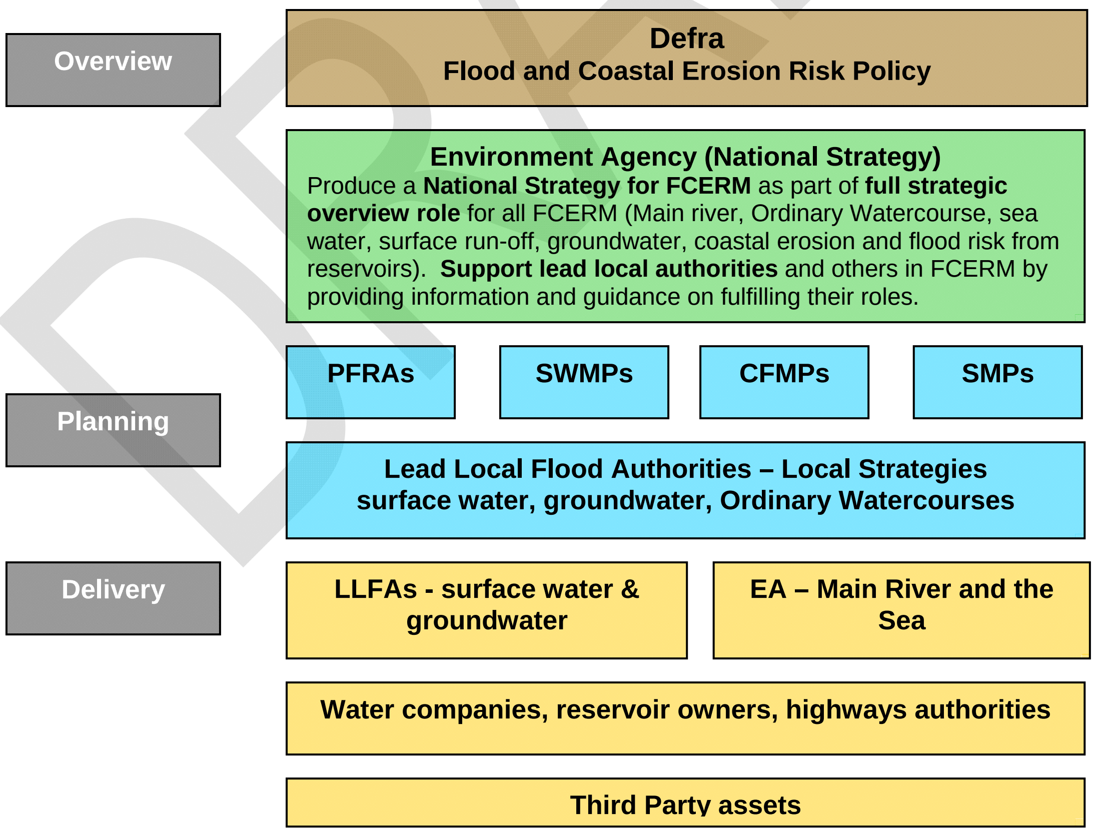


Figure 1-6 Where the SWMP is located within the delivery of local flood and coastal risk management

1.9 LLFA Responsibilities

1.9.1 In addition to forging partnerships and coordinating and leading on local flood management, a number of other key responsibilities were created for Local Lead Flood Authorities by the Flood & Water Management Act 2010 and the Flood Risk Regulations 2009. These responsibilities include:

1. **Investigating flood incidents** – LLFAs have a duty to investigate and record details of significant flood events within their area. This duty includes identifying which authorities have flood risk management functions and what they have done or intend to do with respect to the incident, notifying risk management authorities where necessary and publishing the results of any investigations carried out.
2. **Asset Register & Records** – LLFAs also have a duty to produce and maintain a Register and records of structures or features which are considered to have an effect on flood risk, including as a minimum details of ownership and condition. The Register must be available for public inspection but the records need not, and the Secretary of State will be able to make regulations about the content of the register and records. The Register is being prepared as a separate document and will be placed on the Council's website.
3. **SuDS Approving Body** – LLFAs are designated the SuDS Approving Body (SAB) for any new drainage system, and therefore must approve, adopt and maintain any new sustainable drainage systems (SuDS) that meet their criteria within their area. This responsibility is anticipated to commence in April 2014.
4. **Local flood risk management strategies** – LLFAs are required to develop, maintain, apply and monitor a strategy for local flood risk management in its area. The local strategy will build upon information such as national risk assessments and will use consistent risk-based approaches across different local authority areas and catchments.
5. **Works powers** – LLFAs have powers to undertake works to manage flood risk from surface runoff and groundwater, consistent with the local flood risk management strategy for the area.
6. **Designation powers** – LLFAs, as well as district councils and the Environment Agency, have powers to designate structures and features that affect flooding in order to safeguard assets that are relied upon for flood risk management.

1.9.2 These LLFA requirements have been considered in the production of this document. The SWMP will assist the LLFA in providing evidence for points 1, 2, 3 and 4.

2 Phase 1: Preparation

2.1 Partnership

2.1.1 The FWMA 2010 defines the LLFA for an area as the unitary authority for the area, in this case Luton Borough Council. As such, LBC is responsible for leading local flood risk management including establishing effective partnerships with stakeholders such as the Environment Agency, Thames Water Utilities Ltd and Anglian Water Services, as well as others. 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 (LoSA) or Memoranda of Understanding (MoU). An initial MoU has been formally established between the parties noted above as part of the SWMP study.

2.1.2 As mentioned in section 1.5.9 of this report, the study area falls within the Thames RFCC. LBC is currently represented as part of their 'constituent authority group' on the Thames RFCC by Councillor David Schofield from Buckinghamshire County Council.

2.1.3 At a borough level, LBC have set up the Luton Flood Management Group which currently includes departmental representatives from Highways Maintenance, Sustainability and Emergency Planning, in recognition of the cross-department input required on managing local flood risk.

2.1.4 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 Borough. 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.

2.2 Data Collection

2.2.1 Data was collected from each of the following organisations:

- Luton Borough Council
- Environment Agency
- Thames Water
- Anglian Water
- British Geological Survey
- Luton Airport
- Highways Agency
- Bedfordshire Fire Brigade

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

Table 2-1 Data Sources and Use

Source	Dataset	Description	Use in this SWMP
Environment Agency	Main River centre line	GIS dataset identifying the location of Main Rivers across they study area.	To define waterway locations within the borough.
	Environment Agency Flood Map (Flood Zones)	Shows extent of flooding from rivers during a 1 in 100yr flood and 1 in 1000yr return period flood. Shows extent of flooding from the sea during 1 in 200yr and 1 in 1000yr flood events. Ignores the presence of defences.	To identify the fluvial and tidal flood risk within the borough and areas benefiting from fluvial defences.
	Areas Susceptible to Surface Water Flooding	A national outline of surface water flooding held by the EA and developed in response to Pitt Review recommendations.	To assist with the verification of the pluvial modelling.
	Flood Map for Surface Water	A second generation of surface water flood mapping which was released at the end of 2010.	To assist with the verification of the pluvial modelling.
	Groundwater Flooding Incidents	Records of historic incidents of groundwater flooding as recorded by the Environment Agency.	To identify recorded groundwater flood risk & assist with verifying groundwater flood risk.
	LiDAR topographic data (main river corridor only)	2m resolution terrain model compiled from aerial surveys in 2002, 2004 and 2006.	Creation of terrain model for pluvial modelling.
	National Receptors Dataset	A nationally consistent dataset of social, economic, environmental and cultural receptors including residential properties, schools, hospitals, transport infrastructure and electricity substations.	Utilised for property/infrastructure flood counts and to determine CDAs.
	Luton Flood Risk Management Strategy and Strategic Environmental Assessment Report	Sustainable management of fluvial flood risk over the next 100years.	To ensure a coordinated approach is taken for mitigation solutions.
	Historic Flood Outline	Attributed spatial flood extent data for flooding from all sources.	Used to assist with the verification of modelling results and CDA locations (where available).
	Rainfall Data	Records from approximately 2000 – 2010 for gauge sites across the study area.	Used in the initial stages of rainfall modelling to determine appropriate model durations and hyetographs.
	Areas Susceptible to Groundwater Flooding	Mapping showing areas susceptible to groundwater flooding.	To assess groundwater flood risk.
	Vale of St. Albans Numerical Groundwater Model Final Report (Feb 2010)	Groundwater modelling investigation, primarily developed to address specific abstraction related low flow issues.	To assess groundwater flood risk.
	Source protection zones	Show zones around important groundwater sources which may be impacted by contamination that might cause pollution in the area. The maps show three main zones (inner, outer and total catchment).	Within the assessment of groundwater flooding to determine permeable geology.

Source	Dataset	Description	Use in this SWMP
	Thames River Basin Management Plan	This plan deals with the pressures facing the water environment in this river basin district and the actions that will address them.	To ensure a coordinated approach is taken for mitigation solutions.
	Thames Catchment Flood Management Plan and Luton Policy Unit	Summarises the scale and extent of flooding now and in the future, and set policies for managing flood risk within the catchment.	To ensure a coordinated approach is taken for mitigation solutions.
	River Lea – Modelling and Mapping reports and outputs	Detailed river modelling and related results for the upper Lea River.	To understand the influence of the River Lea on flooding in the study area.
	Asset data	Details on the location and extent of fluvial flood defences within the study area.	To determine asset locations within the modelling process.
Luton Borough Council	Strategic Flood Risk Assessment (SFRA) – Level 1	Contains useful information on historic flooding, including local sources of flooding from surface water and groundwater.	Provide a background to flood risk in the study area.
	Anecdotal information relating to local flood history and flood risk areas	Records of flooding from surface water, groundwater and Ordinary Watercourses.	Where available used to assist with the verification of modelling results and CDA locations.
	Water Cycle Strategy – Luton and South Bedfordshire: Phases 1 and 2	Details the water cycle related actions and infrastructure needed to facilitate planned growth in the Luton and South Bedfordshire Growth Area.	To ensure a coordinated approach is taken for mitigation solutions.
	OS Mapping / MasterMap	Topographic maps of the study area.	Used to derive modelling parameters.
	Core Strategy Development Plans	Local Development Scheme	Understanding of areas of future development.
	Local Climate Impacts Profile – Media Record Summary	Summary of media reports of climate related events (heat, rain, snow etc) from 2004 to 2008.	To assist with the verification of the pluvial modelling
	Flood Alleviation Schemes	Location and description of existing flood alleviation schemes within the borough.	Used in Phase 3: Options Assessment to determine options of each CDA.
Thames Water / Anglian Water	DG5 Register *(Thames Only)*	DG5 Register logs and records of sewer flooding incidents in each area (as at March 2012)	Mapping sewer flooding incidents.
	Sewer pipe network	GIS dataset providing the geo-referenced location of surface water, foul and combined sewers across the study area. Includes pipe sizes and some information on invert levels.	Verifying CDA locations and Phase 3:Options Assessment.
	Pump station locations	The locations of pump stations within the study area.	Mapping of critical infrastructure.
British Geological Society	Geological datasets	Licensed GIS datasets including: Geological indicators of flooding; Susceptibility to groundwater flooding; Permeability; Bedrock and superficial geology.	Understanding the geology of the borough and assessment of groundwater flood risk

Source	Dataset	Description	Use in this SWMP
Bedfordshire Fire Brigade	Historic flooding records	'Flooding' related call outs between April 2009 and October 2010. Does not specify the source or type of flooding.	Understanding of possible flood locations within the borough.
Infoterra	LiDAR topographical data	High resolution elevation data derived from airborne sources – at a 0.5m grid to fill the gaps in the equivalent EA LiDAR data. A laser is used to measure the distance between the aircraft and ground and between the aircraft and the vegetation canopy or building tops. Typical (unfiltered) accuracy ranges are +/- 0.15m.	Filtered LiDAR was utilised within the creation of the pluvial models to define the ground surface of the catchment and to understand the general topography of the study area.
	Photogrammetry	Lower resolution elevation data derived from aerial photography at a 5m resolution grid.	Data was used to fill LIDAR coverage gaps in the rural areas around the edges of the study area.
Luton Airport	Flood Risk Assessment	Asset performance report relating to surface water flood risk.	Validation of flooding predicted in this area.

2.3 Data Review

Historic Records of Local Flooding

2.3.1 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.

2.3.2 Thames Water have provided postcode linked data on records of sewer flooding, (known as the DG5 register), however more detailed data on the location and cause of sewer flooding is not currently available.

2.3.3 Some incidents have been digitised into GIS from anecdotal evidence provided by LBC Officers, however there is very little information on the probability, hazard or consequence of flooding.

2.3.4 Similarly, the Bedfordshire Fire Brigade have recorded incidents of call outs related to flooding, however there is no information on the source of flooding (e.g. pipe bursts or rainfall), or probability, hazard or consequence of the flooding.

Groundwater Flooding

2.3.5 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.

2.3.6 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.

Flooding Consequences

2.3.7 The National Receptors Database (NRD), version 1.0 data set, was provided by the EA in December 2010 to allow property counts to be undertaken for this SWMP. Version 1.1 of the NRD has subsequently been issued and contains modifications and corrections since version 1.0. However, in order to avoid repetition of work, and ensure consistency between the SWMP, PFRA and the EA Pluvial flooding (Areas Susceptible to Surface Water Flooding and Flood Map for Surface Water), it was decided to complete the SWMP using NRD version 1.0.

Topographic / Elevation Data

2.3.8 A mixture of elevation data has been obtained for this study. The EA LiDAR information provides good coverage along the River Lea, but omits large parts of the Luton / Dunstable urban area. Additional LiDAR base elevation data was obtained from InfoTerra and was used to cover the missing urban areas within Luton and Dunstable. No LiDAR data was available for the rural areas around the north, east and western parts of the study area. To cover these areas, photogrammetry data was obtained from InfoTerra. The elevation data used in the modelling part of this SWMP is therefore a combination of these three data sources.

Main River Information

2.3.9 A substantial quantity of high quality information on the River Lea and it's tributaries within the study area has been provided by the EA. This will form an excellent basis for understanding fluvial impacts on flooding.

2.4 Security, Licensing and Use Restrictions

2.4.1 A number of datasets used in the preparation of this SWMP are subject to licensing agreements and use restrictions.

2.4.2 The following national datasets provided by the Environment Agency are available to the LLFA for local decision making:

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

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

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

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

- Records of property flooding held by the Council and by Thames Water Utilities Ltd;
- Flood risk assessment provided by Luton Airport;
- British Geological Society geology datasets; and
- Bedfordshire Fire Brigade call outs for flooding.

2.4.5 Necessary precautions must be taken to ensure that all restricted information given to third parties is treated as confidential. This could be by sending a covering letter with the data that includes the terms and conditions of use issued by the data licensee. This should include the statements that the information must not be used for anything other than the purpose stated in the terms and conditions of use issued by the data holder and accompanying the data. No information may be copied, reproduced or reduced to writing, other than what is necessary for the purpose stated in the agreement.

3 Phase 2: Risk Assessment

3.1 Intermediate Assessment

Aims

3.1.1 The aim of the Intermediate Risk Assessment is to "*identify the sources and mechanisms of surface water flooding across the study area*" which will be achieved through an intermediate assessment of pluvial flooding, sewer flooding, groundwater flooding and flooding from Ordinary Watercourses along with the interactions with main rivers.

3.1.2 SWMPs can function at different geographical scales and therefore necessarily at differing levels of detail. Table 3-1 defines the potential levels of assessment within a SWMP. This SWMP has been prepared at the 'Borough' scale and fulfils the objectives of a second level 'Intermediate Assessment'.

Table 3-1: SWMP Study Levels of Assessment (Defra 2010)

Level of Assessment	Appropriate Scale	Outputs
1. Strategic Assessment	County or region	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.
2. Intermediate Assessment	Borough or city wide	Identify flood hotspots which might require further analysis through detailed assessment. Identify immediate mitigation measures which can be implemented. Inform spatial and emergency planning.
3. Detailed Assessment	Known flooding hotspots	Detailed assessment of cause and consequences of flooding. Use to understand the mechanisms and test mitigation measures, through modelling of surface and sub-surface drainage systems.

3.1.3 As shown in Table 3-1 above, the intermediate assessment is applicable across a large town, city or borough. In the light of the results from the over-arching national pluvial modelling, suggesting that there are 22,100 properties at risk across LBC alone during a rainfall event of 1 in 200 chance of occurring in any given year, it is appropriate to adopt this level of assessment to further quantify the risks (EA, 2011).

Methodology – Pluvial and Ordinary Watercourse Flooding

3.1.4 The purpose of the assessment of surface water and Ordinary Watercourse flooding is to further identify those parts of the study area that are likely to be at greater risk of surface water flooding and require more detailed assessment. The methodology used for this SWMP is summarised below. Further details of the methodology are provided in **Error! Reference source not found.**.

- A Direct Rainfall modelling approach using TUFLOW software has been selected whereby rainfall events of known probability are applied directly to the ground surface and water is routed by the model at a 5m square resolution over a representation of the ground surface to provide an indication of potential flow path directions and velocities and areas where surface water may pond.
- The direct rainfall modelling has been supported by field visits and detailed discussions with LBC staff and EA staff.
- The outputs from the pluvial modelling have been verified (where possible) against historic surface water flood records and more generally against the EA National Flood Map for Surface Water.

Methodology – Groundwater and Sewer Flooding

3.1.5 Groundwater flooding has not been identified as a significant risk in the study area by previous studies. As such, this study will focus on updating previous assessments by desktop review of newly available information relating to groundwater. No detailed modelling or site investigations are included within the study.

3.1.6 To obtain a detailed understanding of sewer flooding, detailed modelling and investigation of the sewer network is required. Sewer network modelling is generally undertaken by the responsible sewerage undertaker (Thames Water and Anglian Water in this context). Therefore, no detailed investigation has been undertaken as part of this study. Probable overland flow routes created by flooding from sewers during extreme rainfall events are represented in the pluvial modelling undertaken to investigate surface water flooding.

Method Limitations

- The mapping shown within this report is suitable to identify broad areas which are more likely to be vulnerable to surface water flooding. This allows LBC and its partners to undertake more detailed analysis in areas which are predicted to be most vulnerable to surface water flooding.
- In addition, the maps can be used as an evidence base to support spatial planning. This will ensure that surface water flooding is appropriately considered when allocating land for future development. The maps can also be used to assist emergency planners in preparing their Multi-Agency response plans.
- Maps only show the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall in urban areas) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses. Individual properties therefore may not always face the same chance of flooding as the areas that surround them.
- There may also be particular occasions when flooding occurs and the observed pattern of flooding does not in reality match the predicted patterns shown on these maps. All that can reasonably be done to ensure that the maps reflect all the data available to us has been done, and expert knowledge has been applied to create conclusions based on that data that are as reliable as possible. It is essential that anyone using these maps fully understands the complexity of the data utilised in production of the maps, is aware of the limitations and does not use the maps in isolation.
- We will not be liable if the maps by their nature are not as accurate as might be desired or are misused or misunderstood despite our warnings. For this reason we are not able to promise that the maps will always be completely accurate or up to date, and we will not be liable for any future flooding that is not highlighted in this report.
- Any use made of the maps and other information in this report by third parties must take these limitations and disclaimers into account in that use.

3.2 Risk Overview

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

- Pluvial 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.

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

3.3 Pluvial Flooding

Description

3.3.1 Pluvial flooding is the term used to describe flooding which occurs when intense, often short duration rainfall is unable to soak into the ground or to enter drainage systems and therefore runs over the land surface causing flooding. It is most likely to occur when soils are saturated so that they cannot absorb 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 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.

3.3.2 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, slope, climate, rainfall, saturation, soil type, urbanisation and vegetation.

Causes and classifications

3.3.3 Pluvial flooding can occur in rural and urban areas, but usually causes more damage and disruption in the latter. Flood pathways include the land and water features over which floodwater flows. These pathways can include drainage channels, rail and road cuttings. Developments that include significant impermeable surfaces, such as roads and car parks may increase the volume and rate of surface water runoff.

3.3.4 Urban areas which are close to artificial drainage systems, or located at the bottom of hill slopes, or in valley bottoms and hollows, may be more prone to pluvial flooding. This may be the case in areas that are down-slope of land that has a high runoff potential including impermeable areas and compacted (and hence less permeable) ground.

Impacts of pluvial flooding

3.3.5 Pluvial flooding can affect all forms of the built environment, including:

- Residential, commercial and industrial properties;
- Infrastructure, such as roads and railways, telecommunication systems and sewer systems.

3.3.6 It can also impact on:

- Agriculture; and
- Amenity and recreation facilities.

3.3.7 This type of flooding is usually short-lived and may only last as long as the rainfall event. However occasionally flooding may persist in low-lying areas where ponding occurs. Due to the typically short duration, this type of flooding tends not to have consequences as serious as other forms of flooding, such as flooding from rivers; however it can still cause significant damage and disruption on a local scale.

Historic Records – Pluvial Flooding

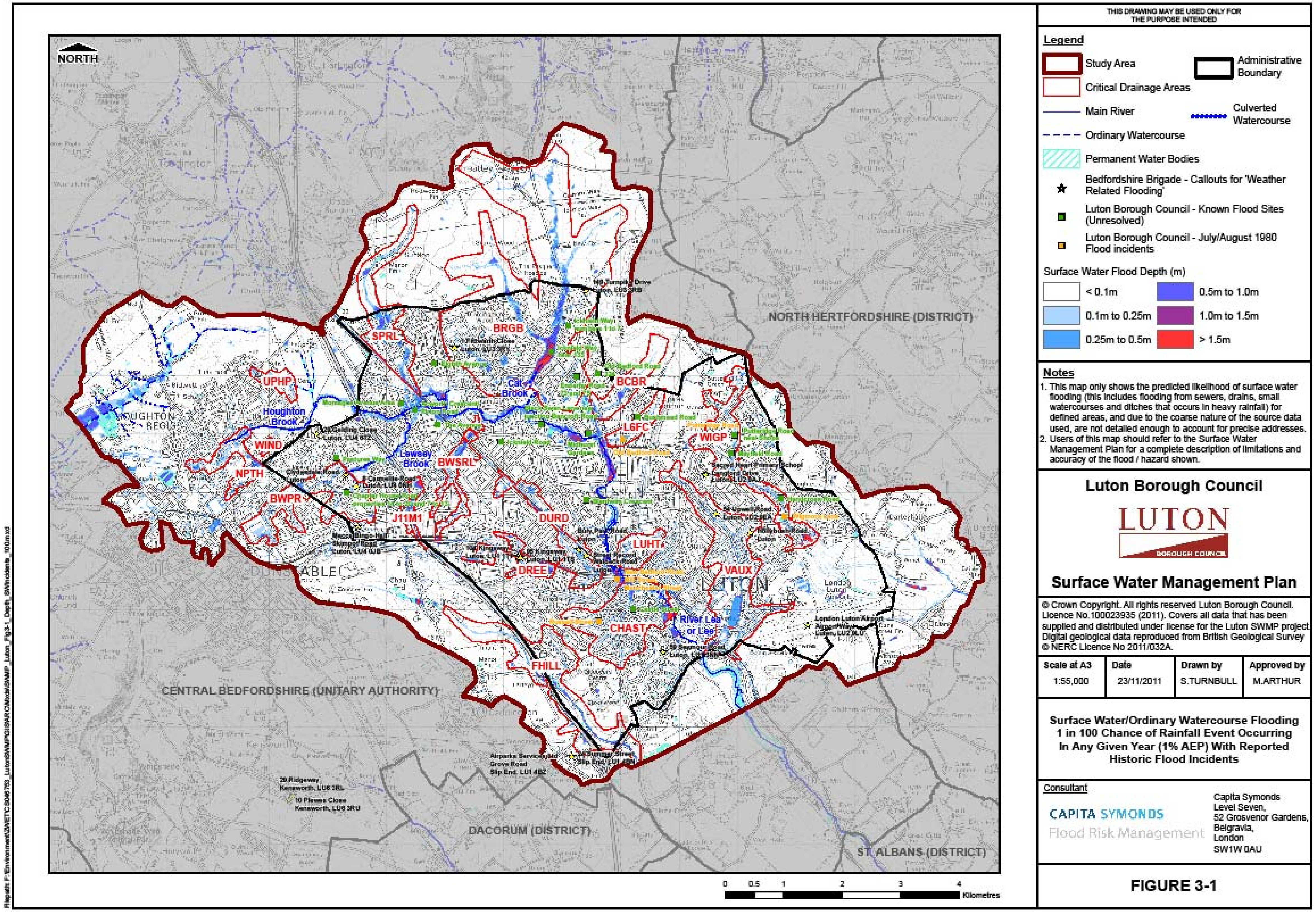
3.3.8 Past records of surface water flooding within the study area have been gathered mainly from LBC officers. These incidents have been mapped as part of the SWMP and shown in Figure 3-1 along with predicted flood extents for the 100year return period rainfall event.

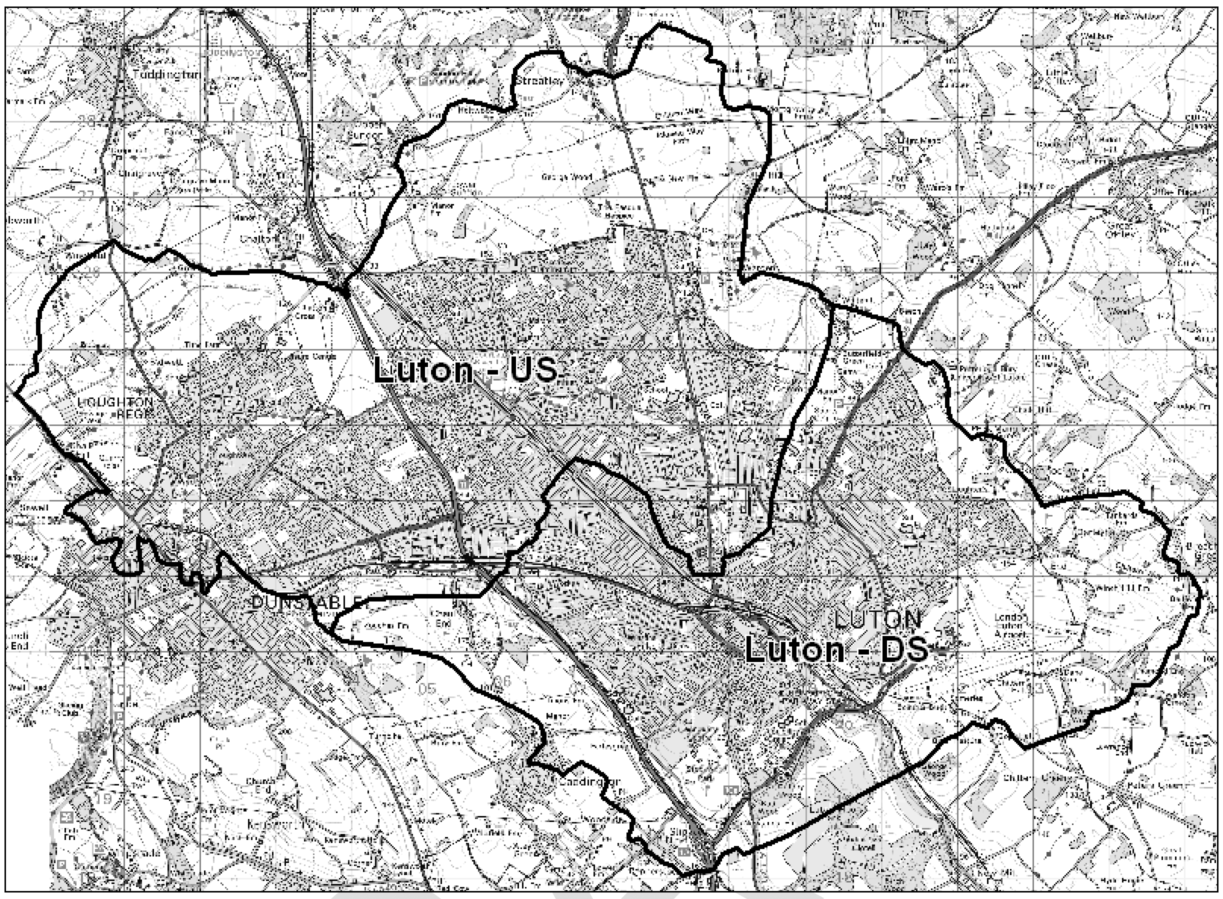
Methodology for Assessment of Pluvial Flooding

3.3.9 As part of the SWMP process, hydraulic modelling has been undertaken for the study area. Two 2-dimensional direct rainfall models were created using TUFLOW software to determine the likelihood, mechanisms and consequences of pluvial flooding. The results of the models provide an indication of key flow paths, velocities and areas where water is likely to pond.

3.3.10 The extents of the models have been based upon catchment boundaries as agreed with LBC. Two models were required to cover the study area at the agreed resolution of 5m. The model coverage figure below indicates the extent of the models utilised within the risk assessment.

Figure 3-1: Surface Water/Ordinary Watercourse Flooding 1 in 100 Chance of Rainfall Event Occurring In Any Given Year (1% Annual Probability) With Reported Historic Flood Incidents





Model coverage for the Study Area

3.3.11 The hydraulic models were run for the following rainfall events:

- 1 in 30 chance of occurring in any given year
- 1 in 75 chance of occurring in any given year
- 1 in 100 chance of occurring in any given year
- 1 in 100 chance of occurring in any given year with allowance for climate change (30% increase in rainfall)
- 1 in 200 chance of occurring in any given year

3.3.12 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 **Error! Reference source not found.** of this report. When viewing the maps, it is important that the limitations of the modelling are considered. The key assumptions include the use of a continuous loss (6.5mm/hr[1]) to represent the presence of the underground drainage network. The model does not take into account any capacity issues associated with the drainage network such as surcharging of manholes or blocked outfalls leading to backing up of surface

[1] This value was selected on the basis of historic design standards for sewer systems in the UK – 6.5mm/hr = ¼ inch of rainfall per hour

water (refer to **Error! Reference source not found.** for a more detailed discussion on the hydraulic modelling methodology).

3.3.13 The figures presented in **Error! Reference source not found.** 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 constricted behind an obstruction or embankment. An example of this flooding mechanism within the study area is in the Kingsway area, where water is observed to back up behind an artificial embankment. Overland flowpaths have been observed to follow natural valleys within the study area such as the one shown running along Vauxhall Way.

3.3.14 Railway lines in cuttings may also be particularly susceptible, such as the stretch entering the study area from the north.

3.3.15 Some of the records of surface water flooding shown in Figure 3-1 have been used to verify the modelling results. Discussions with Council staff have also provided anecdotal support for several of the locations identified as being susceptible to flooding.

3.3.16 The results of the assessment have been used to identify 'Local Flood Risk Zones' (LFRZs) and 'Critical Drainage Areas' (CDAs) across the study area. These CDAs are also shown in Figure 3-1. Section 3.8 provides clear definitions of each of these terms and a summary of the risk of flooding within each CDA.

Uncertainty in flood risk assessment – Surface Water Modelling

3.3.17 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.

3.3.18 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 does not include underground sewerage and drainage systems (however 6.5mm/hr has been removed from the rainfall to account for the drainage system);
- The mapping should not be used at a different scale in an attempt to identify individual properties at potential 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 more prolonged winter rainfall are likely to exacerbate flooding in the future.

3.4 Ordinary Watercourse Flooding

Description

3.4.1 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 its potential to cause significant and widespread flooding. However, this is not to say watercourses classified as Ordinary Watercourses cannot cause localised flooding. The Water Resources Act (1991) defines a ‘Main River’ as “a watercourse shown as such on a Main River Map”. The Environment Agency keep and maintain information on the spatial extent of the Main River designations. The Floods and Water Management Act (2010) defines any watercourse that is not a Main River as an Ordinary Watercourse – including ditches, dykes, drains (as in ‘land drains’), streams and rivers but not public sewers.

3.4.2 The Environment Agency have duties and powers in relation to Main Rivers. Local Authorities, or in some cases Internal Drainage Boards (none within the study area), have powers and duties in relation to Ordinary Watercourses.

3.4.3 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. The main reasons for water levels rising in Ordinary Watercourses are:

- Intense or prolonged rainfall causing rapid run-off increasing flow in watercourses, exceeding the capacity of the channel. This can be exacerbated by wet antecedent (the preceding time period) conditions and where there are significant contributions of groundwater;
- Constrictions/obstructions within the channel causing flood water to backup;
- Blockage/obstructions of structures causing flood water to backup and overtop the banks; and
- High water levels in rivers preventing discharge at the outfall of the Ordinary Watercourse (often into a Main River).

3.4.4 Table 3.2 summarises the watercourses present in the borough and their classification. These watercourses are also shown in Figure 1-1.

Table 3-2: Watercourses in the Study Area

Watercourse	Classification	Responsibility under the FWMA 2010
River Lea (Lee*)	Main River	EA
Houghton Brook	Main River (primary reach from Leagrave Common to Houghton Hall) Ordinary Watercourse (culverted section upstream of Houghton Hall and minor tributaries in Houghton Park)	EA Central Bedfordshire Council
Lewsey Brook	Main River (from confluence with Houghton Brook at Montague Ave to western end of Lewsey Park)	EA
Catbrook	Main River (from confluence with River Lea to Duxford Close)	EA
Riddy Brook	Ordinary Watercourse (culverted and open sections upstream of confluence with the River Lea at New Bedford Road)	Luton Borough Council
Ouzel Brook and associated field drainage system – Houghton Regis	Ordinary Watercourse	Central Bedfordshire Council

* Both versions of the spelling of Lea / Lee are generally accepted. For consistency in this report 'Lea' has been used throughout as directed by LBC. It is noted that the EA use the 'Lee' spelling.

Impacts of Flooding from Ordinary Watercourse

3.4.5 The consequence of Ordinary Watercourse flooding is dependent upon the degree of hazard generated by the flood water (as specified within the Defra/ Environment Agency research on Flood Risks to People - FD2321/TR2) and what the receptor is (e.g. the consequence of hospital flooding is greater than that of a commercial retailer). The hazard posed by flood water is related to the depth and velocity of water which, in Ordinary Watercourses, depends on:

- Constrictions in the channel causing flood water to backup;
- The magnitude of flood flows;
- The size, shape and slope of the channel;
- The width and roughness of the adjacent floodplain; and
- The types of structures that span the channel.

3.4.6 The hazard posed by floodwater is proportional to the depth of water, the velocity of flow and the speed of onset of flooding. Hazardous flows can pose a significant risk to exposed people, property and infrastructure.

3.4.7 Whilst low hazard flows are less of a risk to life (shallow, slow moving/still water), they can disrupt communities, require significant post-flood clean-up and can cause costly and possibly permanent structural damage to property.

Historic Records – Ordinary Watercourse Flooding

Figure **3-1** (in the previous section) summarises the historical records of flooding from Ordinary Watercourses occurring within the study area

Methodology for Assessing Ordinary Watercourses

3.4.8 Ordinary Watercourses have been included in the pluvial flood modelling. Watercourses have been defined by digitising 'breaklines' along the centre line of each watercourse. 'Breaklines' are used primarily to raise the elevation of the watercourse to the level of the surrounding banks to represent a "bank full" scenario. Elevations of watercourses have been determined from LiDAR.

3.4.9 Structures along the watercourse have been modelled as either 1D or 2D elements, depending on the length and location of the structure. The dimensions of structures have been determined from asset information obtained in the data collection stage where available or inferred from site visits or LiDAR data. A list of the modelled structures is contained in Appendix B.

3.4.10 The assessment of flood risk from Ordinary Watercourses has been based on outputs from the pluvial modelling process described in **Error! Reference source not found.** and presented in **Error! Reference source not found.**.

Uncertainties and Limitations – Ordinary Watercourse Modelling

3.4.11 As with any hydraulic model, these models have been based on a number of assumptions which may introduce uncertainties into the assessment of risk. The assumptions within the models should be noted and understood such that informed decisions can be made when using model results.

3.4.12 In relation to Ordinary Watercourses, the limits of the modelling include (but are not limited to):

- Modelling of structures has not been based on detailed survey data;
- The watercourses are assumed to be bank full at the start of the rainfall event, hence river flows and channel capacities have not been taken into account; and
- Only one storm duration was considered for this study.

3.4.13 Taking these uncertainties and constraints into consideration, the estimation of risk of flooding from rivers presented in this report is considered robust for the level of assessment required in the SWMP.

3.5 Groundwater Flooding

Description

3.5.1 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. The actual flooding can occur some distance from the emergence zone, with increased flows in local streams resulting in flooding at downstream pinch points. 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.

3.5.2 There are many mechanisms associated with groundwater flooding, which are linked to high groundwater levels, and can be broadly classified as:

- Direct contribution to channel flow.
- Springs erupting at the surface.
- Inundation of drainage infrastructure.
- Inundation of low-lying property (basements).

Impacts of Groundwater Flooding

3.5.3 The main impacts of groundwater flooding are:

- Flooding of basements of buildings below ground level – in the mildest case this may involve seepage of small volumes of water through walls, temporary loss of services etc. In more extreme cases larger volumes may lead to the catastrophic loss of stored items and failure of structural integrity;

- Overflowing of sewers and drains – surcharging of drainage networks can lead to overland flows causing significant but localised damage to property. Sewer surcharging can lead to inundation of property by polluted water. Note: it is complex to separate this flooding from other sources, notably surface water or sewer flooding;
- Flooding of buried services or other assets below ground level – prolonged inundation of buried services can lead to interruption and disruption of supply;
- Inundation of roads, commercial, residential and amenity areas – inundation of grassed areas can be inconvenient, however the inundation of hard-standing areas can lead to structural damage and the disruption of commercial activity. Inundation of agricultural land for long durations can have financial consequences; and
- Flooding of ground floors of buildings above ground level – can be disruptive, and may result in structural damage. The long duration of flooding can outweigh the lead time which would otherwise reduce the overall level of damages.

3.5.4 In general terms groundwater flooding rarely poses a risk to life. Figure 3-2 shows the BGS Susceptibility to Groundwater Flooding Map.

Historic Records

3.5.5 Figure 3-2 also includes a summary of the previous records of flooding attributed to groundwater in the study area. Only one record of this type of flooding was available from the EA – LBC had no records of historic groundwater flooding.

Groundwater Flooding Risk Assessment

3.5.6 The data sources listed below have been reviewed to produce an overall interpretation of groundwater flood risk in the study area.

- British Geological Survey (BGS) Groundwater Flood Susceptibility Map (BGS, 2011);
- Areas Susceptible to Groundwater Flooding (EA, 2011)
- NE Thames Groundwater Flooding Database – Records since May 2000 (EA, 2011)
- Vale of St. Albans Numerical Groundwater Model – Final Report (Atkins, 2010)
- Vale of St. Albans Groundwater Model - Phase 1: Data Collation and Formulation of Initial Conceptual Model (Atkins, 2007)
- The Upper Lee Catchment Abstraction Management Strategy (EA, 2006)
- River Mimram and Upper Lee Water Resources Sustainability Study Groundwater Model – Phase 4: Final Report (Entec, 2002)

3.5.7 While only the first three data sources above are directly related to groundwater flood risk, the other studies were reviewed to gain an understanding of groundwater behaviour in the study area.

3.5.8 The information sources listed above were reviewed as part of this study.

3.5.9

3.5.10 Table 3-3 summarises the content of each source and how it has been used within the risk assessment.

Figure 3-2: Susceptibility to Groundwater Flooding Map with Reported Historic Incidents

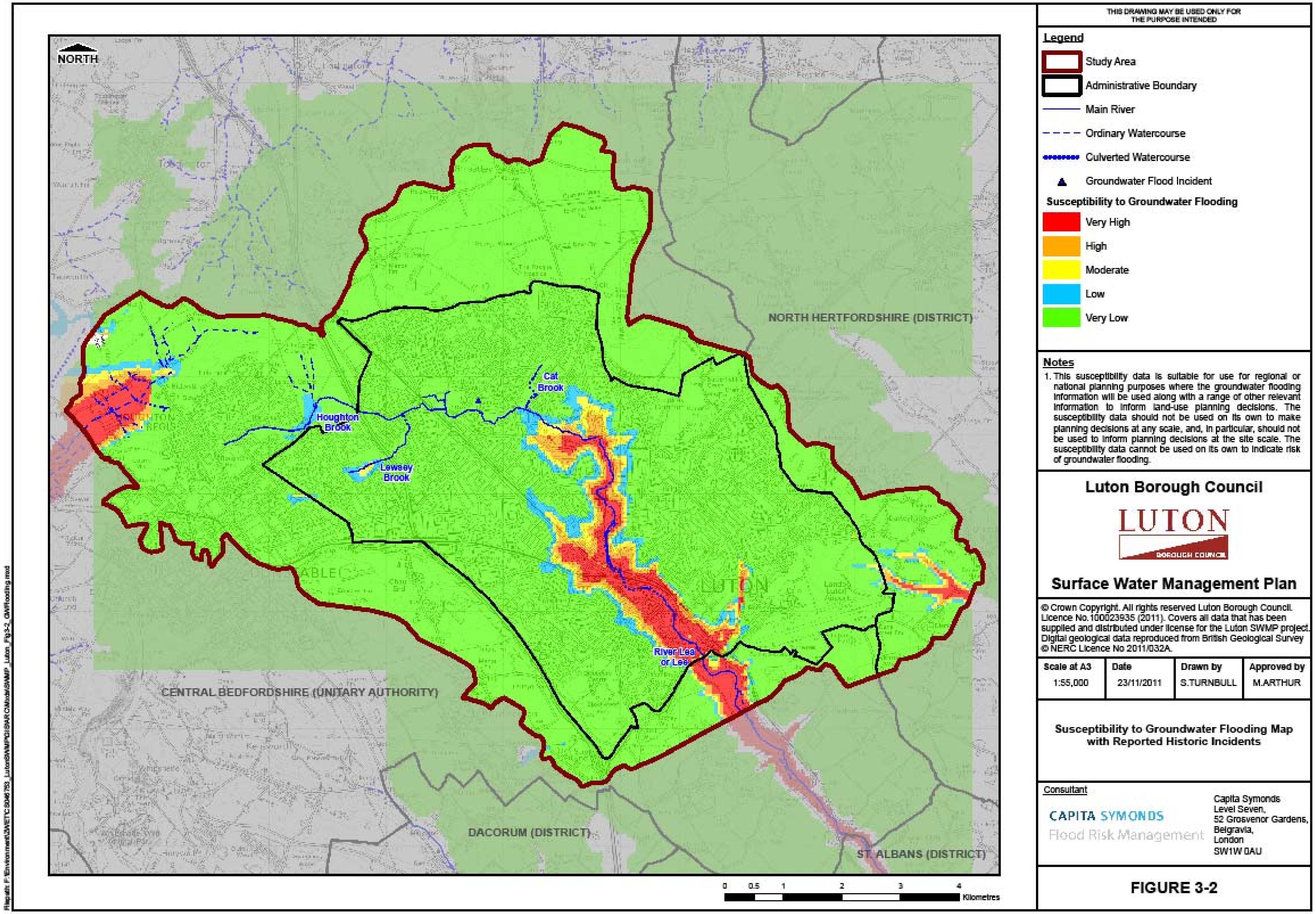


Table 3-3: Review of Available Groundwater Information

Source	Summary	Risk Assessment Application
BGS Groundwater Flood Susceptibility Map	Dataset was derived by identifying geology types that are known aquifers then applying nationally derived groundwater level contours to estimate water level proximity to the ground surface at a 50m grid size scale. <u>It should be noted that this is a susceptibility data set, so does not indicate hazard, risk or likelihood of occurrence.</u>	This was identified as the best available dataset for assessment of potential groundwater flood risk. During the risk assessment process for each CDA this map was reviewed and potential susceptibility highlighted where relevant.
EA Areas Susceptible to Groundwater Flooding	Strategic scale map showing groundwater flood areas on a 1km square grid. This data has used the top two susceptibility bands of the British Geological Society – hence is it a lower resolution version of the BGS Groundwater Susceptibility Flood Map	Not used in assessment as data is a lower resolution of the above BGS dataset.
NE Thames Groundwater Flooding Database	This database only provided a single incident record for the study area.	Record is displayed on Figure 3-2.
Vale of St Albans Numerical Groundwater Model	Report summarising the development and calibration of a numerical groundwater model representing the physical processes in the Vale of St Albans area (including the Luton area and the River Lea). Grid resolution is 200m. The calibration point for the Luton area at Luton Hoo does not show good correlation with observed data	Due to lack of historic evidence of groundwater flooding in the study area, use of the groundwater model is not appropriate for this study. It could be used in future if significant groundwater flooding issues are observed.
Vale of St. Albans Groundwater Model - Phase 1: Data Collation and Formulation of Initial Conceptual Model	The above report supersedes this report. No further review undertaken.	N/A
Upper Lee Catchment Abstraction Management Strategy (CAMS)	An assessment of current abstractions and guidance for licensing of future groundwater abstractions. The Upper River Lea is identified to be an area where no new abstractions should be	As groundwater abstractions reduce over time, this may lead to an overall rise in groundwater levels in the study area. This could increase

Source	Summary	Risk Assessment Application
	allowed and existing ones should be reduced. The purpose of this policy is to protect river baseflow in the Lea.	baseflows in the River Lea and reduce its overall capacity. Similarly, groundwater flood incidents may also increase in number. It is recommended that LBC monitor the areas identified as 'very high' susceptibility to groundwater flooding.
River Mimram and Upper Lee Water Resources Sustainability Study Groundwater Model – Phase 4: Final Report	The Vale of St Albans study above supersedes this report. No further review undertaken.	N/A

3.5.11 The basis for the groundwater flood risk assessment for this study is predominantly the BGS Groundwater Flood Susceptibility Map. This map uses underlying geological information to infer groundwater flood susceptibility. As shown in Figure 3-2 the higher vulnerability areas are generally associated with the path of the River Lea.

3.5.12 The River Lea is associated with an unconfined Chalk aquifer and its baseflow is dependent on groundwater. Compared to other aquifer units, Chalk is more vulnerable to groundwater flooding because of its geological formation. It contains many pores and fractures which can result in rapid rises in groundwater levels, which take a long time to recede.

3.5.13 Groundwater levels rise and fall in response to rainfall patterns and distribution, with a time scale of months rather than days. The significance of this rise and fall for flooding, depends largely on the type of ground it occurs in, i.e. how permeable to water the ground is, and whether the water level comes close to or meets the ground surface.

3.5.14 Groundwater flooding is often highly localised and complex. Large areas within the study area are underlain by permeable substrate and thereby have the potential to store groundwater. Under some circumstances groundwater levels can rise and cause flooding problems in subsurface structures or at the ground surface. The mapping technique adopted by the BGS aims to identify only those areas in which there is the greatest potential for this to happen.

3.5.15 There is currently no research specifically considering the impact of climate change on groundwater flooding. The mechanisms of flooding from aquifers are unlikely to be affected by climate change, however if winter rainfall becomes more frequent and heavier, groundwater levels may increase. Higher winter recharge may however be balanced by lower recharge during the predicted hotter and drier summers.

Groundwater Flooding Management

3.5.16 Management is highly dependent upon the characteristics of the specific situation. The costs associated with the management of groundwater flooding are highly variable. The implications of groundwater flooding should be considered and managed through development control and building design. Possible responses include:

- Raising property ground or floor levels or avoiding the building of basements in areas considered to be at risk of groundwater flooding.
- Provide local protection for specific problem areas such as flood-proofing properties (e.g. tanking, sealing of building basements, raising electrical sockets/TV aerial sockets, etc).
- Replacement and renewal of leaking sewers, drains and water supply reservoirs. Sewerage undertakers and water companies have programmes to address leakage from their infrastructure, so there is clear ownership of the potential source.
- Major ground works (such as construction of new or enlarged watercourses) and improvements to the existing surface water drainage network to improve conveyance of floodwater from surface water of fluvial events through and away from areas prone to groundwater flooding.

3.5.17 Most options involve the management of groundwater levels. It is important to assess the impact of managing groundwater with regard to water resources, and environmental designations. Likewise, placing a barrier to groundwater movement can shift groundwater flooding from one location to another. The appropriateness of infiltration based drainage techniques should also be questioned in areas where groundwater levels are high or where source protection zones are close by.

Uncertainties and Limitations – Groundwater Flooding

3.5.18 Within the areas delineated, the local rise of groundwater will be heavily controlled by local geological features and artificial influences (e.g. structures or conduits) which cannot currently be represented. This localised nature of groundwater flooding compared with, say, fluvial flooding suggests that interpretation of the map should similarly be different. The map shows the area within which groundwater has the potential to emerge but it is unlikely to emerge uniformly or in sufficient volume to fill the topography to the implied level. Instead, groundwater emerging at the surface may simply runoff to pond in lower areas.

3.5.19 Locations shown to be at risk of surface water flooding are also likely to be most at risk of runoff/ponding caused by groundwater flooding. Therefore the susceptibility map should not be used as a "flood outline" within which properties at risk can be counted. Rather, it is provided, in conjunction with the surface water mapping, to identify those areas where groundwater may emerge and what the major water flow pathways would be in that event.

3.5.20 It should be noted that this assessment is broad scale and does not provide a detailed analysis of groundwater; it only aims to provide an indication of where more detailed consideration of the risks may be required.

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

3.5.22 There is a lack of reliable measured datasets to undertake flood frequency analysis on groundwater flooding but, even with datasets, this analysis is complicated due to the non-independence of groundwater level data. Studies therefore tend to analyse incidences of historic flooding which means that it is difficult to assign a level of certainty.

3.5.23 The impact of climate change on groundwater levels is highly uncertain. More winter rainfall may increase the frequency of groundwater flooding incidents, but drier summers and lower recharge of aquifers may counteract this effect.

3.6 Sewers

Description

3.6.1 Flooding from foul and combined sewers occurs when rainfall exceeds the capacity of networks or when there is an infrastructure failure. In the study area the sewer network is a largely separated foul and surface water system with some small areas of combined system.

Causes of sewer flooding

3.6.2 The main causes of sewer flooding are:

- Lack of capacity in the sewer drainage networks due to original under-design;
- Lack of capacity in sewer drainage networks due to an increase in flow (such as climate change and/or new developments connecting to the network);
- Exceedance of capacity of sewer drainage networks due to events larger than the system designed event;

- Loss of capacity in sewer drainage networks when a watercourse has been fully culverted and diverted or incorporated into the formal drainage network (lost watercourses);
- Lack of maintenance or failure of sewer networks which leads to a reduction in capacity and can sometimes lead to total sewer blockage;
- Failure of sewerage infrastructure such as pump stations or flap valves leading to surface water or combined foul/surface water flooding;
- Groundwater infiltration into poorly maintained or damaged pipe networks; and
- Restricted outflow from the sewer systems due to high water or tide levels in receiving watercourses ('tide locking').

Impacts of Sewer Flooding

3.6.3 The impact of sewer flooding is usually confined to relatively small localised areas but, because flooding is associated with blockage or failure of the sewer network, flooding can be rapid and unpredictable. Flood waters from this source are also often contaminated with raw sewage and pose a health risk. The spreading of illness and disease can be a concern to the local population if this form of flooding occurs on a regular basis.

3.6.4 Drainage systems often rely on gravity assisted dendritic (tree-like) systems, which convey water in trunk sewers located at the lower end of the catchment. Failure of these trunk sewers can have serious consequences, which are often exacerbated by topography, as water from surcharged manholes will flow into low-lying urban areas.

3.6.5 The diversion of "natural" watercourses into culverted or piped structures is a historic feature of the study area drainage network. Where it has occurred, deliberately or accidentally, it can result in a reduced available capacity in the network during rainfall events when the sewers drain the watercourses catchment as well as the formal network. Excess water from these watercourses may flow along unexpected routes at the surface (usually dry and often developed) as its original channel is no longer present and the formal drainage system cannot absorb it.

Historic Records – Sewer Flooding

3.6.6 Figure 3-3 provides a summary of the historic records of flooding attributed to the sewerage network in the study area along with the key components of the surface water sewer network.

3.6.7 The risk of flooding from sewers is increasing due to the increasing urbanisation of areas and rising rainfall intensities. Several recent flood events across the country have been attributed to the inability of the drainage network to contain runoff during severe storm events and the occurrence of events which exceed the design capacity of the drainage network may be increasing.

3.6.8 The data provided by Thames Water for use in this SWMP shows postcodes where properties are known to have experienced sewer flooding prior to March 2012. Figure 3-3 displays this data. The data provides a broad overview of flood incidents in the borough as it is not property specific, instead providing information in postcode sectors (a four digit postcode). The figure shows a general distribution of sewer flooding within the study area. Sewer flooding locations may be distributed throughout the postcode area or may be clustered in a specific location.

3.6.9 The highest concentrations of sewer flooding incidents are in Limbury and in Luton Town Centre. These two areas correlate with low lying topography adjacent to the River Lee. The gravity sewer system in Luton is generally aligned with the river as it provides a consistent downhill gradient. These two locations represent the lowest sections of the sewer network and therefore are the most likely to transmit the highest volume of water and subsequently have higher probability of flooding.

3.6.10 Analysis and discussion of sewer flooding incidents that generally align with Critical Drainage Areas is provided in section 3.8,

3.6.11 A similar dataset was not supplied by Anglian Water. However, as the portion of the study area controlled by Anglian Water is small, this is of little impact to the overall study.

Methodology for Drainage Network Modelling

3.6.12 Consultation with Thames Water and Anglian Water determined that the sewer system across the study area could be assumed to have an approximate capacity of 6.5mm/hr. This was represented in the surface water modelling by removing 6.5mm/hr from the rainfall totals for the duration of the model run.

3.6.13 The sewer system was not modelled explicitly, hence interaction between the sewer system and surface water modelling is not investigated. This was beyond the scope of the catchment- wide study but, in specific areas where the sewer network has been identified to be of particular relevance to flood risk, more detailed integrated modelling may be required at a later date.

Uncertainties in Flood Risk Assessment – Sewer Flooding

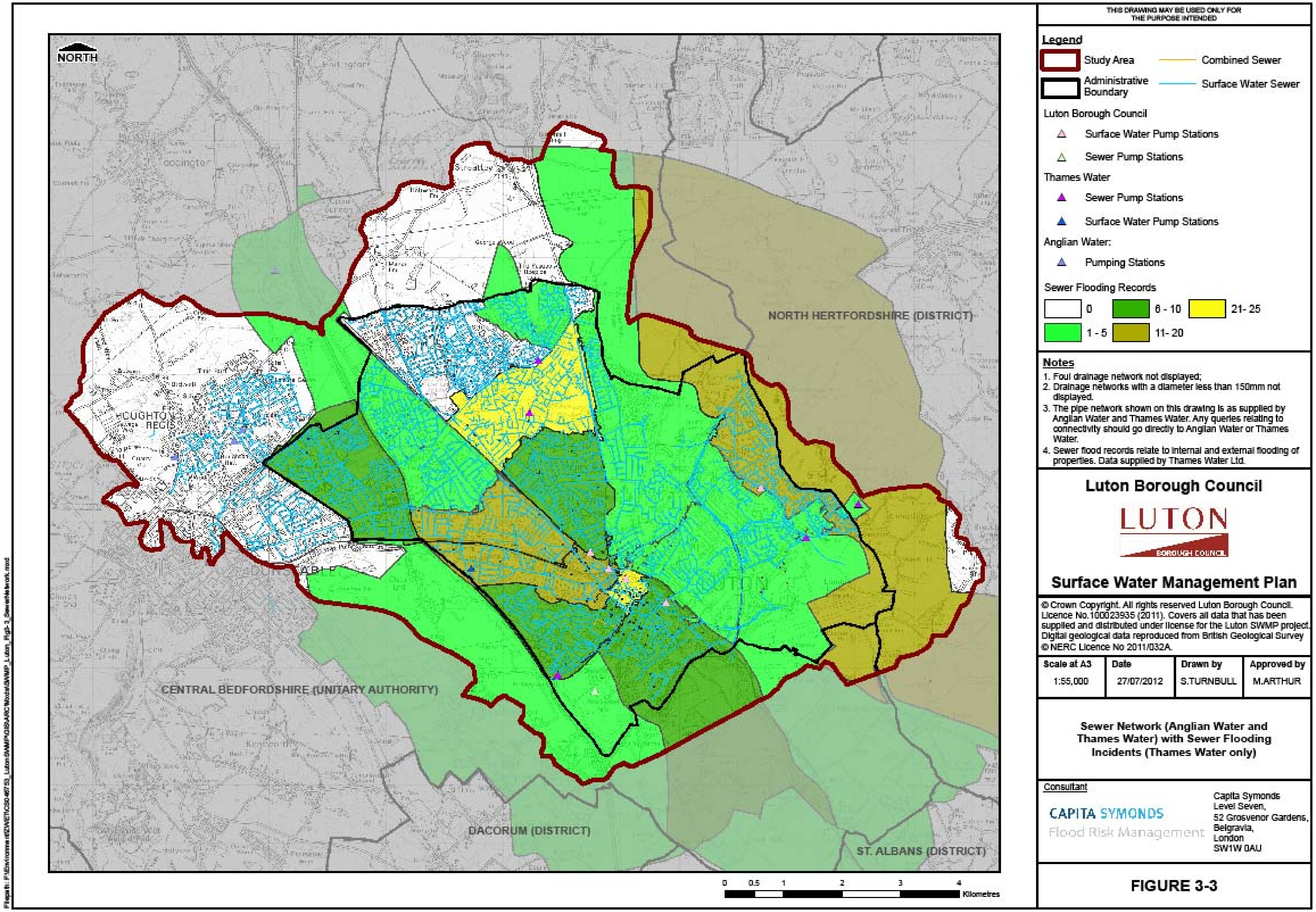
3.6.14 Assessing the risk of sewer flooding over a wide area is limited by the lack of data and the quality of data that is available. Furthermore, flood incidents may be caused by a combination of surface water and groundwater influences coupled with blockage or lack of hydraulic capacity within the pipe system.

3.6.15 An integrated modelling approach is required to assess and identify the potential for sewer flooding but these models are complex and require detailed information. Obtaining this information can be problematic as datasets held by stakeholders are often confidential, contain varying levels of detail and may not be complete. Sewer flood models require a greater number of parameters to be input and this increases the uncertainty of the model predictions.

3.6.16 Existing sewer models are generally not capable of predicting flood routing (flood pathways and receptors) in the above ground network of flow routes (for example, streams, dry valleys, and highways)

3.6.17 Use of historic data to estimate the probability of sewer flooding is the most practical approach; however it does not take account of possible future changes due to climate change or future development, nor does it account for improvements to the network, including clearance of blockages, which may have occurred.

Figure 3-3: Sewer Network (Anglian Water and Thames Water) with Sewer Flooding Incidents (Thames Water only)



3.7 Other Influences on Local Flooding

Main River Fluvial Flooding

3.7.1 Interactions between surface water and fluvial flooding are generally a result of watercourses being unable to store 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.

3.7.2 Main Rivers have been considered in the surface water modelling by assuming a 'bank full' condition, in the same way that Ordinary Watercourses have been modelled. Structures such as weirs, locks and gates along watercourses have not been explicitly modelled.

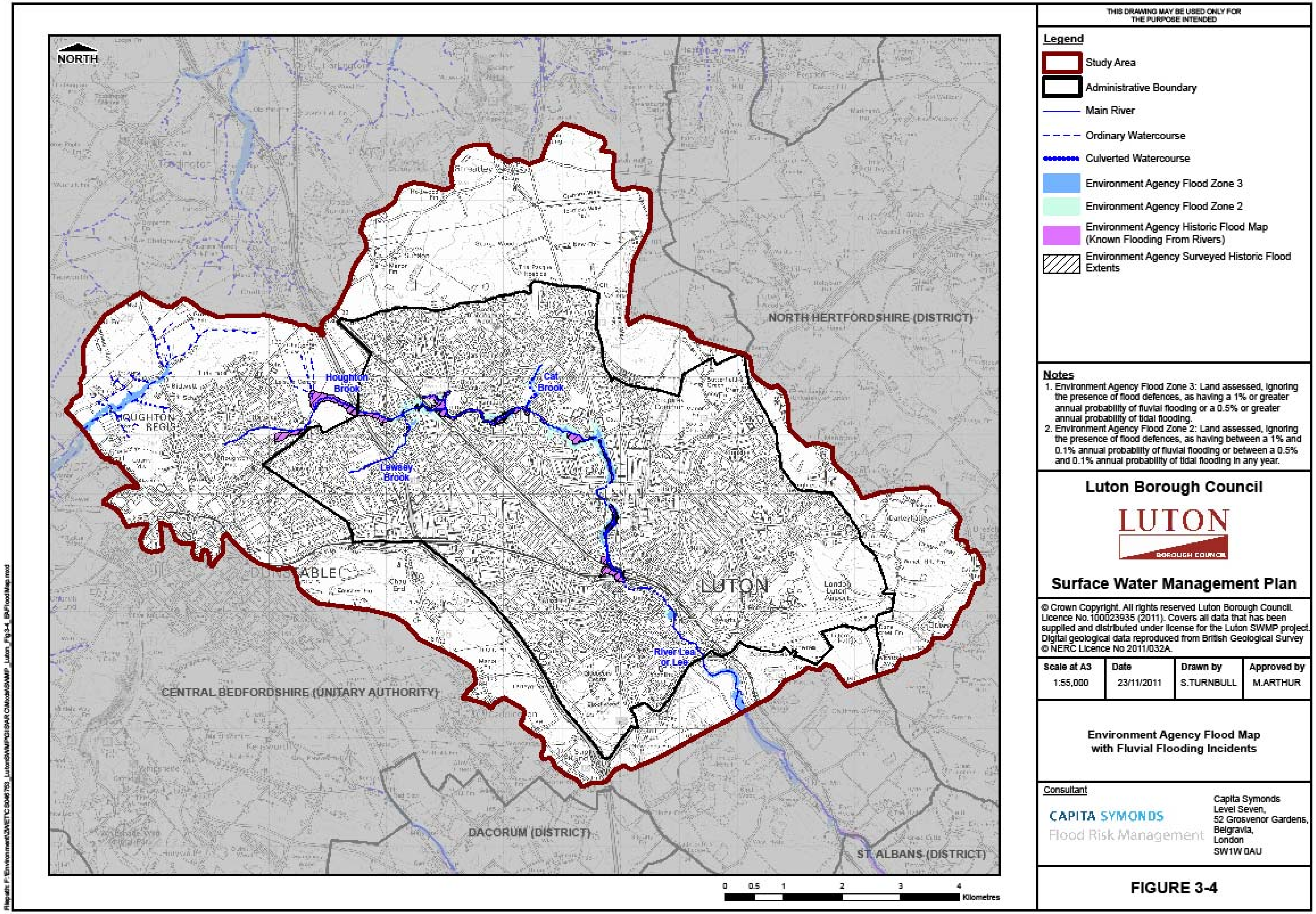
3.7.3 Figure 3-4 shows the Environment Agency's Flood Risk Zones mapped alongside historical records of flood events. The outlines show that the risk of fluvial flooding from Main Rivers is largely concentrated around the River Lea and its upper tributaries. Much of the River Lea and its tributaries are defended, but this does not eliminate the risk of flooding entirely as there is the possibility of the defences being overtopped or failing.

3.7.4 Further information on fluvial (Main River) flooding can be found in the CBC and LBC Level 1 SFRA (September 2008).

Artificial Drainage Bodies

3.7.5 There are no large water reservoirs or canals located within the study area.

Figure 3-4: Environment Agency Flood Map with Fluvial Flooding Incidents



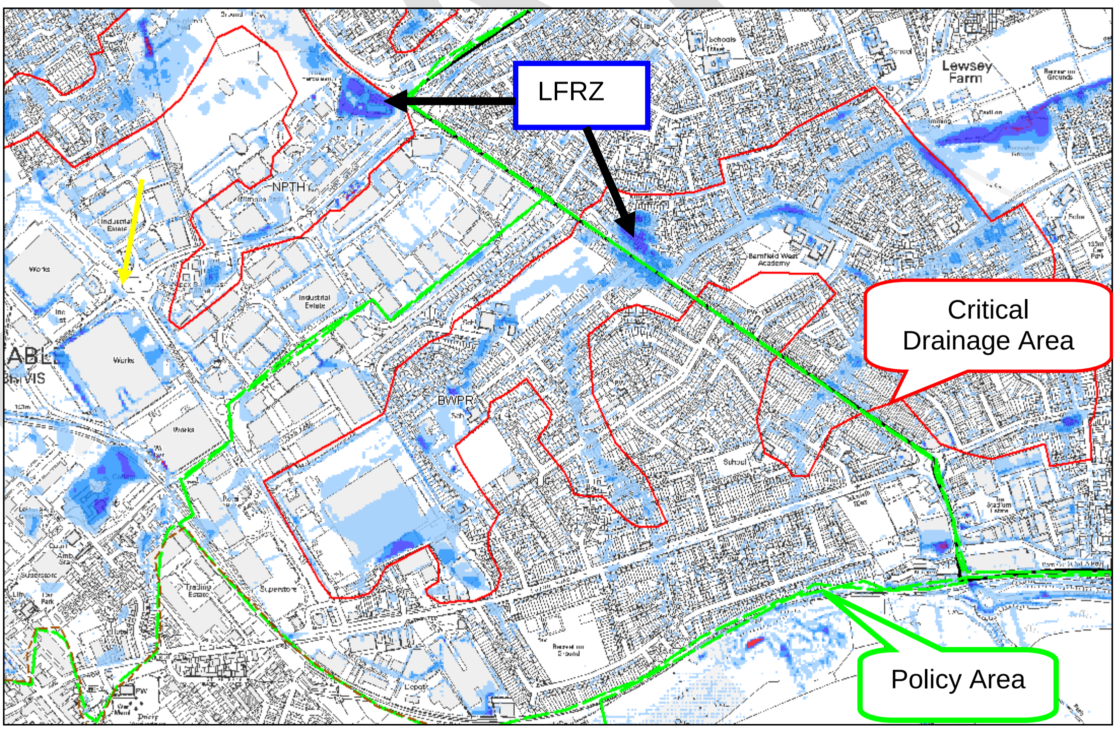
3.8 Critical Drainage Areas

Definitions

3.8.1 A critical drainage area (CDA) is defined as *"a discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer and/or river) often cause flooding during severe weather thereby affecting people, property or local infrastructure."*

3.8.2 Within these CDAs, Local Flood Risk Zones (LFRZ) have also been identified. These are defined as *"the actual spatial extent of predicted flooding in a single location. LFRZs are discrete areas of flooding that do not exceed the national criteria for a 'Flood Risk Area' but still affect houses, businesses or infrastructure."* LFRZs across the study area have been identified based on both the probability and consequence of flooding from the above 'local' sources referred to in 3.8.1.

3.8.3 The figure below shows an example of a CDA and LFRZ. Note that the LFRZ has not been delineated with a boundary to prevent implying properties not shown at risk to be within a flood risk "zone".



Example Critical Drainage Area (CDA) and Local Flood Risk Zone (LFRZ)

Interpretation

3.8.4 Surface water flood depth maps have been generated using the computational model described in Section 3.3 at a 5m resolution. <u>The reader should refer to</u>

Section 3.3 to ensure they understand the assumptions and limitations of the modelling methodology. Predicted flood depths shown in this document has been filtered to only show depth greater than 100mm.

3.8.5 Flow direction is also shown on the maps. This is not a direct output of the modelling process, but has been defined to show the overall direction of overland flow. The length of the direction arrow is not proportional to the flow rate or velocity of the water. Similarly, only general direction is shown and local variations may exist depending on local topography not represented by the model.

3.8.6 Flood hazard rating is a combination of depth and velocity parameters. The ratings shown in mapping within this document have been derived using the Defra / Environment Agency research on Flood Risks to People (FD2320/TR2).

3.8.7 Derivation of the hazard rating is done using the formula shown below for the maximum values of depth and velocity recorded within each 5m x 5m cell in the surface water flood model for the duration of the rainfall event considered.

Flood Hazard Rating = Depth x (Velocity + 0.5) + Debris Factor

Where:

Debris Factor for Depth <= 0.25m is 0.5

Debris Factor for Depth > 0.25m is 1.0

3.8.8 Interpretation of the hazard ratings is shown in Table 3-4.

Degree of Flood Hazard	Hazard Rating (HR)		Description
Low	<0.75	Caution	Flood zone with shallow flowing water or deep standing water
Moderate	0.75 – 1.25	Dangerous for some (i.e. children)	Danger: Flood zone with deep or fast flowing water
Significant	1.25 -2.5	Dangerous for most people	Danger: Flood zone with deep fast flowing water
Extreme	>2.5	Dangerous for all	Extreme danger: Flood zone with deep fast flowing water

Table 3-4 Legend for Hazard Rating Figures

3.8.9 Deprived / Non-Deprived households have been classified using the National Statistics' Indices of Multiple Deprivation. 'Deprived' households are identified as those falling into the lowest 20% of ranks by the Index of Multiple Deprivation.

CDA Index

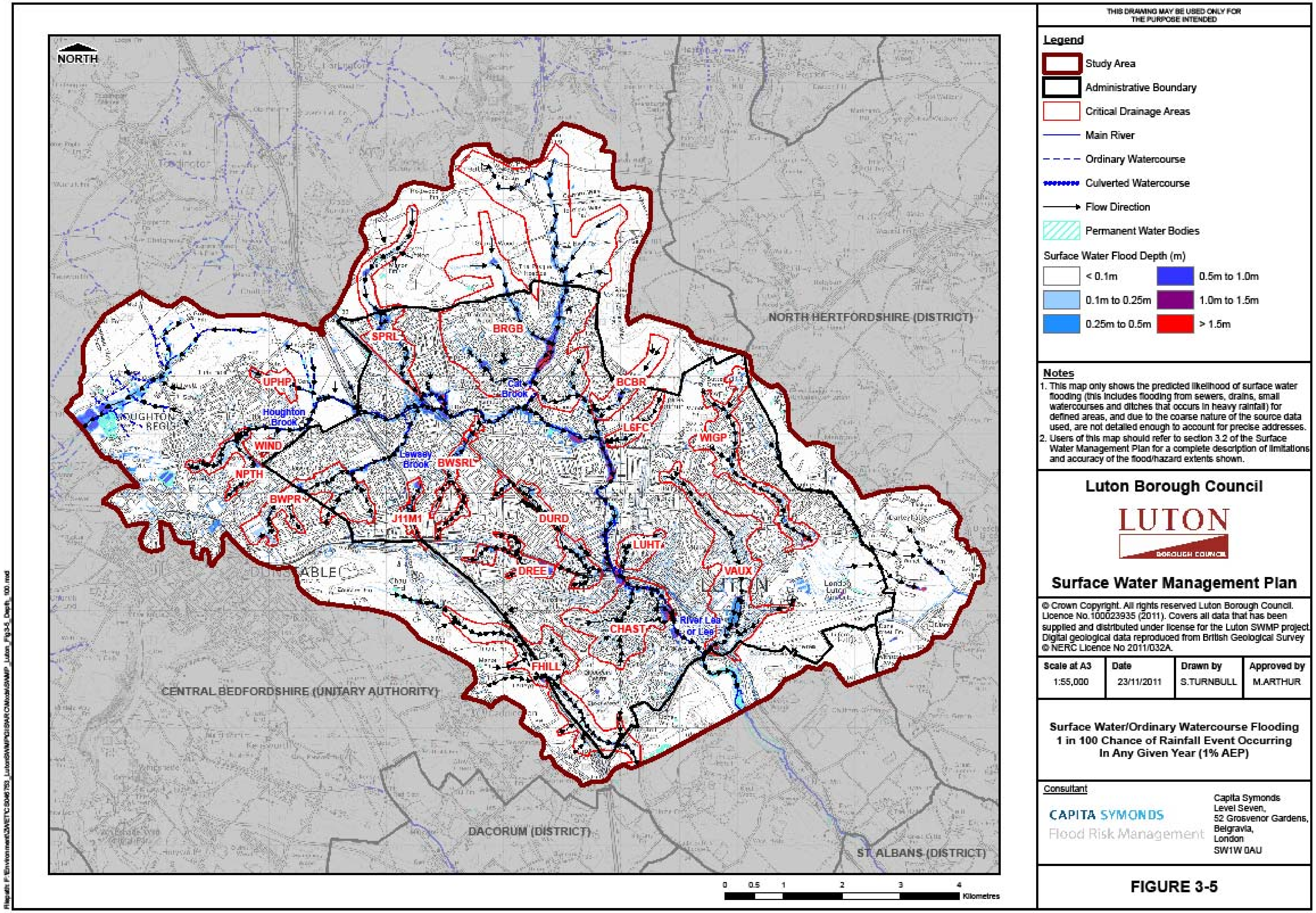
3.8.10 The following sections of the report provide a summary of the location, probability, consequences and mechanisms of flooding in each CDA within the borough. Each CDA is supported by two Figures at the end of this section - one showing the extent of the CDA displayed with the 1 in 100 year maximum depth results and the other with the Flood Hazard Rating calculated for the same return period.

3.8.11 Figure 3-5 shows a summary of the 17 CDAs identified within the study area, including their IDs and a description of their general locations. The sections following this and the figures at the end of this section are in the order given in Table 3-5.

ID	Location Description
BCBR	Barnfield College, Barnfield Avenue
BRGB	Barton Road/Great Bramingham
BWPR	Barnfield West Academy/Poynters Road
BWSRL	Beechwood Primary School/Railway Line
CHAST	Chapel Viaduct, Stuart Street
DREE	Dalroad Enterprise Estate
DURD	Dunstable Road/Luton Town Football Ground
FHILL	Farley Hill
J11M1	Junction 11 M1
L6FC	Luton Sixth Form College
LUHT	Luton High Town
NPTH	Nimbus Park/The Herculean
SPRL	Sundon Park/Railway Line
UPHP	Upstream of Houghton Park
VAUX	Vauxhall Road
WIGP	Wigmore Lane/Eaton Green Road
WIND	Windsor Drive

Table 3-5: CDA Summary

Figure 3-5: Surface Water/Ordinary Watercourse Flooding 1 in 100 Chance of Rainfall Event Occurring In Any Given Year (1% AEP)



Barnfield College / Barnfield Avenue (BCBR)

CDA ID	BCBR			
Location	Barnfield College, Barnfield Avenue		**NGR**	508829, 224417
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	
	Groundwater			
Flood Mechanism Description	Overland flow accumulates near the east side of Old Bedford Road, then excess flood water overtops the road to flow towards the River Lea via Barnfield Avenue and Barnfield College. Flooding may also occur due to the lack of drainage systems around the upstream end of Old Bedford Road.			
Validation	LBC have indicated that this area has previously flooded. Good correlation with EA Surface Water flood maps for 1 in 200 year event and 1 in 30 year event. Low concentration of sewer flooding incidents reported.			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	109	0	0	5
>0.5m	22	0	0	2
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	0	0
>0.5m	0	0	0	0
Flood Impacts	Numerous households are predicted to be affected by flooding during this rainfall event. Barnfield College grounds are affected, but not the buildings themselves.			
Key Assumptions	Drainage system is not explicitly considered by modelling			
Figure References	3-5-1A	Surface Water Depth (1% AEP)		
	3-5-1B	Surface Water Flood Hazard (1% AEP)		

Barton Road / Great Bramingham (BRGB)

CDA ID	BRGB			
Location	Barton Road/Great Bramingham		**NGR**	508035, 226434
Flood Source	***Local***		***Other***	

	Surface Water	✓	Sewer	✓
	Ord. Watercourse	✓	Main River	✓
	Groundwater			
Flood Mechanism Description	Overland flow originating in the farmland to the north flows through Bramingham Park in two locations, then accumulates along Icknield Way before discharging into Catbrook. Catbrook is defined to be a Main River.			
Validation	Generally correlates well with EA Surface Water Maps. There are 3 flooding incidents recorded within the CDA: (1) Surface water runoff from Warden Hill Road & Barton Road surcharges manhole in Icknield Way which floods gardens and under floors of properties. Carriageway flooding occurs & flows over the footway into properties 1 to 7. Directly attributed to watercourse over-topping. (2) Icknield Way near house number 133, carriageway flooding occurs and flows over the footway into the property at 133 and on occasion two other properties. Surface water system surcharges at this point. (3) Around 73 and 75 Enderby Road, sewers described as surcharging in storm conditions (from gullies and manholes), water flows off highway and surrounds the above two properties flooding garages and threatening to flood properties. Luton Fire Brigade reported two flooding incidents within the CDA between April 2009 and October 2010. Council officers indicated that open land around Dewsbury Road / Springfield Road had flooded in the past. High concentration of sewer flooding incidents reported in lower part of CDA (south of Bramingham Road / Icknield Way). Low concentration of sewer flooding incidents in the northern part of the CDA (Great Bramingham Wood / Marsh Farm).			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	892	120	25	79
>0.5m	374	4	10	17
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	1	4	1
>0.5m	0	1	2	1
Flood Impacts	The flood level reaches between 1.5-2.0m during the 100 year event around Icknield Way and is predicted to flood a substantial number of properties. Many residential properties along A6 near Statham Close roundabout, Chard Drive, Sacombe Green and the Whitehorse Vale are observed to have a significant hazard rating. The highly vulnerable infrastructure identified is the church /			

	community hall at the corner of Catsbrook Road and Icknield Way. More vulnerable items are schools throughout the CDA.		
Key Assumptions	- Drainage system is not explicitly considered by modelling - The mapping shows that overland flow is trapped northeast of Catsbrook Road. This is due to the Catbrook culvert running under the playing fields being assumed to be blocked during all rainfall events modelled.		
Figure References	3-5-2A	Surface Water Depth (1% AEP)	
	3-5-2B	Surface Water Flood Hazard (1% AEP)	

Barnfield West Academy/Poynters Road (BWPR)

CDA ID	BWPR			
Location	Barnfield West Academy / Poynters Road		**NGR**	503846, 222976
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	
	Groundwater			
Flood Mechanism Description	Overland flow originating from the Western Way / Boscombe Road area flows along Goldstone Crescent towards Poynters Road and Barnfield West Academy, finally emptying into the open channel in Lewsey Park after substantial flooding in Pastures Way. Another overland flow originating at Evelyn Road and running along Chapter House Road also contributes to the flooding at Pastures Way. Flood mechanism is primarily surface water flow, probably exacerbated by lack of capacity in surface water sewers. Medium concentration of sewer flooding evident in eastern part of CDA (between Poynters Road and the M1). Note that no sewer flooding data was available within the Anglian Water area of this CDA – west of Poynters Road.			
Validation	Model generally correlates with the flood extent of EA Surface Water Flood Map. Historically Chapter House Road properties 14 to 20 and 7 to 13 have experienced carriageway flooding under storm conditions; water has also entered front and rear gardens of two properties flooding them and a garage on one occasion. Fire Brigade has reported two flood incidents within the CDA. The dates of the incidents range from April 2009 to October 2010.			

Flooded Property Summary (1% AEP Rainfall Event)

Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	225	29	5	10
>0.5m	7	0	0	0

Approx. Depth	Infrastructure			
	Essential	Highly Vulnerable	More Vulnerable	Other
>0.1m	0	0	2	0
>0.5m	0	0	0	0
Flood Impacts	The properties between Poynters Road and Amhurst Road are flooded with observed flood depths between 0.4m and 0.75m, this is due to the area of ground which is lower than the surrounding area. Similarly a group of properties along Pastures Way is also identified to be flooded by approximately 0.2m. Minor flooding is predicted at two schools within the CDA (more vulnerable infrastructure).			
Key Assumptions	Drainage system is not explicitly considered by modelling			
Figure References	3-5-3A	Surface Water Depth (1% AEP)		
	3-5-3B	Surface Water Flood Hazard (1% AEP)		

Beechwood Primary School / Railway Line (BWSRL)

CDA ID	BWSRL			
Location	Beechwood Primary School / Railway Line		**NGR**	506338, 223712
Flood Source	*Local*		*Other*	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse	☐	Main River	☐
	Groundwater			
Flood Mechanism Description	Overland flow runs off the urbanised areas around Sandgate Road, Fieldgate Road and Oakley Road and similarly from Thirlestone Road, Newbury Close and Oakley Road, converging in Morgan Close to run down Linden Road and pond at the west side of the railway line at the corner of Linden Road, Dordans Road and Filmer Road. Flood water builds up at this location then partially flows through the rail underpass which connects Linden Road and Archway Road. Surface water then ponds around Mostyn Road and flows towards Ambleside, resulting in the predicted flooding of a number of residential properties. Mechanism is primarily surface water flow, probably exacerbated by lack of capacity in surface water sewers.			
Validation	The modelled results correlate well with the EA Surface Water Maps for both the 30yr and 200yr events. Poor validation of flooding in this area - no reports from Fire Brigade or anecdotal evidence from LBC. Low to medium concentration of sewer flooding incidents (lower in the northern part of the CDA).			
Flooded Property Summary (1% AEP Rainfall Event)				

Approx. Depth	Households		Commercial / Industrial	Other (unclassified land use)
	Non-Deprived	Deprived		
>0.1m	184	0	2	11
>0.5m	27	0	0	3
Approx. Depth	Infrastructure			
	Essential	Highly Vulnerable	More Vulnerable	Other
>0.1m	0	0	0	1
>0.5m	0	0	0	0
Flood Impacts	The majority of flooded households are centred on Morgan Close, Linden Road and Mostyn Road – typical depths are between 0.7m and 1.0m for the 1% AEP event.			
Key Assumptions	- Drainage system is not explicitly considered by modelling			
Figure References	3-5-4A	Surface Water Depth (1% AEP)		
	3-5-4B	Surface Water Flood Hazard (1% AEP)		

Chapel Street, Stuart Street (CHAST)

CDA ID	CHAST			
Location	Chapel Street, Stuart Street		NGR	509761, 220890
Flood Source	Local		Other	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	✓
	Groundwater	✓		
Flood Mechanism Description	Two areas of substantial flooding are predicted in this CDA. Three overland flow paths originating from Farley Hill in the west run down Chapel Street, Russell Rise / Elizabeth Street and London Road. These overland flows converge at the northern end of Chapel Street and are predicted to flow into The Mall at the intersection with George Street. The flow then continues towards Silver Street via the car park and joins the River Lea. The second area of flooding is centred on Manor Park in the east of the CDA. This area is primarily influenced by fluvial flooding from the River Lea, but the surface water flooding shows the extent to be much larger than the fluvial impact alone. The BGS Groundwater Flooding Susceptibility maps also show a high to very high risk of groundwater flooding in the town centre area – but there are no incident records to validate this.			
Validation	The SWMP modelling predicts larger flood extents than the EA			

	Surface Water Flood Map near The Mall and Manor Road Park. The SWMP model of the area around The Mall is a better representation than the EA mapping. However, the flooding in the Manor Road Park area could be overestimated by the SWMP model due to its assumption relating to the River Lea running bank full. There is a flooding incident recorded from July 2010 around Castle Street. Outside the Methodist church water was described as coming up through footway flooding church property, however this area appears to be not flooding in the SWMP model. There is a flood incident reported from July/August 1980 in Russell Street, 0.3m deep approximately - road, houses (approx 6) flooded. A high concentration of sewer flooding is evident in the town centre area and is surrounded by an area of medium concentration to the south and medium to high concentration to the west.			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	103	308	124	112
>0.5m	0	9	6	20
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	3	1
>0.5m	0	0	0	0
Flood Impacts	The majority of household flooding is predicted along the Russell Street / Elizabeth Street overland flow path. Predicted commercial property flooding is generally centred within and around The Mall. Of most concern is the predicted 0.4m to 0.6m deep overland flow through The Mall.			
Key Assumptions	- Drainage system is not explicitly considered by modelling - River Lea is assumed to be running at bank full (the EA have advised that the River at this location may have sufficient capacity to convey flows greater than a 1% AEP – modelled surface water flood extents may thus be smaller than shown)			
Figure References	3-5-5A	Surface Water Depth (1% AEP)		
	3-5-5B	Surface Water Flood Hazard (1% AEP)		

Dalroad Enterprise Estate (DREE)

CDA ID	DREE			
Location	Dalroad Enterprise Estate		**NGR**	507638, 221695
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓

	Ord. Watercourse		Main River	
	Groundwater			
Flood Mechanism Description	Overland flow accumulates around the properties near Connaught Road and Bilton Way, then flows towards the Kingsway underpass where it ponds in the road. The flow then continues towards Dunraven Avenue and into the Dalroad Enterprise Estate, where it accumulates and ponds to a significant depth. Mechanism is primarily surface water flow, probably exacerbated by lack of capacity in surface water sewers.			
Validation	EA's surface water flood maps generally correlates with the predicted outlines from the SWMP model. There is a recorded incident around Kingsway which was identified as the flooding hot spot in this area. Highway flooding issues were noted here during prolonged storm rain in 1998. Flood water also runs off Hatters Way (where the sewers are known to surcharge in storm conditions) and runs down through the builder's yard (Dalroad Estate). There have been two incidents of flooding reported to the Fire Brigade on Kingsway between April 2009 and October 2010. There is a medium concentration of sewer flooding incidents within this CDA with a slightly higher concentration to the north of Hatters Way.			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	51	4	21	17
>0.5m	0	0	2	8
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	0	0
>0.5m	0	0	0	0
Flood Impacts	Most of the predicted flooded properties are along Kingsway or within the Bilton Way Industrial Estate or Dalroad Estate.			
Key Assumptions	Drainage system is not explicitly considered by modelling			
Figure References	3-5-6A	Surface Water Depth (1% AEP)		
	3-5-6B	Surface Water Flood Hazard (1% AEP)		

Dunstable Road / Luton Town Football Ground (DURD)

CDA ID	DURD		
Location	Dunstable road/Luton Town Football Ground	**NGR**	508419, 221938

	Local		Other	
Flood Source	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	
	Groundwater	✓		

Flood Mechanism Description	Overland flow originates from a commercial area on Wingate Road and crosses the rail line towards Leagrave Road. The flow then continues through the rail depot on Leagrave Road to the south and into the Leagrave Road underpass where it ponds and affects several households. The flow proceeds down Dunstable Road and ponds again near the intersection at Waldeck Road before heading towards the south east to join the large predicted flood area at Telford Way. Two smaller overland flows from the Luton Town Football Club and Dallow Primary School also contribute to the ponding area at Waldeck Road. A smaller flow begins near the corner of Selbourne Road and Maidenhead Road, then terminates in a low lying area between Selbourne Road and the railway to the south. The mechanism for flooding in both areas is likely to be a combination of overland flow and under-capacity surface water sewers. The BGS Groundwater Flooding Susceptibility maps also show a high to very high risk of groundwater flooding in the town centre area – but there are no incident records to validate this.
Validation	Generally good correlation with EA Surface Water Map. Records from LBC show that Waldeck Road floods during heavy storm conditions. There are 2 Fire Brigade records of flooding related callouts occurring between April 2009 and October 2010. It is noted that the pumping station in Waldeck Road has recently been refurbished and now functions satisfactorily. There is a medium concentration of sewer flooding incidents within this CDA with a slightly higher concentration to the downstream end in Bury Park.

Flooded Property Summary (1% AEP Rainfall Event)

Approx. Depth	*Households*		*Commercial / Industrial*	*Other (unclassified land use)*
	Non-Deprived	*Deprived*		
>0.1m	29	148	38	55
>0.5m	3	4	0	1

Approx. Depth	*Infrastructure*			
	Essential	*Highly Vulnerable*	*More Vulnerable*	*Other*
>0.1m	0	0	0	1
>0.5m	0	0	0	0

Flood Impacts	Residential property flooding is generally associated with the

	predicted flooding at Leagrave Road underpass and at Waldeck Road. Commercial property flooding is concentrated in the rail depot on Leagrave Road and Wingate Road. Flooding of A6 at New Bedford Road underpass and B579 at Leagrave Road underpass (both are main east-west routes through Luton)	
Key Assumptions	- Drainage system is not explicitly considered by modelling	
Figure References	3-5-7A	Surface Water Depth (1% AEP)
	3-5-7B	Surface Water Flood Hazard (1% AEP)

Farley Hill (FHILL)

CDA ID	FHILL			
Location	Farley Hill		**NGR**	507994, 219664
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	
	Groundwater			
Flood Mechanism Description	A major flow path runs south along the west side of the M1 crossing over to the east side at Luton Road and continuing down Newlands Road affecting the M1 underpasses at Church Road and Newlands Farm. Flood mechanism is surface water overland flow as little significant sewer infrastructure exists in this CDA due to its mainly rural nature.			
Validation	Very good correlation with EA Surface Water Map. There are no specifically recorded incidents of flooding in this CDA, but the existence of a submersible pumping station located in the Luton Road M1 underpass confirms flooding is an issue. Substantial flooding predicted in the south-east corner of the intersection of Luton Road and the B4540 is generally contained within the two surface water ponds in this location. The urbanised part of this CDA has a medium concentration of sewer flooding incidents reported.			

Flooded Property Summary (1% AEP Rainfall Event)

Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	3	33	3	2
>0.5m	0	1	0	0
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	0	0

>0.5m	0	0	0	0
Flood Impacts	All of the household flooding predicted in this CDA is located in the Farley Hill area. Deeper flooding is associated with the predicted overland flow path through The Grove, Farley Farm Road and Leyhill Drive.			
Key Assumptions	Drainage system is not explicitly considered by modelling			
Figure References	3-5-8A	Surface Water Depth (1% AEP)		
	3-5-8B	Surface Water Flood Hazard (1% AEP)		

Junction 11 M1 (J11M1)

CDA ID	J11M1			
Location	Junction 11 M1		**NGR**	505397, 222796
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	
	Groundwater			
Flood Mechanism Description	Overland flow from the eastern side of the M1 to the south of Junction 11 and from Derby Road to the west flow parallel to the M1 and converge at the Junction 11 underpass. The overland flow is predicted to pond in the low area, then continue to flow towards the north east and pond to the north side of Challney High School within the playing fields. The mechanism for flooding in both areas is likely a combination of overland flow and under-capacity surface water sewers.			
Validation	Extents generally correlate with EA Flood Map, but there are no other supporting records of historic flooding. The three postcode areas showing sewer flooding that intersect within this CDA show a low to medium concentration of sewer flooding incidents.			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	7	0	0	2
>0.5m	0	0	0	0
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	0	0
>0.5m	0	0	0	0
Flood Impacts	Predicted household flooding is adjacent to the M1 motorway. One 'other' property listed here as flooded is one of the outbuildings at Challney High School. The second 'other' property no longer exists			

	and is now part of the north bound M1 off-slip (it should be noted that the Ordnance Survey mapping still shows this as a large warehouse and hence is included in the overall flooded property count). While the M1 itself is not predicted to be flooded the Junction 11 access point may be affected.	
Key Assumptions	Drainage system is not explicitly considered by modelling	
Figure References	3-5-9A	Surface Water Depth (1% AEP)
	3-5-9B	Surface Water Flood Hazard (1% AEP)

Luton Sixth Form College (L6FC)

CDA ID	L6FC			
Location	Luton Sixth Form College		**NGR**	509146, 223993
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	✓
	Groundwater			
Flood Mechanism Description	An overland flow starting on Stopsley Common runs across Foxhill Road and into the Luton Sixth College playing field, then across Old Bedford Road and into properties along Marston Gardens, Avebury Avenue and Stratton Gardens followed by discharge into the River Lea. The mechanism for flooding in both areas is likely a combination of overland flow and under-capacity surface water sewers with the influence of the River Lea at the western end of the CDA.			
Validation	Generally modelled results correlate reasonably well with the EA Surface Water maps. There is a recorded incident in Bushmead Road, however this location is not in the vicinity of the flooded area. The LBC Highway Maintenance Team installed additional surface water drainage in Bushmead Road and Fairford Avenue to prevent flooding to frontages in Bushmead Road in conjunction with Thames Water, and flooding during low return period events is no longer an issue in that area. There is a recorded incident around Stratton Gardens from July 2010, but this is located in the vicinity of fluvial flooding adjacent to the River Lea and could be related to either source. There is a flooding incident reported from the July/August 1980 event in Old Bedford Road, 0.2m deep approx. Road, houses (approx 6) on downhill side of the road flooded. LBC indicated that there was a flooding incident in the past around the properties just upstream (east side) of Marston Gardens and			

	that area was confirmed as a flooding hotspot in the SWMP model. The CDA lies within an area of low concentration of sewer flooding incidents.			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	42	0	1	0
>0.5m	2	0	0	0
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	0	0
>0.5m	0	0	0	0
Flood Impacts	Residential properties along Avebury Avenue, Marston Gardens, Old Bedford Road and Foxhill Road are flooded as a result of overland flow. More significant flooding is predicted for the properties between the Luton College playing field and Marston Gardens, with modelled flooding of between 0.4m and 0.5m near the houses.			
Key Assumptions	Drainage system is not explicitly considered by modelling			
Figure References	3-5-10A	Surface Water Depth (1% AEP)		
	3-5-10B	Surface Water Flood Hazard (1% AEP)		

Luton High Town (LUHT)

CDA ID	LUHT			
Location	Luton High Town		**NGR**	509329, 222224
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	
	Groundwater	✓		
Flood	Overland flow from the north east of the High Town area towards			

Mechanism Description	the west accumulates in the lower spots as the natural valley turns to the south. Excess surface water runoff flows towards the River Lea through properties around Reginald Street, Frederick Street and Dudley Street. The mechanism for flooding in both areas is likely a combination of overland flow and under-capacity surface water sewers. The BGS Groundwater Flooding Susceptibility maps also show a high to very high risk of groundwater flooding in the town centre area – but there are no incident records to validate this.				
Validation	Generally correlates with the EA's surface water flood extents, but there are no other supporting records of historic flooding. The CDA lies within an area of low concentration of sewer flooding incidents.				
Flooded Property Summary (1% AEP Rainfall Event)					
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***	
	Non-Deprived	***Deprived***			
>0.1m	86	54	6	25	
>0.5m	0	0	0	0	
Approx. Depth	***Infrastructure***				
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***	
>0.1m	0	0	1	0	
>0.5m	0	0	0	0	
Flood Impacts	A large number of flooded households are centred around the low point on Frederick Street. The more vulnerable infrastructure identified as being at risk of minor flooding is a drugs clinic on Clarendon Road.				
Key Assumptions	Drainage system is not explicitly considered by modelling				
Figure References	3-5-11A	Surface Water Depth (1% AEP)			
	3-5-11B	Surface Water Flood Hazard (1% AEP)			

Nimbus Park / The Herculean (NPTH)

CDA ID	NPTH			
Location	Nimbus Park/The Herculean		**NGR**	502746, 223483
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	
	Groundwater			
Flood	Overland flow from the Apex Business Park area flows towards the			

Mechanism Description	Herculean buildings through Nimbus Park and joins the Houghton Brook in the park to the north. A similar overland flow originates in the Townsend Industrial Estate and flows through the residential area around Cemetery Road and into the Houghton Brook. The mechanism for flooding in both areas is likely a combination of overland flow and under-capacity surface water sewers.			
Validation	Good correlation between EA's surface water maps and the predicted flood outlines of the SWMP model. There are no recorded incidents of flooding at this location. No incidents recorded by the fire brigade within the CDA. This is not unusual as the predicted flood extents generally impact commercial areas. No sewer flooding incident data is available for this CDA.			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	56	0	18	6
>0.5m	0	0	0	0
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	0	0
>0.5m	0	0	0	0
Flood Impacts	Commercial property flooding is generally located in the three business parks – Townsend Estate, Apex Business Centre and The Herculean. Most of the residential flooding is located on the Townsend Industrial Estate flow path on Dunstable Road and Cemetery Road.			
Key Assumptions	Drainage system is not explicitly considered by modelling			
Figure References	3-5-12A	Surface Water Depth (1% AEP)		
	3-5-12B	Surface Water Flood Hazard (1% AEP)		

Sundon Park / Railway Line (SPRL)

CDA ID	SPRL			
Location	Sundon Park/Railway Line		**NGR**	505288, 225488
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse	☐	Main River	☐
	Groundwater			
Flood	Overland flow travels down through Lower Sundon, then flows			

Mechanism Description	south to pond on the northern side of the properties near Dencora Way / Grampian Way in a lower lying area. Then surface water flows towards the school in Sundon Park through properties on either side of Sundon Park Road to eventually join the Houghton Brook just before it's confluence with the River Lea in Leagrave Common. The mechanism for flooding in both areas is likely a combination of overland flow and under-capacity surface water sewers.			
Validation	Good correlation with EA surface water flood maps for areas of shallow flooding except in the area near Lower Sundon and further north. In this location the SWMP model flood outlines are slightly larger than the EA maps but are also shallower. This is explained by the fact that the SWMP model has used higher accuracy topographic data in this area. No historical flood events were reported and also no reports from the Fire Brigade. Available sewer flooding data shows no records within this CDA.			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	138	0	25	47
>0.5m	21	0	4	5
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	2	0
>0.5m	0	0	1	0
Flood Impacts	The residential properties within the modelled flood extent are generally along both sides of Sundon Park Road while the commercial properties are located around Dencora Way. The infrastructure predicted to be affected by flooding is the school on Sundon Park Road (two buildings).			
Key Assumptions	Drainage system is not explicitly considered by modelling			
Figure References	3-5-13A	Surface Water Depth (1% AEP)		
	3-5-13B	Surface Water Flood Hazard (1% AEP)		

Upstream of Houghton Park (UPHP)

CDA ID	UPHP			
Location	Upstream of Houghton Park		**NGR**	502,896, 224,990
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	

	Groundwater			
Flood Mechanism Description	Overland flow travels through the properties near Sundon Road / Kent Road and then flows southeast to Hillcrest School and properties near Houghton Park Road, then keeps flowing through Houghton Park to join Houghton Brook. The mechanism for flooding in both areas is likely a combination of overland flow and under-capacity surface water sewers.			
Validation	Modelled results correlate well the EA Surface Water maps. No historical flood events were reported and also no reports from the Fire Brigade. No sewer flooding incident data is available for this CDA.			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	83	0	0	3
>0.5m	0	0	0	0
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	0	0
>0.5m	0	0	0	0
Flood Impacts	Minor flooding is predicted for properties between Kent Road and Sundon Road with several more affected along the western side of Houghton Park Road. Although part of the overland flow is predicted to be through Hillcrest School, the depths are not predicted to significantly affect buildings.			
Key Assumptions	Drainage system is not explicitly considered by modelling			
Figure References	3-5-14A	Surface Water Depth (1% AEP)		
	3-5-14B	Surface Water Flood Hazard (1% AEP)		

Vauxhall Road (VAUX)

CDA ID	VAUX			
Location	Vauxhall Road		**NGR**	511061, 220800
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	
	Groundwater	✓		
Flood	Overland flow originating from Sunningdale Road travel towards the			

<table>
<tr><td><u>Mechanism Description</u></td><td colspan="4">Kimpton Road / Airport Way roundabout via Vauxhall Way(A505). The overland flow remains within the road for most of this reach with the exception of an area adjacent to Eaton Valley Road where it enters a low area behind the residential properties. Surface water backs up before it reaches the Kimpton Road / Airport Way roundabout as the ground level gets higher. The surface water is diverted towards the entrance of the General Motors yard and flows along the path on the east side of the building, and ponds in the car park at the south end of the complex. Once the water level reaches the crest level of Kimpton road, it overtops and flows towards the River Lea passing via the Vauxhall Road rail underpass and Parkway Road via a pedestrian underpass.
Deep flooding is also predicted to occur in the Airport Way underpass adjacent to the airport. The mechanism for flooding in all areas within this CDA is likely a combination of overland flow and under-capacity surface water sewers.
The BGS Groundwater Flooding Susceptibility maps also show a high to very high risk of groundwater flooding Vauxhall Road / Parkway Road area – but there are no incident records to validate this.</td></tr>
<tr><td><u>Validation</u></td><td colspan="4">Extents generally correlate with EA surface water flood map. LBC was previously aware of the open land and the cark park on the east side of Parkway Road as flooding hot spots. Similarly, Luton Airport has also confirmed historic flooding in the underpass on Airport Way. Sewer flooding incident information shows a low concentration of incidents in this area.</td></tr>
<tr><td colspan="5"><u>Flooded Property Summary (1% AEP Rainfall Event)</u></td></tr>
<tr><td rowspan="2">Approx. Depth</td><td colspan="2">Households</td><td rowspan="2">Commercial / Industrial</td><td rowspan="2">Other (unclassified land use)</td></tr>
<tr><td>Non-Deprived</td><td>Deprived</td></tr>
<tr><td>>0.1m</td><td>184</td><td>31</td><td>9</td><td>28</td></tr>
<tr><td>>0.5m</td><td>0</td><td>0</td><td>1</td><td>6</td></tr>
<tr><td rowspan="2">Approx. Depth</td><td colspan="4">Infrastructure</td></tr>
<tr><td>Essential</td><td>Highly Vulnerable</td><td>More Vulnerable</td><td>Other</td></tr>
<tr><td>>0.1m</td><td>0</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>>0.5m</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td><u>Flood Impacts</u></td><td colspan="4">Predicted commercial property flooding is primarily within the General Motors area along Vauxhall Way and Vauxhall Road. Modelled residential property flooding is generally related to smaller overland flows contributing to the main flow path along Vauxhall Way.
In addition to the infrastructure noted above, Parkway Road is also predicted to experience significant flooding. This is currently the only access road to Luton Airport Parkway Station. Similarly, significant overland flow is predicted along Vauxhall Way (A505).</td></tr>
<tr><td><u>Key</u></td><td colspan="4">Drainage system is not explicitly considered by modelling</td></tr>
</table>

Assumptions		
Figure References	3-5-15A	Surface Water Depth (1% AEP)
	3-5-15B	Surface Water Flood Hazard (1% AEP)

Wigmore Lane / Eaton Green Road (WIGP)

CDA ID	WIGP			
Location	Wigmore Lane / Eaton Green Road		**NGR**	511,001, 223,711
Flood Source	***Local***		***Other***	
	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	
	Groundwater			
Flood Mechanism Description	Surface water flows from higher ground around Butterfield, Manor Farm and Stopsley towards the balancing pond further south via Swifts Green Road, Putteridge Road, Mayfield Road and Wigmore Lane. Surface water then accumulates at the Thames Water balancing pond around the intersection of Wigmore Lane / Crawley Green Road. After the balancing pond fills, excess water travels through Wigmore Lane southwards to reach another balancing pond on Eaton Green Road at its intersection with Wigmore Lane. Once the capacity of the balancing pond is exceeded, surface water ponds on the Wigmore Lane / Eaton Green Road intersection to a substantial depth. The mechanism for flooding in all areas within this CDA is likely a combination of overland flow and under-capacity surface water sewers			
Validation	There are 5 recorded incidents within the CDA from the last 10 years: (i) The highway ditch taking surface water runoff from the highway and adjacent fields silts up readily and the outfalls where it's piped across the road become blocked around Butterfield Green Road; (ii) Four properties and the carriageway flood here 2 to 3 times a year in recent years around the Swifts Green Road; (iii) For many years the carriageway has flooded at the low point near the shops, with some property flooding around Putteridge Road; (iv) Highway flooding and flooding of private gardens at this location is believed to be the surface water system surcharging around the Mayfield Road; (v) Highway flooding in this area which occasionally floods garages to properties. The flooding occurs at the low point in the road, likely to be a sewer capacity issue as the system surcharges around Handcross Road; There were a further two flooding incidents reported during July/August 1980: (i) In Putteridge Road, 0.75m deep approx. roads, 6 shops, 4 houses flooded; (ii) In Wigmore Lane, 0.2m deep approx. Flooding contained on roads and gardens, local balancing pond overwhelmed.			

	Fire Brigade reported two flooding incidents between April 2009 and October 2010. LBC Officers indicated that they received a few complaints from the area near Manor Farm (near Butterfield Green Road). Sewer flood incident information shows a low to medium concentration of historic incidents in this area.			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	124	0	4	2
>0.5m	18	0	0	0
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	2	0
>0.5m	0	0	1	0
Flood Impacts	Depths of water along majority of Wigmore Lane are in the range of 0.3m to 0.7m during the 1%AEP event. Under these conditions, the road is likely to be impassable to vehicles - especially at the southern end where ponding reaches 1m deep. The majority of predicted residential property flooding is located adjacent to Wigmore Lane. Flooding is likely to make the Wigmore Lane / Eaton Green Road intersection impassable. Predicted flooding of infrastructure includes the Thames Water foul water pumping station at the Wigmore Lane / Eaton Green Road intersection			
Key Assumptions	- Drainage system is not explicitly considered by modelling (including culvert adjacent to Luton Airport draining the Wigmore Lane / Eaton Green Road intersection) - The above assumption means that the flood extent predicted by the SWMP model is the likely extent that could occur in the event of culvert failure in this location. It is known that this particular culvert is in poor condition (as reported by LBC Officers).			
Figure References	3-5-16A	Surface Water Depth (1% AEP)		
	3-5-16B	Surface Water Flood Hazard (1% AEP)		

Windsor Drive (WIND)

CDA ID	WIND		
Location	Windsor Drive	**NGR**	502,970, 223,766
Flood	***Local***	***Other***	

Source	Surface Water	✓	Sewer	✓
	Ord. Watercourse		Main River	✓
	Groundwater			
Flood Mechanism Description	Overland flow travels through the properties near Windsor Drive and then flows northeast towards Tudor Drive and Evans Close to join the Houghton Brook. The mechanism for flooding in all areas within this CDA is likely a combination of overland flow and under-capacity surface water sewers. High water levels in the Houghton Brook are also likely to restrict the surface water sewer outflows in this CDA.			
Validation	Modelled results correlate well with the EA Surface Water flood maps. No historical flood events were reported and also no reports from the Fire Brigade. No sewer flooding incident data is available for this CDA.			
Flooded Property Summary (1% AEP Rainfall Event)				
Approx. Depth	***Households***		***Commercial / Industrial***	***Other (unclassified land use)***
	Non-Deprived	***Deprived***		
>0.1m	15	0	0	0
>0.5m	0	0	0	0
Approx. Depth	***Infrastructure***			
	Essential	***Highly Vulnerable***	***More Vulnerable***	***Other***
>0.1m	0	0	0	0
>0.5m	0	0	0	0
Flood Impacts	Minor surface flooding is predicted to affect the residential properties and local roads in this area.			
Key Assumptions	Drainage system is not explicitly considered by modelling			
Figure References	3-5-17A	Surface Water Depth (1% AEP)		
	3-5-17B	Surface Water Flood Hazard (1% AEP)		

3.9 Summary of Risk - CDAs

3.9.1 Table 3-6 (below) summarises the surface water flood risk to infrastructure, households and commercial/industrial receptors for each of the CDAs

Table 3-6: Summary of Surface Water Flood Risk in CDAs

CDA ID	Location	Infrastructure								Households				Commercial / Industrial		Other (Unclassified Landuse)	
		Essential		Highly Vulnerable		More Vulnerable		Other		Non-Deprived		Deprived					
		All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep
BCBR	Barnfield College, Barnfield Avenue	0	0	0	0	0	0	0	0	109	22	0	0	0	0	5	2
BRGB	Barton Road/Great Bramingham	0	0	1	1	4	2	1	1	892	374	120	4	25	10	79	17
BWPR	Barnfield West Academy/Poynters Road	0	0	0	0	2	0	0	0	225	7	29	0	5	0	10	0
BWSRL	Beechwood Primary School /Railway Line	0	0	0	0	0	0	1	0	184	27	0	0	2	0	11	3
CHAST	Chapel Viaduct, Stuart Street	0	0	0	0	3	0	1	0	103	0	308	9	124	6	112	20
DREE	Dalroad Enterprise Estate	0	0	0	0	0	0	0	0	51	0	4	0	21	2	17	8
DURD	Dunstable Road /Luton Town Football Ground	0	0	0	0	0	0	1	0	29	3	148	4	38	0	55	1
FHILL	Farley Hill	0	0	0	0	0	0	0	0	3	0	33	1	3	0	2	0
J11M1	Junction 11 M1	0	0	0	0	0	0	0	0	7	0	0	0	0	0	2	0
L6FC	Luton Sixth Form College	0	0	0	0	0	0	0	0	42	2	0	0	1	0	0	0
LUHT	Luton High Town	0	0	0	0	1	0	0	0	86	0	54	0	6	0	25	0
NPTH	Nimbus Park/The Herculean	0	0	0	0	0	0	0	0	56	0	0	0	18	0	6	0
SPRL	Sundon Park /Railway Line	0	0	0	0	2	1	0	0	138	21	0	0	25	4	47	5
UPHP	Upstream of Houghton Park	0	0	0	0	0	0	0	0	83	0	0	0	0	0	3	0
VAUX	Vauxhall Road	0	0	0	0	0	0	1	0	184	0	31	0	9	1	28	6
WIGP	Wigmore Lane /Eaton Green Road	0	0	0	0	2	1	0	0	124	18	0	0	4	0	2	0
WIND	Windsor Drive	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0

3.10 Summary of Risk – Non-Critical Drainage Areas

As can be seen in the figures in the previous section, surface water flood risk is also predicted to affect other parts of the study area that are not within defined CDA extents. Predicted flooding in these areas is generally from non-point source surface water runoff that does not accumulate into large, deep areas of flooding – but ponds in smaller areas that generally only affect small groups of properties. Predicted surface water flooding impacts within the study are that occur outside CDAs are summarised in the table below.

Key items of infrastructure predicted as being affected by surface water flooding deeper than 0.5m are summarised below:

Highly Vulnerable

- Fire Station (Corner of New Bedford Road and Studley Road) – mainly influenced by Main River flooding from the River Lea

More Vulnerable

- Health Care Centre (Mill Street) – Mainly influenced by Main River flooding from the River Lea through the Luton Town Centre
- Health Care Centre (Bridge Street) - Mainly influenced by Main River flooding from the River Lea through the Luton Town Centre
- Educational Building – Driver Training (Corner Telford Road and New Bedford Road) - Mainly influenced by Main River flooding from the River Lea through the Luton Town Centre

Other

- Electricity Substation (Corner of Mill Street and New Bedford Road) - Mainly influenced by Main River flooding from the River Lea through the Luton Town Centre

Table 3-7: Summary of Surface Water Flood Risk in Non-Critical Drainage Areas

Infrastructure								Households				Commercial / Industrial		Other (Unclassified Landuse)	
Essential		Highly Vulnerable		More Vulnerable		Other		Non-Deprived		Deprived					
All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep
0	0	1	1	11	3	2	1	1254	29	727	90	83	32	244	53

4 Phase 3: Options

4.1 Objective

4.1.1 The purpose of Phase 3 is to identify a range of structural and non-structural measures with the potential to alleviate flood risk and to assess each measure in order to eliminate those that are not feasible or economically viable.

4.2 Assessment Approach

4.2.1 Phase 3 delivers a high level option assessment for each of the Critical Drainage Areas (CDAs) identified in Phase 2. Unless otherwise stated, no financial damages have been calculated and flood mitigation costs have been determined using engineering judgement rather than through detailed analysis. Costs should therefore be treated at an 'order of magnitude' level of accuracy.

4.2.2 Once identified as generally feasible, the measures are combined together into 'options'. The options are then developed and tested against their relative effectiveness, benefits and costs. The target level of flood protection from surface water flooding has been set at 1 in 75 years. This aligns with the likely level of flood protection necessary to enable commercial insurance cover to be provided to the general public.

4.2.3 The option identification process has taken place on an individual CDA basis following the delineation established in Phase 2. The options assessment process assesses and short-lists the measures for each CDA in turn.

4.2.4 The options assessment presented here follows the process described in the Defra SWMP Guidance but is focussed on highlighting areas for further detailed analysis and immediate 'quick win' actions. Further detailed analysis may occur for high priority CDAs in the future.

4.2.5 In addition to options developed for CDAs, the study area is also viewed in an holistic way through the use of Policy Areas (PAs). The overall volume and rate of surface water runoff can also be influenced by managing larger areas at the planning policy level.

4.2.6 Where new developments are planned, this can be implemented in the short to medium term timeframe. However, this will generally be a long term process on an individual site by site basis for existing urban areas. PAs are defined to facilitate this process, and include general guidance on the type of policy that can be adopted to manage the study area as a whole.

4.2.7 To accommodate the CDA and PA aspects, the assessment approach focuses mitigation solutions as follows:

- CDA – Capital works and site specific solutions such as new culverts or above ground storage.
- PA – General catchment wide solutions such as planning policy to control runoff quantity / quality, flood warning systems or community flood plans.

4.3 Measures

4.3.1 Surface water flooding mechanisms and impacts are often highly localised and complex. Its management is therefore highly dependent on the characteristics of the area and there are few solutions which will provide benefits in all locations. This section outlines potential measures which have been considered for mitigating surface water flood risk within the study area.

4.3.2 The SWMP Technical Guidance (Defra 2010) identifies the concept of Source, Pathway and Receptor as an appropriate basis for understanding and managing flood risk. The figure below shows the relationship between these different components, and how some components could be considered within more than one category.

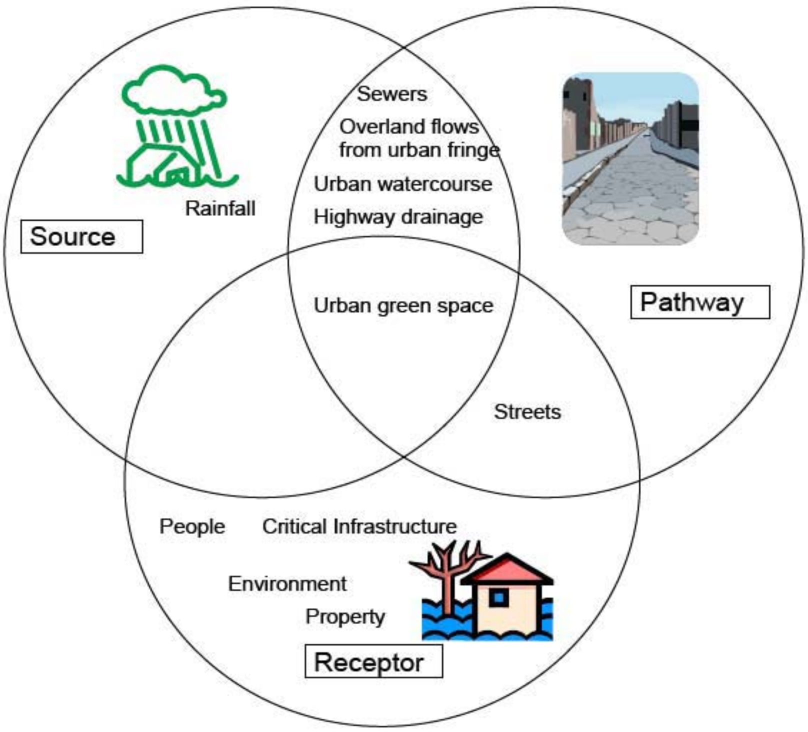


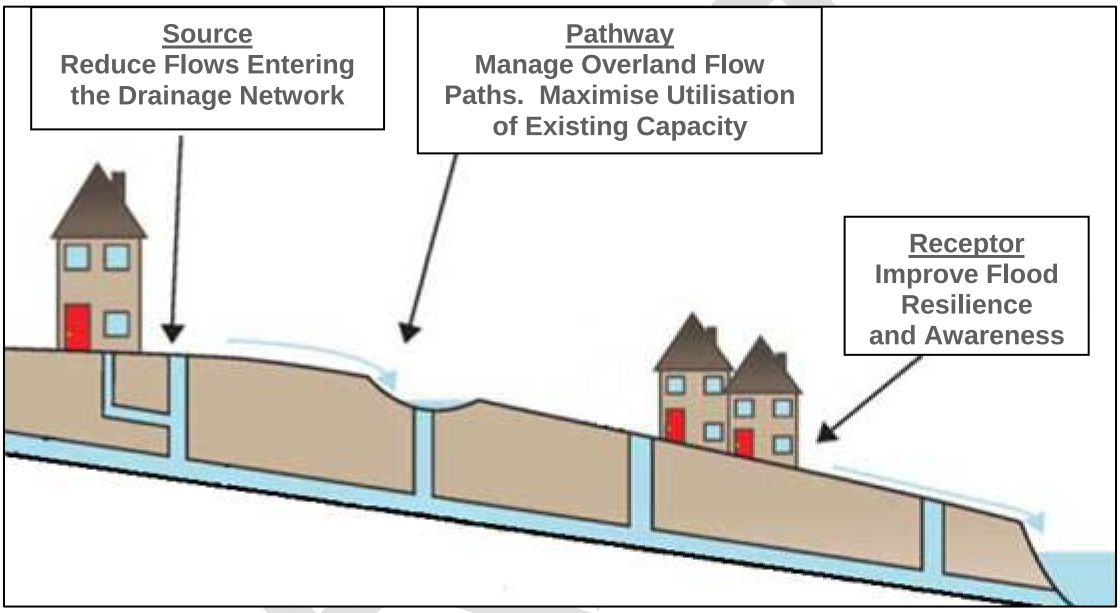
Illustration of Sources, Pathways & Receptors (extract from SWMP Technical Guidance, Defra 2010)

4.3.3 When identifying potential measures it is useful to consider the source, pathway, receptor approach (refer to figures above and below). Both structural and non-structural measures were considered in the optioneering exercise undertaken for the identified CDAs.

4.3.4 Structural measures can be considered as those which require fixed or permanent assets to mitigate flood risk (such as a detention basin, increased capacity pipe networks, etc).

4.3.5 Non-structural measures may not involve fixed or permanent facilities, and the benefits to flood risk reduction are likely to occur through influencing behaviour (planning policies, education about flood risk and possible flood resilience measures, understanding the benefits of incorporating rainwater reuse within a property, etc).

Source, Pathway and Receptor Model (adapted from Defra SWMP Technical Guidance, 2010)



4.3.6 Methods for managing flood risk from surface water flooding can be divided into methods which influence either the Source, the Pathway or the Receptor, as described below and in Table 4-1:

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

people know what to do if a flood does occur (or is forecast to occur), and flood resilience measures.

Table 4-1 Typical Surface Water Flood Risk Management Measures

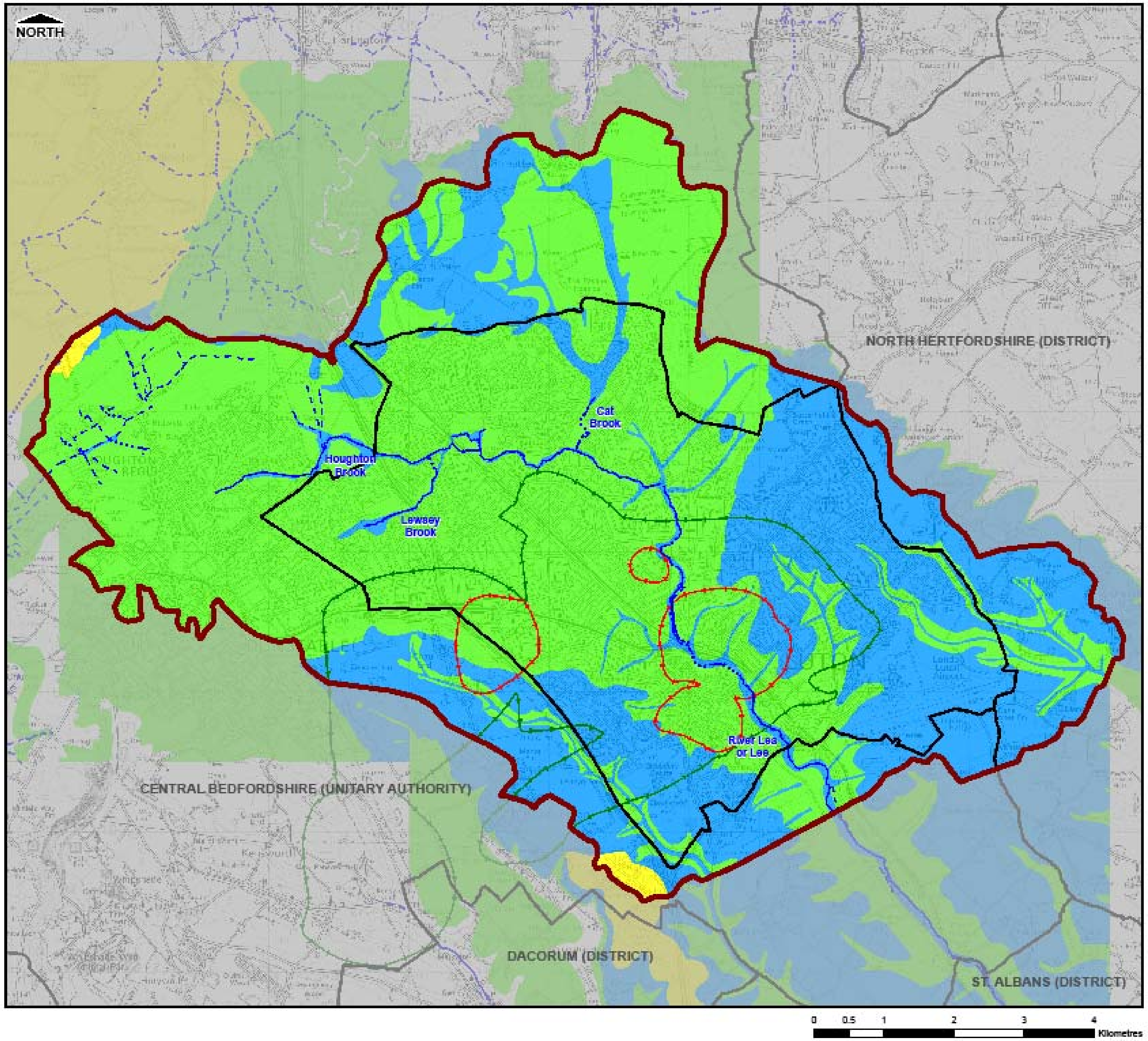
	Generic measures	Site specific measures
	• Do Nothing (do not continue maintenance) • Do Minimum (continue current maintenance)	
Source control	• Bioretention car park pods • Soakaways, water butts and rainwater harvesting • Green roofs • Permeable paving • Underground storage Other 'source' measures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

Infiltration Based Source Control Measures / SuDS

4.3.7 Many of the source control measures noted above rely on some available infiltration capacity within the local geology to dispose of surface water. The available capacity for infiltration is not only influenced by the local permeability, but also by the sensitivity of the receiving groundwater to receive potential pollutants. Some areas of groundwater need to be protected as they are used for potable water supplies.

4.3.8 Figure 4-1 shows an 'Infiltration SuDS Suitability Map'. This map has been developed using permeability information obtained from the BGS and groundwater source protection zones supplied by the EA. This information has been used to complete the options assessment and develop planning policy guidance for the study area.

Figure 4-1: Infiltration SuDS Suitability Map



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Study Area
- Administrative Boundary
- Infiltration SUDs Potentially Suitable
- Infiltration SUDs Potentially Unsuitable
- Infiltration SUDs Suitability Uncertain

EA Groundwater Source Protection Zone

- Inner Zone
- Outer Zone

Notes

Luton Borough Council

LUTON BOROUGH COUNCIL

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:55,000	23/11/2011	S.TURNBULL	M.ARTHUR

Infiltration SuDS Suitability Map

Consultant

CAPITA SYMONDS
Flood Risk Management

Capita Symonds
Level Seven,
52 Grosvenor Gardens,
Belgravia,
London
SW1W 0AU

FIGURE 4-1

Excluded Measures

4.3.9 The following sections discuss the preferred site specific options for each of the CDAs and PAs in turn (the CDAs are as described in Section 3, PAs are described later in this Section). Two specific options were considered but generally excluded for all assessments during the optioneering exercise, these were;

- Do Nothing: no longer undertaking maintenance (e.g. no longer maintaining gulley pots)
- Do Minimum: continuing the current maintenance regime (e.g. maintaining the current level of maintenance on a gulley pot).

4.3.10 The *Do Nothing* approach was excluded as a preferred option as it will provide no benefit to reducing the flood risk within a Local Flood Risk Zone (LFRZ) and wider CDA or PA and would, in fact, be likely to lead to an increased probability of flooding, and its consequences, in the borough.

4.3.11 The *Do Minimum* approach was excluded as a preferred option due to the predicted effects of climate change increasing the intensity and volume of rainfall. Maintaining the proposed maintenance regime will only be beneficial whilst rainfall intensities and volumes remain at a level similar to that of current conditions. If intensities and volumes increase as a result of climate change (as is anticipated) then the standard of protection afforded by assets (e.g. gulley pots) will diminish over time.

Construction Cost Estimates

4.3.12 A high level construction cost estimate is calculated for each flood mitigation solution proposed. <u>These should be considered as approximate order of magnitude costs only.</u> Cost estimates are summarised below along with references to relevant industry standard guidance from which they have been adapted. Values have been adjusted to 2011 equivalent values where appropriate.

Classification	Measure	Cost Rate (£)	Unit	Notes / Source
Source	green roof	146	m^2 of roof	Greater London Authority - Living Roofs and Walls - Technical Report: Supporting London Plan Policy (2008)
	soakaways	219	m^3 of stored volume	CIRIA SuDS Manual (2007)
	swales	16	m^2 of swale area	CIRIA SuDS Manual (2007)
	permeable paving	44	m^2 of surface	CIRIA SuDS Manual (2007)
	rainwater harvesting	1,100	m^3 of stored volume	Adapted from: http://www.rainwaterharvesting.co.uk/
	detention basins	22	m^3 of detention	CIRIA SuDS Manual (2007)

			volume	
	ponds and wetlands	33	m^3 of detention volume	CIRIA SuDS Manual (2007)
	other 'source' measures	N/A	N/A	Determined on case-by-case basis
Pathway	increasing capacity in drainage systems	Table 21	m of culvert	EA FRM Estimating Guide (2010) – Refer Appendix B
	separation of foul and surface water sewers	465	m^2 of separated catchment area	Adapted from Thames Water Counters Creek Project (http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/9344.htm)
	improved maintenance regimes	N/A	N/A	Determined on case-by-case basis
	managing overland flows	N/A	N/A	
	land management practices	N/A	N/A	
	other 'pathway' measures	N/A	N/A	
Receptor	improved weather warning	N/A	N/A	Pitt Report (2008)
	provide advanced flood warning	5,000 to 10,000	Borough wide	
	emergency response (flood) planning and exercising	3,000 to 5,000	Annual borough wide costs	
	planning policies to influence development	N/A	Borough wide	
	temporary or demountable flood defences	25,000	Per property protected	Adapted from: http://www.floodguarduk.co.uk/ AND http://www.ukfloodbarriers.com/
	social change, education and awareness	N/A	N/A	Determined on case-by-case basis
	improved resilience and resistance measures	22,000	Per property protected	Adapted from Defra "Flood resistance and resilience solutions: an R&D scoping study" (2007)
	other 'receptor' measures	N/A	N/A	Determined on case-by-case basis

4.3.13 The following standard assumptions have also been applied:

- The costs are the capital costs for implementation of the scheme only.
- Costs do not include provisions for consultancy, design, supervision, planning process, permits, environmental assessment or optimum bias.

- No provision is made for weather (e.g. winter working).
- No provision is made for access constraints.
- Land acquisition costs are not included
- No operational or maintenance costs are included.
- No provision is made for disposal of materials (e.g. for flood storage or soakaway clearance).

4.4 CDA Prioritisation

Methodology

4.4.1 To assist with prioritisation and programming of further work on all CDAs, a basic prioritisation methodology was applied to the CDAs identified in Section 3. At this stage of flood risk investigation and mitigation it is important to keep this method simple and transparent to ensure clear interpretation of the decision-making process to prioritise one area over another. This will aid in demonstrating that future spending on surface water management is distributed equitably around the borough. The general method proposed is summarised below:

- Identify ***high priority CDAs*** based upon overall verified risk and potential synergy with other projects.
- To prioritise further work in remaining ***medium and low priority CDAs***, use risk assessment outputs to count the number of properties flooded within the following general categories:
  - Infrastructure
    - Essential (e.g. water treatment works, primary electricity substations and mass evacuation routes)
    - Highly Vulnerable (e.g. police stations, fire stations and ambulance stations)
    - More Vulnerable (e.g. hospitals, retirement homes and schools)
  - Households
  - Commercial / Industrial
- For each category above determine the number of properties which are predicted to be flooded to a depth of:
  - 0.1m or more
  - 0.5m or more (highest confidence banding of depth)
- Assign a relative importance weighting associated with each of the above parameters.

- o Multiply and sum the parameters above to produce a 'total impacts' score.
- o Using the estimated level of flood mitigation achieved by the proposed solution, determine the number of properties benefiting from the scheme.
- o Calculate a 'mitigation score' by multiplying the same weightings as above by the number of properties benefitting from the scheme.
- o Use the 'total impacts', 'mitigation' and overall cost estimate for the scheme to produce a high level cost / benefit ranking to prioritise future work.

4.4.2 The above process also incorporates an 'override' parameter. This is used to raise the priority of a specific scheme based on unquantifiable factors. For example, predicted flooding of regionally important infrastructure such as substations or railway stations.

4.4.3 The above prioritisation method has been applied using good engineering judgement (high priority areas) and a simple spreadsheet tool (medium and low priority area).

Prioritisation Outcomes

4.4.4 The outcomes of the above prioritisation process are detailed in the tables below. 'High' priority areas are justified in Table 4-2, while 'Medium' and 'Low' priority areas are shown in Table 4-3. Medium and Low priorities were decided based on the Estimated Cost per Property Mitigated values – a CDA with an estimated cost per property mitigated of less than £25,000 was allocated as 'Medium' and the remaining CDAs were classified as 'Low', on the basis that CDAs with a lower cost ratio were more likely to achieve a favourable cost / benefit ration for future funding opportunities.

Table 4-2 Prioritisation Outcomes – High Priority Justification

CDA ID	Location	High Priority Justification
BRGB	Barton Road / Great Bramingham	• Highest number of potentially flooded properties within a CDA for the study area • Numerous records available to validate predicted flooding • Potential to work in partnership with the EA to deliver a solution • Potential for central government funding based on large number of properties affected
BWPR	Barnfield West Academy / Poynters Road	• High potential for low cost solution to surface water flooding in CDA if integrated with a potential flood alleviation scheme.? • CDA has the fourth highest number of predicted flooded properties in the study area. ? • Predicted flooding is supported by numerous historic

CDA ID	Location	High Priority Justification
		flooding incidences.
CHAST	Chapel Street, Stuart Street	• Predicted flooding affects Luton Town Centre including the Arndale Centre • SWMP modelling assumptions have potentially underestimated capacity in the River Lea in this area - CDA will directly benefit from immediate further study. • CDA has the second highest number of predicted flooded properties in the study area.?
VAUX	Vauxhall Way	• Predicted flooding impacts critical infrastructure – including access to Luton Airport and Luton Airport Parkway Rail Station. • Local knowledge from LBC officers confirms model predictions in several locations • A Thames Water combined sewer overflow structure exists in Kimpton Road. This regularly affects water quality in the River Lea. High potential to work with Thames Water and EA to achieve mutually beneficial solution • CDA has the fifth highest number of predicted flooded properties in the study area

Table 4-3 Prioritisation Outcomes Summary

Priority	CDA	Location	Impact Score	Estimated Cost per Property Mitigated
Medium	DURD	Dunstable Road/Luton Town Football Ground	305	£5,000
Medium	LUHT	Luton High Town	183	£4,000
Medium	WIGP	Wigmore Lane/Eaton Green Road	170	£18,000
Medium	BCBR	Barnfield College, Barnfield Avenue	162	£22,000
Medium	DREE	Dalroad Enterprise Estate	114	£7,000
Medium	UPHP	Upstream of Houghton Park	86	£11,000
Medium	FHILL	Farley Hill	43	£24,000
Low	SPRL	Sundon Park/Railway Line	274	£27,000
Low	BWSRL	Beechwood Primary School/Railway Line	237	£28,000
Low	L6FC	Luton Sixth Form College	34	£29,000
Low	WIND	Windsor Drive	15	£68,000
Low	J11M1	Junction 11 M1	9	£401,000
Low	NPTH	Nimbus Park/The Herculean	4	£856,000

4.4.5 High priority CDAs are discussed in Section 4.5 and medium / low priority CDAs are discussed in Section 4.6

4.5 High Priority CDA Options Assessment

4.5.1 This section discusses the preferred option identified for each high priority CDA based on the measures discussed in Table 4-1. The locations of the capital works shown in the figures are indicative only. It is strongly recommended that a feasibility assessment is carried out at each CDA prior to the commencement of any capital works.

4.5.2 Option appraisal assessments were undertaken on a range of options for each CDA before the preferred option was chosen. This process was fully documented and details can be found within **Error! Reference source not found.**.

Barton Road / Great Bramingham CDA (BRGB)

Discussions with LBC officers and model results confirm that this CDA has the potential to impact numerous residential dwellings and commercial premises. Furthermore, the planned North Luton Strategic Specific Site Allocation (SSSA) urban extension provides an excellent opportunity to mitigate flood risk in this area. The potential capital solutions for flood mitigation in this CDA include:

- Flood storage areas to the north
- Opening up the culverted section of Catbrook through the playing field area beside Catbrook Road
- Property level protection for buildings remaining within the floodplain (approx. 200 houses – including flood warning system)
- SUDs installed throughout the CDA (assumed to be permeable paving of road surfaces to determine an approximate construction cost)

An approximate high level cost estimate is shown in Table 4-4. Potential partners for funding of works in this CDA include the Environment Agency (Catbrook is defined as 'Main River') and potential future North Luton SSSA developers. In addition, as noted during the options review meeting on 27 June 2011, a scheme in this area may attract Flood Defence Grant in Aid (FDGiA) funding from EA / Defra as it affects a significant number of properties and has some easily identifiable co-funding opportunities.

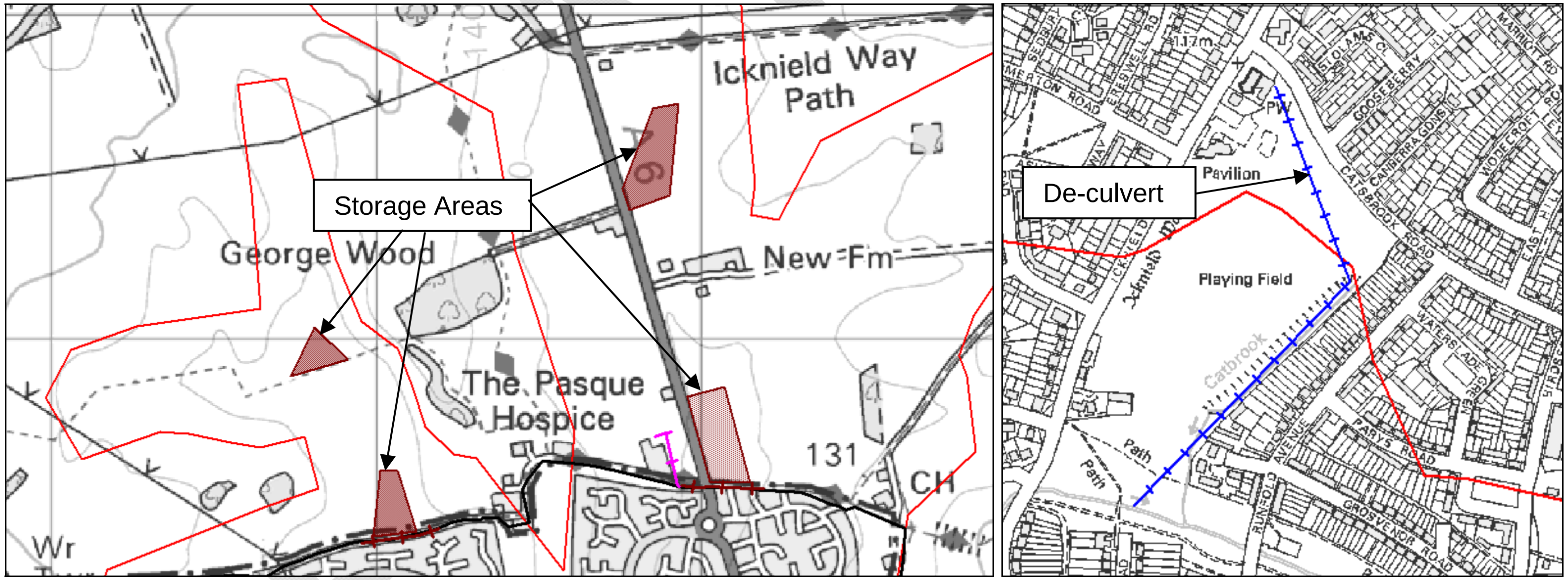


Figure 4-2: BGRB – Indicative Locations for Flood Mitigation Solutions

Table 4-4 High Level Cost Estimate – BRGB

Description	Approximate Capital Cost
De-culvert Catsbrook in playing fields	£468,000
Create dry storage areas	£1,540,000
Implement de-mountable individual property defences and warning system (any flood depth below 600mm)	£5,000,000
General SuDS throughout CDA (permeable paving selected as it can be used in road areas)	£88,000
TOTAL	£7,096,000

Due to the highlighted potential for this CDA to attract FDGiA funding, a preliminary cost benefit analysis was undertaken for the proposed flood mitigation solutions. The methodology applied for this analysis is a simplified method using a flood damage calculation adapted from the industry standard 'Multi-Coloured Manual' *(The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques – 2010 Edition)*. A summary of the simplified method, key assumptions and results are shown in Table 4-5.

The analysis shows a net overall present value loss of approximately £500,000 for scheme implementation and a benefit / cost ratio of 0.94. These metrics indicated that, in the most basic sense, overall capital costs could be reduced to achieve a financially beneficial scheme. Similarly, if additional benefits could also be achieved, then this could also tip the balance of the metrics to demonstrate a viable overall scheme. A combination of actions to reduce cost and improve benefit is the best course to deliver a scheme in this CDA – the following recommendations are made to achieve these goals:

- Detailed feasibility study:
    - Asset investigations (e.g. inspection / CCTV of existing infrastructure to confirm condition, size and connectivity)
    - Integrated modelling of the CDA (i.e. addition of below ground pipe systems to the model)
    - Conceptual level sizing of storage areas and open channels
    - Initial underground service investigations (obtain and review relevant service plans)
- Initial consultation:
    - Discussions with residents to confirm flooding history
    - Discussions with LBC Parks team
    - Discussions with EA to review potential impacts on River Lea flooding (especially around Riverside Road and Mallard Gardens to the south) and determine potential for FDGiA funding.

Table 4-5 Preliminary Cost / Benefit Analysis Summary

Step	Description	Assumptions	Results
1	Calculate potential damages caused by flooding in the CDA for a selection of rainfall events with no mitigation solutions installed (baseline scenario). Damages incurred are determined using flood depth related costs detailed in the Multi-Coloured Manual. Damages are calculated for the following rainfall events: • 1 in 30yr (3.33% AEP) • 1 in 75yr (1.33% AEP) • 1 in 100yr (1% AEP) • 1 in 100yr plus climate change	• Damages are only calculated for residential properties where the average modelled flood depth within the building footprint is greater than 30mm (i.e. flood water has accumulated within the building) • No damages are calculated for non-residential buildings (residential buildings make up 98% of the potentially flooded buildings in the CDA) • 1 in 200yr event is not considered as the 1 in 100yr plus climate change event causes the largest flood extent in the CDA. • Only direct flooding damages are considered – no indirect costs related to emergency services or re-housing of residents are considered.	Potential damages for each modelled rainfall event for BASELINE scenario: • 1 in 30yr = £23,190,000 • 1 in 75yr = £28,770,000 • 1 in 100yr = £29,820,000 • 1 in 100yr plus climate change = £34,620,000
2	Create a model with all proposed mitigation solutions installed (options scenario) and repeat Step 1 with the results to determine the total potential damages for each rainfall event.	• Refer above	Potential damages for each modelled rainfall event for OPTIONS scenario: • 1 in 30yr = £19,020,000 • 1 in 75yr = £21,100,000 • 1 in 100yr = £22,000,000 • 1 in 100yr plus climate change = £24,840,000
3	Determine the ‘average annual damage’ of the two scenarios within the CDA by multiplying the potential value of damage caused by each rainfall event by it’s probability	• The maximum potential damage caused by flooding in the CDA is equal to the 1 in 100yr plus climate change rainfall event.	• BASELINE Scenario = £1,120,000 / yr • OPTIONS Scenario = £860,000 / yr
4	Calculate the potential total damage caused by flooding over the lifetime of the flood mitigation solutions proposed using a discount	• Discount rate of 3.5% based on Defra Guidance (A social time preference rate for use in long term discounting –	• BASELINE Scenario = £33,360,000 • OPTIONS Scenario = £25,710,000

Step	Description	Assumptions	Results
	rate to determine the 2011 equivalent value (both scenarios)	2002) • Lifetime of mitigation solution is 100 years	
5	Calculate the potential lifetime cost of the flood mitigation solution over the same time period as Step 4. This begins with the initial construction cost, then ongoing maintenance for the lifetime of each asset created.	• Construction cost is as shown in Table 4-5. • Ongoing maintenance equals 1% of initial construction cost. • No cost is incurred to 'dispose' of the asset at the end of its life.	• Present Value of Mitigation Solution = £8,150,000 (2011 equivalent)
6	Determine the difference between the damages incurred for the BASELINE (Step 4) and OPTIONS (Step 4) scenarios – this is the potential value of 'monetary benefit' for constructing the flood mitigation scheme	• None	• (BASELINE damages) less (OPTIONS damages) = £7,650,000
7	Divide the potential benefit value (Step 6) by the lifetime cost of the mitigation scheme (Step 5) to obtain an approximate Benefit / Cost Ratio	• None	• Potential Benefit Value = **-£500,000** • Benefit / Cost Ratio = **0.94**

Chapel Street / Arndale Centre CDA (CHAST)

Modelled flood extents in this area generally align with LBC officer experiences of flooding around the Luton town centre. However, as noted by the EA during the options review meeting, predicted flood extents adjacent to the River Lea are possibly overestimated. EA modelling of the River Lea in this area shows that the capacity of the culvert system through the town centre area is sufficient to convey the 100year return period fluvial flows.

A significant aspect of risk in this area is the condition of the culverts conveying the River Lea through the town centre area. The EA have noted that the condition is extremely poor in several locations. Exacerbating this risk is the fact that large sections of the culvert are under individual property riparian ownership. As a result of this, structural repairs are unlikely to be undertaken unless a significant failure occurs. A structural failure of the 4.8m wide by 2.3m high box culvert would have a significant impact on the town centre even in non-flood conditions.

The combination of the above two factors demonstrates that flood risk within the town centre needs to be carefully monitored by LBC and the EA. While the surface water flood modelling may be a conservative representation, it does provide a good indication of the potential impact of a structural failure in the River Lea culvert during heavy rainfall conditions.

The potential capital solutions for flood mitigation in this CDA include:

- Installation of a new culvert from the corner of Chapel Street and George Street to Manor Road Park (refer Figure 4-3 for indicative location)
- Property level protection and flood warning system for buildings remaining within the floodplain (including properties around Manor Road Park)

An approximate high level cost estimate is shown in Table 4-6. Due to substantial capital cost, SWMP model uncertainty and significance of decisions made for this area of Luton, it is justifiable to undertake further investigation work before selecting a preferred mitigation solution for this area. Furthermore, review of the pipe system in the area shows that a 1.2m diameter surface water pipe already runs from Dunstable Road, along George Street and into Manor Park. This pipe also serves the southern part of the Dunstable Road CDA (DURD). Assuming some capacity in the River Lea is available in the Telford Way area, there could be an opportunity to divert the DURD portion of the catchment to increase available capacity in the pipeline for the CHAST area. The following actions are proposed for this CDA:

- LBC to work with the EA to proactively manage the risk of the River Lea culvert collapse
- Staged further investigation:
  1. Explicit representation of River Lea in SWMP flood risk model to gain better understanding of flood risk in the town centre.
  2. Detailed integrated modelling if the previous action demonstrates significant flood risk in the town centre to determine:
     - Probable impact of proposed solution on flood level in Manor Park
     - Probable impact of diverting the DURD CDA into the upstream section of the River Lea

Table 4-6 High Level Cost Estimate – CHAST

Description	Approximate Cost
Increasing the conveyance along London Road, Castle Street & Chapel Street	£1,080,000
Property level protection for houses (including warning system)	£1,050,000
New pipeline from George Street into Manor Park (approximately 1.5m diameter pipe)	£2,813,000
Introducing additional gullies along Chapel Street, Castle Street and London Road	£7,000
TOTAL	£4,950,000

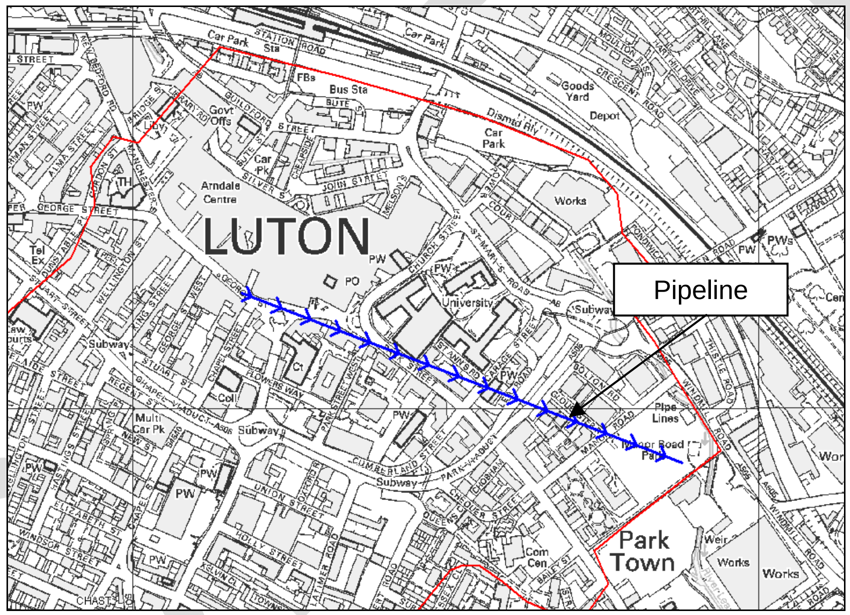


Figure 4-3: CHAST – Indicative Locations for Flood Mitigation Solution

Barnfield West / Poynters Road CDA (BWPR)

Surface water flooding within the CDA has been confirmed by LBC officers to occur in Poynters Road, Leagrave High Street outside Barnfield West Academy and particularly in Pastures Way.

The covers have blown off manholes on the Thames Water-owned surface water sewer near the swimming pool access in Pastures Way on a number of occasions during heavy rainfall events. This is related to the grilles in the sewer outfall headwall often being heavily ragged up. ~~Thames Water therefore have at least a partial responsibility for flooding in the vicinity, and an associated interest in putting things right.~~ In addition the Lewsey Brook watercourse is heavily silted up over the whole reach within Lewsey Park between its source and the culvert under the M1 motorway, significantly reducing its flow capacity.

This is therefore an excellent opportunity to work in partnership to deliver a scheme with multiple benefits.

The potential revenue and capital solutions for flood mitigation in this CDA include:

- Removal of silt from the watercourse to restore flow capacity and provide flood storage capacity in-bank;
- Replacement of the sewer outfall grilles with a low maintenance design that will still allow flow even when ragged up;
- Subsequently, more frequent watercourse and grille maintenance;
- Property level protection for buildings remaining within the floodplain (including a flood warning system).

An approximate high level cost estimate is shown in Table 4-7 *this will need to be revised*.

The key short term actions for LBC would be to carry out restoration works in Lewsey Brook from its source to the culvert under the motorway, and for TWU would be replacement of the SW sewer outfall grilles.

Table 4-7 High Level Cost Estimate – BWPR

Description	Approximate Cost
Watercourse restoration	£40,000
Replacement of SW sewer outfall grilles	£2,000
~~Increasing pipe sizes along Ridgeway Avenue, Goldstone Crescent & Jillifer Road towards Pastures Way~~	~~£2,430,000~~
~~Creation of below ground storage to attenuate runoff into Lewsey Park (Excludes EA FSA scheme cost of approx. ~£1million)~~	~~£44,000~~
~~Property level protection for houses (including flood warning systems)~~	~~£1,150,000~~
~~Localised entry capacity improvements~~	~~£6,000~~
TOTAL	~~£3,677,000~~

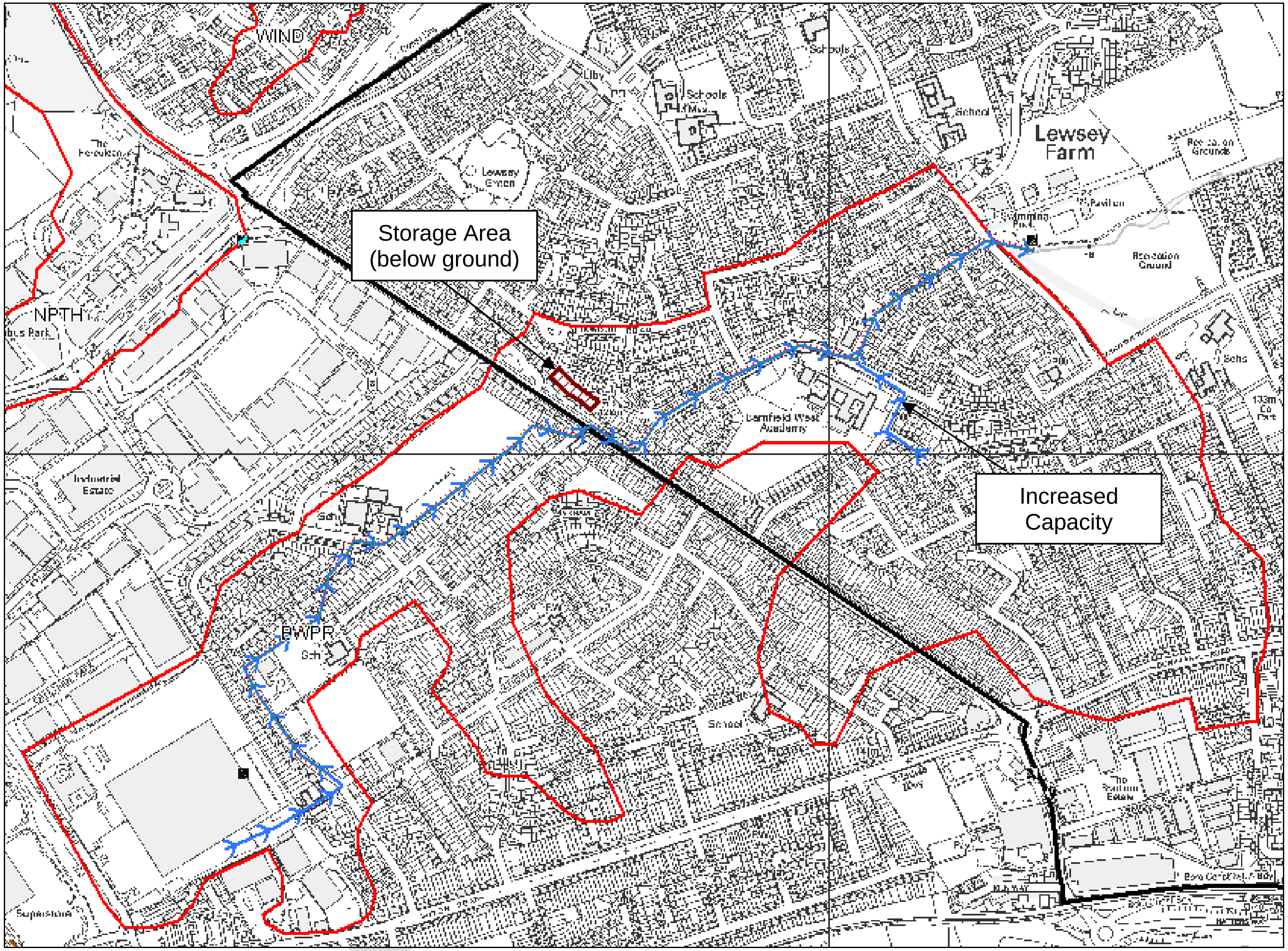


Figure 4-4: BWPR – Indicative Locations for Flood Mitigation Solutions *to be revised*

Vauxhall Way CDA (VAUX)

Review of this CDA shows that predicted surface water flooding does not significantly impact properties until the overland flow concentrates to the south of Crawley Green Road. In the southern part of the CDA, the SWMP model predicts substantial flooding of:

- The General Motors building to the west of Vauxhall Way
- Deep flooding (>0.5m) of Parkway Road (the only access road to Luton Airport Parkway rail station)
- Deep flooding (>0.5m) of Airport Way in the underpass adjacent to the airport entrance (the main public entry to the airport)

Discussions with Thames Water have shown that a large combined sewer overflow (CSO) structure exists near the corner of Kimpton Road and Vauxhall Road. The CSO discharges into a surface water sewer that runs to the east along Kimpton Road then to the south under Airport Way and directly to Luton Hoo Park via a 1.5m diameter pipeline. The EA noted that this CSO has previously caused some water quality issues in the River Lea near to the discharge point. The River Lea is currently failing to meet the strict water quality targets required by the EU Water Framework Directive and the CSO is a known contributor. Drainage from Luton Airport, including some de-icing runoff, can also affect water quality in the river.

LBC discussions with General Motors have shown that no known existing flood issues exist on their site. The predicted flood extents and depths in this area may be conservative as they do not take account of the available drainage capacity – however, their significant extent and depth should not be ignored even though anecdotal evidence does not confirm the issue. Potential capital solutions for this predicted area of flooding are summarised below.

Luton Airport has advised that flooding has previously been experienced in the Airport Way underpass and a substantial drainage system has been installed to mitigate this. Parkway Road and the adjacent vacant lot have not been observed to flood significantly in recent memory. However, it should be noted that Parkway Road was only constructed recently and may not have experienced significant flooding to date.

The potential capital solutions for flood mitigation in this CDA include:

- Flood storage areas along Vauxhall Way adjacent to Eaton Valley Road
- Property level protection for General Motors buildings (including a flood warning system)
- Increased conveyance from Airport Way underpass
- Creation of a storage area or wetland in the vacant lot adjacent to Parkway Road and associated pipe work to route excess flow under Parkway Road and the A505 into the River Lea

An approximate high level cost estimate is shown in Table 4-8. The flood storage areas along Vauxhall Way and at Eaton Valley Road and property level protection could be funded by General Motors as they are the direct beneficiaries of the flood mitigation. Partial funding of the Parkway Road storage area and associated works by General Motors may also be feasible if it can be clearly demonstrated that they receive some benefit. If a wetland were installed at Parkway Road, then some of the flow from Thames Water CSO could be diverted here for preliminary treatment before being discharged into the River Lea. Both the EA and Thames Water benefit from this solution and would therefore likely be able to provide some funding. Given the low level of validation of flooding in this area, the following actions are proposed:

- LBC to maintain regular contact with General Motors/IBC and Luton Airport to ensure any future flooding is recorded appropriately and fully assessed.
- Create a detailed integrated model of the CDA to confirm flood predictions and for use as a tool to work with Thames Water and the EA to mitigate water quality issues in the area.

Table 4-8 High Level Cost Estimate – VAUX

Description	Approximate Cost
Increase pipe conveyance at southern end of CDA	£810,000
Series of above ground storages along Vauxhall Way	£198,000
Above ground storage around Parkway Road	£330,000
Implement flood gates for the industrial yard near Vauxhall Way (including a flood warning system for the CDA)	£700,000
SUDs integrated with other options (including downpipe disconnection in combined areas)	£440,000
Increase inlet capacity	£8,000
TOTAL	£2,486,000

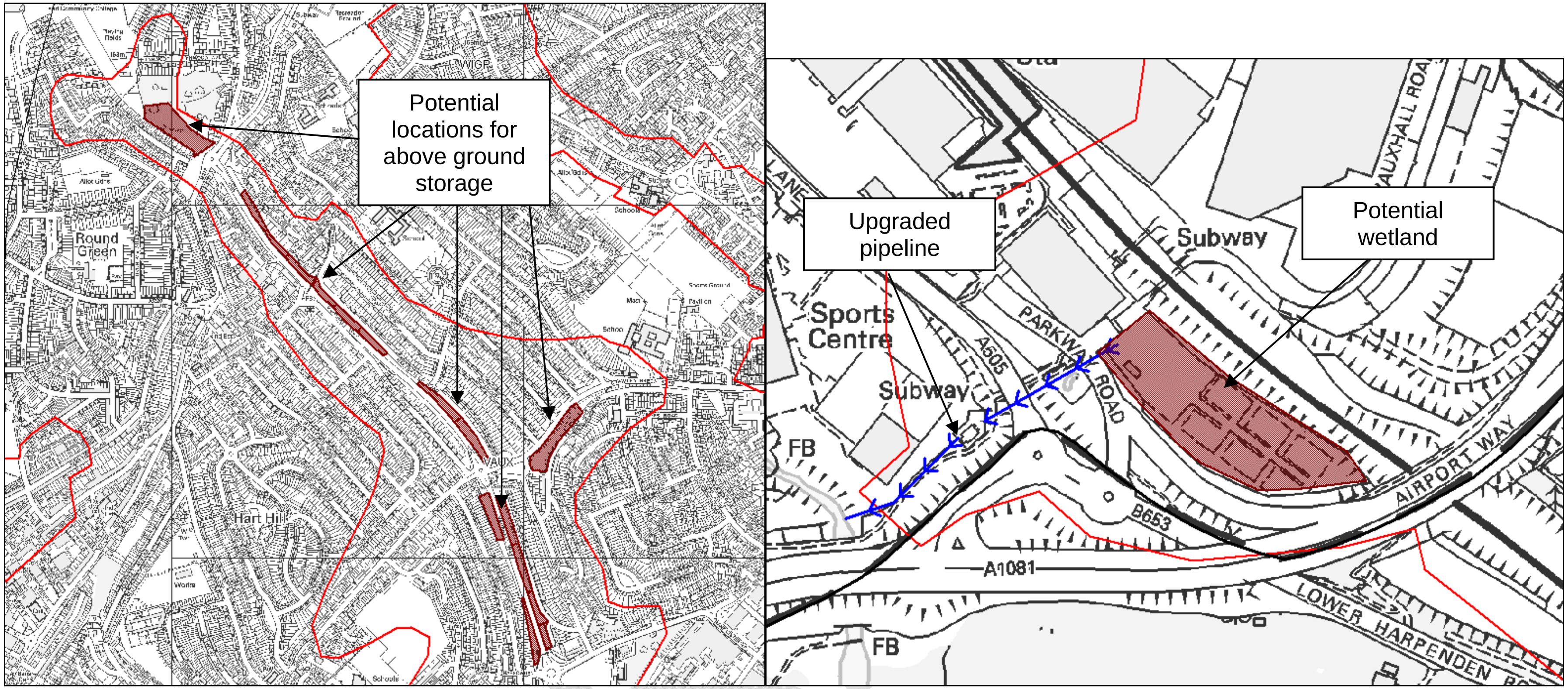


Figure 4-5: VAUX – Indicative Locations for Flood Mitigation Solutions

4.6 Medium / Low Priority CDAs

4.6.1 The table below summarises the preferred options for each of the low / medium priority CDAs. Actions are also proposed for each based upon the level of confidence associated with the SWMP model predictions.

4.6.2 Where flooding has been validated by anecdotal evidence supplied by LBC, Bedfordshire Fire Brigade or other stakeholders then specific CDA based actions are proposed. However, where predicted flood extents or issues have not been validated by this type of evidence, a monitoring approach is proposed to collect more information in the future, prior to further investigation of possible solutions.

4.6.3 Detailed documentation showing CDA maps and justifications for each of the preferred solutions summarised below are included in Appendix C.

Table 4-9 Low / Medium Priority CDA Option Summary

Priority Rating	ID	Location	Preferred Option Description	Approximate Capital Cost	Proposed Action
Medium	BCBR	Barnfield College, Barnfield Avenue	Construct new surface water sewers around Cromer Way, The Magpies and Rookery Drive; Create a dry storage area by bunding along Cromer Way; Below ground storage at the upstream end of Old Bedford Road; Property level flood protection	£1,500,000	Initiate public consultation to confirm scope of problem and probable level of acceptance of proposed solution
Low	BWSRL	Beechwood Primary School/Railway Line	Increasing pipe capacity around Linden Road & Mostyn Road; Below ground storage near Beechwood Primary School; Introducing individual property protection; Additional gullies along Linden Road and Mostyn Road.	£3,800,000	No anecdotal validation of issues predicted in this area - monitor area for future problems
Medium	DREE	Dalroad Enterprise Estate	Below ground storage near Connaught Road and Dunraven Avenue; Introduce property level protection; Additional gullies along Kingsway.	£500,000	Initiate public consultation to confirm scope of problem and probable level of acceptance of proposed solution
Medium	DURD	Dunstable Road/Luton Town Football Ground	Below ground storage around Selbourne Road; Implementing flood gates; Additional gullies on Dunstable Road.	£1,100,000	Review connectivity with CHAST after further investigation completed.

Priority Rating	ID	Location	Preferred Option Description	Approximate Capital Cost	Proposed Action
Medium	FHILL	Farley Hill	Increasing pipe diameter; Implement individual property protection; Improve the existing flood storage near B4540/Newlands Road and also create new flood storage north west of Lawn Cottage	£900,000	Monitor CDA for future development and ensure appropriate mitigation measures are implemented.
Low	J11M1	Junction 11 M1	Flood storages; implementing individual protection for the properties near Derby Road, green roof for the Challney School; Inclusion of SuDS and related education programme for Challney School; additional gullies for the M1 within the CDA	£2,800,000	No anecdotal validation of issues predicted in this area - monitor area for future problems
Low	L6FC	Luton Sixth Form College	Introducing pipes around Foxhill Road & increase pipe size around Avebury Avenue and Stratton Gardens. Above ground storages along flow route; Introducing flood gates and SuDS for remaining flooded properties.	£900,000	Initiate public consultation to confirm scope of problem and probable level of acceptance of proposed solution
Medium	LUHT	Luton High Town	Introducing individual property protection; Localised inlet capacity improvement.	£400,000	No anecdotal validation of issues predicted in this area - monitor area for future problems
Low	NPTH	Nimbus Park/The Herculean	Flood attenuation pond and preferential overland flows near the Houghton Brook. Permeable paving around the Herculean Buildings; Temporary/ demountable defences; Green roof areas in business parks.	£1,700,000	No anecdotal validation of issues predicted in this area - monitor area for future problems
Low	SPRL	Sundon Park/Railway Line	Above ground storage at the upstream end of Camford Way and creating a bund along this road; Implementing individual property protection; Green roofs for the Industrial Estate buildings.	£4,600,000	No anecdotal validation of issues predicted in this area - monitor area for future problems
Medium	UPHP	Upstream of Houghton Park	Introducing new pipes near Kent Road/Sundon Road; Improve the overland drainage channel between the College and Houghton Park Road; Introduce individual property protection;	£600,000	No anecdotal validation of issues predicted in this area - monitor area for future problems

Priority Rating	ID	Location	Preferred Option Description	Approximate Capital Cost	Proposed Action
Medium	WIGP	Wigmore Lane/Eaton Green Road	Increase pipe sizes in the local road network; Increase size of existing balancing ponds; protect at risk houses	£2,300,000	Initiate public consultation to confirm scope of problem and probable level of acceptance of proposed solution
Low	WIND	Windsor Drive	Introduce new surface water sewers around Tudor Drive; Individual property protection	£600,000	No anecdotal validation of issues predicted in this area - monitor area for future problems

4.7 Proposed Surface Water Drainage Policy

LBC Wide Policy

4.7.1 Although the CDAs define 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 LBC implement policies that i) will reduce the risk from surface water flooding throughout the whole borough, that ii) CBC also implement similar policies, particularly for that part of their administrative area that contributes surface water flow to the Luton catchment, and that iii) both authorities promote and apply Best Management Practises (BMP) to the implementation of SuDS and the reduction of runoff volumes.

4.7.2 The SWMP Action Plan (discussed in Section 5), which is a major output of this project, recommends that the following policies are implemented within the boundaries of the catchment to reduce the flood risk therein:

Policy 1*: All developments across the catchment (excluding minor house extensions less than 250m^2) which relate to a net increase in impermeable area are to include at least one 'at source' SuDS measure (e.g. water butt, rainwater harvesting tank, bioretention planter box, etc). This is to assist in reducing the peak volume of runoff discharging from the site.*

Policy 2*: Proposed 'brownfield' redevelopments of more than one property or of an area greater than 0.1 hectare are required to reduce post-development runoff rates to 50% of the existing site conditions for events up to and including the 1 in 100 year return period event plus climate change (in line with PPS25 and UKCIP guidance). If this results in a discharge rate lower than the Greenfield conditions it is recommended that the Greenfield rate (calculated in accordance with IoH124[2]) is used.*

Policy 3: *Developments located in CDAs and for redevelopments of more than one property or of an area greater than 0.1 hectare are required to reduce runoff to that of a pre-development Greenfield runoff rate (calculated in accordance with IoH124). It is recommended that a SuDS treatment train is utilised to assist in this reduction.*

4.7.3 The Councils may also wish to consider the inclusion of the following policy to manage the pollutant loads generated from proposed development applications:

Policy 4: *Best Management Practices are required to be demonstrated for development applications greater than 0.1 hectare within the catchment. Developers should aim to achieve the following load-reduction targets when assessing the SuDS treatment train for the post-developed sites (comparison of unmitigated developed scenario versus developed mitigated scenario):*

[2] Defra/Environment Agency, September 2005, Flood and Coastal Defence R&D Programme: Preliminary Rainfall Runoff Management for Developments (R&D Technical Report W5-074/A/TR/1 Revision D)

- 80% reduction in Total Suspended Sediment (TSS);

- 45% reduction in Total Nitrogen (TN);

- 60% reduction in Total Phosphorus (TP); and

- 90% reduction in litter (sized 5mm or greater). not sure how this could be implemented and monitored

4.7.4 The Councils may also wish to consider specific policy relating to site-based flood risk assessments for surface water that is similar to the current practice of the EA for fluvial flood risk. The flood risk maps produced as part of the SWMP can be used to trigger the need for a Flood Risk Assessment under the National Planning Policy Framework and the related Technical Guidance. The level of assessment required could be implemented in a similar fashion to the EA Flood Zones:

- 100yr Surface Water Flood Depth >0.5m = Assessment similar to EA Flood Zone 3
- 100yr Surface Water Flood Depth between 0.1 and 0.5m = Assessment similar to EA Flood Zone 2

4.7.5 Implementation of this policy is beyond the scope of this SWMP document and an action has been included in the Action Plan for LBC to undertake internal consultation with their and CBC's planning staff to determine how this type of policy could be implemented.

Policy Areas

4.7.6 This section provides an outline of planning policy tailored to specific areas within the study area that can be implemented to manage surface water flood risk. The purpose of this type of policy is to address the non-point source flooding that occurs in:

- Parts of CDAs that are not specifically addressed by a capital works solution
- Areas not defined as CDAs

4.7.7 The purpose of Policy Areas (PAs) is twofold. Firstly to give the Councils a clear framework to manage ongoing re-development within existing urban areas, and secondly to influence development in rural areas outside the Luton Borough boundary that has the potential to impact local flood risk in the catchment. PAs have been defined for the SWMP study area and are shown in Figure 4-6.

4.7.8 The PAs within the LBC boundary have been defined based on geological suitability to accommodate Sustainable Urban Drainage Systems (SuDS) and on groundwater source protection zones. Both of these factors influence the type of SuDS that can be implemented to manage property-level surface water runoff. The two main types of SuDS are i) infiltration based and ii) storage based. Infiltration base SuDS are generally limited to areas with good soil permeability and away from areas that are used for groundwater abstraction (infiltration type SuDS can introduce groundwater contamination in certain situations).

4.7.9 This method provides the opportunity to integrate the concept of Urban Blue Corridors (Defra Scoping Study FD2619 – 2011) in the planning process. The development and delivery of Urban Blue Corridors offers the potential for the delivery of multiple social, environmental and economic benefits from multifunctional land use, and the opportunity to deliver climate change resilient development, and this concept fits very well with the SuDS ethos.

4.7.10 PAs have also been defined outside of the LBC boundary. These generally extend from the LBC boundary out to the study area extent. The study area extent is the overall hydrological catchment potentially contributing to surface water flooding in Luton, with the exception of the Houghton Regis green fields area. These PAs have been defined to give the Council's guidance on how they could respond to development in these areas. A summary of the PAs is provided in Table 4-10 along with an indication of the policy that could be pursued in each PA.

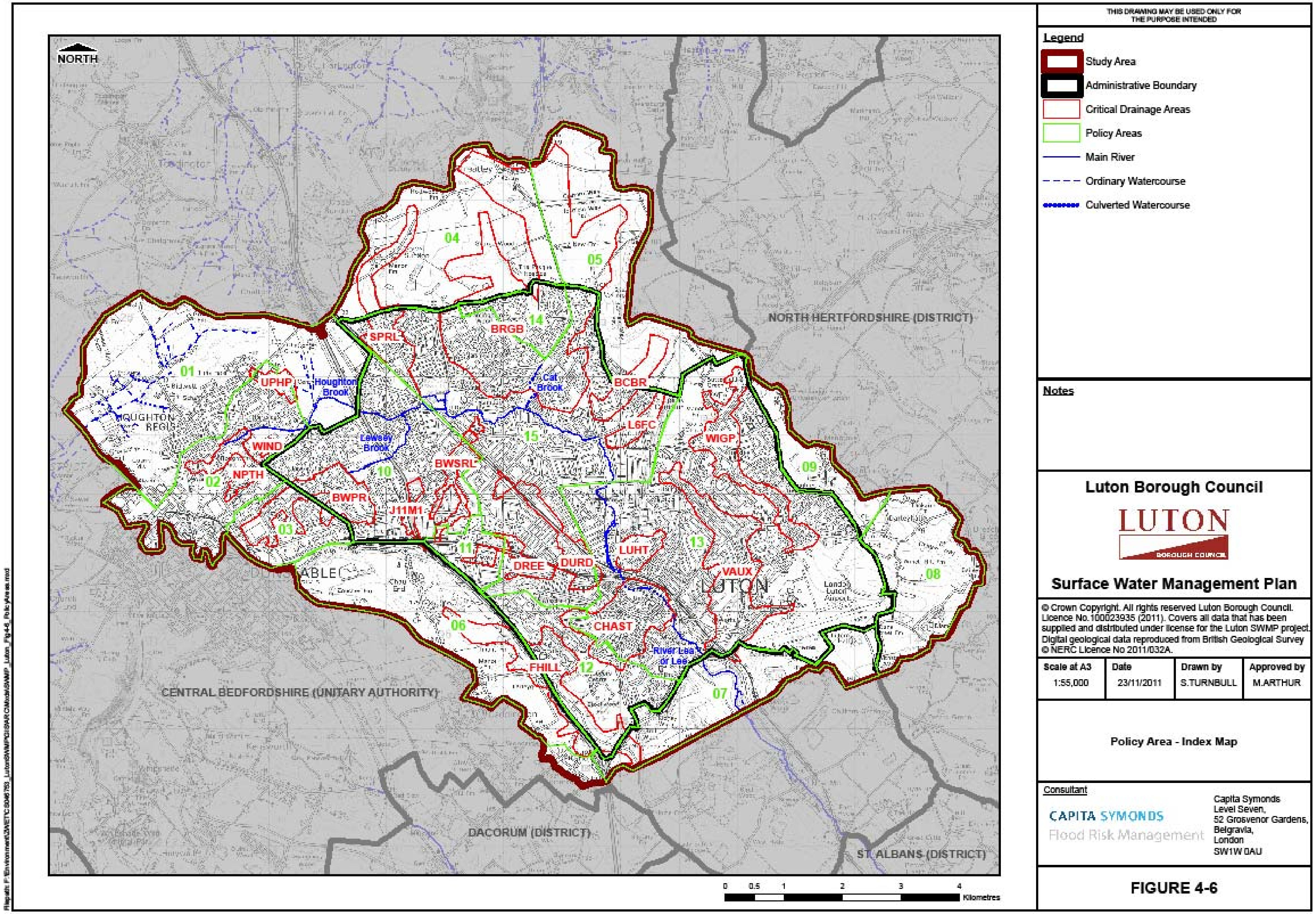
4.7.11 As with the borough-wide policy, it is recommended that LBC officers involved with the SWMP discuss this proposal with the LBC planning team to obtain initial feedback on the concept. Discussion should focus on how this type of policy can be integrated into current documents and procedures. LBC should also consider how they plan to accommodate the SuDS Approval Body (SAB) role as required by the FWMA 2010 in future. Implementation of this type of policy is closely linked to this new role for LLFA.

Table 4-10 Policy Summary

Policy Area ID	Policy Summary
1	Influence planned development to manage existing flood risk and ensure risk to LBC is not increased .
2	Influence ongoing developments in the area to implement SuDS
3	Influence ongoing developments in the area to implement SuDS
4	Influence planned development to manage existing flood risk and ensure risk to LBC is not increased .
5	Influence any future development to minimise runoff towards Luton BC
6	Influence any future development to minimise runoff towards Luton BC through use of non-infiltration based SuDS
7	Actively monitor development to ensure downstream constraints are not introduced
8	Influence planned development to manage existing flood risk and ensure risk to LBC is not increased .

9	Influence any future development to minimise runoff towards Luton BC
10	Manage ongoing site by site development in the area to implement SuDS and minimise runoff
11	Manage ongoing site by site developments in the area to implement non-infiltration based SuDS
12	Manage ongoing developments in the area to implement SuDS on a site-by-site basis (Practicality of infiltration based SuDS uncertain – individual site investigations needed)
13	Manage ongoing developments in the area to implement SuDS on a site-by-site basis (Practicality of infiltration based SuDS is uncertain – individual site investigations needed. Area is a groundwater source protection zone)
14	Manage ongoing developments in the area to implement SuDS on a site-by-site basis (Practicality of infiltration based SuDS is uncertain – individual site investigations needed)
15	Manage ongoing developments in the area to implement SuDS

Figure 4-6: Policy Area Index Map



5 Phase 4: Implementation and Review

5.1 Action Plan

5.1.1 The Action Plan is presented in Appendix G as a simple summary spread-sheet 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 LBC, as actions are progressed and investigated.

5.1.2 It should be understood that following further detailed investigation the preferred option in each CDA, and even in some cases the need for any action other than basic investigation in a particular CDA may be discounted. Likewise new actions may be identified by LBC, or may be required by changing legislation and guidance over time.

5.1.3 The Action Plan identifies:

- *Legislative actions* required to satisfy the FWMA 2010 and FRR requirements - (these are common to all LLFAs);
- *General flood risk management actions* to integrate outcomes and new information from this study into the practices of other LBC services and external partner organisations;
- *Policy actions* to assist LBC and CBC manage future developments in the context of local flood risk management;
- *Maintenance actions* to prompt review of current schedules in the context of new information presented in this study;
- *General CDA actions* to be implemented across all CDAs identified within this study;
- *High priority CDA actions* to be implemented to better understand flood risk in specific areas and proactively manage operational risks; and
- *Underpass risk assessment* actions to highlight at-risk pedestrian underpasses and understand the potential risk associated with each.

5.2 Review Timeframe and Responsibilities

5.2.1 Proposed actions have been classified into the following categories:

- Short term: Actions to be undertaken within the next year.
- Medium term: Actions to be undertaken between one and five years.
- Long term: Actions to be undertaken beyond five years.

5.2.2 The Action Plan identifies the relevant internal departments and external partnerships that should be consulted and asked to participate when addressing an action. After an action has been completed, it is recommended that the responsible department should review the Action Plan and update it to reflect any issues (communication or stakeholder participation) that arose during completion of an action and whether or not additional actions are required.

5.2.3 In order to capture the works undertaken by LBC, its partners and other stakeholders, and to reflect any other necessary amendments, it is recommended that the Action Plan should be reviewed on a not greater than annual basis and preferably on a no more than quarterly basis. Examples of things which might 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 is different to the preferred option, 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.

5.2.4 For clarity, it is noted that the FWMA 2010 places immediate or imminent new responsibilities on LLFAs. The main actions required are contained in the Action Plan but are also summarised below:

- Develop, maintain, apply and monitor a Strategy for local flood risk management of the area.
- Duty to maintain a local flood risk asset register.
- Investigate flood incidents and record in a consistent manner.
- Establish a SuDS Approval Body (SAB).
- Contribute towards achievement of sustainable development.
- On-going responsibility to co-operate with other authorities through sharing of data and expertise.
- Preparation of Local Flood Risk Management Strategies

5.3 Ongoing Monitoring

5.3.1 It is intended that the partnership arrangements established as part of the SWMP process, the Luton Flood Management Group, will continue beyond the completion of the SWMP in order to i) discuss, guide and monitor implementation of the proposed actions, ii) review opportunities for operational efficiency and iii) review and implement any legislative changes.

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

5.4 Incorporating new datasets

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

- Identify new dataset.
- Save new dataset/information.
- Record new information in a log so that the next Action Plan review can incorporate this information.

5.5 Updating SWMP Reports and Figures

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

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

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

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Appendix A Data Review

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Appendix B Risk Assessment: Technical Details

Introduction

Capita Symonds constructed two hydraulic models to represent the study area using TUFLOW (Two Dimensional Unsteady Flow) software (www.tuflow.com – an industry standard hydraulic modelling package for pluvial flooding). Two models of the area were needed to optimise overall model run times and data processing.

The extents of the two models have been based upon catchment boundaries to limit the amount of cross-boundary interaction between the two models. This was carried out to limit the dependency of one model on the results of other. Figure B1 shows the extent of the study area models and Table B1 shows the naming convention applied during the modelling process. Abbreviations used and conventions applied are:

LTN - Luton;
US – Upstream;
DS – Downstream;
100YR – Rainfall event probability
031 / 037 – Version numbers.

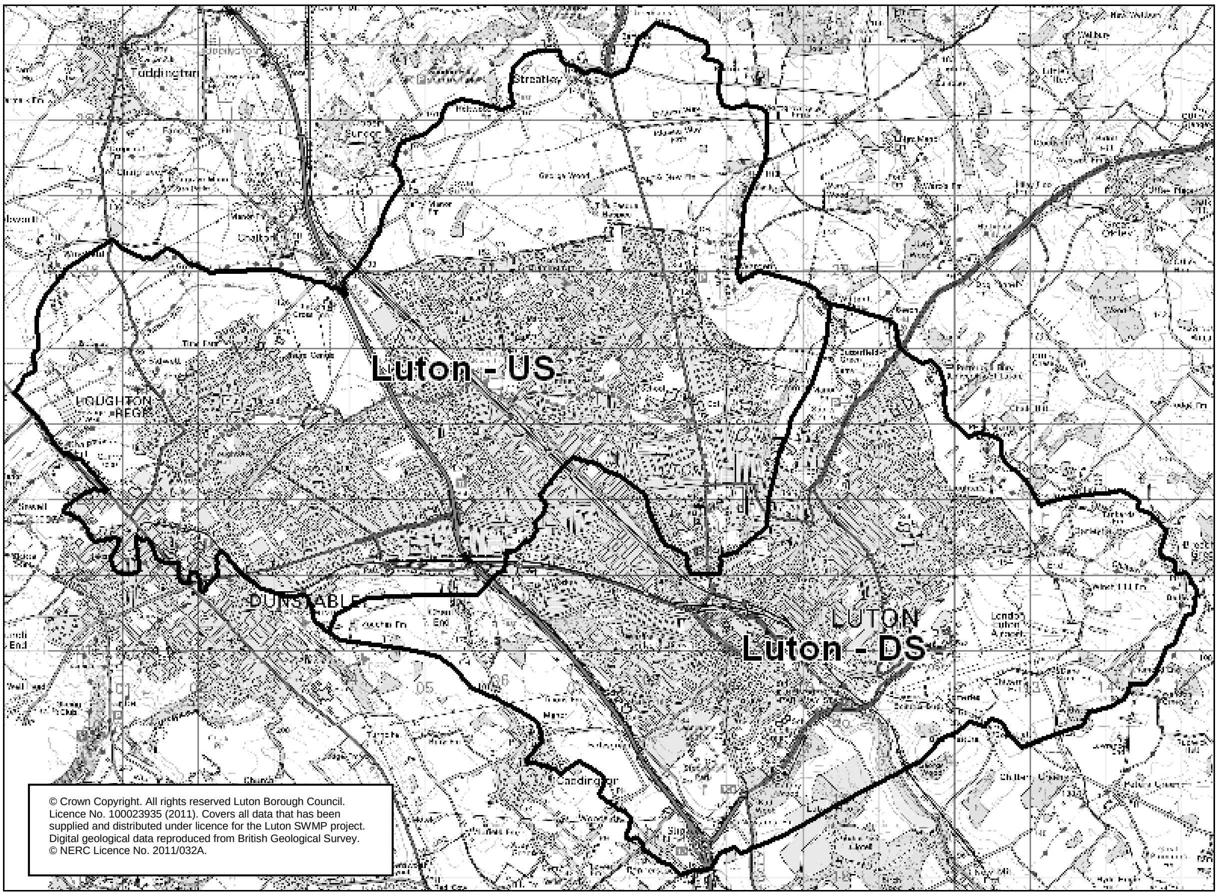

Figure B1: Model Coverage

Model Name	Naming Convention (100 year Flood Event example)
LTN_US	LTN_US_100R_031
LTN_DS	LTN_DS_100R_037

Table B1: Model Naming Convention

Software Version

All models have been run using TUFLOW build 2010-10-AA-iDP software. All models were run on the 64bit version of this build to take advantage of the faster simulation times and more advanced handling of larger models.

Direct Rainfall Methodology

The purpose of this modelling task is to analyse the impact of significant rainfall events across the study area by assessing flow paths, velocities and catchment response. This method essentially consists of building a virtual representation of the ground topography, then applying water to the surface and using a computational algorithm to determine the direction, depth and velocity of the resulting flows. Further explanation of this industry standard method is available in the Defra SWMP Guidance – Annexes C and D.

Key Assumptions

This method incorporates conservative allowances for the drainage network and infiltration. The following key assumptions were made to generate the model input:
Initial Loss – None
Infiltration Loss – None
Allowance for Drainage System – A constant value of 6.5mm/hr was applied
No areal reduction factor applied
'Summer' rainfall profile was used

Runoff Coefficients and Continuous Losses

Runoff Coefficients and continuous losses have been applied to the rainfall profiles as per the table below.

Feature Code	Descriptive Group	Comment	Runoff Coefficients	Drainage - Continuous Loss (mm/hr)
10021	Building		0.9	6.5
10053	General Surface	Residential yards	0.5	6.5
10054	General Surface	Step	0.8	6.5
10056	General Surface	Grass, parkland	0.35	0
10062	Building	Glasshouse	0.95	6.5

Feature Code	Descriptive Group	Comment	Runoff Coefficients	Drainage - Continuous Loss (mm/hr)
10076	Land; Heritage And Antiquities		0.85	6.5
10089	Water	Inland	1	0
10111	Natural Environment (Coniferous/Non-coniferous Trees)	Heavy woodland and forest	0.2	0
10119	Roads Tracks And Paths	manmade	0.85	6.5
10123	Roads Tracks And Paths	tarmac or dirt tracks	0.75	6.5
10167	Rail		0.35	6.5
10172	Roads Tracks And Paths	Tarmac	0.85	6.5
10183	Roads Tracks And Paths (roadside)	Pavement	0.85	6.5
10185	Structures	Roadside structure	0.9	6.5
10187	Structures	Generally on top of buildings	0.9	6.5
10203	Water	foreshore	1	0
10210	Water	tidal water	1	0
10217	Land (unclassified)	Industrial Yards, Car parks	0.85	6.5

Table B2: Runoff Coefficients and Losses

Hydrology – Rainfall Events

Rainfall inputs were generated at a standard 10km grid square resolution. Hyetographs for the following rainfall events were generated:

1 in 30 year
1 in 75 year
1 in 100 year
1 in 100 year plus climate change (+30%)
1 in 200 year

Total rainfall depths at each 10km grid centroid for all required return periods were extracted from the FEH CD-ROM (v3) Depth Duration Frequency (DDF) model. A comparison between the peak rainfall depths in adjacent 10km grid squares was completed to confirm the suitability of the 10km grid resolution for modelling purposes. The difference in total rainfall depths between the grid centroids for 10km grid squares was approximately 2%. This suggests that the 10km grid data is suitable for use in the study as a finer grid would have a minimal effect on the hyetographs. It was decided to extract the rainfall from a point at NGR OSGR

505000 225000. The location of this point is in the north west of the catchment and was considered to be representative of the whole catchment.

Hydrology – Critical Duration

Critical duration is a complex issue when modelling large areas for surface water flood risk. The critical duration can change rapidly even within a small area, due to the topography, land use, size of the upstream catchment and nature of the drainage systems. The ideal approach would be to model a wide range of durations. However this is not always practical or economic when modelling large areas using 2D models which have long simulation times, such as within this study

An investigation was undertaken to understand the effect of rainfall event duration on the study area. The intention of the investigation was to show variation in critical duration across the study area and thus identify whether it was possible to identify a single critical duration for the model.

The standard FEH equation which approximates the critical duration provides a useful starting point for the determination of the critical storm duration. The Time to Concentration (tc) was also used to assess the critical duration and provide a range of durations that should be tested.

The critical storm duration derived from tc was 2.1hrs and the FEH Duration was 6hrs. Therefore based on the duration results and previous experiences on catchments of a similar size, it was decided to run the model with the following durations--1hr, 2hr, 3hr, and 6hr for the 200 year return period event using the summer profile. The results were used to assess the change in rainfall depths across the study area.

The 1 hour storm duration model depth results were generally lower when compared to the depths of longer durations. In areas of lower ground elevations the depth differences ranged from 0.25m to 0.75m. Therefore, the 1hr storm duration was considered to be too short.

There were no significant depth differences noted when the 2hr and 3hr duration events were compared. For the 6 hour storm duration, modelled depths were deeper along the path of the River Lea. This is a logical outcome as this is what would be expected during a longer 'fluvial' type rainfall event. The differences along the River Lea are of no significant consequence for the surface water flooding investigation as significant fluvial flooding is predicted to occur in these locations already. The differences between the 2hr, 3hr and 6hr duration depths were insignificant in remaining parts of the study area.

Although there were minor differences in the depths across the study area the influence was not sufficiently significant to justify considering multiple event durations within the study. Therefore a single duration of 3hrs was selected to be used in the model because it was considered that 3 hours represented the size of the catchment well and its runoff characteristics.

Grid Size

The models were constructed with a 5m grid size. This grid size was chosen as it represented a good balance between the degree of accuracy (i.e. ability to model overland flow paths along roads or around buildings) whilst maintaining reasonable model run ("simulation") times. For example, refining the grid size from a 5m grid to a 2m grid is likely to increase the model simulation time from ~12hrs to approximately 18 days.

Topography

LiDAR data from Environment Agency and Infoterra covers more than 95% of the urbanised area with resolutions of 2m and 0.5m respectively. The remaining area was covered with photogrammetric data with a resolution of 5m, which was also obtained from Infoterra. Extents of each dataset are shown in Figure B2.

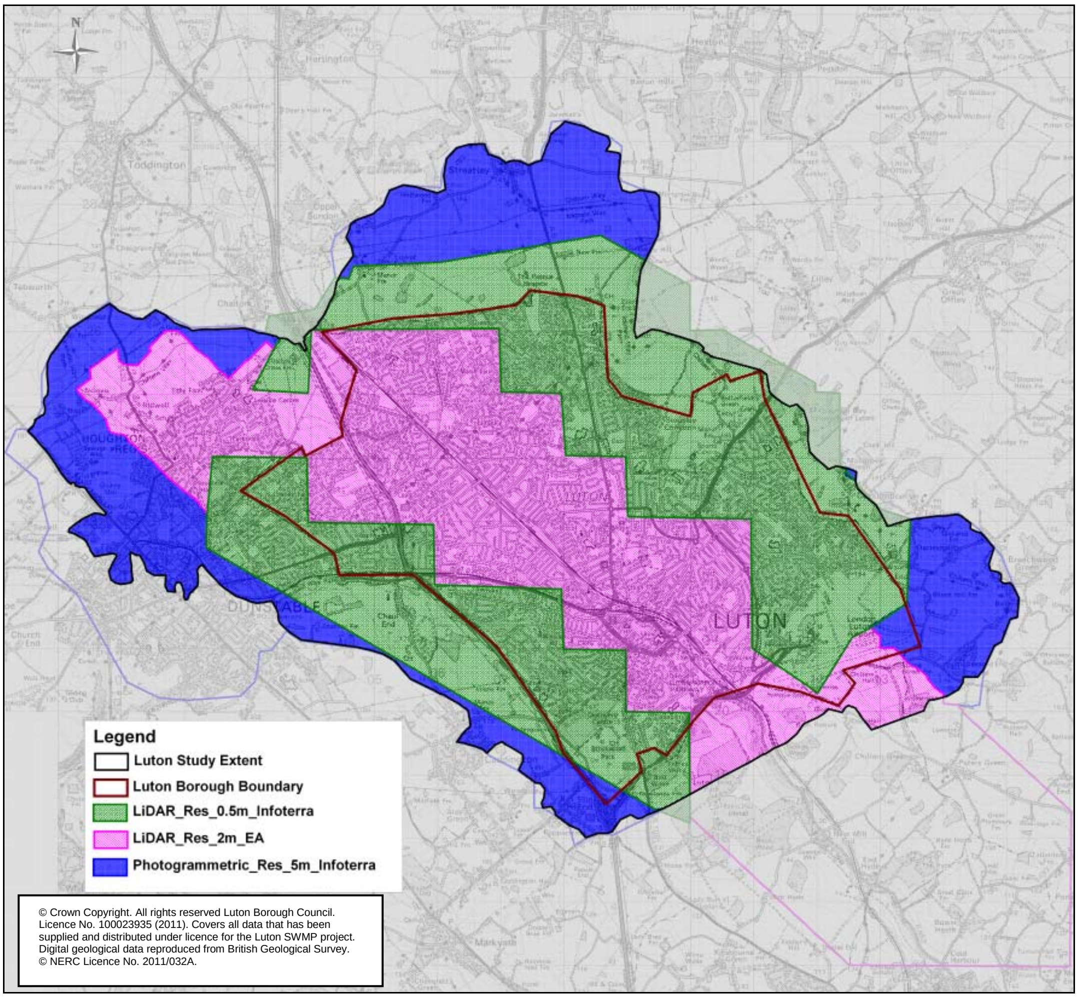

Figure B2: Topographic data

The topographic data was reviewed as part of the model build process. It was observed in several locations that the DTM showed inconsistent ground elevations. These were manually amended based on aerial photography, site observations and the surrounding DTM levels.

- Guildford Street (NGR 509094, 221434) – Ground elevations increased approximately by 2.25m over 200m long;
- Near Kimpton Road/Railway line (NGR 510227, 220851) – DTM shows lower ground elevations;
- Airport Way near Barratt Industrial Park (NGR 511113, 220581) – Ground elevations for the road were not represented well;
- Airport Way near Railway line (NGR 510849, 220342) – DTM shows higher levels whereas no reason for the higher elevation in the location;
- Airport Way near Newlands Farm (NGR 508916, 218622) – DTM defines lower spots along the road;
- Church Road near Newlands Road (NGR 508229, 218778) – Abnormal crest levels for the road;
- M1 near rugby/football club (NGR 508149, 219194) – DTM shows higher ground heights in some places along M1;
- Subway near the intersection of Wigmore Lane/Hayling Drive (NGR 511363, 223075) – DTM omitted subway entrance.

Structures

Structures within the study area were modelled in 2D, an approach consistent with the strategic nature of this project. Structures modelled in 2D include those on watercourses and underpasses or culverts within the floodplain. The structures were modelled by using the ZSHP function in TUFLOW which allows the user to specify the object width representing the structure opening. Invert levels were determined by inspecting the LiDAR DTM with widths of structures either observed on site visits, from Google Maps, or derived from the LiDAR DTM.

Initially, a base hydraulic model was simulated without the structures to identify where structures should be included or not represented at all. Based on this output, the hydraulic model was then amended to better represent the key structures (large culverts, road underpasses etc). The key structures that are explicitly modelled in 2D are listed in Table B3 below. The representation of these structures has been simplified, therefore the model results at these locations should be verified by undertaking more detailed investigation before making significant decisions relating to flood risk mitigation.

NGR	Location Description	NGR	Location Description
504507, 224389	Culvert underneath M1 upstream of Butely Road	508724, 223098	South east corner of intersection A5228/A6
504775, 224373	Butely Road	508593, 223052	Abigail Close
505001, 224270	Brickly Road	508734, 222345	New Bedford Road downstream of Wardown Lake
505746, 224432	Culvert which runs underneath the Railway line immediately upstream of Source of the River Lea	508737, 222223	Studley Road
506139, 224307	Structure on the east side of the Sundon Park Road/ Bramingham Road intersection	508742, 222058	Cromwell Road
507203, 224465	Icknield Way/ Neville Road	508801, 221724	Culvert underneath Railway line near Mill Street
507457, 224400	Runfold Avenue	509426, 221398	St. Marys Road
507694, 224206	Bancroft Road	509760, 221139	Crawley Green Road
508479, 223940	Midhurst Gardens	509906, 220810	Near Park Town Road
508582, 223930	Culvert – Intersection of New Bedford Road and Kingsdown Avenue	510405, 220188	Culvert on River Lea underneath Airport Way (A1081)

Table B3: List of Structures

Manning's Values

The following Manning's roughness coefficient values were used across both hydraulic models.

Feature Code	Descriptive Group	Comment	Mannings Roughness
10021	Building		0.500
10053	General Surface	Residential yards	0.040
10054	General Surface	Step	0.025
10056	General Surface	Grass, parkland	0.030
10062	Building	Glasshouse	0.500
10076	Land; Heritage And Antiquities		0.500
10089	Water	Inland	0.035
10111	Natural Environment (Coniferous/Non-coniferous Trees)	Heavy woodland and forest	0.100
10119	Roads Tracks And Paths	manmade	0.020
10123	Roads Tracks And Paths	tarmac or dirt tracks	0.250
10167	Rail		0.050
10172	Roads Tracks And Paths	Tarmac	0.020
10183	Roads Tracks And Paths (roadside)	Pavement	0.020
10185	Structures	Roadside structure	0.030
10187	Structures	Generally on top of buildings	0.500
10203	Water	foreshore	0.040
10210	Water	tidal water	0.035
10217	Land (unclassified)	Industrial Yards, Car parks	0.035
10096	Land, (Cultivation lands)	Dense vegetation, Cliff, Cultivation areas	0.100

Initial Conditions - Balancing Ponds

There are several balancing ponds within the study area. They are operated by Thames Water and Luton Airport. During a site visit to each of these structures, it was observed that the ponds are generally "dry". Therefore, they have been represented in the model as open 'holes' in the DTM. Details of flow controls (inlet/outlet levels and sizes) were not available and therefore have not been represented in the model.

Building Representation

In order to determine the influence raised building pads will have within the model, the following approach has been used for the representation of buildings in the models through the coding of the TUFLOW Materials File (*.tmf) file. The method is also described in Figure B3.

- A GIS layer containing the locations of all 'buildings' was created based on the buildings polygons in the OS Mastermap dataset;
- The LiDAR DTM was then interrogated to obtain an average 'bare earth' ground level for each building polygon.
- This average ground level was applied to the building polygons to give them their base elevation in the Tuflow model;
- The building polygons were then raised 100mm above their average 'bare earth' ground level to create stubby building pads (reflecting an average building threshold level). This ensures that the buildings form an obstruction to flood water and that shallow flows must pass round the buildings (and not flow through them).

A high Manning's n value (n = 0.5) was applied to the buildings to represent the high resistance that buildings have to flow. However, for very shallow depths of flow (up to 30mm) a lower Manning's n value (n = 0.015) ensure shallow flows did not incorrectly accumulate within the building footprint.

The TUFLOW model used is a direct rainfall model which applies a rainfall hyetograph to every active cell within the 2D model extent. This includes the cells representing buildings. The Manning's n value for buildings is reduced for these very shallow depths so that the flow which is created on buildings as a consequence of the application of direct rainfall is able to flow away from the building. If the Manning's n value was not reduced for these shallow depths, the rainfall applied to the building cells would pond here in an unrealistic manner.

The only exception to this method was in situations where the polygon representing the building was large or long. In these locations, the use of a single elevation to represent the floor level resulted in parts of the building being raised metres above the surrounding ground level.

This issue was identified around the General Motors factory buildings near Vauxhall Way and this is therefore represented slightly differently in the model. The floor level for the building was assumed as constant level and 2D cells along the exterior walls were raised except for the upstream side. This process creates constant flood depth across the building footprint and directs the remaining water flow along the Vauxhall Way.

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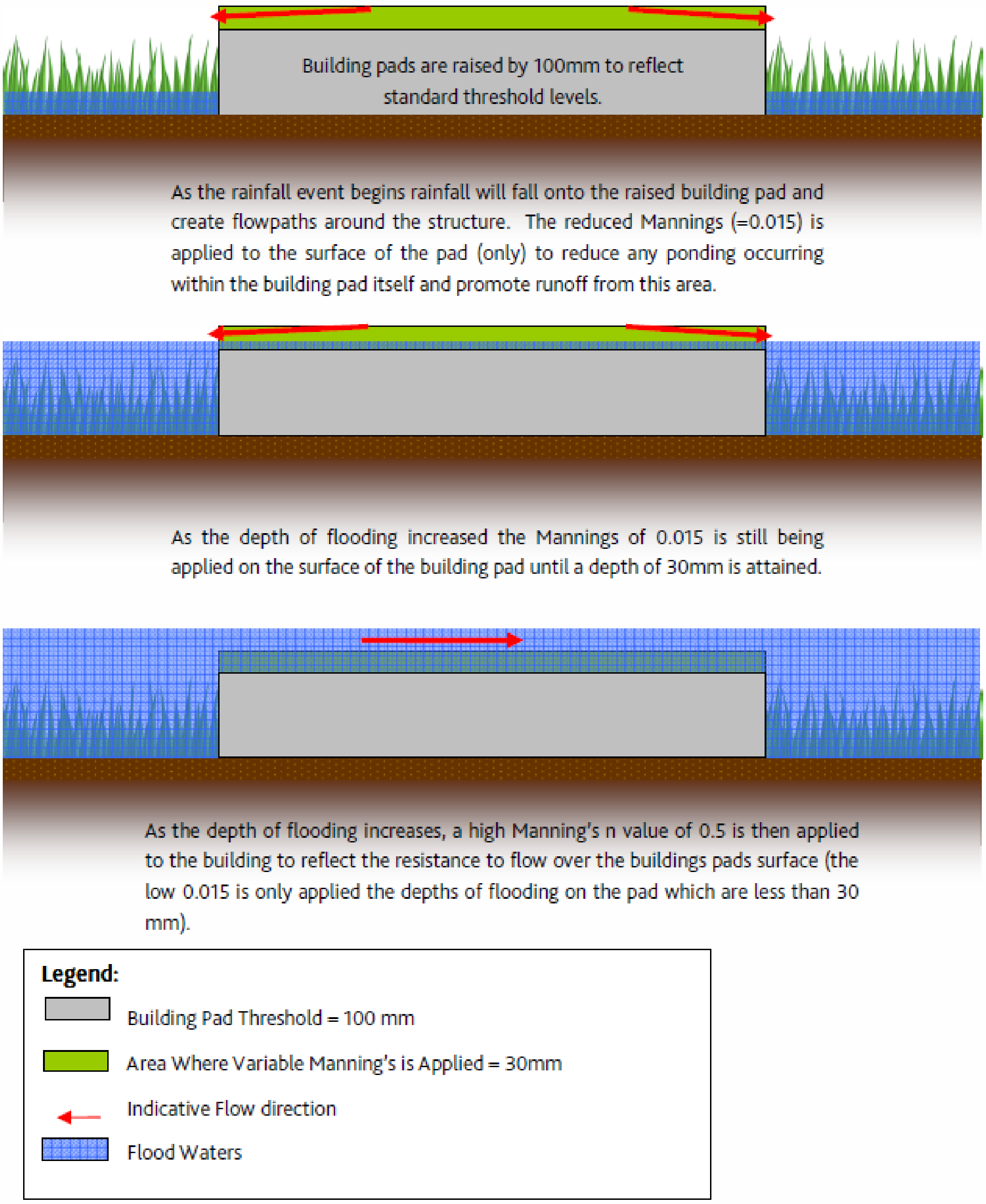


Figure B3 Building Pad Methodologies

Formal and Informal Defences

A GIS layer containing defences from the Environment Agency's NFCDD dataset was provided. These defences have been included in all models. Formal EA defences are listed in Table B4.

Type of Defence	NGR	Description of Location
Earth embankment	507822, 224160	Approximately 300m long man made defence along River Lea immediately downstream of Bancroft Road
Earth embankment	508749, 223667	Approximately 540m long earth defence along left bank of River Lea immediately downstream of Kingsdown Avenue
Earth embankment	508789, 221920	Approximately 760m long earth embankment on the left immediately upstream of Railway line. Also there is a little earth embankment (approximately 60m) on the right bank upstream of Brook Street.
Raised earth embankment	509927, 220895	Approximately 270m long earth defence along the recreation ground/Windmill Road

Table B4: List of Defences modelled using the NFCDD data

Where additional data was provided by the Borough or informal defences such as walls were observed on site or through Google Maps, these were included in the model where it was thought that their presence would influence surface water flow paths. Information was gathered from sources such as the existing EA ISIS model of the River Lea, LiDAR DTM and observations from site visits. These locations are summarised in the table below.

Type of Defence	NGR	Description of Location
Raised defence (man-made)	507223, 224418	Approximately 240m long along the right bank of River Lea immediately downstream of Neville Road.
Earth embankment	502718, 223877	Approximately 250m long earth embankment on the east side of Windsor Drive in Houghton Regis
Earth embankment	508296, 223881	Earth embankment made of loose topsoil near the north side of Austin Road.

Table B5: List of Defences modelled using ISIS, LiDAR DTM and site observations.

Model Boundaries

Downstream boundaries in the models were included where it was observed that water was able to flow outside of the model extent. The type of downstream boundary used was a flow vs. stage (level) relationship, or HQ boundary. The rating relationship is generated by TUFLOW automatically using a gradient provided by the modeller. Recorded outflow at the downstream end of upstream model along the River Lea was applied as an ‘inflow’ to the downstream model.

There are a number of 2D downstream boundaries included within the models; these have mainly been located on roads and railway lines that make up overland flow routes for the surface water and recorded outflow seems hydraulically insignificant.

Cross-Boundary Issues

In some cases, it was not possible to avoid interaction with a neighbouring model due to the nature of the topography. To ensure that the flow path is represented correctly at all locations of possible overland flow a downstream boundary was positioned and flow recorded. The recorded flow at the boundary near Cromwell Road (NGR 508725, 222039) appears to be significant and was applied as one of the inflows in the other model while remaining flows at the boundaries were deemed minimal so did not require inputting into the neighbouring model.

Simulation Time

Upstream and downstream models were run for 13 hours and 12 hours respectively. The models were then assessed to determine whether this duration was suitable for each specific model. This was carried out by viewing the model results for the final few time steps. The results were checked to determine if water depths were still increasing significantly, and whether new flow paths were forming or existing flow paths still propagating. If either of these conditions were found to exist, the simulation time was extended for a further hour after which the checks were repeated until none of the conditions were satisfied. The simulation times for each of the models are listed below in Table B6:

Model Name	Model Simulation Time (hrs)
LTN_US_100R_031	13
LTN_DS_100R_037	12

Table B6: Model simulation times

Model Parameters

Time Step

The model was initially simulated with a 1 second time step. This resulted in the model reporting anomalous flood depths around steep topographic gradients, particularly around:

- Stopsley Common;
- Wardown Crescent / Trowbridge Gardens / Chartwell Drive / Ashburnham Road / Harthill Lane /Crawley Green Road;
- Intersection of A505 and Chaul End Road;
- Airport Way on the west side of Luton Hoo Park;

The time step was reduced to 0.5s and subsequently delivered appropriate results in the above locations.

Shallow Depth Stability Factor

The Tuflow manual sets the default value for the Shallow Depth Stability Factor (SDSF) for direct rainfall models as 6. With this value, the SWMP model was reporting a high cumulative mass error that significantly exceeded acceptable limits (+/- 5%).

A test was then carried out for the upstream model with varying values for SDSF. Reported cumulative mass error for each SDSF value (SDSF = 6; SDSF=8; and SDSF=9) are plotted in the Figure B4 below. It was concluded that SDSF = 9 was most appropriate for this model.

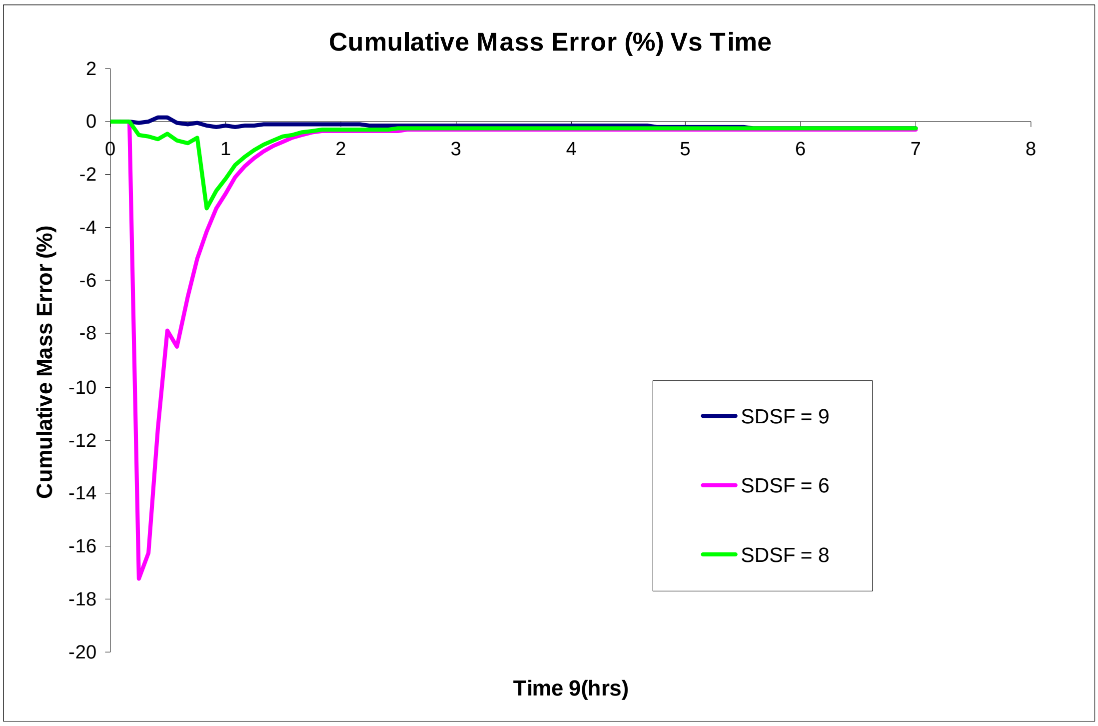


Figure B4: Cumulative mass error (%) vs Time (hrs) from the upstream Luton model

Other Tuflow Parameters

Table B7 describes other key Tuflow parameters that have been used in the study.

Parameter	Value
Cell Wet/Dry Depth	0.001m
Maximum Velocity Cut-off Depth	0m/s

Table B7: Changes to Default TuFlow Parameters

Model Stability

Assessing the stability of a model is a critical step in understanding the robustness of a model and its ability to simulate a flood event accurately. Stability in a TUFLOW model is assessed by examining the cumulative error (or mass balance) of the model as well as the warnings outputted by the model during the simulation. Figures B5 and B6 below show the cumulative error of the models are within the recommended range of +/-1% throughout the simulation.

A single warning message was outputted for the upstream model and none were reported in the downstream model through the simulation for the five flood events. The single warning message was related to an area of poor convergence or, in other words, where TUFLOW has had trouble finding a solution. As this warning was in just one location, this has a negligible impact on the overall model results and the model is considered fit for purpose.

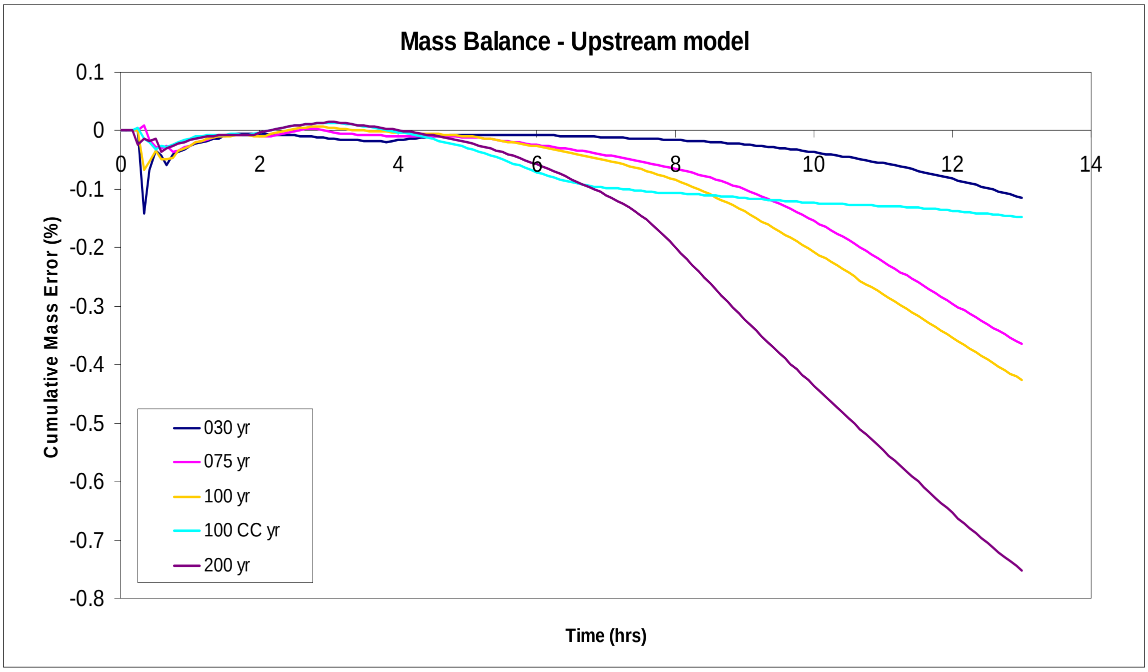


Figure B5: Mass Balance of Upstream Model

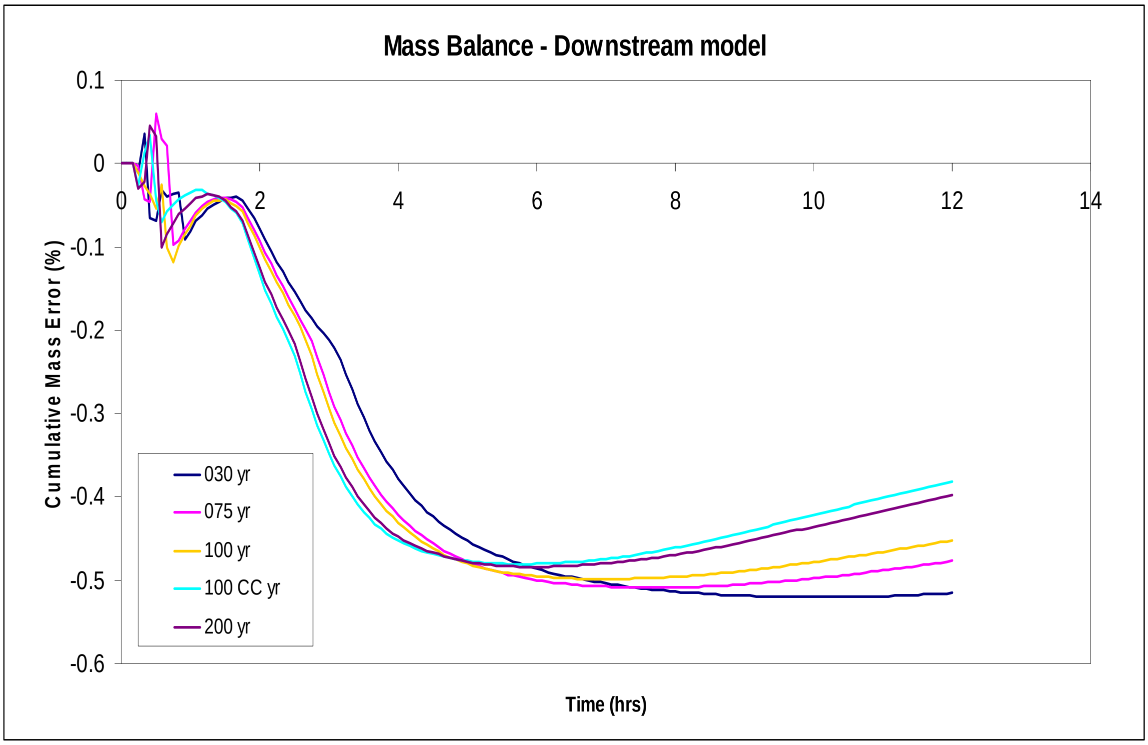


Figure B6: Mass Balance of Downstream Model

Conclusions and Recommendations

The hydraulic models constructed for Phase 2 of the Luton Surface Water Management Plan represents an 'intermediate' approach to identifying areas at risk of surface water flooding. It represents a significant refinement on the previously available information on surface water flooding in the study area. Recommendations for future improvements to the models include (but are not limited to) the following:

- Explicitly model the existing drainage network in key areas of risk;
- Inclusion of survey data for critical structures;
- Inclusion of river flows and channel capacity (where applicable);
- Reduction in model grid size in key areas of risk;
- The use of better quality or more up to date topographic information particularly in areas of recent development.

Appendix C Option Assessment Details

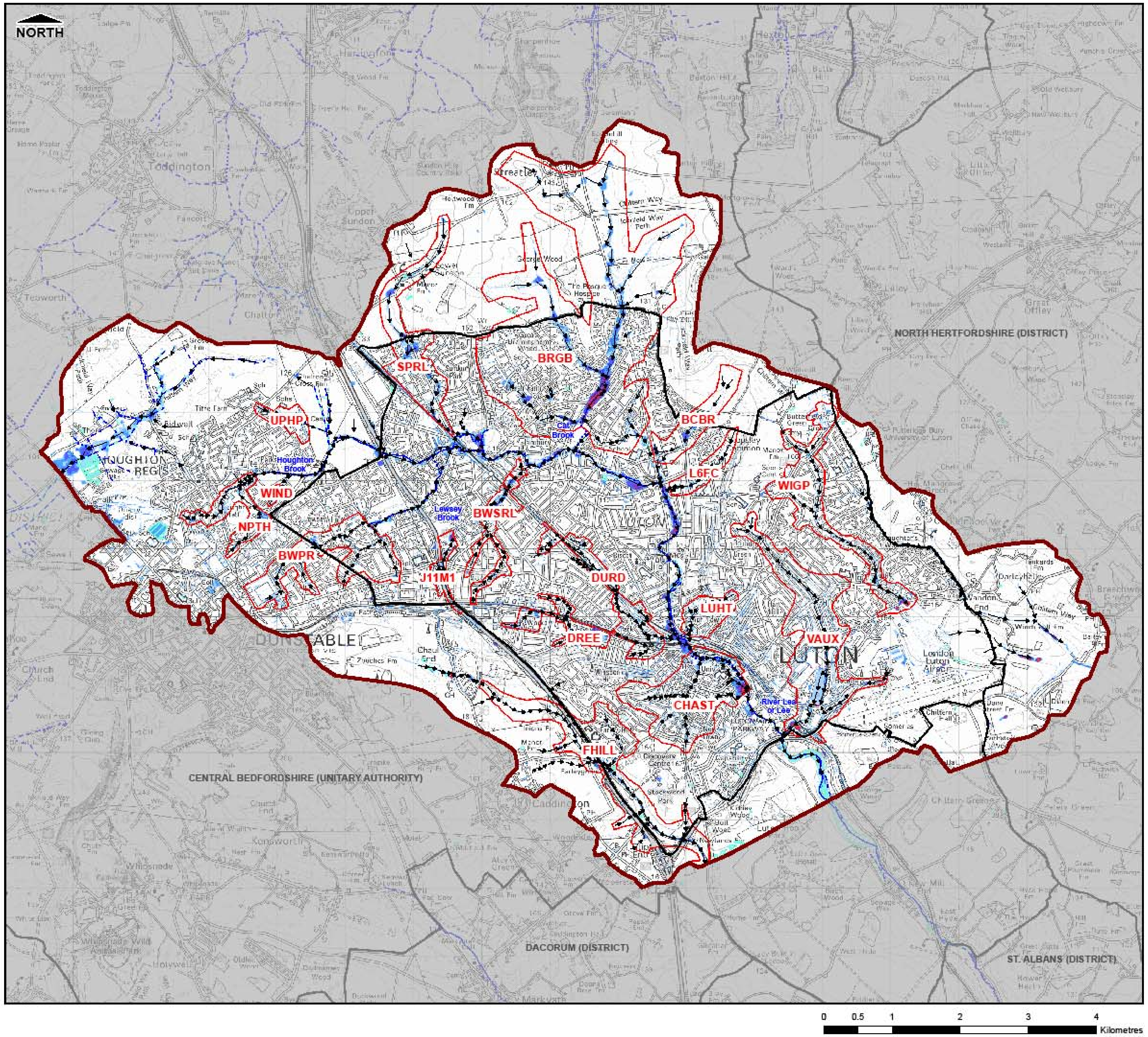
The maps and associated information on the fold-out pages in this Appendix provide the details of the option assessment process that was carried out for each of the Critical Drainage Areas.

CDA ID	CDA Name
BCBR	Barnfield College/Barnfield Avenue
BRGB	Barton Road/Great Bramingham
BWPR	Barnfield West Academy/Poynters Road
BWSRL	Beechwood Primary School
CHAST	Chapel Viaduct/Stuart Street
DREE	Dalroad Enterprise Estate
DURD	Dunstable Road (near Luton Town football club)
FHILL	Farley Hill
J11M1	Junction 11, M1
L6FC	Luton 6th. Form College
LUHT	Luton High Town
NPTH	Nimbus Park/The Herculean, H. Regis
SPRL	Sundon Park, Railway Line
UPHP	Upstream of Houghton Park, H. Regis
VAUX	Vauxhall Road
WIGP	Wigmore Lane/Eaton Green Road
WIND	Windsor Drive, H. Regis

Appendix D Maps

The following maps are included in this Appendix.

Figure Number	Description
D1	1 in 30 year rainfall event Flood Depth
D2	1 in 75 year rainfall event Flood Depth
D3	1 in 100 year rainfall event Flood Depth
D4	1 in 100 year rainfall event Flood Depth with Climate Change
D5	1 in 200 year rainfall event Flood Depth
D6	1 in 30 year rainfall event Flood Hazard
D7	1 in 75 year rainfall event Flood Hazard
D8	1 in 100 year rainfall event Flood Hazard
D9	1 in 100 year rainfall event Flood Hazard with Climate Change
D10	1 in 200 year rainfall event Flood Hazard



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Study Area
- Administrative Boundary
- Critical Drainage Areas
- Main River
- Ordinary Watercourse
- Culverted Watercourse
- Flow Direction
- Permanent Water Bodies

Surface Water Flood Depth (m)

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

Notes

1. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
2. Users of this map should refer to section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood/hazard extents shown.

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Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:40,000	23/11/2011	S.TURNBULL	M.ARTHUR

Surface Water/Ordinary Watercourse Flooding 1 in 30 Chance of Rainfall Event Occurring In Any Given Year (3.33% AEP)

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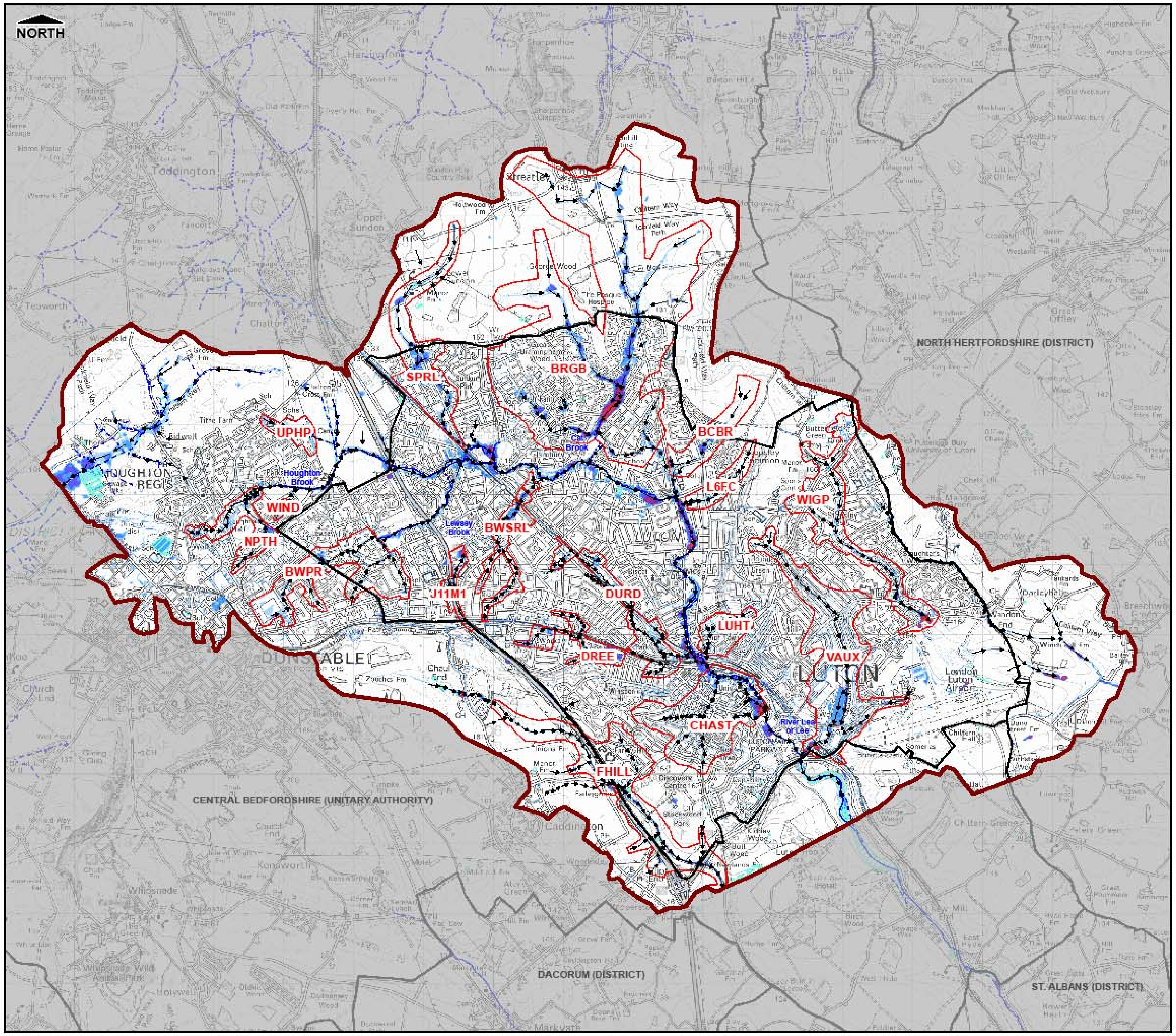
APPENDIX D1



0 0.5 1 2 3 4 Kilometres

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Legend

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- Main River
- Ordinary Watercourse
- Culverted Watercourse
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- Permanent Water Bodies

Surface Water Flood Depth (m)

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

Notes

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Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:40,000	23/11/2011	S.TURNBULL	M.ARTHUR

Surface Water/Ordinary Watercourse Flooding
1 in 75 Chance of Rainfall Event Occurring
In Any Given Year (1.33% AEP)

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APPENDIX D2

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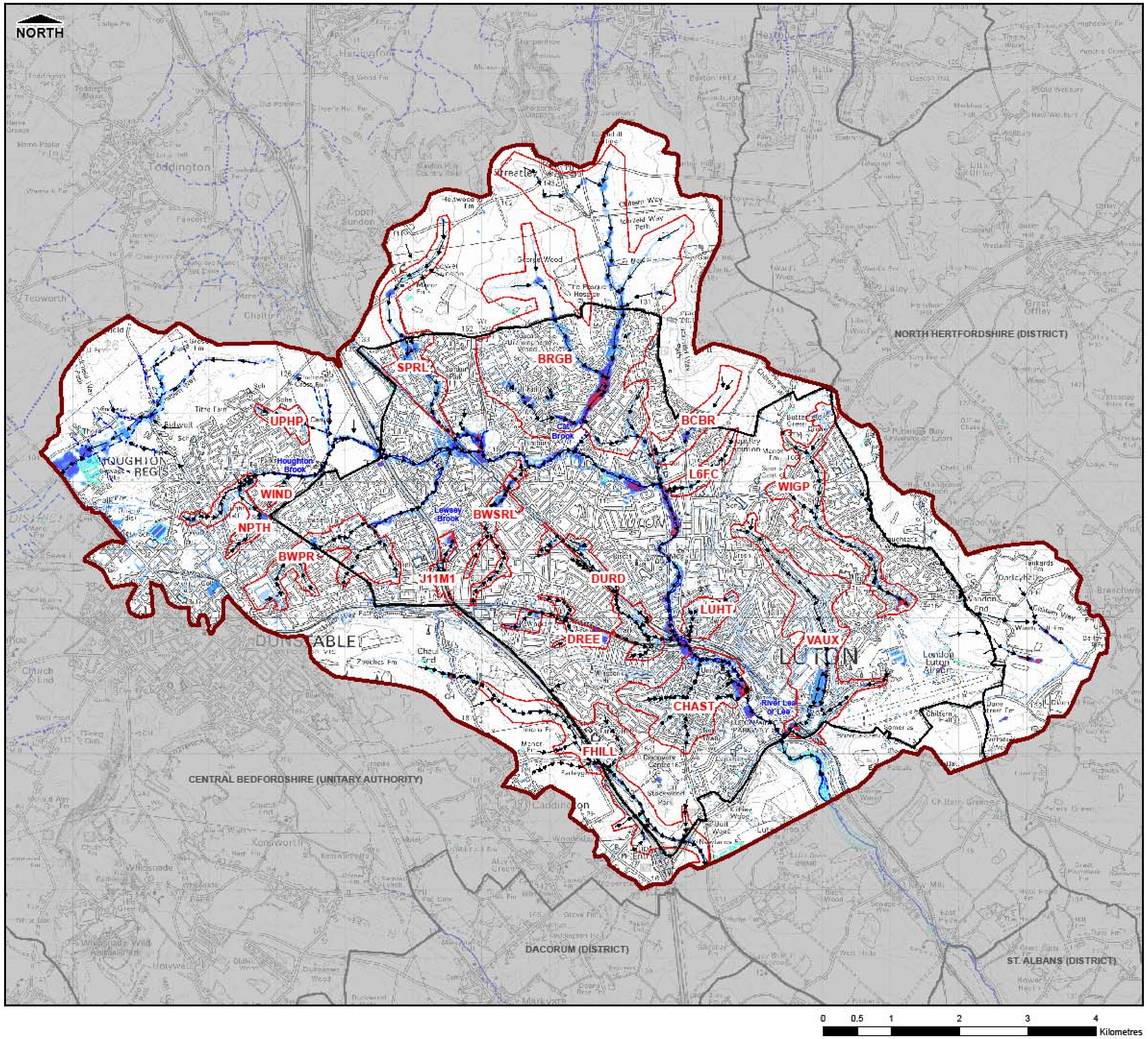

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Study Area
- Administrative Boundary
- Critical Drainage Areas
- Main River
- Ordinary Watercourse
- Culverted Watercourse
- Flow Direction
- Permanent Water Bodies

Surface Water Flood Depth (m)

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

Notes

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Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
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Surface Water/Ordinary Watercourse Flooding 1 in 100 Chance of Rainfall Event Occurring In Any Given Year (1% AEP)

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APPENDIX D3

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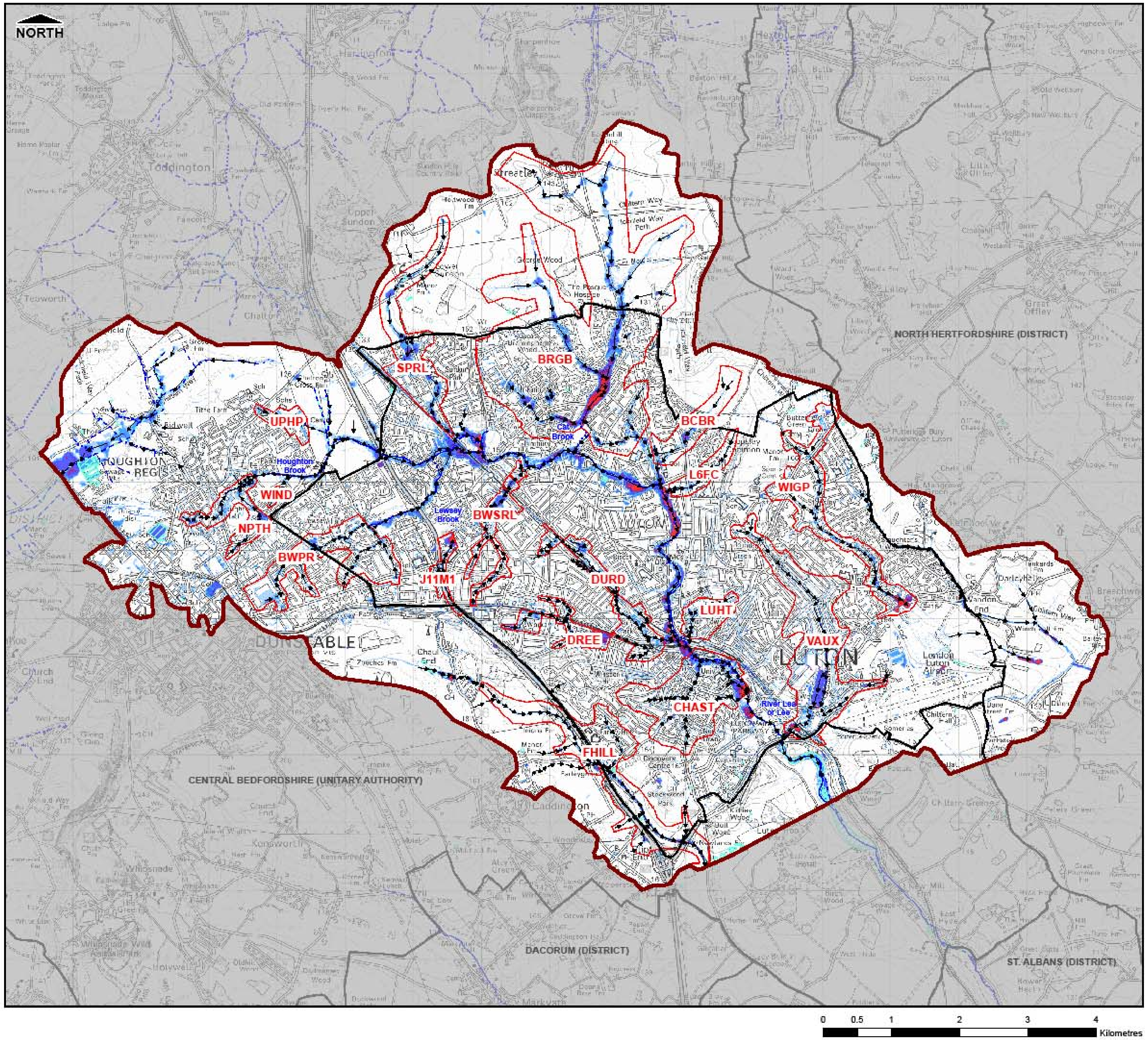

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Study Area
- Administrative Boundary
- Critical Drainage Areas
- Main River
- Ordinary Watercourse
- Culverted Watercourse
- Flow Direction
- Permanent Water Bodies

Surface Water Flood Depth (m)

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

Notes

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Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
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Surface Water/Ordinary Watercourse Flooding 1 in 100 Chance of Rainfall Event Occurring In Any Given Year Plus Climate Change (1% AEP)

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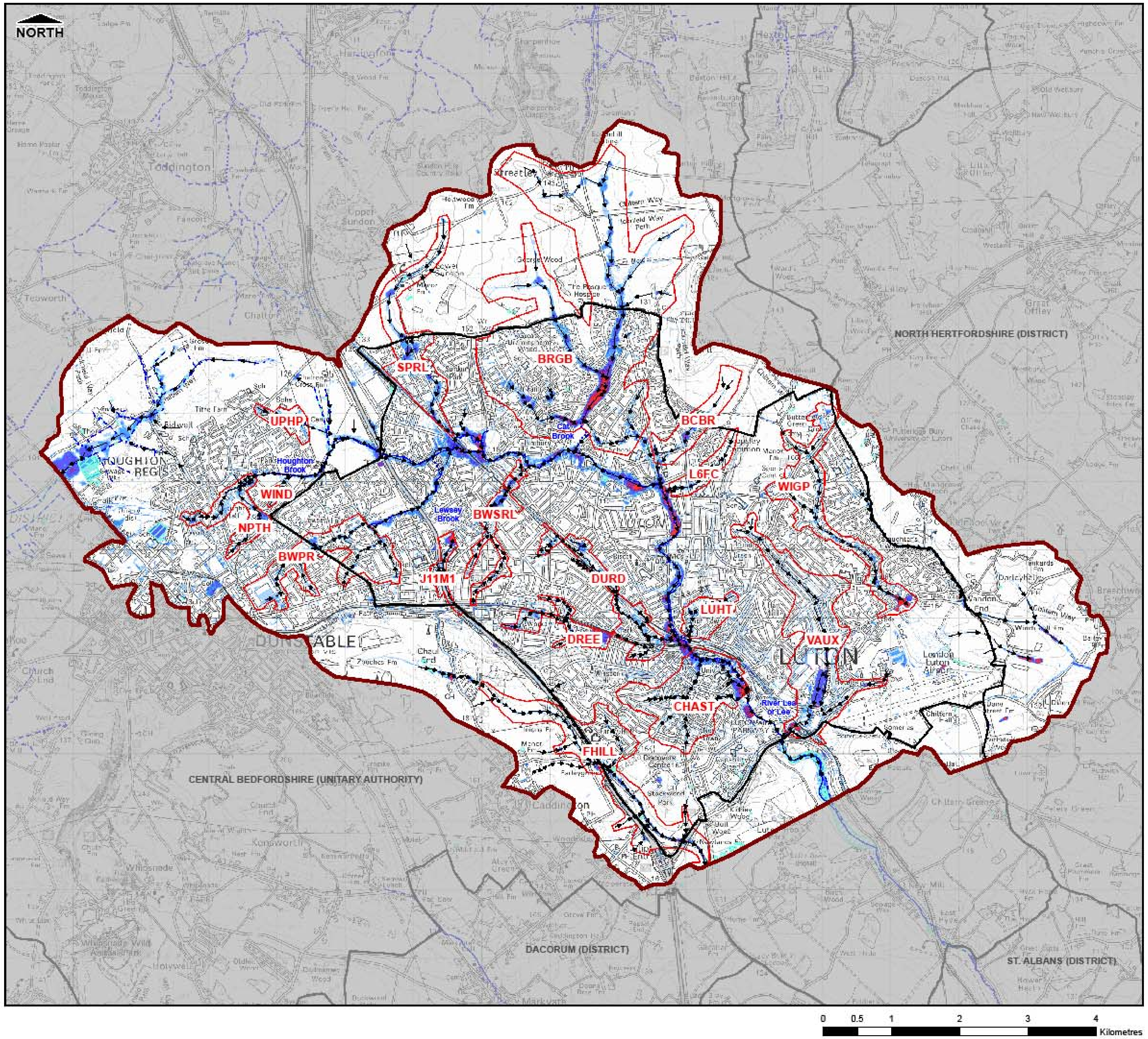
APPENDIX D4



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Study Area
- Administrative Boundary
- Critical Drainage Areas
- Main River
- Ordinary Watercourse
- Culverted Watercourse
- Flow Direction
- Permanent Water Bodies

Surface Water Flood Depth (m)

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

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Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
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**Surface Water/Ordinary Watercourse Flooding
1 in 200 Chance of Rainfall Event Occurring
In Any Given Year (0.5% AEP)**

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APPENDIX D5

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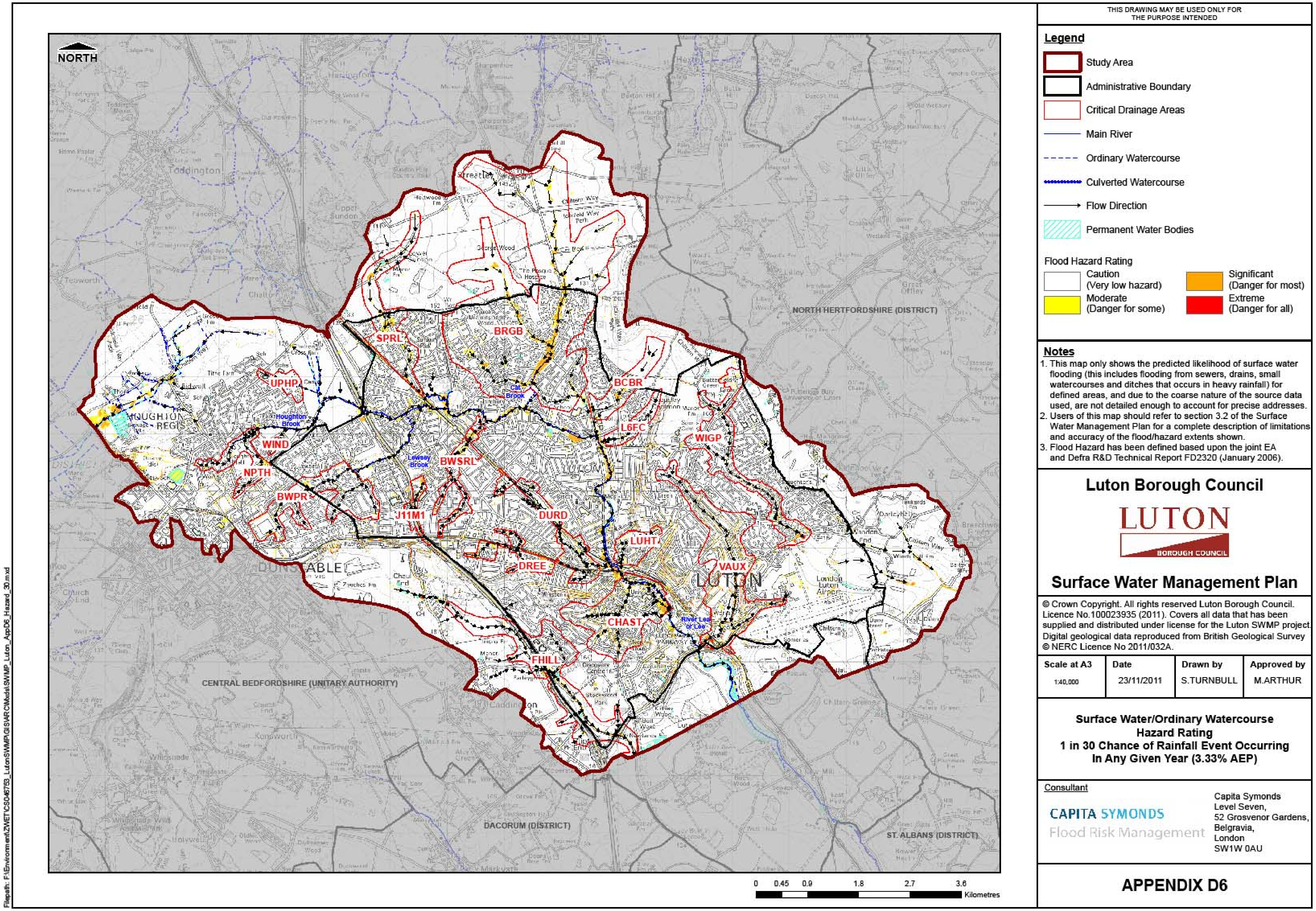

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED
Legend
Study Area
Administrative Boundary
Critical Drainage Areas
Main River
Ordinary Watercourse
Culverted Watercourse
Flow Direction
Permanent Water Bodies
Flood Hazard Rating
Caution (Very low hazard)
Moderate (Danger for some)
Significant (Danger for most)
Extreme (Danger for all)
Notes
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3. Flood Hazard has been defined based upon the joint EA and Defra R&D Technical Report FD2320 (January 2006).
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Surface Water Management Plan
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Scale at A3
1:40,000
Date
23/11/2011
Drawn by
S.TURNBULL
Approved by
M.ARTHUR
Surface Water/Ordinary Watercourse
Hazard Rating
1 in 30 Chance of Rainfall Event Occurring
In Any Given Year (3.33% AEP)
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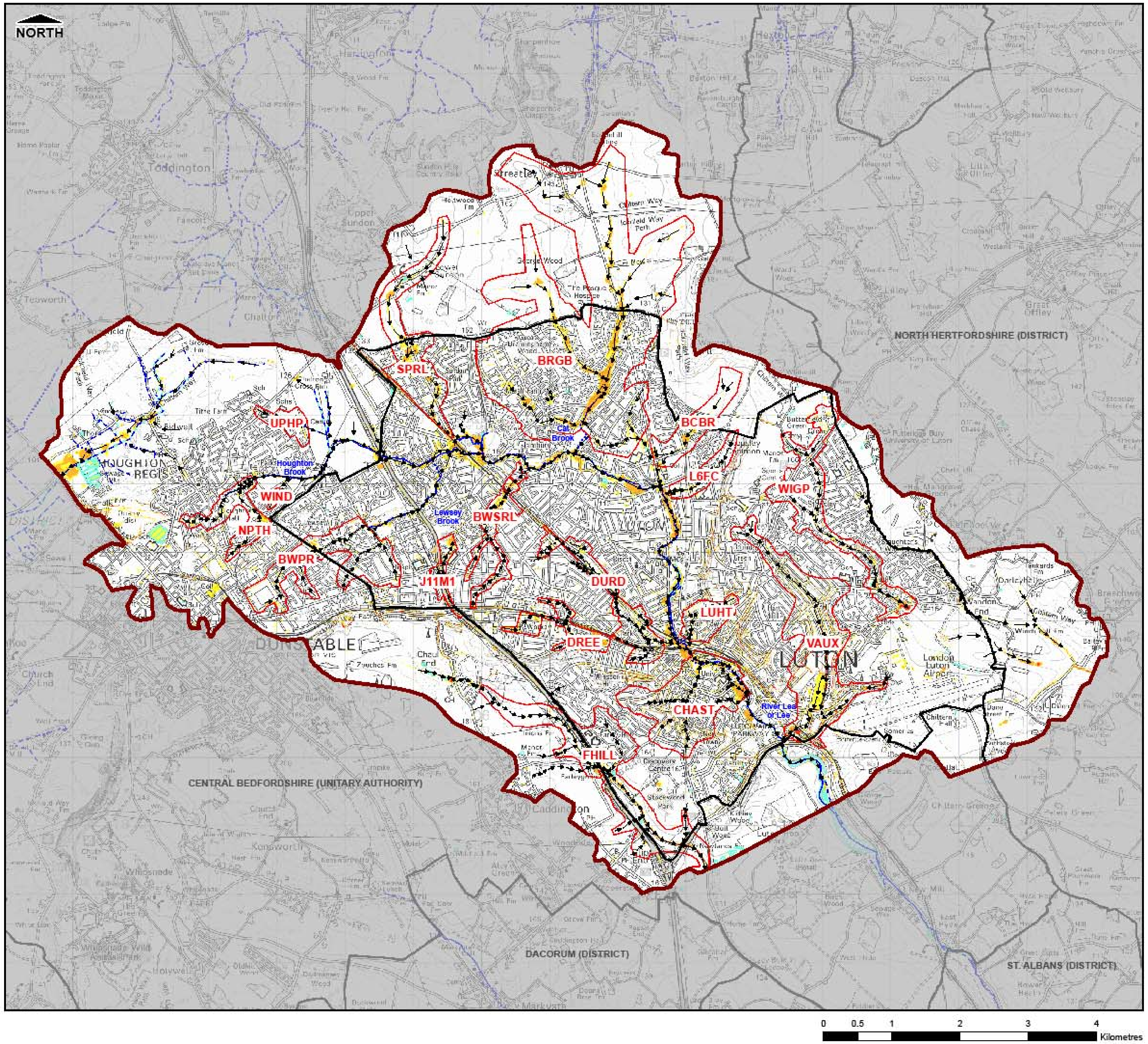
NORTH
NORTH HERTFORDSHIRE (DISTRICT)
CENTRAL BEDFORDSHIRE (UNITARY AUTHORITY)
DACORUM (DISTRICT)
ST. ALBANS (DISTRICT)
SPRL
BRGB
UPHP
BCBR
L6FC
WIGP
WIND
NPTH
BWSRL
BWPR
J11M1
DURD
LUHT
DREE
VAUX
CHAST
FHILL
Houghton Brook
Lewsey Brook
Cat Brook
River Lea or Lee
0
0.45
0.9
1.8
2.7
3.6
Kilometres



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Legend

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- Critical Drainage Areas
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- Ordinary Watercourse
- Culverted Watercourse
- Flow Direction
- Permanent Water Bodies

Flood Hazard Rating

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Scale at A3	Date	Drawn by	Approved by
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Surface Water/Ordinary Watercourse Hazard Rating
1 in 75 Chance of Rainfall Event Occurring In Any Given Year (1.33% AEP)

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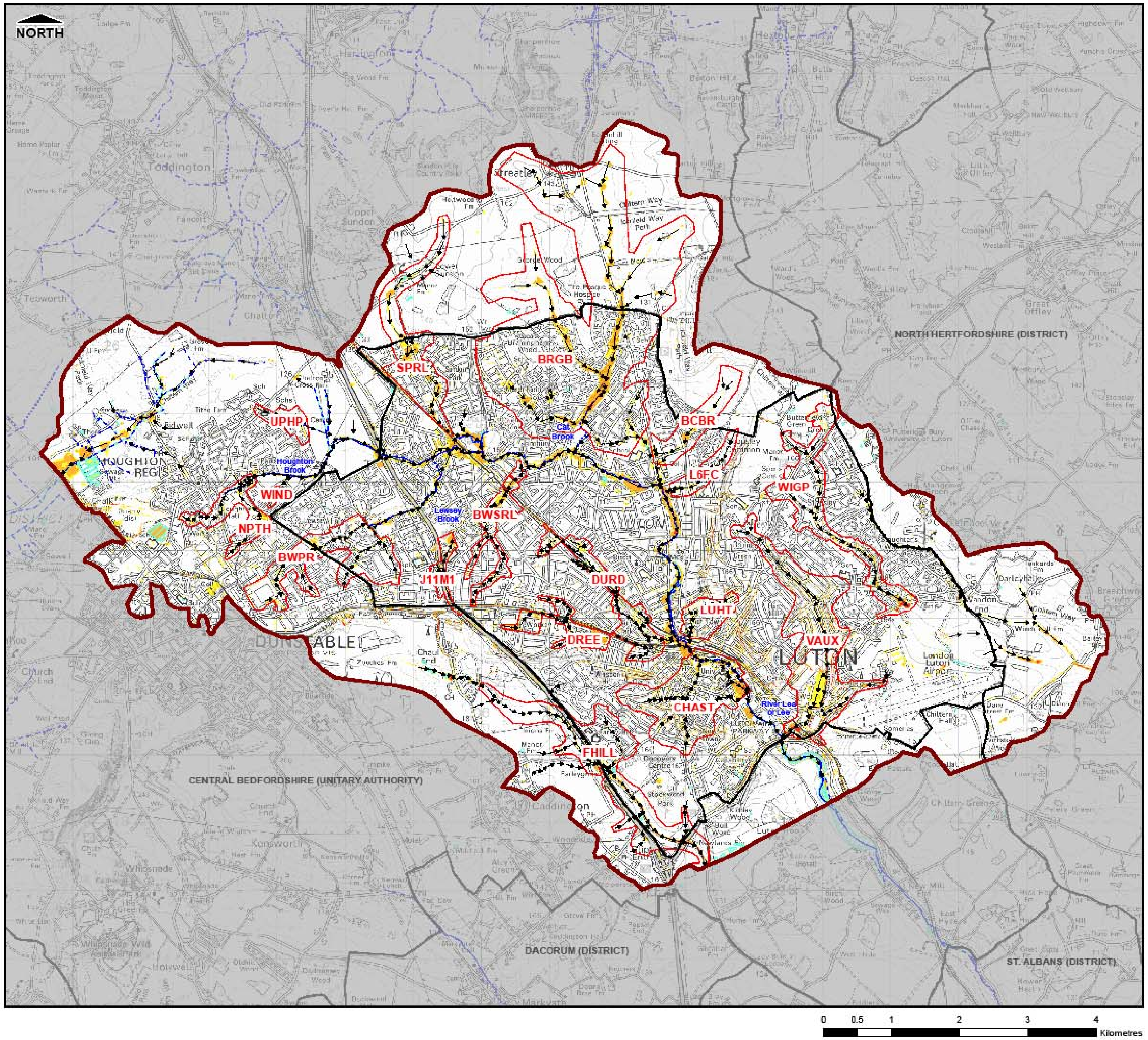

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Legend

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- Main River
- Ordinary Watercourse
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Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
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Surface Water/Ordinary Watercourse Hazard Rating
1 in 100 Chance of Rainfall Event Occurring In Any Given Year (1% AEP)

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APPENDIX D8

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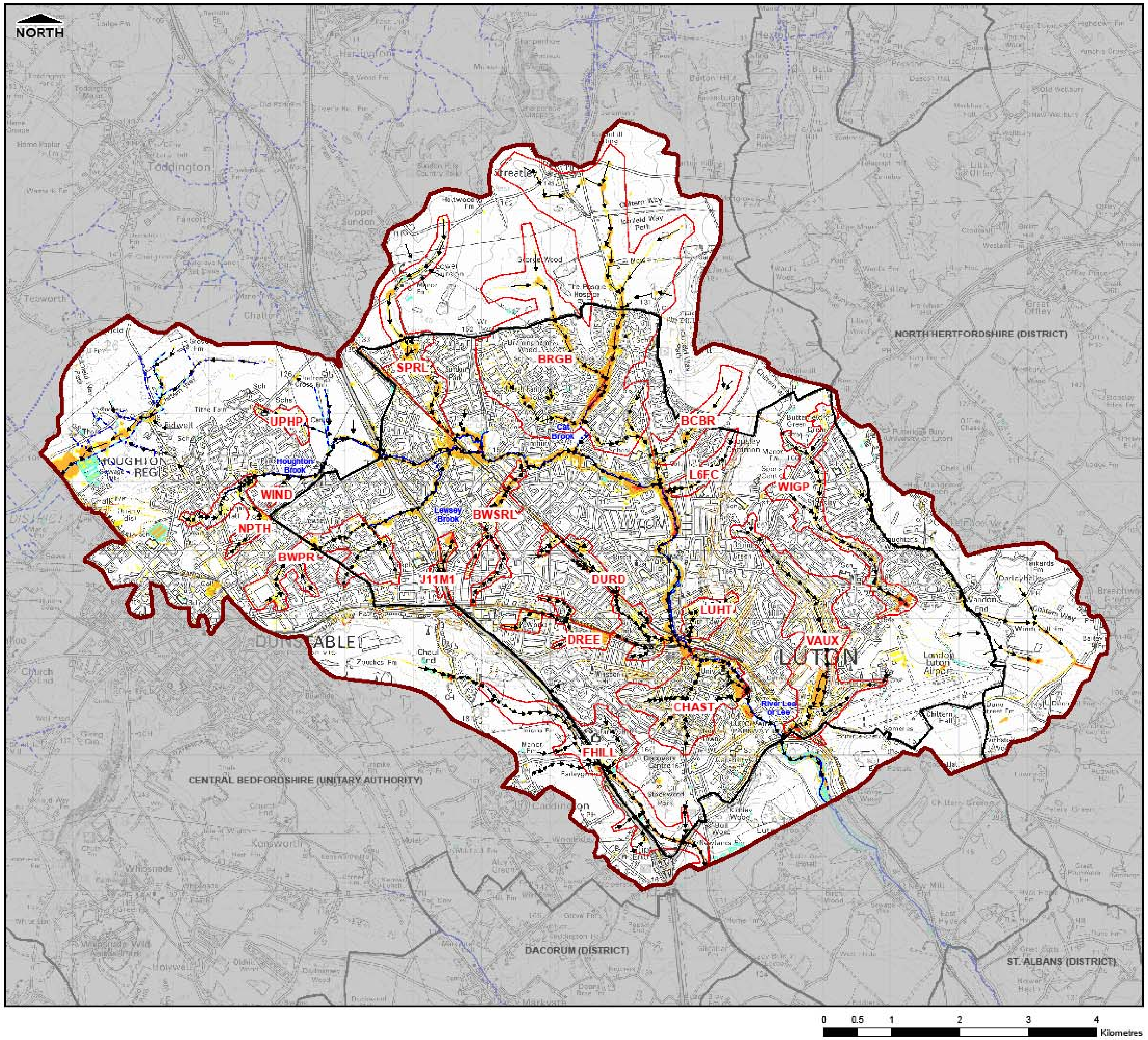

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Study Area
- Administrative Boundary
- Critical Drainage Areas
- Main River
- Ordinary Watercourse
- Culverted Watercourse
- Flow Direction
- Permanent Water Bodies

Flood Hazard Rating

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Scale at A3	Date	Drawn by	Approved by
1:40,000	23/11/2011	S.TURNBULL	M.ARTHUR

Surface Water/Ordinary Watercourse Hazard Rating
1 in 100 Chance of Rainfall Event Occurring In Any Given Year Plus Climate Change (1% AEP)

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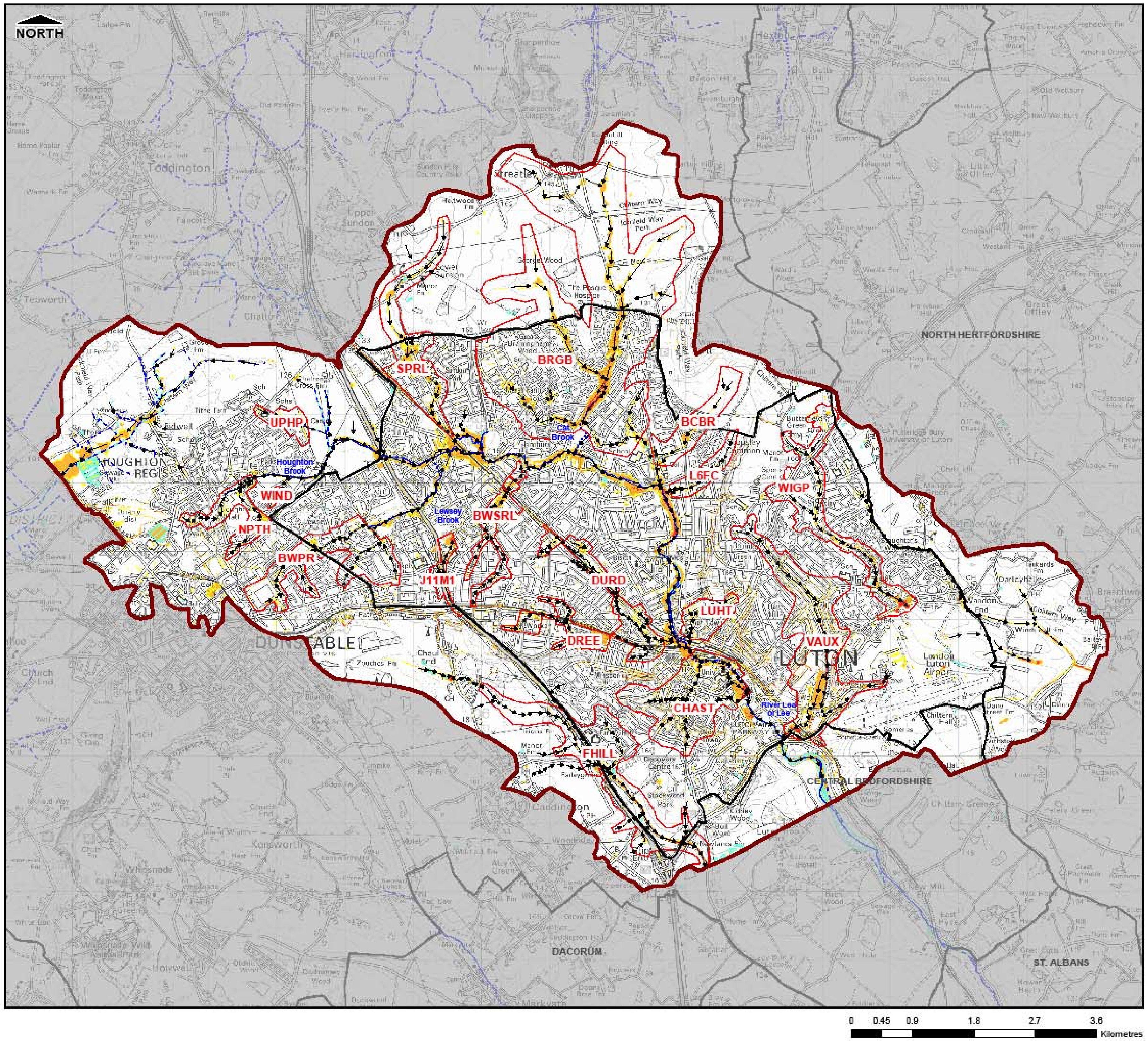
APPENDIX D9



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Study Area
- Administrative Boundary
- Critical Drainage Areas
- Main River
- Ordinary Watercourse
- Culverted Watercourse
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Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:40,000	23/11/2011	S.TURNBULL	M.ARTHUR

Surface Water/Ordinary Watercourse Hazard Rating
1 in 200 Chance of Rainfall Event Occurring In Any Given Year (0.5% AEP)

Consultant

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APPENDIX D10

LUTON BOROUGH COUNCIL

Appendix E Spatial Planner Information Pack

Background

PPS 25 set out national planning guidance for development in relation to flood risk and applied to all forms of flood risk. It took a risk based approach and categorised land uses into different vulnerabilities, appropriate to different flood zones. However, along with all other PPS's PPS 25 has now been subsumed into the new National Planning Policy Framework, but the detail of the Council's planning policies retain the scope and requirements of PPS 25.

Surface water, groundwater and Ordinary Watercourse flood risks are generally less well understood than fluvial or coastal flood risk. In part this is due to the much faster response times of surface water flooding, to a perception that the impacts are relatively minor and to the highly variable nature of influences, e.g. storm patterns, local drainage blockages, interactions with the sewer system, etc.

However, climate change models are predicting more frequent heavy storms and there is emerging evidence that this is already happening. It is also clear from the flooding that occurred in several parts of England in summer 2007 that surface water flooding can have major impacts. In heavily urbanised areas the risks are significant and it is important that appropriate consideration is given to these risks when new development is proposed.

The planning system is a key tool in reducing flood risk and, with this additional information, it can apply to surface water risk as well as fluvial and tidal risk.

In April 2011 Luton Borough Council was given the role of a Lead Local Flood Authority (LLFA) by the Flood and Water Management Act 2010. This means that the borough has new duties. The Planning Department has an important role to play in delivering these new duties and must ensure that it forms part of authority-wide co-ordination of the LLFA role. Whilst this document is titled a SWMP, it also identifies flood risk from Ordinary Watercourses and includes consideration of groundwater flood risk.

Using the SWMP to update the Strategic Flood Risk Assessment (SFRA)

The SFRA for the study area contains some information on historic analysis of surface water, groundwater and Ordinary Watercourse flood risk. Based on these analyses, recommendations and requirements have been devised for new developments. Developments within areas shown to be at risk of groundwater flooding are required to consider prevention and mitigation measures. Where the development proposes useable below ground space, a groundwater flood risk assessment is recommended. In terms of surface water flood risk, the SFRA recommends flood risk assessments are carried out for all developments larger than 1 hectare.

The mapping within this SWMP shows some areas that are vulnerable to extensive deep accumulations of water (>0.5m). These areas have a high certainty of flooding during extreme storms and the damage occurring is likely to be significant. The mapping also shows some small areas of potentially deep water (>0.5m). These areas may have particular risks associated with them, but risk may also occur due to irregularities in mapping and modelling. The mapping also shows areas of shallower flooding (<0.5m), some isolated and some more extensive flooding. Maps show general flow directions and approximate velocities (in the form of 'hazard' maps) as even relatively shallow water flowing at high velocities can be a threat to life and can cause damage.

The production of this SWMP will be a significant addition of new/updated data. Therefore, in due course, this should trigger a review of the SFRA. The SFRA should consider these risks in the following ways:

- Large areas of deep (>0.5m) flooding should be shown as Local Flood Risk Zones, unless there is evidence to suggest that these risks have been mitigated, for example by high capacity drainage or pumping infrastructure;
- Small, isolated areas of deep (>0.5m) flooding should be investigated to determine how likely they are to be at flood risk but do not need to be shown if there is no significant risk;
- Large areas of shallower flooding should be identified as Local Flood Risk Zones if they pose a significant risk, but do not need to be shown if the risks are relatively minor;
- Smaller isolated areas of shallower flooding should generally not be identified as Local Flood Risk Zones, unless there is a particular significant risk associated with that area, as it must be expected that most areas will be affected to some extent by rainwater;
- Routes of fast flowing water may be considered as Local Flood Risk Zones if they pose a significant risk;
- Areas of 'Very High' and 'High' Susceptibility to Groundwater Flood Risk, should be shown where they are likely to pose a significant risk of flooding or where they are likely to affect the nature of future development, especially for the design and use of sub-surface spaces.

Identifying an area as a Local Flood Risk Zone should mean that it is then to be treated in a similar way to Environment Agency Flood Zone 3, namely that a Flood Risk Assessment is required and measures should be taken to reduce the likelihood and impact of any flooding.

Where a Critical Drainage Area contributes significant amounts of surface water to a Local Flood Risk Zone, the SFRA should identify this and suggest strict application of sustainable drainage measures for developments. Developments should i) utilise SuDS unless there are practical reasons for not doing so, ii) aim to achieve greenfield run-off rates and iii) ensure that surface water run-off is managed as close to its source as possible, in accordance with the following Sustainable Drainage Hierarchy:

1. store rainwater for later use;
2. use infiltration techniques, such as porous surfaces in non-clay areas;
3. attenuate rainwater in ponds or open water features for gradual release;
4. attenuate rainwater by storing in tanks or sealed water features for gradual release;
5. discharge rainwater direct to a watercourse;
6. discharge rainwater to a surface water sewer/drain;
7. discharge rainwater to a combined sewer.

In addition, drainage should be designed and implemented in ways that deliver other policy objectives including water quality, biodiversity, amenity and recreation.

Using the SWMP to update policies in Development Plan Documents

Ideally the review of the borough SFRA should be a pre-cursor to any significant change to the Core Strategy and development control policies. Therefore reference to the SFRA should automatically update the approach to local flood risks. Where the SFRA has not been updated, the review of Development Plan Documents should consider the same steps outlined above for the SFRA review.

Using the SWMP to influence major areas of redevelopment

Where major development areas are proposed these should be examined for:

- local Flood Risk Zones that affect the area;
- susceptibility to Groundwater flooding;
- contribution of run-off to Local Flood Risk Zones beyond the actual redevelopment area.

Given the large scale of major developments, it is unlikely that the Local Flood Risk would prevent redevelopment taking place, but it may affect the location, uses, design and resilience of the proposals. Therefore a Flood Risk Assessment needs to be undertaken, and it should consider:

- the location of different types of land use within the site(s);
- the layout and design of buildings and spaces to take account of flood risk, for example by dedicating particular flow routes or flood storage areas;
- measures to reduce the impact of any flood, through flood resistance/resilience measures/materials;
- incorporating sustainable drainage and rainwater storage to reduce run-off to adjacent areas;
- linkages or joint approaches for groups of sites, possibly including those in surrounding areas.

Using the SWMP to influence specific development proposals

Where development is proposed in an area covered wholly or partially by a Local Flood Risk Zone, this should trigger a Flood Risk Assessment, as already required under PPS25.

Whilst some small scale developments may not be appropriate in high risk areas, in most cases it will be a matter of ensuring that the Flood Risk Assessment considers those items listed under major developments above and also considers some or all of the following site specific issues:

- Are the flow paths and areas of ponding correct, and will these be altered by the proposed development?
- Has the site been planned sequentially to keep major surface water flow paths clear?
- Has exceedance of the site's drainage capacity been adequately dealt with? Where will exceedance flows run off the site?
- Could there be benefits to existing properties at risk downstream of the site if additional storage could be provided on the site?
- In the event of surface water flooding to the site, have safe access to / egress from the site been adequately considered?
- Have the site levels been altered, or will they be altered during development? Consider how this will impact surface water flood risk on the site and to adjacent areas.
- Have inter-dependencies between utilities and the development been considered? (for example, the electricity supply for lifts in building or for water pumps).

Mapping Checklist

Table E-1 below indicates the SWMP maps located throughout this document that are of potential use to spatial planning, and indicates which maps may be suitable for replacing existing SFRA maps:

Issue	SWMP maps	Consider replacing existing SFRA maps?
Surface water flood risk	Figure 3-1 with details shown in Section 3.8 and Appendix D	Yes – more detailed methodology to that used for the SFRA.
Groundwater flooding	Figure 3-2	Yes – more detailed methodology to that used for the SFRA.
Infiltration SUDs suitability map	Figure 4-1	Yes – provides a consistent initial infiltration SUDs screening process for the whole catchment, but does not replace on-site assessments.
Recorded incidents of sewer flooding	Figure 3-3	Yes – similar method (based on postcode sector) but brings the records up-to-date to June 2010.

Table E-1: SWMP maps of potential use to spatial planners

Appendix F Resilience Forum and Emergency Planner Information Pack

Background

Presently, surface water flooding is less well understood than other sources of flooding, partly because surface water events tend to happen and disperse quickly so there is a lack of accurate and consistent records, and partly because they are not tied to readily identifiable features such as rivers or the sea. Therefore this SWMP offers an opportunity to communicate up to date information about locations at risk from surface water flooding to those with an interest. Responses in an emergency will be informed by known surface water flooding locations, especially near public buildings and major transport routes and important infrastructure.

The purpose of this information pack is to assist in communicating surface water flood risk to the Local Resilience Forum and Emergency Planners to enable them to ensure that incident management plans are updated based on the improved understanding of surface water flooding. SWMP mapping outputs and knowledge will be used to:

- Update Community Risk Registers (CRR);
- Update Multi-Agency Flood Plans (MAFP).

This pack is presented as a Frequently Asked Questions (FAQ) document and contains information that addresses the following points:

1. How can SWMP outputs improve Community Risk Registers?
2. How can SWMP outputs improve Multi-Agency Flood Planning?
3. How do SWMP outputs compliment the Flood Forecasting Centre's Extreme Rainfall Alert (ERA)?
4. Examples of Good Practice.

In updating Multi-Agency Flood Plans, as well as the neighbouring local authorities, the Council also has a responsibility to partner with other key stakeholders and risk management authorities, who share the responsibility for decisions and actions. Ideally, the informal relationships established within the context of the SWMP programme should be formalised to ensure clear lines of communication and continued mutual cooperation through the development of a Memorandum of Understanding. This should include appropriate aspects for Surface Water Flood Risk Management.

Frequently Asked Questions

1. How can SWMP outputs improve Community Risk Registers?

Community Risk Registers (CRR) are prepared by Category 1 responders and are required as part of the Civil Contingencies Act (CCA) 2004. The CCA requires that Category 1 responders undertake risk assessments and maintain these risks in a CCR. In this context risks are defined as events which could result in major consequences, and they include risks from flooding.

Outputs from SWMP can be used to reduce the uncertainties associated with assessing the likelihood and impact of surface water flooding (see Community Risk Register HL18 for more information on current risk assessment). The SWMP presents an opportunity for the identification of vulnerable sites and populations which may be at increased risk, and enables risk-based prevention or mitigation actions to be taken.

2. How can SWMP outputs improve Multi-Agency Flood Plans?

Multi-Agency Flood Plans (MAFP) are specific emergency plans which should be developed by LRFs to deliver a coordinated plan to respond to flood incidents. MAFPs recognise the need for specific flooding emergency plans, due to the complex nature of flooding and the consequences that can arise. Guidance on producing a MAFP is available at http://www.ukresilience.gov.uk/media/ukresilience/assets/flooding_ma_planning_guidance_0208.pdf.

Outputs from SWMPs should inform the development of, or update, the MAFP.

The SWMP surface water mapping should be used as an initial indicator of a possible risk. A Flood Risk Assessment at a site shown as being at risk of surface water flooding should consider:

- Impacts on flood receptor sites
- The degree of receptor vulnerability
- In the event of surface water flooding to the site, has safe access to / egress from the site been adequately considered?

Table F-1 below indicates the SWMP maps which are of potential use to emergency planning, and indicates which maps may be suitable for updating existing MAFP maps.

Issue	SWMP maps	Consider updating existing MAFP maps?
Surface water flood risk	Appendix D	Yes – more detailed methodology to that used for the MAFP.
Groundwater flooding	Figure 3-2	Yes – more detailed methodology to that used for the MAFP.

Table F-1: SWMP maps of potential use to emergency planners

3. How do SWMP outputs compliment the Flood Forecasting Centre's Extreme Rainfall Alert (ERA)?

In 2008 the Met Office and the Environment Agency set up the Flood Forecasting Centre to provide services to emergency and professional partners. The Flood Forecasting Centre provides an Extreme Rainfall Alert (ERA) service to Category 1 and Category 2 responders. The ERA is issued at county level and is used to forecast and warn of extreme rainfall that could lead to surface water flooding, particularly in urban areas. It is designed to help local response organisations manage the impact of flooding via two products:

1. Guidance – issued when there is a 10% or greater chance or extreme rainfall;
2. Alert – issued when there is a greater than 20% chance of extreme rainfall.

The ERA cannot provide site-specific real-time surface water flood forecast, but does offer a county level alert of impending rainfall. The alert is based on the probability of rainfall occurring, rather than being a definitive forecast.

Surface water flooding has very short lead times and is hard to predict in real time because local topography and drainage infrastructure affect the direction of runoff and location of flooding. However, the assessment carried out as part of this SWMP study has taken an important step towards identifying the likely flow pathways and locations of ponding of surface water. Used in parallel with the ERA, this can be used to improve emergency planning and responses for surface water flooding events.

4. Examples of Good Practice for Emergency Planners

- **Ensure that a programme of engagement on flood risk awareness is initiated within the Borough.** Meet with key corporate communications teams to agree an approach to social change, education and awareness-raising in line with the needs of the Borough.

- **Build trust -** Public and stakeholder trust in authorities through **long term, transparent engagement.**

  - Ensure there are key messages in the programme of engagement that encourage attitude and behaviour change with the public. This will help to address misconceptions that flooding results from a failure on someone's part.

  - Educate the public to help them better understand where responsibilities lie, changes they can make to their own lifestyles, and actions they can take to physically reduce personal flood risk.

  - Encourage communities towards creating their own community action/response plans to support wider ownership of risk and responsibilities

  - Consider holding face to face interviews with at-risk families and groups to better inform your Community Risk Register. This will help both you and them to better understand risk and plan to manage it.

- Establish a **common baseline for flood data** and information in line with EA requirements. Set up a Borough '**One-Stop Shop'** to enable efficient information consolidation and data sharing. This will support efficient planning and updating of the MAFP.

- **Develop a surface water flooding response plan with vulnerable receptors as external partners**. Vulnerable receptors could include hospitals, schools and care homes. Identify these through Emergency Planning and other relevant forums and build into stakeholder engagement. This will assist with prioritisation decisions. For example 'early warning' processes, appropriate measures, funding and resourcing.

- Link the actions from the SWMP directly to the **Flood Risk Management Strategy** for the Borough such that a programme of work is visible.

- Link with the Planning Department's **Strategic Flood Risk Assessment** (SRFA) to ensure that Emergency Planners are involved in land use decisions for new development.

- Create a key facts and 'what to do' section for surface water flooding in **emergency handbooks**. Provide easy- to- reach contact points, and regularly update your website

- Work with other agencies, such as the **Environment Agency flood alert/warning schemes**, in the interests of cost effectiveness and good communication - but still own the responsibility for your borough. Use others' information to reinforce your own process.

LUTON BOROUGH COUNCIL

Appendix G Action Plan Table

Group	ID	Action: What?	Action: How?	Action: Where?	Priority Ranking	Benefit	Potential Funding Source	Timing: Timeframe	Timing: Start Date	Responsibility: Lead Organisation	Responsibility: Primary Support	Other Stakeholders
Legislative Actions	1	Co-operate with other local Risk Management Authorities in exercising functions under both the Act and the Regulations.	Regular sharing of data and expertise in addressing local flooding issues	Catchment-wide	High	Meeting obligations under the Floods and Water Management Act (FWMA) and Flood Risk Regulations (FRR). Effective management of local flood risk.	LBC and CBC	Ongoing	2011	LBC	Environment Agency Thames Water Anglian Water	Network Rail
	2	Establish and Maintain a Register of structures or features which are considered to have an effect on flood risk	Integrate 'Register' with existing LBC Highways Asset Management System (AMS)	Catchment-wide	High	Meeting obligations under FWMA. Improved understanding of local flood risk mechanisms and asset importance. Knowledge of local flood risk management assets	LBC	Establishment - Short Maintain - Ongoing	2011	LBC	Environment Agency	
	3	Establish internal procedure for implementing 'designation powers' as provided by the FWMA	Review designation powers and implement procedures in relevant council services	LBC	Medium	Full utilisation of available legislative powers to manage local flood risk	LBC	Ongoing	2011	LBC		
	4	Investigate flood incidents as they are reported	Investigate flooding incidents (where other risk management authorities do not respond and to the extent considered necessary or appropriate) to identify which authorities have relevant functions to deal with the flood and whether each of them intends to respond.	Catchment-wide	High	Meeting obligations under FWMA. Improved understanding of local flood risk issues.	LBC and CBC	Ongoing	2011	LBC	Environment Agency	
	5	Establish a SuDS Approval Body (SAB)	Refer to Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management 'A Living Document', February 2011, Local Government Association.	Catchment-wide	High	Meeting obligations under FWMA. Long term implementation of sustainable flood risk management.	LBC and CBC	Short	TBC	LBC	Defra	Relevant representation from other Council services

Group	ID	Action			Priority Ranking	Benefit	Potential Funding Source	Timing		Responsibility		Other Stakeholders
		What?	How?	Where?				Timeframe	Start Date	Lead Organisation	Primary Support	
	6	Develop, maintain, apply and monitor a Strategy for local flood risk management of the catchment.	Use the outcomes of the SWMP as the first stage of preparing a strategy. Refer to Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management 'A Living Document', February 2011, Local Government Association.	Catchment-wide	High	Meeting obligations under FWMA. Effective management of local flood risk	LBC and CBC	Ongoing	2012	LBC	Environment Agency	
	7	Record flooding incidents in a consistent manner	Develop and use a standardised data capture form (proforma)	Catchment-wide	High	Consistency of data records	LBC and CBC	Ongoing	2011	LBC	Emergency Planning	Highways
	8	Contribute towards achievement of corporate sustainable development goals related to flood risk and water management	Look for opportunities to integrate fluvial and surface water flood risk reduction measures through liaison with Planning & Development Control	Catchment-wide	High	Meeting obligations under FWMA. Long term implementation of sustainable flood risk management.	LBC and CBC	Ongoing	2011	LBC	Planning	
	9	Review Preliminary Flood Risk Assessment in line with Flood Risk Regulations requirements	Undertake review in line with guidance issued by EA / Defra	LBC	Low	Flood Risk Regulations compliance	Defra / EA	Long	2017	LBC		
	10	Establish internal procedure for implementing 'works powers' as provided by the FWMA	Review works powers and implement procedures in relevant council services	LBC	Medium	Full utilisation of available legislative powers to manage local flood risk	LBC	Ongoing	2011	LBC		
Local Actions - General Flood Risk Management	11	Take forward actions set out in the SWMP with partners and other flood risk management authorities including Central Beds Council and others (if any)	Continue to run a Flood Management Group within the Council and liaise with CBC and others as necessary	Catchment-wide	High	Co-ordinated delivery of local flood risk management across the catchment	LBC, partners, CBC, others	Ongoing	2011	LBC and CBC	Luton Flood Group, partners, CBC, others	Environment Agency, Thames Water, Network Rail
	12	Seek opportunities to integrate fluvial and surface water flood risk reduction measures	Review and monitoring of policy implementation and in partnership with EA	Catchment-wide	High	Mid-long term reduction in flood risk and improvement in water quality	Private developer	Ongoing	2011	LBC and CBC	All other LLFA Departments	
	13	Look for opportunities to reduce flood risk to critical transport infrastructure whilst upgrading the existing drainage network in partnership with TW and Network Rail	Discussion with relevant officers of LBC & CBC	Catchment-wide	High	Refine understanding of risk to critical infrastructure. Prioritise localised drainage improvements	TW and Network Rail	Medium	2011	LBC	Highways	Thames Water, Network Rail, LLAOL

LUTON BOROUGH COUNCIL

Group	ID	Action			Priority Ranking	Benefit	Potential Funding Source	Timing		Responsibility		Other Stakeholders
		What?	How?	Where?				Timeframe	Start Date	Lead Organisation	Primary Support	
	14	Ensure current emergency response to catchment-wide surface water flooding is appropriate	Liaise with Emergency Planning forum	Catchment-wide	High	Emergency response based on best available information	LBC and CBC	Short	2011	LBC	Local Resilience Forum	Network Rail
	15	Determine extent of i) residential use of at-risk basements, ii) groundwater boreholes and iii) geological conditions, and decide if a risk from flooding exists.	Use predicted extent of 75year flood to enable determination.	Catchment-wide	High	Better understanding of scope of flooding impact, and improving identification of solutions and funding	LBC and CBC	Medium	2011	LBC	Development Control	Local Residents
	16	Consider retrofitting flood resilience and resistance measures to basement properties where there is a history (and likely future risk) of groundwater ingress	Impermeable membranes, additional drainage.	Catchment-wide	Medium	Reduction in the impact of flooding	Property Level Flood Protection (Defra)	Long	TBC	LBC	Building Control	Local Residents
	17	Determine whether services (e.g. power, telecommunications) are resilient to surface water flooding	Discuss the overall resilience of services with relevant companies	Catchment-wide	Medium	Community resilience to flooding	Service providers	Medium	2011	LBC	Emergency Planning	
	18	Installation of additional road gullies or alternative drainage systems to reduce standing water depth and duration	As part of highways improvement programme include additional construction task of installing additional gullies or alternative drainage systems where feasible and required. Consultation with Thames Water may be required.	In relevant CDAs across catchment	Medium	Reduction in the probability of flooding	LBC/CBC/Developer contributions / other?	Medium	2011	LBC	Thames Water	
	19	Determine areas within the catchment which are appropriate for retrofitting bioretention basins and carparking pods	Desktop study to determine feasibility of incorporating these SUDs	Catchment-wide	Medium	Will assist in reducing runoff volumes and improving quality of water discharging to watercourses	Developer contributions / other?	Medium	2011	LBC		Environment Agency
Policy	20	Developments across the catchment to include at least one 'at source' SuDS measure, resulting in a net improvement in water quantity or quality discharging to sewer	Development Control Review and Monitoring of policy implementation	Catchment-wide	High	Mid-long term reduction in flood risk and improvement in water quality	Private developer	Ongoing	2011	LBC		Environment Agency, CBC

Group	ID	Action			Priority Ranking	Benefit	Potential Funding Source	Timing		Responsibility		Other Stakeholders
		What?	How?	Where?				Timeframe	Start Date	Lead Organisation	Primary Support	
	21	Developments across the catchment consisting of more than 1 property or greater than 0.1 hectares to reduce runoff from site to the greenfield equivalent volume and runoff rate	Development Control Review and Monitoring of policy implementation	Catchment-wide	High	Mid-long term reduction in the probability of flooding	Private developer	Ongoing	2011	LBC	Environment Agency?	Environment Agency, CBC
	22	Developments across the catchment consisting of more than 1 property or greater than 0.1 hectare in CDAs to reduce runoff to at least 50% of existing volume and rate,	Development Control Review and Monitoring of policy implementation	Catchment-wide	High	Mid-long term reduction in the probability of flooding	Private developer	Ongoing	2011	LBC	Environment Agency	Environment Agency, CBC
	23	Implement Policy Area recommendations made during Phase 3 of SWMP	Development Control Review and Monitoring of policy implementation	Catchment-wide	High	Mid-long term reduction in the probability of flooding	Private developer	Ongoing	2011	LBC	Environment Agency	Environment Agency, CBC
Maintenance	24	Ensure drainage systems are operating at capacity - maintenance of gullies	Review existing gully clearance/ maintenance schedules and if necessary revise/prioritise CDAs	Catchment-wide	High	Flooding isn't exacerbated	LBC and CBC	Ongoing	2011	LBC	Street Cleansing	Thames Water
	25	Ensure drainage systems are operating at capacity - maintenance of SW sewers	May require mapping of existing drainage infrastructure. Review existing maintenance schedules and if necessary revise/prioritise CDAs	Catchment-wide	High	Flooding isn't exacerbated	Thames Water	Ongoing	2011	Thames Water	LBC and CBC	Thames Water
Local Actions - General CDA	26	Developments in CDAs to contribute to measures to reduce surface water flood risk in the CDA.	Section 106, Community Infrastructure Levy, Development Control Policy	LBC, and CBC?	High	Mid-long term reduction in the probability of flooding	Private developer	Ongoing	2011	LBC	Building Control	Environment Agency, CBC
	27	Seek to include SuDS retrofitting policies in Planning reform to enhance or replace conventional drainage systems in Critical Drainage Areas (CDAs), or elsewhere as opportunities arise	Review and monitoring of policy implementation	Catchment-wide	Low	Mid-long term reduction in flood risk and improvement in water quality	Private developer	Medium	2012	LBC and CBC	Building Control	

Group	ID	Action			Priority Ranking	Benefit	Potential Funding Source	Timing		Responsibility		Other Stakeholders
		What?	How?	Where?				Timeframe	Start Date	Lead Organisation	Primary Support	
	28	Use SWMP mapped outputs to require developers In CDAs to demonstrate compliance with PPS 25 to ensure development will remain safe and will not increase risk to others, where necessary supported by more detailed integrated hydraulic modelling.	Development Control Policy	LBC, and CBC?	High	Mid-long term reduction in the consequences of flooding	Private developer	Ongoing	2011	LBC/CBC	Building Control	
	29	Ensure any development in a CDA falling within a Strategic Growth Area is designed to limit runoff to low predevelopment Greenfield runoff rates.	Development Control Policy	All Strategic Growth Areas	High	Long term reduction in flood risk in the GA	Private developer	Ongoing	2011	LBC		Environment Agency, CBC
	30	Investigate whether flooding incidents have occurred in CDAs	Review flooding reports, then conduct survey of local residents (e.g. mail drop, door knocking) to update database	Catchment-wide	High	Validate model outputs, resident 'buy in'	LBC and CBC	Short	2011	LBC	Local Resilience Forum	Local Residents
	31	Monitor Low and Medium Priority CDAs for future flood risk related problems and manage future development to minimise impact on flood risk	Development control policy and monitoring of flood risk incident register	Low / Medium Priority CDAs	Low / Medium	Proactive management of potential flood risk in areas of higher risk probability	LBC	Ongoing	2011	LBC	Highways	
	32	Carry out more detailed studies including further investigation of the technical issues and consultation with local stakeholders	Site investigations and modelling	High Priority CDAs	High	Refine understanding in CDAs	LBC	Short	2011	LBC		Environment Agency
Local Actions - High Priority CDAs	33	Undertake a detailed feasibility study to confirm significant level of flood risk predicted by SWMP study and use as justification for possible FDGiA funding	Engage consultant to complete detailed study and work with EA to investigate FDGiA opportunities	Barton Road / Great Bramingham / Catbrook	High	Improved understanding of CDA flood mechanisms and potential funding opportunities for mitigation solutions	FDGiA / LBC / EA	Short	2011	LBC	EA	Thames Water, Local Residents
	34	Undertake a detailed feasibility study to ensure maximum benefit of proposed EA Flood Storage Area in Lewsey Park for surface water flooding issues in the CDA	Engage consultant to complete detailed study and work with EA, Thames Water and Anglian Water to maximise benefits from proposed scheme	Barnfield West Academy / Poynters Road	High	Partnership working with other RMAs to achieve multiple benefits for local flood risk mitigation	EA / LBC / Thames Water / Anglian Water	Short	2011	EA	LBC	Thames Water, Anglian Water, Local Residents

Group	ID	Action			Priority Ranking	Benefit	Potential Funding Source	Timing		Responsibility		Other Stakeholders
		What?	How?	Where?				Timeframe	Start Date	Lead Organisation	Primary Support	
	35	Undertake a staged investigation to better understand flood risk in this CDA - starting with a modelling study joining the EA River Lea model to the SWMP surface water flood model.	Engage consultant to complete modelling investigation	Chapel Street, Stuart Street	High	Understanding of flood mechanisms, potential impacts and opportunities for mitigation	EA / LBC	Short	2011	LBC	EA	Local Residents
	36	Work proactively with the EA to monitor the condition of the River Lea culvert through the town centre	Share condition assessment information and jointly review other information as it becomes available	Luton Town Centre	High	Understanding of culvert condition and associated potential collapse risk	EA / LBC	Ongoing	2011	EA	LBC	Local Residents
	37	Engage with General Motors and Luton Airport to monitor any future flooding and assess the associated risk	Maintain regular contact with relevant parties to share flood risk information	Vauxhall Way	High	Understanding of local flood risk and potential impacts	LBC / Land owners	Ongoing	2011	LBC	Land owners	
	38	Work with the EA and Thames Water to mitigate the water quality impacts related to the CSO at Kimpton Road / Vauxhall Road	Joint investigation of mitigation solutions that have multiple benefits	Vauxhall Way	High	Partnership working with other RMAs to achieve multiple benefits for local flood risk mitigation and river water quality improvement	LBC / EA / Thames Water / EU	Short	2011	LBC	EA	Thames Water
Underpass Risk Assessment	39	Carry out a flood risk assessment for the pumping station/drainage system serving the underpass in Wigmore Lane	This should include ascertaining the standard of protection currently provided and, if necessary, carrying out further investigation/ modelling to improve the level of understanding. Establish need for more detailed analysis and/or higher standard of protection.	Adjacent to Someries Infant School	Low	Refine understanding of flood risk in underpass	LBC	Medium	2011	LBC	Street Lighting	
Underpass Risk Assessment	40	Carry out a flood risk assessment for the pumping station/drainage system serving the underpass to Crawley Road	This should include ascertaining the standard of protection currently provided and, if necessary, carrying out further investigation/ modelling to improve the level of understanding. Establish need for more detailed analysis and/or higher standard of protection.	Under Telford Way	Low	Refine understanding of flood risk in underpass	LBC	Medium	2011	LBC	Street Lighting	

Group	ID	Action			Priority Ranking	Benefit	Potential Funding Source	Timing		Responsibility		Other Stakeholders
		What?	How?	Where?				Timeframe	Start Date	Lead Organisation	Primary Support	
	41	Carry out a flood risk assessment for any pumping station/drainage system serving any underpass or tunnel in CBC area of catchment	This should include ascertaining the standard of protection currently provided and, if necessary, carrying out further investigation/ modelling to improve the level of understanding. Establish need for more detailed analysis and/or higher standard of protection.	CBC area of catchment	Low	Refine understanding of flood risk in underpass or tunnel	CBC	Medium	2011	CBC	LBC	