Leicestershire and Leicester City Level 1 Strategic Flood Risk Assessment

Final Report

October 2017

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Contract

This report describes work commissioned by the non-unitary authorities of Leicestershire, Leicester City Council and Leicestershire County Council. The Council's joint representative for the contract was David Nash, Strategic Planning Consultant supporting the Joint Strategic Planning Manager for the County and Districts of Leicestershire, Leicester City and the LLEP.

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Purpose

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JBA Consulting has no liability regarding the use of this report except to the client.

Acknowledgements

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- All the commissioning authorities;
- The Lead Local Flood Authorities (Leicester City Council and Leicestershire County Council);
- Environment Agency;
- Canal and River Trust;
- Highways England;
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- Trent Rivers Trust;
- Welland Rivers Trust; and,
- Planners at the neighbouring authorities

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Executive Summary

Introduction

The main purpose of this Strategic Flood Risk Assessment (SFRA) is to provide a comprehensive and robust evidence base to support the production of the Strategic Growth Plan (SGP), being prepared by the seven non-unitary borough and district councils in Leicestershire, Leicestershire County Council and Leicester City Council.

SFRA objectives

The key objectives of the 2017 Strategic Flood Risk Assessment are:

- To provide up to date information and guidance on flood risk across Leicestershire County and Leicester City, taking into account the latest flood risk information and the current state of national planning policy;
- To determine the variations in current and future flood risk from all sources of flooding in Leicestershire County and Leicester City;
- To identify the requirements for site-specific flood risk assessments;
- To consider opportunities to reduce flood risk to existing communities and developments;
- To enable the commissioning authorities to apply the Sequential Test and aid authorities in identifying when the Exception Test is required, when determining preferred directions of growth; and,
- To inform the Sustainability Appraisal of the SGP, so that flood risk is taken into account when considering strategic growth options.

SFRA outputs

This report fulfils a Level One SFRA requirement.

- Assessment of all potential sources of flooding;
- Mapping of location and extent of functional floodplain;
- Mapping of areas covered by an existing flood alert and flood warning;
- Mapping of areas protected by existing flood defences and their condition;
- Assessment of standard of protection provided by existing flood risk management infrastructure;
- Assessment of the potential impact of climate change on flood risk;
- Assessment of locations where additional development may increase flood risk elsewhere;
- Details of where proposed flood schemes are planned;
- Recommendations of the criteria that should be used to assess future development proposals and the development of a Sequential Test and sequential approach to flood risk; and,
- Guidance for developers including requirements for site-specific flood risk assessments and the application of sustainable drainage systems.

Summary of the SFRA

Appraisal of flood risk

- There have been several recorded flood incidents across Leicestershire County and Leicester City, from a combination of sources. Prominent sources of flooding are fluvial, surface water, sewer and flood incidents associated with water infrastructure issues such as culvert blockages or insufficient capacity in the sewer network.
- Much of the fluvial flood risk in the study area is associated with the River Soar and its tributaries, as well as the River Welland, the River Avon and the River Sence. There are also numerous ordinary watercourses that pose a flood risk in the area. Often the combination of watercourses and the interaction of two or more sources of out of bank flow across the floodplain can have profound implications for the extent of the risk.
- Surface water is one of the primary flood risks in the study area. Several urban areas and rural settlements have a well-documented history of surface water flooding and the Risk of Flooding from Surface Water (RoFfSW) mapping shows several prominent overland flow

routes, following topographical flow paths of existing watercourses or dry valleys and local road infrastructure with some isolated ponding located in low-lying areas.

- The sewers are managed by two Water and Sewerage Companies; Anglian Water and Severn Trent Water. Previous SFRAs note much of the sewer network dates to the Victorian era and the capacity and conditions of sections of the network is unknown.

  Several historic records relate to sewer flooding. However, for areas where there were re-occurring issues maintenance work may have been undertaken and the risk may have been removed or reduced.

- There are very few recorded incidents of groundwater flooding in the study area. A desk-study review of existing assessments and documents has identified six potential groundwater flooding mechanisms in Leicester City and Leicestershire County.
- There are no records of flooding from reservoirs impacting properties inside the study area.
- There are three canals in the study area: Grantham Canal, Grand Union Canal and Ashby Canal. 26 records of a canal overtopping have been recorded across the study area from 1969 to 2013.
- Currently there are 16 Flood Alert Areas and 59 Flood Warning Areas (FWAs) covering the study area.

Flood defences

- A high-level review of existing flood defences was undertaken and found several communities benefit from flood defences and alleviation schemes in Leicestershire County and Leicester City.
- The Environment Agency's Raised Flood Defences dataset indicates that there are notable differences between the design and current standard of protection and there are locations where defences are considered to be in a poor condition.
- There are also several assets which are considered to significantly affect whether areas will flood in Leicester and there are also other flood risk management initiatives such as property level flood protection schemes and retro-fits SuDS schemes.
- There are several on-going schemes and projects to reduce the risk of flooding in Leicestershire comprising natural flood management initiatives.
- Where areas benefit from defences and alleviation measures, there remains a residual risk, should the defences breach or fail. At the time of preparing this SFRA, the areas benefiting from defences dataset was in the process of being updated.

Relevant studies

- There are many relevant regional and local key studies which complement the SFRA and have been considered, such as the Catchment Flood Management Plan, River Basin Management Plan, Preliminary Flood Risk Assessments and Local Flood Risk Management Strategies. Other policy considerations have also been incorporated, such as sustainable development principles, climate change and flood risk management

Policy Recommendations

The following policy recommendations are to be considered by the commissioning authorities in the development of the Strategic Growth Plan.

Development and planning considerations

Identifying potential growth areas and future development

- The sequential approach to development and flood risk should be adopted, directing new development to areas of lowest risk.
- It is recommended that the climate change modelling and mapping in this SFRA is taken into consideration when identifying sites for development in the proposed growth areas.
- The potential growth area summary tables provide an indication on where flood risk may need to be investigated in more detail as part of a site-specific Flood Risk Assessment. This may include areas where:
  - The Environment Agency's Flood Zone maps do not cover the watercourse. Environment Agency mapping of Flood Zones covers watercourses with a catchment greater than 3km^2 (Rivers and Sea). If a watercourse or drain is shown on OS mapping but is not covered by a Flood Zone, this does not mean there is no potential flood risk.

- Locations where surface water flooding is the predominant flood risk could be investigated further by use of surface water hydraulic modelling, or in combination with fluvial modelling, to assess the interactions between the two in more detail. Similarly, for any locations which suffer from sewer flooding or sewer capacity issues; this data can be incorporated into hydraulic models to more accurately represent the surface water system.
- Any developments shown to be at residual flood risk, for example from a breach or overtopping scenario (e.g. reservoir, canal, perched watercourse), may require modelling.

Site-specific Flood Risk Assessments

- The Level 1 SFRA is not intended to replace site-specific Flood Risk Assessments (FRA). Site-specific FRAs are required by developers to provide a greater level of detail on flood risk and any protection provided by defences and, where necessary, demonstrate the development passes the Exception Test.
- Developers should consult with the relevant local planning authorities, Lead Local Flood Authority and the Environment Agency (where relevant), at an early stage to discuss flood risk including requirements for site-specific FRAs, detailed hydraulic modelling, and drainage assessment and design. For example, there are watercourses where it was not possible to model the impacts of climate change (i.e. the River Welland) and developers may need to further investigate the flood risk as part of a site-specific FRA. Appendix H provides a list of all detailed hydraulic models used in this SFRA.
- New development and re-development of land should wherever possible seek opportunities to reduce overall level of flood risk at the site.

Surface water management and SuDS

- Planners should be aware of local requirements set by the Lead Local Flood Authorities for surface water management for major and minor developments and ensure development proposals and applications are compliant with the LLFA's policy and specific requirements. Where necessary, consultations should be undertaken with the relevant LLFA to confirm the specific requirements in relation to post-development, surface water runoff management on-site.
- Developers should submit applications in accordance with the requirements of the DEFRA Non-Statutory Technical Standards for SuDS and in line with CIRIA C753 the SuDS Manual.
- Where reasonably practical, all drainage proposals should follow the SuDS discharge hierarchy and management train which prioritises infiltration at source first. How proposals follow this hierarchy and management train should clearly be demonstrated, with adequate evidence and reasoning. If necessary, adequate evidence and explanation concerning why

infiltration methods are not considered to be feasible and why methods lower down the hierarchy are considered to be feasible, may need to be provided with drainage proposals.

- All new development should aim to minimise areas of impermeable ground to reduce surface water runoff and sustainable drainage systems (SuDS) should be used on all new development, unless it is proved technically unfeasible given best available techniques. SuDS which provide multiple benefits should be maximised.
- It should be demonstrated through a Surface Water Drainage Strategy or as part of a site-specific Flood Risk Assessment, that the proposed drainage scheme, and site layout and design, will prevent properties from flooding from surface water. A detailed site-specific assessment of SuDS would be needed to incorporate SuDS successfully into the development proposals and where possible, seek to identify betterment. All development should adopt source control SuDS techniques to reduce the risk of frequent low impact flooding due to post-development runoff.
- For proposed developments, it is imperative that a site-specific infiltration test is conducted early on as part of the design of the development, to confirm whether the water table is low enough to allow for SuDS techniques that are designed to encourage infiltration and to confirm the adequacy of infiltration rates.
- Where sites lie within or close to Groundwater Source Protection Zones or aquifers, there may be a requirement for a form of pre-treatment prior to infiltration. Further guidance can be found in the CIRIA SuDS manual on the level of water quality treatment required for drainage via infiltration.
- Consideration must also be given to residual risk and maintenance of sustainable drainage and surface water systems. Developers should produce a maintenance plan for SuDS, stating who will own and who will maintain the proposed SuDS scheme.
- SuDS proposals should contain an adequate number of treatments stages to ensure any pollutants are dealt with on site and do not have a detrimental impact on receiving waterbodies.
- The promotion and adoption of water efficient practices in new development will help to manage water resources and work towards sustainable development and will help to reduce any increase in pressure on existing water and wastewater infrastructure.
- Opportunities for SuDS to link with green infrastructure should be investigated and where appropriate, taken forward.

Infrastructure and safe access

Safe access and egress at sites will need to be demonstrated by the developer; the development should be higher than the 1 in 100-year (1% Annual Exceedance Probability [AEP]) flood level, plus an allowance for climate change, and emergency vehicular access should be possible during times of flood. Finished Floor Levels should be above the 1 in 100-year (1% AEP) flood level, plus an allowance for climate change and an appropriate allowance for freeboard. The additional height that the floor level is raised above the maximum water level is referred to as the “freeboard”.

Safe access and egress should also be considered when appraising the residual risk posed by surface water drainage schemes. For example, if the highway forms part of the route of exceedance for surface water drainage, this should be considered in the assessment of safe access and egress.

Residual risk

Any developments located within an area protected by flood defences, where the condition of those defences is ‘fair’ or ‘poor’, or where the standard of protection is not of the required standard should be identified.

Development located in an area benefiting from defences and / or located behind a defence will require breach and overtopping analysis to be undertaken as part of a site-specific FRA.

Resistance and resilience measures will be required if buildings are situated in the flood risk area. Such measures may include raising electrics and plug sockets and tiling the ground floor. An emergency Flood Plan may need to be prepared to help manage the residual risk of flooding. As applicable in all cases of flood risk, opportunities to enhance green infrastructure and reduce flood risk by making space for water should be sought.

Cumulative impact and land use change considerations

- The cumulative impact of development and the effect of land use change should be considered at the planning application and development design stages. Appropriate

mitigation measures should be identified and informed by an appropriate FRA, to ensure flood risk is not exacerbated, and in many cases the development should be used to improve the flood risk.

- When considering developing land within the proposed growth areas, consideration must be given to the potential cumulative impact of the loss of floodplain as a result of development. The effect of the loss of floodplain storage should be assessed, at both the development and elsewhere in the catchment and, if required, the scale and scope of appropriate mitigation should be identified. The application of SuDS should be used to help mitigate the impact of development and prevent increases in flood risk to third party land.
- Onsite attenuation schemes would need to be tested against the hydrographs of the unnamed drain to ensure flows are not exacerbated downstream within the catchment.
- Maintenance and upkeep of SuDS have been neglected in the past because of lack of clarity over where responsibility for it lies. Therefore, is it important that maintenance and upkeep for mitigation measures, such as SuDS, has been set out as part of a drainage strategy and that management funding for the lifetime of the development has been agreed

Future flood management in Leicester City and Leicestershire County

Green Infrastructure and WFD

Developments should demonstrate opportunities to create, enhance and link green assets. This can provide multiple benefits across several disciplines including flood risk and biodiversity/ ecology and may provide opportunities to use the land for an amenity and recreational purposes. Development that may adversely affect green infrastructure assets should not be permitted.

Strategic flood risk solutions

The information provided in the SFRA should be used as a basis for investigating potential strategic flood risk solutions within the Leicestershire County and Leicester City. Opportunities could consist of the following:

- Floodplain restoration
- Upstream storage schemes
- Opening up culverts, weir removal, and river restoration.

Where possible, developers should identify and work with partners to explore all avenues for improving the wider riparian environment.

Cross-boundary partnership working

The SGP is an excellent example of cross-boundary partnership working amongst local authorities in Leicestershire County and Leicester City. For successful future flood risk management, it is recommended that local planning authorities adopt a catchment partnership working approach in tackling flood risk and environmental management. It is also recommended that local planning authorities continue to work with their partners and other risk management authorities to strengthen the direction of future flood risk management and flood risk solutions.

Use of Strategic Flood Risk Assessment data

The Strategic Flood Risk Assessment has been developed using the best available information, supplied at the time of preparation. This relates both to the current risk of flooding from rivers, and the potential impacts of future climate change.

This SFRA is a high level strategic document. The datasets used to inform this SFRA may periodically be updated and following the publication of this SFRA, new information on flood risk may be provided by Risk Management Authorities.

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Abbreviations and definitions

Term	Definition
1D model	One-dimensional hydraulic model
2D model	Two-dimensional hydraulic model
AEP	Annual Exceedance Probability
AStGWF	Areas Susceptible to Groundwater Flooding
Brownfield	Previously developed parcel of land
CC	Climate change - Long term variations in global temperature and weather patterns caused by natural and human actions.
CDA	Critical Drainage Area - A discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure.
CFMP	Catchment Flood Management Plan- 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.
CIRIA	Construction Industry Research and Information Association
Cumecs	The cumec is a measure of flow rate. One cumec is shorthand for cubic metre per second; also m^3/s.
Defra	Department for Environment, Food and Rural Affairs
Designated Feature	A form of legal protection or status reserved for certain key structures or features that are privately owned and maintained, but which make a contribution to the flood or coastal erosion risk management of people and property at a particular location.
DTM	Digital Terrain Model
EA	Environment Agency
EU	European Union
Exception Test	Set out in the NPPF, the Exception Test is a method used to demonstrate that flood risk to people and property will be managed appropriately, where alternative sites at a lower flood risk are not available. The Exception Test is applied following the Sequential Test.
FCERM	Flood and Coastal Erosion Risk Management
FCRMGiA	Defra's Flood and Coastal Risk Management Grant in Aid
FEH	Flood Estimation Handbook
Flood defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Flood Map for Planning	The Environment Agency Flood Map for Planning (Rivers and Sea) is an online mapping portal which shows the flood zones in England. The flood zones refer to the probability of river and sea flooding, ignoring the presence of defences and do not account for the possible impacts of climate change.
Flood Risk Area	An area determined as having a significant risk of flooding in accordance with guidance published by Defra and WAG (Welsh Assembly Government).
FRMP	Flood Risk Management Plans - A high-level management plan which summarises the flooding affecting the area and describes the measures to be taken to address the risk in accordance with the Flood Risk Regulations.
Flood Risk Regulations	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.
Floods and Water Management Act	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a main river
FRA	Flood Risk Assessment - A site specific assessment of all forms of flood risk to the site and the impact of development of the site to flood risk in the area.

Term	Definition
FRM	Flood Risk Management
FWMA	Flood and Water Management Act
Green Infrastructure (GI)	Green Infrastructure – a network of natural environmental components and green spaces that intersperse and connect the urban centres, suburbs and urban fringe
Greenfield	Undeveloped parcel of land
Ha	Hectare
IDB	Internal Drainage Board
Indicative Flood Risk Area	Nationally identified flood risk areas, based on the definition of 'significant' flood risk described by Defra and WAG.
JBA	Jeremy Benn Associates
Jflow	2D generalised hydrodynamic modelling software.
LFRMS	Local Food Risk Management Strategy
LIDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority - Local Authority responsible for taking the lead on local flood risk management
LPA	Local Planning Authority
mAOD	metres Above Ordnance Datum
Main River	A watercourse shown as such on the Main River Map, and for which the Environment Agency has responsibilities and powers
NFM	Natural Flood Management
NPPF	National Planning Policy Framework
NPPG	National Planning Practice Guidance
NRD	National Receptor Database
Ordinary Watercourse	All watercourses that are not designated Main River. Local Authorities or, where they exist, IDBs have similar permissive powers as the Environment Agency in relation to flood defence work. However, the riparian owner has the responsibility of maintenance.
PFRA	Preliminary Flood Risk Assessment
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 as a result of high intensity rainfall when water is ponding or flowing over the ground surface (surface runoff) before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity.
PUA	Principal Urban Area – the Leicester City Principal Urban Area identified in the East Midlands Plan 2009 and Regional Spatial Strategy for Leicestershire County and Leicester City and comprises the principal urban area of Leicester and its suburbs which extend into adjoining Boroughs and Districts in Leicestershire.
Residual risk	Residual risk refers to the risks that remain in circumstances after measures have been taken to alleviate flooding (such as flood defences).
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Return Period	Is an estimate of the interval of time between events of a certain intensity or size, in this instance it refers to flood events. It is a statistical measurement denoting the average recurrence interval over an extended period of time.
Riparian owner	A riparian landowner, in a water context, owns land or property, next to a river, stream or ditch.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.
Risk Management Authority	Operating authorities who's remit and responsibilities concern flood and / or coastal risk management.
RoFfSW	Risk of Flooding from Surface Water (formerly known as the Updated Flood Map for Surface Water (uFMfSW)

Term	Definition
Sequential Test	Set out in the NPPF, the Sequential Test is a method used to steer new development to areas with the lowest probability of flooding.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
SFRA	Strategic Flood Risk Assessment
SoP	Standard of Protection - Defences are provided to reduce the risk of flooding from a river and within the flood and defence field standards are usually described in terms of a flood event return period. For example, a flood embankment could be described as providing a 1 in 100-year (1% AEP) standard of protection.
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
SuDS	Sustainable Drainage Systems - Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques
Surface water flooding	Flooding as a result of surface water 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 watercourse, or cannot enter it because the network is full to capacity, thus causing what is known as pluvial flooding.
SWMP	Surface Water Management Plan - The SWMP plan should outline the preferred surface water management strategy and identify the actions, timescales and responsibilities of each partner. It is the principal output from the SWMP study.
WFD	Water Framework Directive – Under the WFD, all waterbodies have a target to achieve Good Ecological Status (GES) or Good Ecological Potential (GEP) by a set deadline. River Basin Management Plans (RBMPs) set out the ecological objectives for each water body and give deadlines by when objectives need to be met.

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1 Introduction

1.1 Purpose of the Strategic Flood Risk Assessment

The key objectives of this SFRA are:

- To provide up to date information and guidance on flood risk across Leicestershire County and Leicester City, taking into account the latest flood risk information and the current state of national planning policy;
- To determine the variations in current and future flood risk from all sources of flooding in Leicestershire County and Leicester City;
- To identify the requirements for site-specific flood risk assessments;
- To consider opportunities to reduce flood risk to existing communities and developments;
- To enable the commissioning authorities to apply the Sequential Test and aid authorities in identifying when the Exception Test is required, when determining preferred directions of growth; and,
- To inform the Sustainability Appraisal of the SGP, so that flood risk is taken into account when considering strategic growth options.

1.2 Levels of SFRA

The Planning Practice Guidance advocates a tiered approach to risk assessment and identifies the following two levels of SFRA:

- Level One: where flooding is not a major issue and where development pressures are low. The assessment should be sufficiently detailed to allow application of the Sequential Test.
- Level Two: where land outside Flood Zones 2 and 3 cannot appropriately accommodate all the necessary development creating the need to apply the NPPF's Exception Test. In these circumstances, the assessment should consider the detailed nature of the flood characteristics within a Flood Zone and assessment of other sources of flooding.

This report fulfils a Level One SFRA requirement.

1.3 SFRA outputs

To meet the objectives, the following outputs have been prepared:

- Assessment of all potential sources of flooding;
- Mapping of location and extent of functional floodplain;
- Mapping of areas covered by an existing flood alert and flood warning;
- Mapping of areas protected by existing flood defences and their condition;
- Assessment of standard of protection provided by existing flood risk management infrastructure;
- Assessment of the potential impact of climate change on flood risk;
- Assessment of locations where additional development may increase flood risk elsewhere;
- Details of where proposed flood schemes are planned;
- Recommendations of the criteria that should be used to assess future development proposals and the development of a Sequential Test and sequential approach to flood risk; and,
- Guidance for developers including requirements for site-specific flood risk assessments and the application of sustainable drainage systems.

1.4 SFRA user guide

Table 1-1: SFRA report contents

Section	Contents
1. Introduction	Provides a background to the study, defines objectives, outlines the approach adopted and the consultation performed.
2. The Planning Framework and Flood Risk Policy	Includes information on the implications of recent changes to planning and flood risk policies and legislation, as well as documents relevant to the study.
3. The Sequential, risk based approach	Describes the Sequential Approach and application of Sequential and Exception Tests.
4. Climate change	Outlines climate change guidance and the implications for Leicestershire County and Leicester City
5. Sources of information used in preparing the SFRA	Outlines what information has been used in the preparation of the SFRA
6. Understanding flood risk in Leicestershire County and Leicester City	Gives an introduction to the assessment of flood risk and provides an overview of the characteristics of flooding affecting the study area Provides a summary of responses that can be made to flood risk, together with policy and institutional issues that should be considered.
7. Flood defences	Assessment of residual risk from flood defences, including future protection from climate change.
8. Cumulative impact of development / land use change	Broadscale assessment of areas where the cumulative impact of development and land use change may be detrimental to flood risk. An assessment of potential cross boundary flood risk issues as a result of future large-scale growth.
9. FRA requirements and flood risk management guidance	Identifies the scope of the assessments that must be submitted in FRAs supporting applications for new development. Provides guidance for developers and outlines conditions set by the LLFAs that should be followed.
10. Surface water management and SuDS	Advice on managing surface water runoff and flooding
11. Options to reduce flood risk	Summary of strategic options that can be considered by commissioning authorities and their partners, to avoid, control, mitigate and / or reduce flood risk in the County.
13. Summary	Summary of SFRA findings
14. Recommendations	Summary of recommendations
Appendix A: **Mapping of all sources of flood risk**	County-wide mapping of flood risk from all sources including the functional floodplain (Flood Zone 3b) and climate change mapping.
Appendix B: **Historic flood records in Leicestershire County and Leicester City**	Maps showing the locations where historic flooding has been recorded.
Appendix C: **Watercourses in Leicestershire County and Leicester City**	Maps showing the location of watercourses in Leicestershire County and Leicester City including Main Rivers, Ordinary Watercourses and IDB drains
Appendix D: **Flood Defences**	Maps showing the location of flood defences across their study area including their Standard of Protection and current condition.
Appendix E: **Flood Warning and Flood Alert coverage**	Maps showing the extent of the Environment Agency's Flood Warning Service.

Section	Contents
Appendix G: Sequential and Exception Test	Flow charts showing the Sequential and Exception Test processes.
Appendix H: Mapping Support Information	A technical summary, providing supporting information on the methodology used in this SFRA and datasets in the GeoPDF Appendix A layers.
Appendix I: Land use change indicative hydrographs	Supporting information and hydrographs of cumulative impact assessment

1.5 Consultation

The following parties (external to the commissioning authorities) have been consulted during the preparation of this version of the SFRA:

- Environment Agency
- Leicester City Council (as Lead Local Flood Authority)
- Leicestershire County Council (as Lead Local Flood Authority)
- Anglian Water
- Severn Trent Water
- Trent Valley Internal Drainage Board
- Highways (Leicestershire County Council)
- Neighbouring local authorities
- Highways England
- Fire and Rescue Service
- Canal and River Trust
- Trent Rivers Trust
- Welland Rivers Trust
- Leicestershire and Rutland Wildlife Trust

1.6 Use of SFRA data

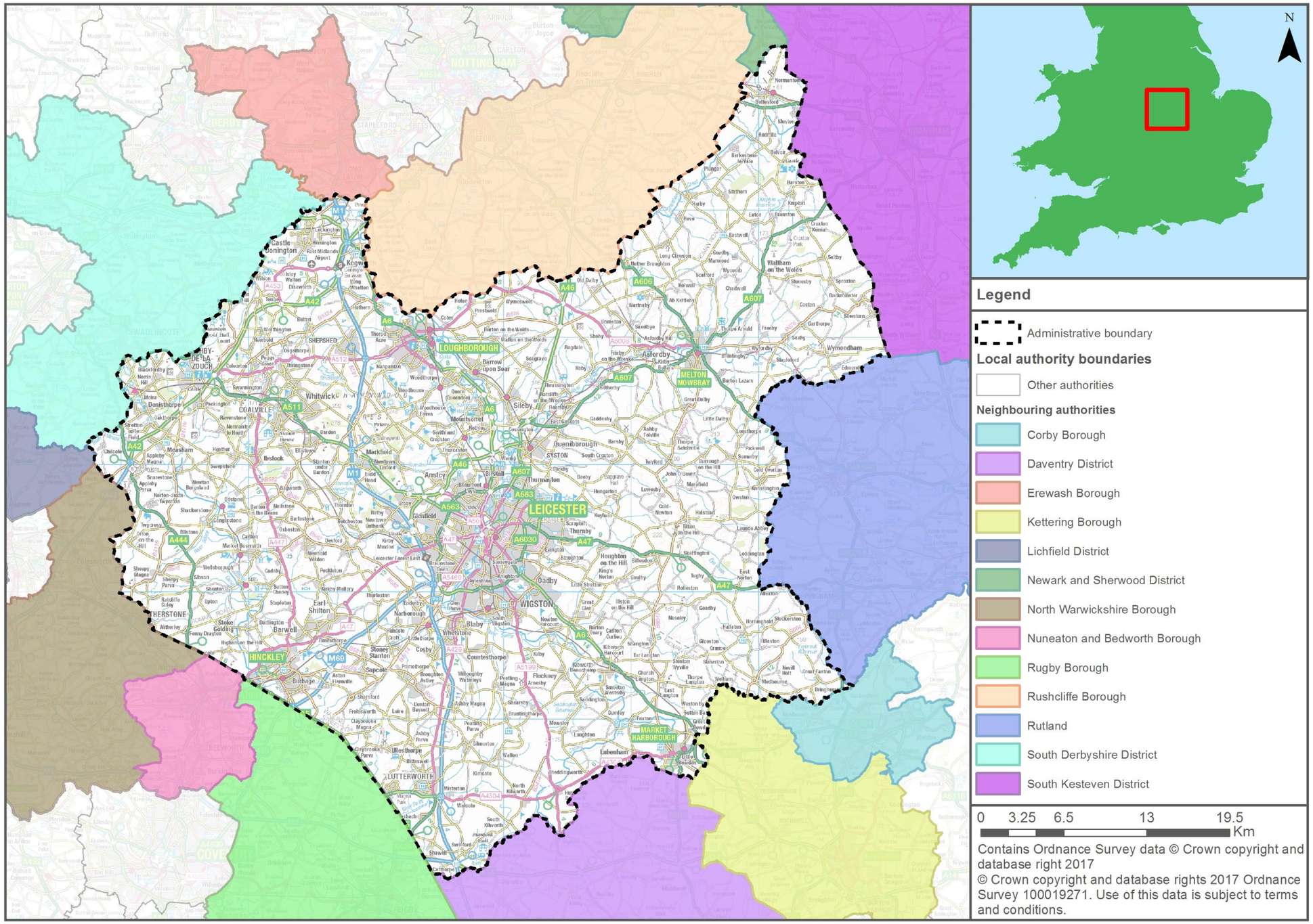
It is important to recognise that SFRAs are high level strategic documents and, as such, do not go into detail on an individual site-specific basis. The SFRA has been developed using the best available information at the time of preparation. This relates both to the current risk of flooding from rivers, and the potential impacts of future climate change.

New information on flood risk may be provided by the commissioning authorities, Lead Local Flood Authorities, the Environment Agency, the Highways Authority, Internal Drainage Board, Anglian Water, and Severn Trent Water. Such information may be in the form of:

- New hydraulic modelling results
- Flood event information following a flood event
- Policy/ legislation updates
- Environment Agency flood map updates
- New flood defence schemes etc.

The Environment Agency regularly reviews their flood risk mapping, and it is important that they are approached to determine whether updated (more accurate) information is available prior to commencing a detailed Flood Risk Assessment.

Figure 1-1: Study area



2 The Planning Framework and Flood Risk Strategies

2.1 Introduction

The overarching aim of development and flood risk planning policy in the UK is to ensure that the potential risk of flooding is considered at every stage of the planning process. This section of the SFRA provides an overview of the planning framework, flood risk policy and strategic documents and flood risk responsibilities.

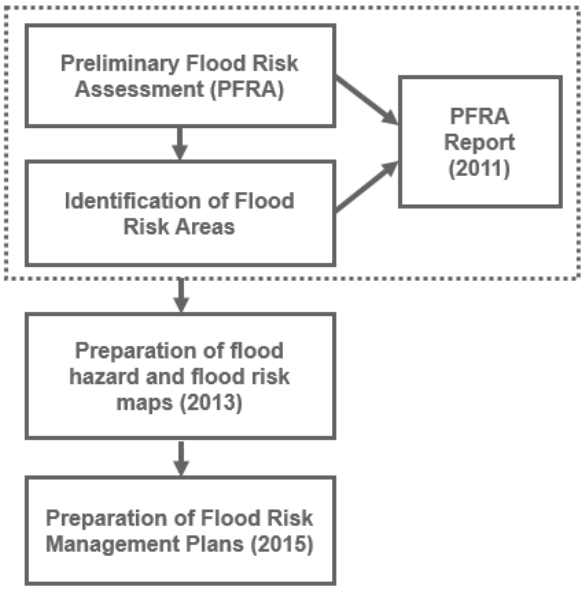
2.2 Flood Risk Regulations (2009) and Flood and Water Management Act (2010)

2.2.1 Flood Risk Regulations, 2009

The Flood Risk Regulations (2009) translate the current EU Floods Directive into UK law and place responsibility upon all Lead Local Flood Authorities (LLFAs) to manage localised flood risk. Under the Regulations, the responsibility for flooding from rivers, the sea and reservoirs lies with the Environment Agency; however, responsibility for local and all other sources of flooding rests with LLFAs. In the instance of this SFRA, there are two LLFAs in the study area: Leicester City Council and Leicestershire County Council.

Figure 2-1 illustrates the steps taken to implement the requirements of the EU Directive in the UK via the Flood Risk Regulations.

Figure 2-1: Flood Risk Regulation Requirements



The next cycle of the Flood Risk Regulations has now begun (2015 – 2021).

2.2.2 Preliminary Flood Risk Assessments (PFRAs)

In accordance with the Regulations, LLFAs had the task of preparing a Preliminary Flood Risk Assessment (PFRA) report.

PFRAs report on significant past and future flooding from all sources except from Main Rivers and reservoirs, which are covered by the Environment Agency, and sub-standard performance of the adopted sewer network (covered under the remit of Anglian Water and Severn Trent Water). PFRAs are a high-level screening exercise and consider floods which have significant harmful consequences for human health, economic activity, the environment and cultural heritage. Two PFRA documents cover the study area: Leicestershire County Council PFRA published in June 2011 and Leicester City Council PFRA published in September 2011. The Regulations require the LLFAs to identify significant Flood Risk Areas. The threshold for designating significant Flood Risk Areas is defined by Defra and the PFRA is the process by which these locations can be identified.

Leicester City has been identified as one of the ten national indicative Flood Risk Areas by the Defra/Environment Agency; Figure 5-2 of Leicestershire County Council's PFRA indicates that the extent of this Indicative Flood Risk Area also encroaches within surrounding areas of Leicester City

(i.e. within Leicestershire County). The main source of flooding is surface water and secondly, from ordinary watercourses. Numerous critical infrastructure, dwellings and transport links such as the M1/M69 interchange are within the indicative Flood Risk Area.

The next cycle of the Flood Risk Regulations has now begun; as part of this, the PFRA will be reviewed. The new / reviewed PFRAs are programmed to be completed by June 2017 and are due to be submitted to the European Union (EU) in December 2017. This may alter and / or identify new indicative Flood Risk Areas.

Since the 2011 PFRA was published, more accurate modelling of surface water has been made available i.e. the Risk of Flooding from Surface Water dataset (formerly known as the updated Flood Map for Surface Water). The publication of this dataset means that there is more potential for surface water related indicative Flood Risk Areas to be identified in the PFRA reviews.

2.2.3 Flood Risk Management Plans (FRMPs)

Under the Regulations the Environment Agency exercised an 'Exception' and did not prepare a PFRA for risk from rivers, reservoirs and the sea. Instead they had to prepare and publish a FRMP. The FRMP summarises the flooding affecting the area and describes the measures to be taken to address the risk in accordance with the Flood Risk Regulations.

The study area falls largely within the Humber River Basin District. However, Harborough District partially falls within the Anglian and Severn River Basin Districts and Melton Borough also falls partially within the Anglian River Basin District.

The River Basin District Flood Risk Management Plans (FRMP) were issued in March 2016 and covers the period of 2015 to 2021. The FRMP draws on policies and actions identified in Catchment Flood Management Plans (section 2.6) and incorporates information from Local Flood Risk Management Strategies (Section 2.2.5). Appendix C for the FRMPs contain proposed measures to manage flood risk. The measures relating to Leicestershire and Leicester City are summarised below.

Appendix C of the Anglian FRMP identifies six actions concerning the River Welland catchment and Leicestershire. In this document, it states that the Environment Agency will aim to:

- Influence all LPAs to include policies within Local Plans that will seek to avoid inappropriate development in the floodplain and maximise opportunities to reduce flood risk, in accordance with the principles set out in the NPPF.
- Maintain the current flood forecasting / warning service through ongoing review of community based Flood Warning Areas.
- Work with Local Resilience Forum (LRF) partners, continue to deliver targeted community engagement to encourage people to sign up to receive flood warnings and understand what action to take to protect themselves and their property on receipt of a flood warning.
- Working with LRF partners, complete the review of the Multi-Agency Flood Plans and deliver any associated training.
- Work with Leicestershire County Council, Rutland County Council and Welland Valley Partnership members, and include the farming community to develop an integrated Water Framework Directive (WFD) and flood risk project for the Upper Welland catchment.
- Review existing flood risk assets, understand the risks and where necessary take action to maintain the standard of service of existing assets in Market Harborough.

Appendix C of the Humber FRMP identifies 20 actions across the Leicester City Principal Urban Area (PUA)[1]. The PUA extends to cover areas outside of Leicester City Council's administrative boundary to account for hydrological inflows and proposed regeneration and development areas. The actions are summarised as follows:

- A review of flood risk:
    - From the Scraptoft Brook
    - In Alderman Richard, Hallam

1 The Leicester City Principal Urban Area was identified in the East Midlands Plan 2009 and Regional Spatial Strategy for Leicestershire County and Leicester City and comprises the principal urban area of Leicester and its suburbs which extend into adjoining Boroughs and Districts in Leicestershire.

- In Dane Hills, Leicester
- At Egginton Street, Leicester
- Near Hol Brook, Leicester
- At Leicester Royal Infirmary
- At Oakland Road, Leicester
- At Redhill Way, Leicester
- In the Northfields area, Leicester
- At Nedham Street, Leicester
- From Braunstone Brook, Melton Brook, Saffron Brook and Willow Brook

- Improve flood flow conveyance in Leicester, by opening up sections of the floodplain and desilting structures to encourage unobstructed flood flow
- Expand the coverage of the Environment Agency's Flood Warning Service (FWS) to communities at risk where no service is currently offered and increase registration to the FWS
- Investigate the flood resilience of key infrastructure across the Leicester City PUA
- Investigate re-naturalising watercourses across the Leicester City PUA
- Improve flood forecasts through regular monitoring across the Leicester City PUA.

At the time of preparing this SFRA, a number of the actions identified in the FRMPs are being implemented (see Section 7). The actions identified in the FRMP have been considered in Section 11, opportunities to reduce the risk of flooding, in the 2017 SFRA.

The Plan will be updated as part of the new cycle of the Flood Risk Regulations and is due to be published in December 2021.

2.2.4 Flood and Water Management Act (FWMA), 2010

Following the 2007 floods, Sir Michael Pitt was appointed to chair an independent review into the floods. The final report was published in June 2008. The Flood and Water Management Act (2010) implements Sir Michael Pitt's recommendations and aims to create a simpler and more effective means of managing both flood risk and coastal erosion.

The FWMA established Lead Local Flood Authorities (LLFAs). Further information on the LLFA role and responsibilities are provided in Section 2.9.2.

2.2.5 Local Flood Risk Management Strategies

Leicestershire County Council and Leicester City Council, in their role as LLFAs, are responsible for developing, maintaining, applying and monitoring a Local Flood Risk Management Strategy (LFRMS). The Strategies are used as a means by which the LLFAs co-ordinate flood risk management on a day to day basis. The Strategies also set measures to manage local flood risk i.e. flood risk from surface water, groundwater and Ordinary Watercourses.

The high-level objectives for managing flood risk, proposed in Leicestershire County Council's LFRMS are:

1. Adopting a collaborative approach to managing flood risk;
2. Improving understanding and awareness of flood risk;
3. Adopting a sustainable approach to reducing flood risk to enhance the natural and historic environment;
4. Reducing the harmful consequences of local flooding to communities by improving resilience;
5. Encourage sustainable development;
6. Using resources effectives; and,
7. Promoting riparian responsibilities.

The high-level objectives for managing flood risk, proposed in Leicester City Council's LFRMS are:

1. Reduce the number of properties at risk of flooding;

2. Help residents, property and business owners in the area become more resilient to flood events;
3. Reduce the area of highway under water for a given storm event and minimise traffic disruption from flooding;
4. Increase the area of green space in the area contributing to mitigating the flooding risk; and,
5. Reducing the number of pollution incidents affecting watercourses in the city.

Both Strategies also set out an action plan of how the LLFA intends to achieve their objectives. The Strategies will be updated regularly or when key triggers are activated. An example of a key trigger would be issues such as amendments to partner responsibilities, updates to legislation, alterations in the nature or understanding of flood risk or a significant flood event.

Leicester City Council are also in the process of developing an Integrated Flood Risk Management Strategy (IFRMS). The IFRMS is identifying opportunities to reduce flood risk in four keys areas across the city: the Soar corridor, Willow Brook, Braunstone Brook and Saffron Brook. This IFRMS is planned to be published in December 2017.

2.2.6 The National Flood and Coastal Erosion Risk Management Strategy for England (2011)

The National Flood and Coastal Erosion Risk Management Strategy for England provides the overarching framework for future action by all risk management authorities to tackle flooding and coastal erosion in England. It was prepared by the Environment Agency with input from Defra.

The Strategy builds on existing approaches to flood and coastal risk management and promotes the use of a wide range of measures to manage risk. It describes how risk should be managed in a co-ordinated way within catchments and along the coast and balance the needs of communities, the economy and the environment.

The strategy encourages more effective risk management by enabling people, communities, business, infrastructure operators and the public sector to work together to:

- ensure a clear understanding of the risks of flooding and coastal erosion, nationally and locally, so that investment in risk management can be prioritised more effectively;
- set out clear and consistent plans for risk management so that communities and businesses can make informed decisions about the management of the remaining risk;
- manage flood and coastal erosion risks in an appropriate way, taking account of the needs of communities and the environment;
- ensure that emergency plans and responses to flood incidents are effective and that communities are able to respond effectively to flood forecasts, warnings and advice; and,
- help communities to recover more quickly and effectively after incidents.

2.3 National Planning Policy and Guidance

The National Planning Policy Framework (NPPF) was issued in 2012 to replace the previous documentation as part of reforms to make the planning system less complex and more accessible, and to protect the environment and promote sustainable growth. It replaces most of the Planning Policy Guidance Notes (PPGs) and Planning Policy Statements (PPSs) that were referred to in the previous version of the SFRA. The NPPF sets out the Government's requirements for the planning system and provides a framework within which local people and councils can produce distinctive local and neighbourhood plans to reflect the needs and properties of their communities. The NPPF must be applied by local planning authorities when preparing Local Plans and for applicants preparing planning submissions. The NPPF is also a material consideration in planning decisions and thus must be taken into account when preparing the SGP.

National Planning Practice Guidance (NPPG) was published in 2014 and sets out how the NPPF should be implemented. NPPG: Flood Risk and Coastal Change advises on how planning can account for the risks associated with flooding and coastal change in plan making and the application process. It sets out Flood Zones, the appropriate land uses for each zone, flood risk assessment requirements, including the Sequential and Exception Tests and the policy aims for developers and authorities regarding each Flood Zone. Further details on Flood Zones and associated policy is provided in Table 3-1 and throughout this report. The Sequential and Exception tests are covered in greater detail in Section 3 and Appendix G.

2.4 Planning, surface water and SuDS

On 18 December 2014 a Written Ministerial Statement laid by the Secretary of State for Communities and Local Government set out changes to the planning process that would apply for major development from 6 April 2015.

Major developments are defined as

- residential development: 10 dwellings or more, or residential development with a site area of 0.5 hectares or more where the number of dwellings is not yet known; and
- Non-residential development: provision of a building or buildings where the total floor space to be created is 1,000 square metres or more or, where the floor area is not yet known, a site area of 1 hectare or more.

When considering major planning applications, Local Planning Authorities should consult the LLFA on the management of surface water in order to satisfy that:

- the proposed minimum standards of operation are appropriate
- there are clear arrangements for on-going maintenance over the development's lifetime, through the use of planning conditions or planning obligations.

In March 2015 the LLFA was made a statutory consultee which came into effect on 15 April 2015. As a result, Leicestershire County Council and Leicester City Council, are required to provide technical advice on surface water drainage strategies and designs put forward for new major developments.

2.4.1 Defra Non-Statutory Technical Standards for SuDS

On 23 March 2015, the Department for Environment, Food and Rural Affairs (Defra) published the Non-Statutory Technical Standards for SuDS. The standards should be used in conjunction with the NPPF and NPPG. These standards cover the following

- Flood risk outside the development
- Peak flow control
- Volume control
- Flood risk within the development
- Structural integrity
- Designing for maintenance considerations
- Construction

2.4.2 SuDS or Surface Water Guidance

Leicester City Council has produced Sustainable Drainage Guidance (February 2015); this provides local examples of where SuDS have been used and practical guidance for anyone proposing to develop land. A check list of information to be provided with development applications is provided in this guidance. Updated technical guidance relating to sustainable drainage is currently being prepared by Leicester City Council; this will include information on the SuDS planning process and necessary approvals, technical requirements on peak flow and volume control for greenfield and brownfield sites and standing advice.

At the time of preparing this SFRA, Leicestershire County Council were in the process of preparing guidance relating to SuDS and surface water management.

2.4.3 C753 CIRIA SuDS Manual (2015)

The C753 CIRIA SuDS Manual (2015) replaces and updates the previous version (C697) providing up to date guidance on planning, design, construction and maintenance of SuDS. The document is designed to help the implementation of these features into new and existing developments, whilst maximising the key benefits regarding flood risk and water quality. The manual is divided into five sections ranging from a high-level overview of SuDS, progressing to more detailed guidance with progression through the document. It is recommended that developers and the LPA utilise the information within the manual to help design SuDS which are appropriate for a development.

2.4.4 Anglian Water's SuDS handbook

Where developers and applicants are considering applying to Anglian Water to adopt SuDS features, reference should be made to Anglian Water's SuDS handbook. Further information can be found on Anglian Water's website at: http://www.anglianwater.co.uk/developers/suds.aspx

2.5 Surface Water Management Plans

Surface Water Management Plans (SWMPs) outline the preferred surface water management strategy in a given location. SWMPs are undertaken by LLFAs in consultation with key local partners who are responsible for surface water management and drainage in their area. SWMPs establish a long-term action plan to manage surface water in an area and are intended to influence future capital investment, drainage maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

There are two SWMPs in the study area: Leicester City SWMP published in 2012 and Loughborough SWMP published in 2013.

Leicester City SWMP proposed 18 recommendations covering the following themes:

- Install a network of rainfall, ordinary watercourse, sewer and groundwater monitoring gauges throughout Leicester and using gauge data to revisit and where necessary update assessments used in the SWMP;
- To gain more detailed understanding of the impacts that potential major development surrounding Leicester could have on flood risk in the City;
- Continue consultation and data sharing with Severn Trent Water and working closely with surrounding authorities and key stakeholders including local communities;
- Strive to assess opportunities for linking and integrating surface water management and green infrastructure, linking the SWMP with GI Strategies;
- Identify and record surface water assets as part of the Asset Register and use the outputs of the SWMP to review current maintenance regimes for ordinary watercourses; and,
- Explore and develop Policy Areas for the City.

The Loughborough SWMP proposed a series of actions to manage surface water flood risk:

- Identify and record surface water assets as part of the Asset Register;
- Investigate any 'significant' surface water flood events under the responsibilities of the FWMA;
- Provide advice on measures that can be taken by residents to mitigate surface water flooding to / around their property;
- Prepare a stakeholder communication plan to communicate and raise awareness of surface water flood risk;
- Determine a protocol for communicating local flood risk and sharing findings of the SWMP;
- Prepare feasibility studies to review the effectiveness of water butts to reduce runoff during rainfall events, for those properties identified in flooding hotspots and to determine the viability of options to reduce flood risk in CDAs identified in the SWMP; and,
- Use the outputs of the SWMP to review current maintenance regimes for ordinary watercourses.

2.6 Catchment Flood Management Plans

Catchment Flood Management Plans (CFMPs) are a high-level strategic plan providing an overview of flood risk across each river catchment. The Environment Agency use CFMPs to work with other key-decision makers to identify and agree long-term policies for sustainable flood risk management.

There are six pre-defined national policies provided in the CFMP guidance and these are applied to specific locations through the identification of 'Policy Units'. These policies are intended to cover the full range of long-term flood risk management options that can be applied to different locations in the catchment.

The six national policies are:

1. No active intervention (including flood warning and maintenance). Continue to monitor and advise.
2. Reducing existing flood risk management actions (accepting that flood risk will increase over time).
3. Continue with existing or alternative actions to manage flood risk at the current level (accepting that flood risk will increase over time from this baseline).
4. Take further action to sustain the current level of flood risk (responding to the potential increases in risk from urban development, land use change and climate change).
5. Take action to reduce flood risk (now and/or in the future).
6. Take action with others to store water or manage runoff in locations that provide overall flood risk reduction or environmental benefits, locally or elsewhere in the catchment.

2.6.1 River Trent, River Welland and River Severn CFMPs

The majority of the study area is covered by the River Trent CFMP however, parts of Harborough District also fall within the Welland CFMP and Severn CFMP.

The Policy Units of importance to the study area are:

- **River Trent CFMP, Policy Unit 6 (Mid Staffs and Lower Tame):** within this policy unit the CFMP states that Policy 6 applies.
- **River Trent CFMP, Policy Unit 8 (Rural Leicestershire):** within this policy unit the CFMP states that Policy 6 applies.
- **River Trent CFMP, Policy Unit 9 (Upper Soar and Upper Anker):** within this policy unit the CFMP states that Policy 4 applies.
- **River Welland CFMP, Policy Unit 1 (Upper Tributaries):** within this policy unit the CFMP states that Policy 2 applies.
- **River Welland CFMP, Policy Unit 2 (Welland and Glens):** within this policy unit, the CFMP states that Policy 2 applies.
- **River Welland CFMP, Policy Unit 4 (Market Harborough):** within this policy unit, the CFMP states that Policy 3 applies.
- **River Severn CFMP, Policy Unit 7 (Upper Avon):** within this policy unit, the CFMP states that Policy 6 applies.

In summary, the CFMPs policies indicate that intervention measures will be used across Leicestershire and Leicester City to manage the risk of flooding. Flood risk will either be managed at current levels (now and / or in the future) or reduced (now and / or in the future).

This SFRA will help support the above policies in the CFMPs by aiding the Councils to make informed decisions about the location of future development, as well as identifying where future flood risk management measures may be required. Further, as part of this SFRA , an assessment of green infrastructure has been undertaken.

2.7 River Basin Management Plans

River Basin Management Plans (RBMPs) are prepared under the Water Framework Directive (WFD) and assess the pressure facing the water environment in River Basin Districts. The study area falls within the Anglian, Humber and Severn River Basin Districts.

The updated 2015 Anglian, Humber and Severn RBMPs identified a number of pressures on the water environment and significant water management issues. The RBMPs describes how development and land-use planning needs to consider a number of issues relevant to the RBMP including sustainable drainage systems, green and blue infrastructure, sewage treatment options (tertiary phosphate treatments), water efficiency measures, infrastructure and development locations and the reduction of nutrients from diffuse pollution. The RBMPs provides a summary of measures to protect and improve the water environment in the river basin district.

One action relevant to flood risk in the RBMPs is the need to renaturalise heavily modified watercourses, to restore natural floodplains, remove obstructions and slow down the rate of flow. This action is an example of Natural Flood Management. NFM can be defined as *"a range of techniques that aim to reduce flooding by working with natural features and characteristics to store*

or slow down flood waters."[2] Further information on re-naturalisation and NFM is provided in Section 11.3.2.

The Humber RBMP highlights the Leicester flood risk management strategy which is looking at improving the movement of flood flows through the River Soar corridor as well as several other projects aimed at improving water quality, improving habitat diversity and sustainable drainage solutions. The Welland RBMP highlights the Welland Valley Partnership which has potential projects and measures providing a range of benefits, including flood resilience and community engagement.

2.8 Water Cycle Studies

Water Cycle Studies assist Local Authorities to select and develop sustainable development allocations so that there is minimal impact on the environment, water quality, water resources, and infrastructure and flood risk. This can be achieved in areas where there may be conflict between any proposed development and the requirements of the environment through the recommendation of potential sustainable solutions.

A Leicestershire County and Leicester City Water Cycle Study is being prepared as part of the evidence base for the SGP.

2.9 Roles and responsibilities of Risk Management Authorities

The roles and responsibilities of Risk Management Authorities (RMAs) in study area are summarised below.

2.9.1 Local Planning Authorities

The Local Planning Authorities (LPAs), assess, consult on and determine whether development proposals are acceptable, ensuring that flooding and other, similar, risks are effectively managed.

The LPAs will consult relevant statutory consultees as part of planning application assessments and may, in some cases, also contact non-statutory consultees (such as Trent Valley Internal Drainage Board, Severn Trent Water and Anglian Water) that have an interest in the planning application.

2.9.2 Lead Local Flood Authorities

As LLFAs, Leicester City Council and Leicestershire County Council duties include:

- Local Flood Risk Management Strategy (LFRMS): LLFAs must develop, maintain, apply and monitor a LFRMS to outline how they will manage flood risk, identify areas vulnerable to flooding and target resources where they are needed most.
- Flood Investigations: When appropriate and necessary LLFAs must investigate and report on flooding incidents (Section 19 investigations). The criteria for which flooding incidents require investigation and reporting under Section 19 is determined based on a locally agreed threshold.
- Register of Flood Risk Features: LLFAs must establish and maintain a register of structures or features which, in their opinion, are likely to have a significant effect on flood risk in the LLFA area.
- Designation of Features: LLFAs may exercise powers to designate structures and features that affect flood risk, requiring the owner to seek consent from the authority to alter, remove or replace it.
- Consenting: When appropriate LLFAs will perform consenting of works on ordinary watercourses.

Leicester City Council and Leicestershire County Council are also the Local Highway Authorities managing highway drainage, carrying out maintenance and improvement works on an on-going basis, as necessary, to maintain existing standards of flood protection for highways, making appropriate allowances for climate change. It also has the responsibility to ensure road projects do not increase flood risk and is a statutory consultee to planning.

2 SEPA (2015) Natural Flood Management Handbook: https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf

2.9.3 Environment Agency

The Environment Agency is responsible for protecting and enhancing the environment and contributing to the Government's aim of achieving sustainable development in England and Wales. The Environment Agency has powers to work on Main Rivers to manage flood risk. These powers are permissive, which means they are not a duty, and they allow the Environment Agency to carry out flood and coastal risk management work and to regulate the actions of other flood risk management authorities on main rivers and the coast.

The Environment Agency also has powers to regulate works to Main Rivers and sea defences. Under the Environmental Permitting Regulations (England and Wales) 2016, an environmental permit may be required for flood risk activities for work in, under, over or within 8 metres of any fluvial Main River, flood defence structure or culvert. A permit for works on the floodplain may also be required, beyond the 8m distance for work that is likely to divert or obstruct floodwaters, damage any river control works or affect drainage. Application forms and further information can be found on the government's website: https://www.gov.uk/guidance/flood-risk-activities-environmental-permits.

The Environment Agency also has a strategic overview role across all types of flooding as well as other types of water management matters.

The Environment Agency is a statutory consultee in respect to flood risk for sites in Flood Zones 2 and 3 and within 20m of a Main River.

2.9.4 Internal Drainage Boards

IDBs are local public authorities that manage water levels. They are an integral part of managing flood risk and land drainage within areas of special drainage need in England and Wales. The Trent Valley IDB operates in the study area, maintaining pumping stations and drainage channels which straddle the River Trent and its tributaries, extending to the northern part of Melton Borough.

Roles and responsibilities for IDBs include the following

- IDBs have permissive powers to undertake work to provide water level management within their Internal Drainage District. They undertake works to reduce flood risk to people and property and manage water levels for local needs, this includes the maintenance of rivers, drainage channels, outfalls and pumping stations
- They input into the planning system by facilitating the drainage of new and existing developments within their districts and advising on planning application. However, they are not a statutory consultee to the planning process
- In some cases, a development meeting the following criteria may be required to submit an FRA to the IDB to support any consent applications
    - Development within or adjacent to a drain/watercourse, and/or flood defence structure within the area of an IDB
    - Development within the channel of any ordinary watercourse within an IDB area
    - Where direct discharge of surface water or treated effluent is proposed into an IDB catchment
    - Any development proposal affecting more than one watercourse in an IDBs area and having possible strategic implications
    - Development in an IDB that is an area of known flood risk
    - Development within the maintenance access strips provided under the IDBs bylaws
    - Any other application that may have material drainage implications.
- Some IDBs have other duties, powers and responsibilities under specific legislation.

Further information relating to the Trent Valley IDB is provided in Section 6.3.

2.9.5 Water and wastewater providers

Anglian Water and Severn Trent Water are the water and sewerage undertakers for Leicestershire County and Severn Trent Water is the water and sewerage undertaker for Leicester City. They have the responsibility to maintain surface, foul and combined public sewers to ensure the area is effectively drained. Water and sewerage companies are also responsible for managing the risks of flooding from surface water and foul or combined sewer systems. When flows (foul or surface water) are proposed to enter public sewers, Anglian Water and Severn Trent Water will assess whether the public system has the capacity to accept these flows as part of their pre-application

service. If there is not available capacity, they will provide a solution that identifies the necessary mitigation.

The purpose of Anglian Water's pre-planning service is to provide a feasible water and/ or drainage solution for planning application purposes. There is no requirement to request a pre-planning report; however, Anglian Water encourage developers to make use of their service before submitting a planning application, particularly where the site is of a significant scale.

Anglian Water and Severn Trent Water also comments on the available capacity of foul and surface water sewers as part of the planning application process. Further information can be found on Anglian Water's website and Severn Trent Water's website.

Severn Trent Water and Anglian Water also supply potable water to Leicestershire County and Severn Trent Water supply portable water to Leicester City. Consent, prior to commencing work, is required from the relevant provider if installing water systems, or altering existing systems, is intended.

2.9.6 Highways England

Highways England operates, maintains and improves England's motorways and major A roads and are a statutory consultee in the planning system. Highways England will need to be consulted for applications that could affect the quality and capacity of the Highways England (strategic) road network. Highways England have published guidance regarding working with Highways England on planning matters; this guidance details Highways England's role in and approach to planning, the development plan process (Local Plans and individual applications), funding and provides key contacts.

2.10 When to consult Risk Management Authorities

Table 2-1: When to consult Risk Management Authorities

Key authority	When to consult
Borough, District or City Council (LPA)	Pre-application consultation is recommended to identify the range of issues that may affect the site and, following on from the Sequential and, if necessary, Exception Test, determine whether the site is suitable for its intended use. Should be consulted where an awarded watercourse runs within or adjacent to proposed development consultation
Environment Agency	Should be consulted on development, other than minor or as defined in the Environment Agency's Flood Risk Standing Advice document within Flood Zone 2 or 3, or in Flood Zone 1 where critical drainage problems have been notified to the LPA. Consultation will also be required for any development projects within 20m of a Main River or flood defence, and other water management matters.
Leicestershire County Council and Leicester City Council (LLFA)	Where the proposed work will either affect or use an ordinary watercourse or require consent permission, outside of an IDB's rateable area. As of the 15th April 2015 the LLFA should be consulted on surface water drainage proposal for all major developments.
Leicestershire County Council (Local Highway Authority)	Where the proposed development will either involve a new access to the local highway network or increase or change traffic movements
Highways England	When the quality and capacity of the Highways England (strategic) road network could be affected.
Historic England	Whilst Historic England are not a Risk Management Authority, they should be consulted where proposals may affect heritage assets and their settings.
Natural England	Natural England has mapped 'risk zones' to help developers and LPAs determine whether consultation is required. This is likely where water bodies with special local or European designations (e.g. SSSI or Ramsar) exists

Key authority	When to consult
Anglian Water and Severn Trent Water	Where connection to surface water sewers is required, or where the flow to public sewerage system may be affected Where new connections to the water supply network are required or if any alterations are made to existing connections Water and sewerage companies wish to comment on major development planning applications in their area, where it is proposed to connect to the public sewerage network or for development where the LPA has identified specific issues of relevance to the water and sewerage company Anglian Water and Severn Trent Water offer a pre-planning consultation service
Trent Valley IDB	Where proposed development is in, or in close proximity to, an IDB district

CHAPTER 2 SUMMARY

The overarching aim of development and flood risk planning policy in the UK is to ensure that the potential risk of flooding is considered at every stage of the planning process. The main flood risk related planning policies and strategies are underpinned by the Flood Risk Regulations (2009), Flood and Water Management Act (2010), National Planning Policy Framework (2012) and local authority Local Plans (including evidence base).

There are many relevant regional and local key policies which have been considered within the SFRA such as:

- Preliminary Flood Risk Assessments;
- Flood Risk Management Plans;
- Local Flood Risk Management Strategies;
- The National Flood and Coastal Erosions Risk Management Strategy for England;
- Surface water and SuDS guidance and standards;
- Surface Water Management Plans;
- Catchment Flood Management Plans;
- River Basin Management Plans; and,
- Water Cycle Studies.

Links have been provided for various guidance documents and policies published by other Risk Management Authorities such as the Lead Local Flood Authority and the Environment Agency. Other policy considerations have also been incorporated, such as sustainable development principles, climate change and flood risk management.

CHAPTER 2 RECOMMENDATIONS

Developers and planners should be aware of the above documents and consult these, where appropriate during the master planning stage and the preparation of site-specific Flood Risk Assessments. Developers should be aware that at the time of preparing this SFRA, certain documents were in the process of being updated (i.e. PFRAs and Leicester City Council's SuDS technical guidance) and other guidance documents were in the process of being prepared (i.e. SuDS and surface water management guidance by Leicestershire County Council).

Aside from complying with national and local planning policy, it is recommended that development plans align with the policies of the CFMPs and FRMPs. This is so that local development is planned with consideration of wider sustainable flood risk management strategies.

An overview of roles and responsibilities of Risk Management Authorities has been provided in this SFRA. Certain Risk Management Authorities are statutory consultees for development applications. Developers should consult with Risk Management Authorities, where appropriate.

3 The sequential, risk-based approach

3.1 The sequential, risk-based approach

This approach is designed to ensure areas with little or no risk of flooding (from any source) are developed in preference to areas at higher risk, with the aim of keeping development outside of medium and high flood risk areas (Flood Zones 2 and 3) and other sources of flooding, where possible.

The NPPF advocates a sequential, risk-based approach and this principal should be applied when preparing the Strategic Growth Plan for Leicestershire County and Leicester City. The Strategic Growth Plan may identify broad locations for growth on land that is at risk from flooding. In these circumstances the Flood Zone maps (that show the extent of inundation assuming that there are no defences) are too simplistic and a greater understanding of the scale and nature of the flood risks may be required, if the commissioning authorities consider allocating these locations for future development.

It is often the case that it is not possible for all new development to be allocated on land that is not at risk from flooding. The Flood Zone maps (that show the extent of inundation assuming that there are no defences) are a starting point for a site-specific Flood Risk Assessment (FRA). These maps are only available where the watercourse has been modelled (where the upstream catchment is greater than 3km^2 (Rivers and Sea). Additional 2D modelling of some of these catchments was undertaken as part of the following SFRAs.

- Charnwood Borough SFRA
- Melton Borough SFRA
- Hinckley and Bosworth Borough, Blaby District and Oadby and Wigston Borough joint SFRA

In un-modelled parts of the catchments and areas where the flood zone maps are believed to inadequately represent the local detail, further assessment which could include modelling might be required to create a better understanding of the scale and nature of the risks.

3.1.1 Flood Zones

Table 1 of NPPG Flood Risk and Coastal Change identifies the following Flood Zones. These apply to both Main River and Ordinary Watercourses. Flood risk vulnerability and flood zone compatibility is set out in Table 3 of the NPPG. Table 3-1 summarises this information and also provides information on when an FRA would be required.

Table 3-1: Flood Zone descriptions

Zone	Probability	Description
Zone 1	Low	This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
		All land uses are appropriate in this zone.
		For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water runoff, should be incorporated in a flood risk assessment.
Zone 2	Medium	This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (0.1% - 1%) or between 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.1% – 0.5%) in any year.
		Essential infrastructure, water compatible infrastructure, less vulnerable and more vulnerable land uses (as set out by NPPF) are appropriate in this zone. Highly vulnerable land uses are allowed as long as they pass the Exception Test.
		All developments in this zone require an FRA.

Zone	Probability	Description
Zone 3a	High	This zone comprises land assessed as having a greater than 1 in 100 annual probability of river flooding (>1.0%) or a greater than 1 in 200 annual probability of flooding from the sea (>0.5%) in any year. Developers and the local authorities should seek to reduce the overall level of flood risk, relocating development sequentially to areas of lower flood risk and attempting to restore the floodplain and make open space available for flood storage.
		Water compatible and less vulnerable land uses are permitted in this zone. Highly vulnerable land uses are not permitted. More vulnerable and essential infrastructure are only permitted if they pass the Exception Test.
		All developments in this zone require an FRA.
Zone 3b	Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify, in their SFRA, areas of functional floodplain, in agreement with the Environment Agency. The identification of functional floodplain should take account of local circumstances.
		Only water compatible and essential infrastructure are permitted in this zone and should be designed to remain operational in times of flood, resulting in no loss of floodplain or blocking of water flow routes. They must also be safe for users and not increase flood risk elsewhere. Essential Infrastructure will only be permitted if it passes the Exception Test.
		All developments in this zone require an FRA.

Further information on the delineation of Flood Zone 3b can be found in Section 5.2.2.

3.1.2 Surface water flood risk information

In 2013, the Environment Agency, working with LLFAs, produced the Risk of Flooding from Surface Water (RoFfSW) maps (previously known as the updated Flood Map for Surface Water). The RoFfSW is a national scale map and assesses flooding scenarios as a result of rainfall under a high, medium, low and very low risk scenarios (see Table 5-2 for the full definitions).

The surface water map is available via the Long term flood risk information page on the government's website. In addition to showing the extent of surface water flooding, there are depth and velocity maps for each risk category. These maps should be used when considering other sources of flooding when applying the Sequential and Exception tests.

3.2 Applying the Sequential Test and Exception Test

3.2.1 Sequential Test

The aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding, to keep development outside of areas in Flood Zone 2 and 3 and land affected by other sources of flooding (where possible). Site allocations and strategic development proposed as part of the local planning process is subject to the application of the Sequential Test, to ensure the development is sustainable and safe from a flood risk perspective.

The Strategic Growth Plan will aim to identify the broad locations that are most likely to be developed in the longer term to accommodate the projected growth. Once these locations are identified, the application of the Sequential Test may be required if these locations are considered for development and / or considered as site allocations in the local planning process. This will help the commissioning authorities to demonstrate that a range of options has been considered and to check if there are any flood risk constraints in these locations (and therefore if a more detailed assessment of flood risk is required).

A pragmatic approach should be taken when applying the Sequential Test. Local circumstances must be used to define the area of application of the Sequential Test (within which it is appropriate to identify reasonably available alternatives). The criteria used to determine the appropriate search area relate to the catchment area for the type of development or growth being proposed. For the Strategic Growth Plan, it is likely that the Sequential Test will be applied across the whole of Leicestershire County and Leicester City, to increase the likelihood of identifying growth sites in areas not at risk of flooding. However, other policies in the commissioning authorities Local Plans may determine the search area e.g. a specific area identified for regeneration.

The commissioning authorities, with advice from the Environment Agency, are responsible for considering the extent to which Sequential Test considerations have been satisfied, and will need to be satisfied that any potential growth sites would be safe and not lead to increased flood risk elsewhere.

It is normally reasonable to presume and state that individual sites that lie in Zone 1 satisfy the requirements of the Sequential Test; however, consideration should be given to risks from all sources of flooding including areas with critical drainage problems.

3.2.2 Exception Test

If, following application of the Sequential Test it is not possible for growth to be in areas with a lower probability of flooding, the Exception Test must then be applied if deemed appropriate. The aim of the Exception Test is to ensure that more vulnerable uses, such as residential development can be implemented safely and are not located in areas where the hazards and consequences of flooding are inappropriate. For the Test to be satisfied, the following two elements must be accepted for development to be allocated or permitted:

1. It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared.
2. A site-specific Flood Risk Assessment must demonstrate that the development will be safe for its lifetime, taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Depending on the location of development within proposed growth areas, the Exception Test may need to be passed if sites are in Flood Zones 2 or 3. A site-specific Flood Risk Assessment may also be required, to demonstrate the development passes the second part of the Exception Test.

Appendix F contains flow charts which outline the Sequential and Exception Test processes.

3.2.3 Actual flood risk

A more detailed assessment is needed to understand the implications of locating proposed development in Zones 2 or 3. This is accomplished by considering information on the “actual risk” of flooding. The assessment of actual risk takes account of the presence of flood defences and provides a picture of the safety of existing and proposed development. It should be understood that the standard of protection afforded by flood defences is not constant and it is presumed that the required minimum standards for new development are:

- residential development should be protected against flooding with an annual probability of river flooding of 1% (1 in 100-year chance of flooding) in any year; and
- residential development should be protected against flooding with an annual probability of tidal (sea) flooding of 0.5% (1 in 200-year chance of flooding) in any year.

It should be noted that none of the watercourses in Leicestershire County and Leicester City are tidally influenced.

Through consultation with the Environment Agency, it is also advised that finished floor levels and mitigation measures for single storey developments (e.g. ground floor flats and bungalows) should be designed for the 0.1% AEP (1 in 1,000-year) flood event, where possible.

The assessment of the actual risk should take the following issues into account:

- The level of protection afforded by existing defences might be less than the appropriate standards and hence may need to be improved if further growth is contemplated.
- The flood risk management policy for the defences will provide information on the level of future commitment to maintain existing standards of protection. If there is a conflict between the proposed level of commitment and the future needs to support growth, then it will be a priority for the Flood Risk Management Strategy to be reviewed.
- The standard of safety must be maintained for the intended lifetime of the development. Over time the effects of climate change may reduce the standard of protection afforded by defences, due to increased river flows and levels, and so commitment is needed to invest in the maintenance and upgrade of defences if the present day levels of protection are to be maintained and where necessary land secured that is required for affordable future flood risk management measures.

- The assessment of actual risk can include consideration of the magnitude of the hazard posed by flooding. By understanding the depth, velocity, speed of onset and rate of rise of floodwater it is possible to assess the level of hazard posed by flood events from the respective sources. This assessment will be needed in circumstances where a) the consequences of flooding need to be mitigated or b) where it is proposed to place lower vulnerability development in areas of flood risk.

CHAPTER 3 SUMMARY

The NPPF supports a risk-based and sequential approach to development and flood risk in England, so that development is in the lowest flood risk areas where possible.

The Strategic Growth Plan will aim to identify the broad locations that are most likely to be developed in the longer term to accommodate the projected growth. Once these locations are identified, the application of the Sequential Test may be required if these locations are considered for development and / or considered as site allocations in the local planning process.

Depending on the location of development within proposed growth areas, the Exception Test may need to be passed if sites are in Flood Zones 2 or 3. A site-specific Flood Risk Assessment may also be required, to demonstrate the development passes the second part of the Exception Test.

CHAPTER 3 RECOMMENDATIONS

The commissioning authorities should use the information in this SFRA when deciding and identifying sites in the proposed growth areas. The risk-based and sequential approach to development and flood risk should be adopted.

If the Sequential Test is applied to future development sites identified in the proposed growth areas, it is recommended that the SFRA climate change maps are consulted.

Developers should consult with the relevant local planning authority, the Environment Agency, the relevant LLFA and water and sewerage company (Anglian Water and / or Severn Trent Water), at an early stage to discuss flood risk including requirements for site-specific FRAs, detailed hydraulic modelling, and drainage assessment and design. For example, there are watercourses where it was not possible to model the impacts of climate change (i.e. the River Welland) and developers may need to further investigate the flood risk as part of a site-specific FRA. Appendix H provides a list of all detailed hydraulic models used in this SFRA.

4 Climate change

4.1 Climate change and the NPPF

The NPPF sets out how the planning system should help minimise vulnerability and provide resilience to the impacts of climate change. NPPF and NPPG describe how FRAs should demonstrate how flood risk will be managed over the lifetime of the development, taking climate change into account.

4.2 Revised climate change guidance

The Environment Agency published updated climate change guidance on 19 February 2016, which supports the NPPF and must now be considered in all new developments and planning applications. The document contains guidance on how climate change should be taken into account when considering development, specifically how allowances for climate change should be included with FRAs. The Environment Agency can give a free preliminary opinion to applicants on their proposals at pre-application stage. There is a charge for more detailed pre-application planning advice.

4.3 Climate change allowances

By making an allowance for climate change it will help reduce the vulnerability of the development and provide resilience to flooding in the future.

The 2016 climate change guidance includes climate change predictions of anticipated change for peak river flow and peak rainfall intensity. The guidance also covers sea level rise and water height. These allowances are based on climate change projections and difference scenarios of carbon dioxide emissions to the atmosphere.

Due to the complexity of projecting climate change, there are uncertainties attributed to climate change allowances. Thus, the guidance presents a range of possibilities to reflect the potential variation in climate change impacts over three periods.

4.4 Peak river flows

Climate change is expected to increase the frequency, extent and impact of flooding, reflected in peak river flows. Wetter winters and more intense rainfall may increase fluvial flooding and surface water runoff and there may be increased storm intensity in summer. Rising river levels may also increase flood risk.

The peak river flow allowances provided in the guidance show the anticipated changes to peak flow for the river basin district within which the subject watercourse is located. Once the river basin district has been identified, guidance on uplift in peak flows are provided for three allowance categories, Central, Higher Central and Upper End which are based on the 50th, 70th and 90th percentiles respectively. The allowance category to be used is based on the vulnerability classification of the proposed development and the flood zones within which it is to be located.

These allowances are provided, in the form of figures for the total potential change anticipated, for three climate change periods:

- The ‘2020s’ (2015 to 2039)
- The ‘2050s’ (2040 to 2069)
- The ‘2080s’ (2070 to 2115)

The period used in the assessment depends upon the expected lifetime of the proposed development. Residential development should be considered for a minimum of 100 years, whilst the lifetime of a non-residential development depends upon the characteristics of that development. Further information on what is considered to be the lifetime of development is provided in the NPPG.

The allowances for the Anglian, Humber and Severn River Basin Districts are provided in Table 4-1.

Table 4-1: Peak river flow allowances for the Anglian, Humber and Severn river basin districts

River Basin District	Allowance category	Total potential change anticipated for '2020s' (2015 to 39)	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2115)
Anglian	Upper end	25%	35%	65%
	Higher central	15%	20%	35%
	Central	10%	15%	25%
Humber	Upper end	20%	30%	50%
	Higher central	15%	20%	30%
	Central	10%	15%	20%
Severn	Upper end	25%	40%	70%
	Higher central	15%	25%	35%
	Central	10%	20%	25%

4.4.1 High++ allowances

High++ allowances only apply in assessments for developments that are very sensitive to flood risk, for example large scale energy generating infrastructure, and that have lifetimes beyond the end of the century. H++ estimates represent the upper limit of plausible climate projections and would not normally be expected for schemes or plans to be designed to or incorporate resilience for the H++ estimate. Further information is provided in the Environment Agency publication, Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities.

4.4.2 Which peak river flow allowance to use?

The flood zone and flood risk vulnerability classification should be considered when deciding which allowances apply to the development or the plan and is detailed on the government's website: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances. Vulnerability classifications are found in the NPPG.

4.5 Peak rainfall intensities

Climate change is predicted to result in wetter winters and increased summer storm intensity in the future. Such increased rainfall intensity would affect land and urban drainage systems, resulting in surface water flooding, due to the increased volume of water entering the systems. The table below shows anticipated changes in extreme rainfall intensity in small and urban catchments. These allowances should be used for small catchments and urban drainage sites. For catchments larger than 5km^2, the guidance suggests the peak river flow allowances should be used.

For Flood Risk Assessments, both the central and upper end allowances should be assessed to understand the range of impact.

Table 4-2: Peak rainfall intensity allowance in small and urban catchments

Applies across all of England	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
Upper end	10%	20%	40%
Central	5%	10%	20%

4.6 Using climate change allowances

To help developers decide which allowances to use to inform the flood levels that the flood risk management strategy will be based on for a development or development plan allocation, the following should be considered:

- likely depth, speed and extent of flooding for each allowance of climate change over time considering the allowances for the relevant epoch (2020s, 2050s and 2080s)
- vulnerability of the proposed development types or land use allocations to flooding
- 'built in' resilience measures used, for example, raised floor levels
- capacity or space in the development to include additional resilience measures in the future, using a 'managed adaptive' approach

4.7 Groundwater

The effect of climate change on groundwater flooding problems, and those watercourses where groundwater has a large influence on winter flood flows, is more uncertain. Milder wetter winters may increase the frequency of groundwater flooding incidents in areas that are already susceptible, but warmer drier summers may counteract this effect by drawing down groundwater levels to a greater extent during the summer months. The effect of climate change on groundwater levels for sites in areas where groundwater is known to be an issue should be considered at the planning application stage.

4.8 The impact of climate change in the study area

4.8.1 Previous studies

The UK Climate Projection 2009 (UKCP09) predict the following climatic changes in the East Midlands:

- Increased summer temperatures of 2.8°C by 2050.
- Increased winter temperatures of 2.5°C by 2050.
- Reduced summer rainfall of 17% by 2050 making our summers much drier.
- Increased winter rainfall of 16% by 2050[3].

This may cause the following flood risk related impacts in Leicestershire County and Leicester City:

- Flash flooding
- Damp/waterlogged soil
- Increased flooding caused by more intense winter rainfall
- Increased surface runoff causing increased risks of pluvial flooding.

Several authorities have produced or are in the process of producing studies concerning the likely impacts of climate change to support climate change related policies in adopted / emerging Local Plans. These policies outline how the authorities are proposing to manage the likely impacts of climate change.

4.8.2 SFRA climate change modelling

Climate change modelling for the watercourses in the study area was undertaken based on the new climate change guidance. Existing Environment Agency hydraulic models were run for the 2080s period for all three allowance categories (relevant to the river basin district). Mapping of the climate change modelling outputs are provided in Appendix A.

There are notable cases where the modelled extents indicate sensitivities to an increase in flows due to climate change:

- The River Devon, throughout its course, around Muston, Easthorpe and Bottesford.
- The Whetstone Brook, throughout its course in Whetstone.
- The River Soar, at Quorn, where defences are shown to be over-topped.
- The River Soar at Leicester and to parts of Loughborough.
- The Bushby Brook in Leicester, towards its confluence with the Willow Brook.
- The Wash Brook in Oadby and Wigston borough.

The modelled flood extents indicate that in areas with high ground and steep-sided valleys, the topography confines watercourses and as such, flood extents do no noticeably increase. In general,

3 Charnwood Borough Council, Climate Local Action Plan 2014-2017 Appendix A

modelled flood extents noticeably increase in areas with lower-lying valleys and watercourses with a wider, flatter floodplain, such as the River Soar through Leicester, Quorn and parts of Loughborough. However, it is important to note that although the flood extent may not increase noticeably on some watercourses, the flood depth, velocity and hazard may increase compared to the 1% AEP current day event.

CHAPTER 4 SUMMARY

The NPPF sets out how the planning system should help minimise vulnerability and provide resilience to the impacts of climate change. NPPF and NPPG describe how FRAs should demonstrate how flood risk will be managed over the lifetime of the development, taking climate change into account.

The Environment Agency published updated climate change guidance on 19 February 2016, which supports the NPPF and must now be considered in all new developments and planning applications.

Climate change modelling for the watercourses in the study area was undertaken based on the new climate change guidance. Existing Environment Agency hydraulic models were run for the 2080s period for all three allowance categories (relevant to the river basin district). Mapping of the climate change modelling outputs are provided in the SFRA appendices.

CHAPTER 4 RECOMMENDATIONS

The Strategic Growth Plan will aim to identify the broad locations that are most likely to be developed in the longer term to accommodate the projected growth. As such, some of the impacts of climate change may start to materialise when the development is planned and / or constructed. It is therefore recommended that the climate change modelling and mapping in this SFRA is taken into consideration when identifying sites for development in the proposed growth areas.

Developers should follow the Environment Agency updated climate change guidance, where appropriate. The flood zone and flood risk vulnerability classification and lifetime of the development should be considered when deciding which allowances to apply to the development or the plan. If uncertain as to which allowance should be applied, developers are advised to consult with the Environment Agency. Where appropriate, developers should demonstrate how the impacts of climate change will be managed, over the lifetime of the development, as part of a site-specific Flood Risk Assessment.

5 Sources of information used in preparing the SFRA

5.1 Hydraulic models used in this SFRA

Table 5-1 lists the hydraulic models supplied by the Environment Agency, Leicestershire County Council and Leicester City Council and used to inform this SFRA. A map showing the coverage of these models is provided in Appendix H.

Note: In this table, reference to Appendix H has been made in cases where additional information can be found regarding the modelling and mapping approaches used to define Flood Zone 3b and climate change extents.

Table 5-1: Hydraulic models used to inform the SFRA

Ref. Number	Hydraulic Model Name	Date	Software	Watercourse	Represented in Flood Zone 3b?	Re-run for the climate change?
1	Halcrow JBA SFRM	2010	1D ISIS 1D-2D ISIS-TUFLOW in five urban areas	River Avon	Yes	Yes
2	Measham & Packington	2012	1D-2D ISIS-TUFLOW	Gilwiskaw Brook and the River Mease	Yes	Yes
3	River Sence JBA	2013	1D-2D ISIS-TUFLOW	River Sence (at Sheepy Magna)	Yes	Yes
4	Rugby Hazard Mapping	2015	1D-2D ISIS or ESTRY-TUFLOW	The River Swift	Yes	Yes
5	Stour and Hinckley Final Deliverables	2013	1D-2D ISIS-TUFLOW	Harrow Brook and Sketchley Brook	Yes	Yes
6	UA007649-Ashby_Hazard_Mapping Keep	2015	1D-2D ISIS-TUFLOW	Gilwiskaw Brook and un-named drain	Yes	Yes
7	Cosby Brook Flood Risk Mapping Study	2015	1D-2D ISIS-TUFLOW	Cosby Brook	Yes	Yes
8	Lower_Soar_and_Tribs_SFRM_JBA_2012	2012	1D-2D ISIS-TUFLOW	River Soar, Black Brook, Burleigh Brook, Wood Brook, Rothley Brook	Yes	Yes
9	Lower Wreake and Tributaries	2015	1D-2D ISIS-TUFLOW	River Wreake and the Gaddesby Brook	Yes	Partially – See Appendix H
10	River Wreake and Tributaries (also known as the Melton Mowbray model)	2011	1D-2D ISIS-TUFLOW	River Wreake and tributaries	Yes	Yes
11	GNRT CC Scenario, EA,	2016	1D-2D ISIS-TUFLOW	River Trent	No	Yes – See Appendix H

Ref. Number	Hydraulic Model Name	Date	Software	Watercourse	Represented in Flood Zone 3b?	Re-run for the climate change?
12	River Anker SFRA Model	2006	1D ISIS	River Anker	Yes	Yes
13	River Swift	1999	HEC-RAS	River Swift	No	Yes
14	Whetstone Brook SFRM, Halcrow, November 2005	2005	1D ISIS only	Whetstone Brook	Yes	Yes
15	Broughton Astley Brook SFRM Model	2005	1D ISIS only	Broughton Astley Brook	Yes	Partially – See Appendix H
16	River Sence (Soar)	1998	1D ISIS only	1D ISIS only	Yes	No – See Appendix H
17	Leicester City SFRM modelling	2010	1D-2D ISIS-TUFLOW	River Soar through Leicester City, Willow Brook, Melton Brook, Braunstone Brook, Saffron Brook	Yes	No - See Appendix H
18	Leicester Future Flood Risk Study*	On-going	1D-2D ISIS-TUFLOW	Draft climate change modelling for River Soar through Leicester City, Willow Brook, Bushby Brook, Evington Brook		
19	Welland Catchment Strategic Model	2016	1D MIKE 11 model	Great Easton Brook, River Jordan, Langton Brook, Medbourne Brook, Stonton Brook and the River Welland	Yes	No – See Appendix H
20	Leicestershire County Council Shenton Flood Modelling	2015	1D ISIS only	Shenton Brook	Yes	Yes
21	Leicester City Council Ordinary Watercourse Modelling	2012	1D-2D ISIS-TUFLOW	Ethel Brook, Gilroes Brook, Hol Brook, Queens Road Brook, Portwey Brook, Thurmaston Parish Dyke, and Western Park Brook	See comments in Section 5.2.3 and Appendix H	Partially - See Appendix H
22	Leicester City Council Ordinary Watercourse Modelling - Wash Brook Model	2012	1D-2D ISIS-TUFLOW	Wash Brook	See comments in Section 5.2.3 and Appendix H	No – See Appendix H

Note: draft modelling output from the Leicester Future Flood Risk Study was provided by Riverscape Environmental Consultants Ltd, under the Leicester City Council Professional Services Framework with Arcadis. The output is subject to review and whilst it represents the best available data at the time of writing, the results are subject to review.

5.2 Fluvial flooding

5.2.1 Flood Zones 2 and 3a

Flood Zones 2 and 3a, as shown in Appendix A, show the same extent as the Environment Agency's Flood Map for Planning (at the time of preparing this SFRA).

5.2.2 Flood Zone 3b

Flood Zone 3b, as shown in Appendix A, has been compiled for the study area as part of this SFRA assessment and is based on the 5% AEP (1 in 20-year chance of flooding in any given year) or 4% AEP (1 in 25-year chance of flooding in any given year) extents produced from Environment Agency detailed hydraulic models, where outputs were available.

For some areas not covered by detailed hydraulic models, the functional floodplain has been represented using outputs of Jflow modelling undertaken for the following SFRAs:

- Charnwood Borough;
- Melton Borough; and,
- Hinckley and Bosworth Borough, Blaby District and Oadby and Wigston Borough.

For areas not covered by detailed or the Jflow models, a precautionary approach should be adopted for Flood Zone 3b with the assumption that the extent of Flood Zone 3b would be equal to Flood Zone 3a. If development is shown to be in Flood Zone 3a, further work should be undertaken as part of a detailed site-specific Flood Risk Assessment to define the extent of Flood Zone 3b.

5.2.3 Ordinary watercourses in Leicester City

Leicester City Council provided hydraulic models of eight ordinary watercourses in the city; the models / watercourses are listed by models 21 and 22 in Table 5-1. The following modelled extents have been used to map the flood risk from these watercourses:

- 1 in 25-year defended outline (comparable to Flood Zone 3b)
- 1 in 100-year undefended outline (comparable to Flood Zone 3a)
- 1 in 1,000-year undefended outline (comparable to Flood Zone 2).

The Leicester City Council ordinary watercourse modelling extents are shown as separate layers in the Appendix A maps, covering Leicester City only.

5.3 Climate change

Climate change modelling for the watercourses in study area was undertaken based on the new climate change guidance. Existing Environment Agency hydraulic models, as well as the SFRA 2D hydraulic models (where available) and the Leicester City ordinary watercourse models, were run for the 2080s period for all three allowance categories, for the relevant river basin district. Further detail is provided in Section 4.

Where no hydraulic models exist, no climate change modelling was undertaken. Developers should develop detailed hydraulic models as part of a site-specific flood risk assessment and include climate change in the assessment. Developers are advised to approach the Environment Agency and relevant Local Planning Authority at an early stage, to determine and agree the level of detail required in hydraulic modelling work, prior to commencing modelling studies.

5.4 Surface water

Mapping of surface water flood risk in study area has been taken from the Risk of Flooding from Surface Water (RoFfSW) maps published online by the Environment Agency. These maps are intended to provide a consistent standard of assessment for surface water flood risk across England and Wales in order to help LLFAs, the Environment Agency and any potential developers to focus their management of surface water flood risk.

The RoFfSW is derived primarily from identifying topographical flow paths of existing watercourses or dry valleys that contain some isolated ponding locations in low lying areas. They provide a map which displays different levels of surface water flood risk depending on the annual probability of the land in question being inundated by surface water (Table 5-2).

Table 5-2: RoFfSW risk categories

Category	Definition
High	Flooding occurring as a result of rainfall with a greater than 1 in 30 chance in any given year (annual probability of flooding 3.3%)
Medium	Flooding occurring as a result of rainfall of between 1 in 100 (1%) and 1 in 30 (3.3%) chance in any given year.
Low	Flooding occurring as a result of rainfall of between 1 in 1,000 (0.1%) and 1 in 100 (1%) chance in any given year.
Very Low	Flooding occurring as a result of rainfall with less than 1 in 1,000 (0.1%) chance in any given year.

Although the RoFfSW offers improvement on previously available datasets, the results should not be used to understand flood risk for individual properties. The results should be used for high level assessments such as SFRAs for local authorities. If a site is indicated in the Environment Agency mapping to be at risk from surface water flooding, a more detailed assessment should be considered to more accurately illustrate the flood risk at a site-specific scale. Such an assessment will use the RoFfSW in partnership with other sources of local flooding information to confirm the presence of a surface water risk at that location.

5.5 Groundwater

Mapping of groundwater flood risk has been based on the Areas Susceptible to Groundwater (AStGW) dataset.

The AStGW dataset is a strategic-scale map showing groundwater flood areas on a 1km square grid. It shows the proportion of each 1km grid square, where geological and hydrogeological conditions indicate that groundwater might emerge. It does not show the likelihood of groundwater flooding occurring and does not take account of the chance of flooding from groundwater rebound. This dataset covers a large area of land, and only isolated locations within the overall susceptible area are actually likely to suffer the consequences of groundwater flooding.

The AStGW data should be used only in combination with other information, for example local data or historical data. It should not be used as sole evidence for any specific flood risk management, land use planning or other decisions at any scale. However, the data can help to identify areas for assessment at a local scale where finer resolution datasets exist.

5.6 Sewers

Historical incidents of flooding are detailed by Anglian Water through their DG5 register and Severn Trent Water through their Historic Flood Risk Register (HFRR). The DG5 and HFRR databases records incidents of flooding relating to public foul, combined or surface water sewers and displays which properties suffered flooding. The risk registers have been considered in the assessment of flood risk from sewers (see Section 6.7.1).

5.7 Reservoirs

The risk of inundation because of reservoir breach or failure of reservoirs within the area has been mapped using the outlines produced as part of the National Inundation Reservoir Mapping (NIRIM) study.

5.8 Other relevant flood risk information

Users of this SFRA should also refer to other relevant information on flood risk where available and appropriate. This information includes:

- Anglian, Humber and Severn Catchment Flood Management Plans (2009)

  Provides information on the catchment-wide strategy for flood risk management. It should be ensured that any flood risk management measures are consistent with the strategies. In summary, the CFMPs policies indicate that intervention measures will be used across Leicestershire and Leicester City to manage the risk of flooding. Flood risk will either be managed at current levels (now and / or in the future) or reduced (now and / or in the future). Further information can be found in Section 2.6.

- Anglian, Humber and Severn Flood Risk Management Plans (2016)

  Provides information on the catchment-wide strategy for flood risk management. It should be ensured that any flood risk management measures are consistent with the strategies. Appendix C of the FRMPs list proposed actions and measures to manage flood risk in the respective river basin district. In the Humber river basin district, 20 actions are proposed for the Leicester City Principal Urban Area and in the Anglia river basin district, 6 actions are proposed in the River Welland catchment in Leicestershire. Further information can be found in Section 2.2.3.

- Leicester City Council Local Flood Risk Management Strategy (2015) and Leicestershire County Council Local Flood Risk Management Strategy (2015)

  Provides information on local flooding issues and the plan for managing risk. It should be ensured that development and any flood risk management measures are consistent with the strategies. Further information can be found in Section 2.2.5.

- Leicester City Council Integrated Flood Risk Management Strategy (2017)

  Provides information on opportunities to reduce flood risk in four keys areas across the city: the Soar corridor, Willow Brook, Braunstone Brook and Saffron Brook. It should be ensured that development and any flood risk management measures are consistent with the strategy. The IFRMS is planned to be published in December 2017. Further information can be found in Section 2.2.5.

- Leicester City Council Surface Water Management Plan (2012) and Loughborough Surface Water Management Plan (2013)

  Provides information on surface water flooding issues for Leicester city and Loughborough and the plan for managing risk. It should be ensured that any surface water management measures are consistent with the Plans. Further information can be found in Section 2.5.

- Leicestershire Water Cycle Study supporting the Strategic Growth Plan (2017)

  Developers and planners should use the WCS as a starting point when considering any water supply, sewerage or water quality constraints on a development. Further information can be found in Section 2.8

- Environment Agency's Asset Information Management System (AIMS) – users should note that recently completed schemes may not yet be included in this dataset. Provides information on assets in the area. Can be used to identify where residual risk should be assessed.

CHAPTER 5 SUMMARY

The Strategic Flood Risk Assessment has been developed using the best available information, supplied at the time of preparation. This relates both to the current risk of flooding from rivers, and the potential impacts of future climate change.

This SFRA is a high level strategic document. The datasets used to inform this SFRA may periodically be updated and following the publication of this SFRA, new information on flood risk may be provided by Risk Management Authorities. Such information may be in the form of:

- New hydraulic modelling results
- Flood event information following a flood event
- Policy/ legislation updates
- Environment Agency flood map updates
- New flood defence schemes etc.

CHAPTER 5 RECOMMENDATIONS

If sites are identified in the proposed growth areas, hydraulic modelling may be required as part of a site-specific Flood Risk Assessment, to provide the required level of detail to support a site's development. This may occur where

- The Environment Agency's Flood Zone maps do not cover the watercourse. Environment Agency mapping of Flood Zones covers watercourses with a catchment greater than 3km^2 (Rivers and Sea). If a watercourse or drain is shown on OS mapping but is not covered by a Flood Zone, this does not mean there is no potential flood risk.
- Locations where surface water flooding is the predominant flood risk could be investigated further by use of surface water hydraulic modelling, or in combination with fluvial modelling, to assess the interactions between the two in more detail. Similarly, for any locations which suffer from sewer flooding or sewer capacity issues; this data can be incorporated into hydraulic models to more accurately represent the surface water system.
- Any developments shown to be at residual flood risk, for example from a breach or overtopping scenario (e.g. reservoir, canal, perched watercourse), may require modelling.

Any existing hydraulic models which are represented in 1D-only could be upgraded in future to 1D-2D hydraulic models, if it is deemed necessary (for example if properties are at flood risk or a flood event has occurred and more detailed information is required, or to support the Exception Test). This type of model would provide a greater level of floodplain flood risk information, for example depths, velocity and hazard in the floodplain.

Developers should be aware that the datasets used to inform this SFRA may be updated and new flood risk information may be available, following publication of this SFRA.

6 Understanding flood risk in the study area

6.1 Historic flooding

There have been several recorded flood incidents across Leicestershire County and Leicester City, from a combination of sources. The earliest recorded flood incident was in November 1852 and the most recent records are from March 2016. Notable and more severe flood events to affect the county include the 1947 and Easter 1998 flood events. Several rural settlements have also been affected by the 1999 (December), 2000, Summer 2007, January 2008 and November 2012 flood events. Communities which have experienced frequent flooding include Market Harborough, Melton Mowbray, Great Glen, Burton Overy and Anstey. Prominent sources of flooding are fluvial, surface water, sewer and flood incidents associated with water infrastructure issues such as culvert blockages or insufficient capacity in the sewer network.

Under Section 19 of the Flood and Water Management Act, Leicester City Council and Leicestershire County Council in their role as the Lead Local Flood Authority, have published flood investigation reports covering the following communities and events

- Bardon Road in Coalville – June 2012
- Drome / Vercor Close in Coalville – June 2012
- Cothelstone Avenue in Loughborough – June 2012
- Main Street in Normanton – June 2012
- Mythe Lane in Witherley – June 2012
- Main Road in Sheepy Magna – July 2012
- Shenton Village – November 2012
- Bath Lane in Moira – November 2012
- Town Centre in Market Harborough – July 2013
- Rugby Close in Market Harborough – December 2013
- Main Street in Burton Overy, Harborough – June 2014

Mapping in Appendix B displays the settlements which have historic flood records, represented as a point on a map. The size of this point reflects the frequency of flooding recorded at that settlement. The historic flood records have been informed by previous SFRAs prepared for the commissioning authorities, 2011 Leicester City PFRA, 2011 Leicestershire County Council PFRA, Section 19 reports and additional historic flood information provided by the commissioning authorities. Anglian Water's DG5 register and Severn Trent Water's Historic Flood Risk Register (HFRR) data have not been used to inform the mapping in Appendix B due to the sensitivity and the licencing terms of the datasets. The risk registers have been referred to in Section 6.7.1.

6.2 Topography, geology and soils

6.2.1 Topography

The topography of the study area can be seen in Figure 6-1 and is primarily characterised by the valleys of the River Soar, River Wreake, River Welland and River Anker. Lower elevations are found along these river corridors and range from approximately 65 metres Above Ordnance Datum (m AOD) in the Blaby District, decreasing in a northerly direction to approximately 28m AOD, in Charnwood Borough, towards the River Soar's confluence with the River Trent. Areas of comparatively higher ground are found towards the east, south and west of the study area; these form steep sloping river valleys and can reach elevations of approximately 245m AOD.

The steep topography in certain areas is known to contribute to the flood risk. For example, the 2009 Harborough SFRA notes that the main cause of flooding in the River Welland catchment is heavy rain falling over a short period as steeper topography and impervious geology create higher rates of runoff which discharge directly into the watercourses.

6.2.2 Geology and soils

The geology of the catchment can be an important influencing factor on the way that water runs off the ground surface. This is primarily due to variations in the permeability of the surface material and bedrock stratigraphy.

Figure 6-2 shows the bedrock (solid permeable) formations in the study area and Figure 6-3 shows the superficial (permeable, unconsolidated (loose) deposits). These are classified as the following:

- Principal: layers of rock or drift deposits with high permeability which, therefore, provide a high level of water storage
- Secondary A: rock layers or drift deposits capable of supporting water supplies at a local level and, in some cases, forming an important source of base flow to rivers
- Secondary B: lower permeability layers of rock or drift deposits which may store and yield limited amounts of groundwater
- Secondary undifferentiated: rock types where it is not possible to attribute either category a or b
- Unproductive Strata: rock layers and drift deposits with low permeability and therefore have negligible significance for water supply or river base flow.

North West Leicestershire District, Charnwood Borough, Hinckley and Bosworth Borough, Blaby District and the City of Leicester are primarily underlain by a Secondary A aquifer, associated with mudstone, sandstone and siltstone. Harborough District and Melton Borough are primarily underlain by a Secondary undifferentiated aquifer, associated with the Lias Group. There are outcrops of Principal aquifers located in north west Leicestershire and north east Leicestershire, generally associated with interbedded sandstone and conglomerate rocks and the Inferior Oolite Group which contains limestone. There are also outcrops of unproductive strata towards the eastern boundary of the study area and towards the north of Charnwood Borough.

Much of the study area is underlain by a Secondary undifferentiated aquifer (superficial deposits designation). Areas with a Principal aquifer (superficial deposits designation) tend to be found along river corridors with river terrace and / or alluvium deposits.

Figure 6-1: Topography of Leicestershire County and Leicester City

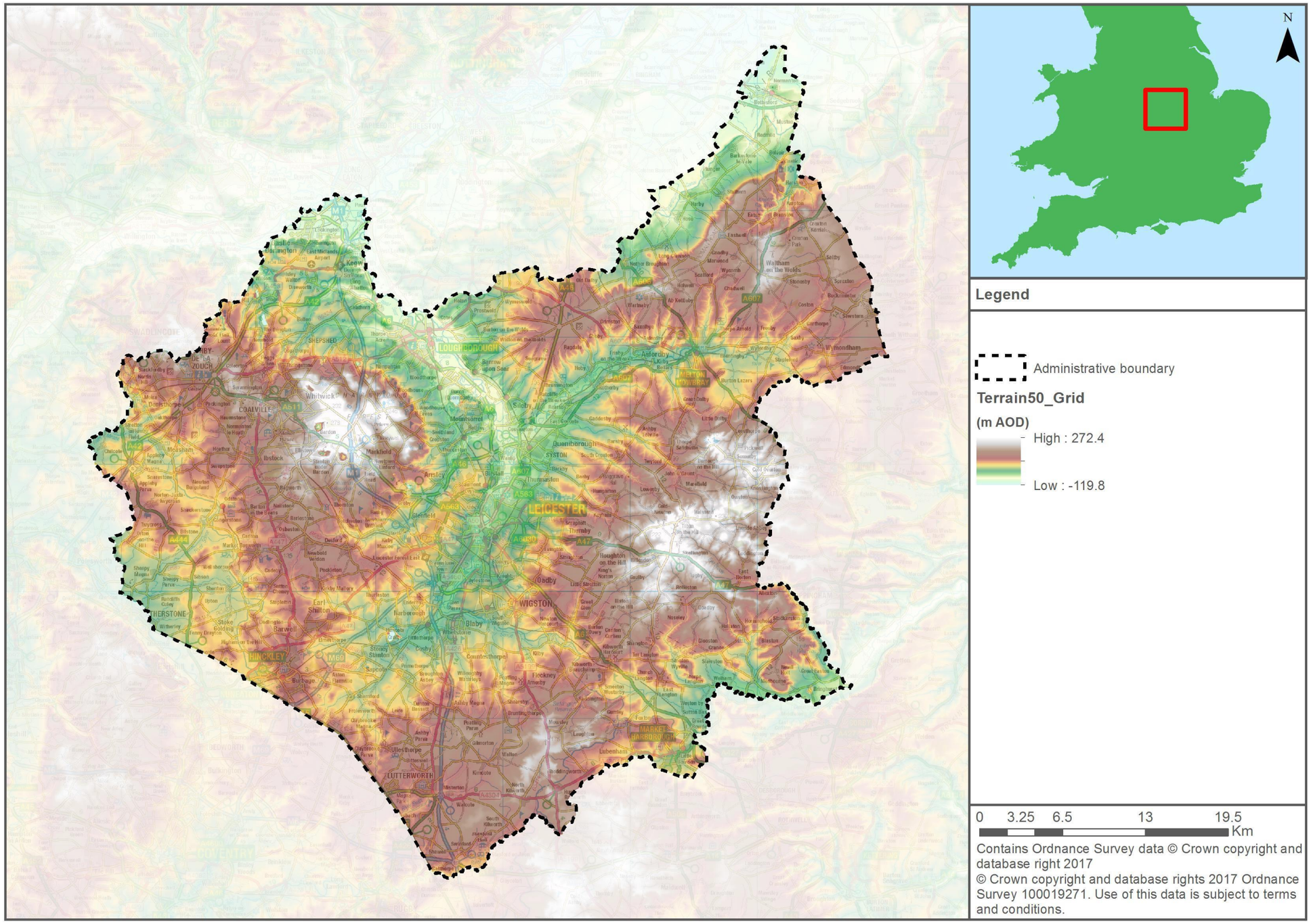


Figure 6-2: Bedrock aquifer classification in Leicestershire County and Leicester City

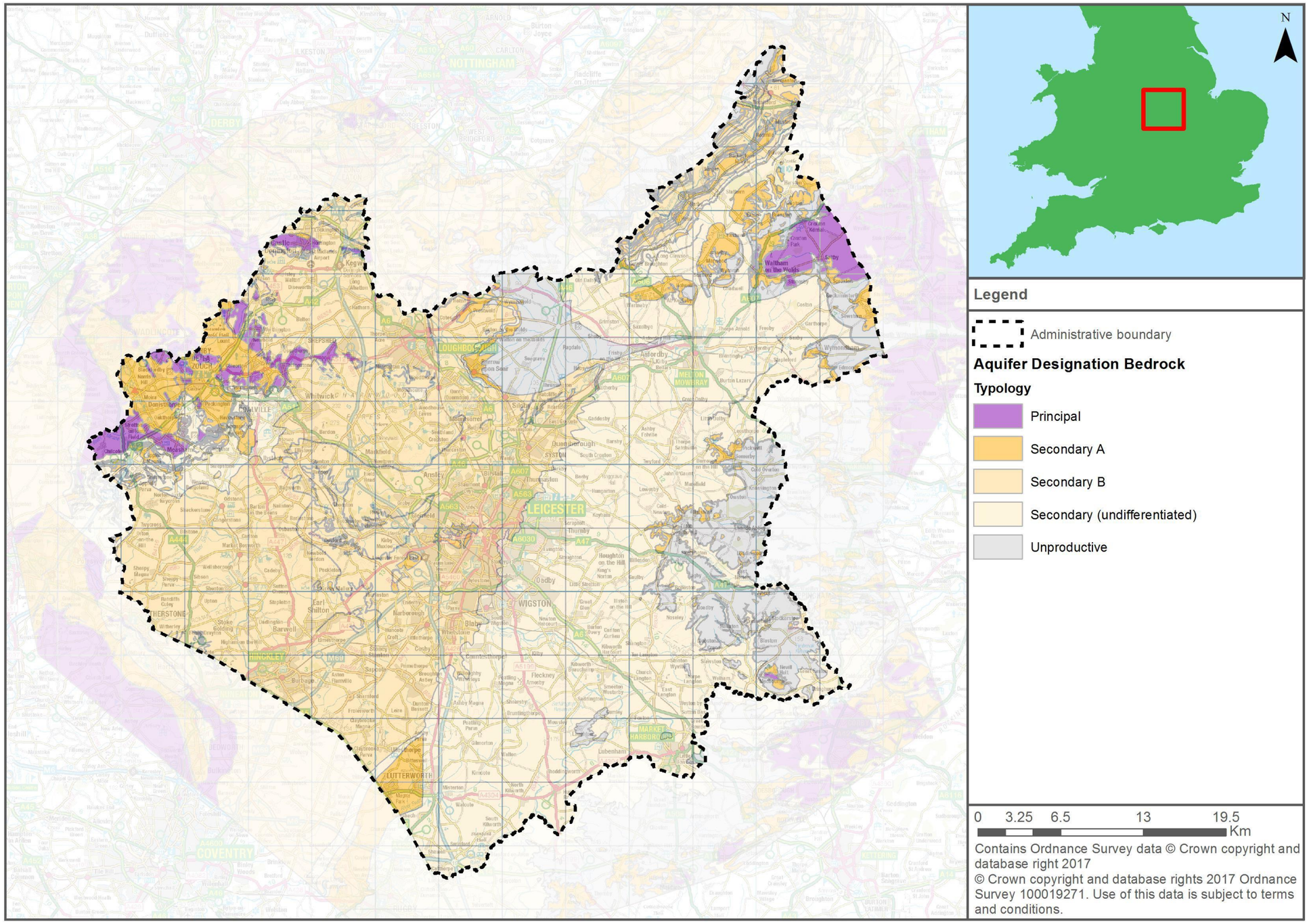
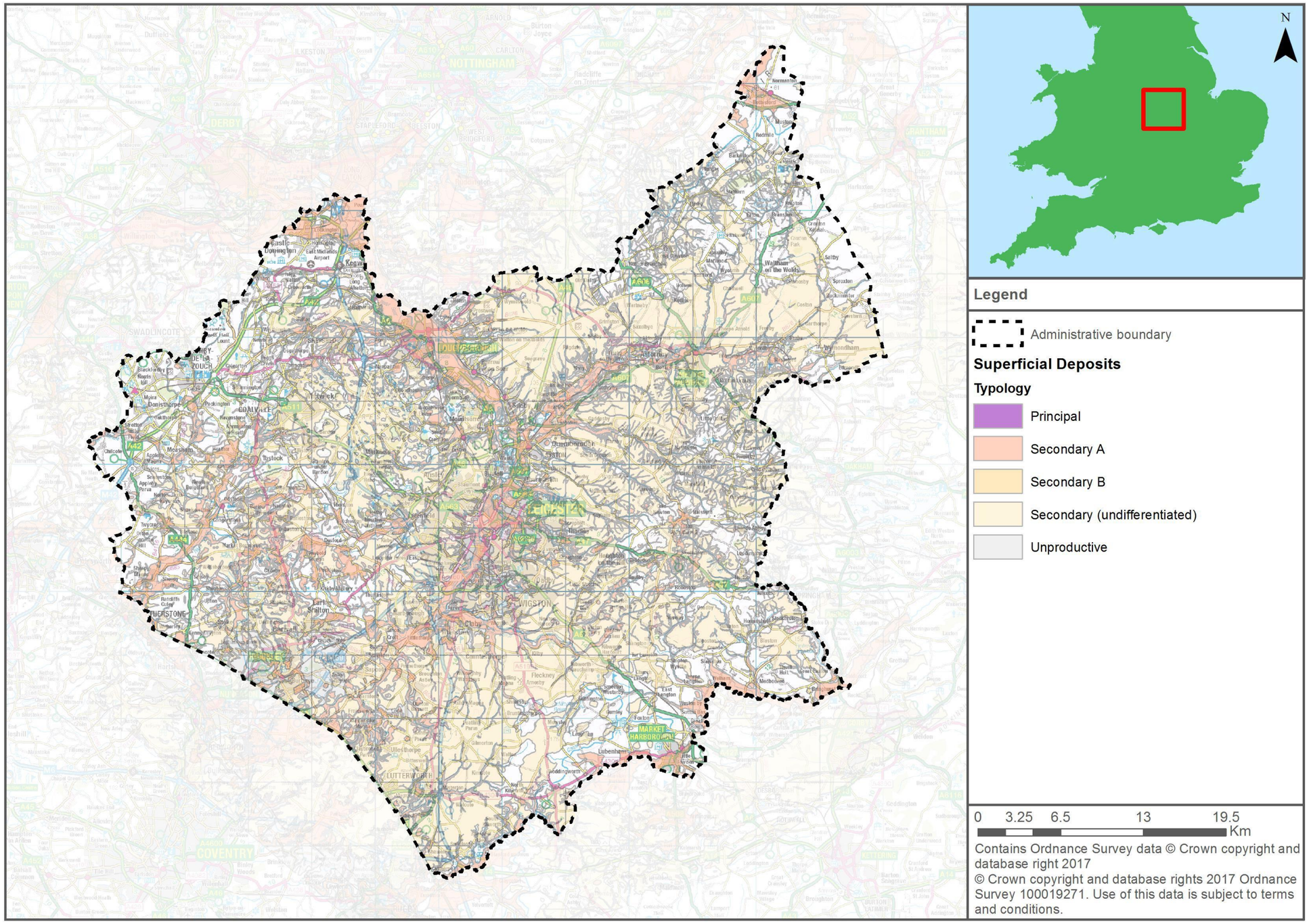


Figure 6-3: Superficial aquifer classification in Leicestershire County and Leicester City



6.3 Watercourses in Leicestershire County and Leicester City

There are numerous watercourses flowing through the study area. These include Main River, ordinary watercourses and the Trent Valley IDB watercourses. Appendix C shows the location of Main Rivers and Ordinary Watercourses for each Local Planning Authority in Leicestershire County and Leicester City.

- Main Rivers: These tend to be larger streams and rivers, though some of them are smaller watercourses of local significance. The Environment Agency has permissive powers to carry out maintenance, improvement or construction work on Main Rivers to manage flood risk. Consultation with the Environment Agency will be required for any development projects within 20m of a Main River or flood defence, and any other water management matters.
- Ordinary watercourses: These are all watercourses not designated as Main River or IDB watercourses. The operating authority (local authority or IDB) has permissive powers to maintain them, but the responsibility lies with the riparian owner.
- Internal Drainage Board watercourses and drains: Numerous smaller watercourses and drains form the Trent Valley Internal Drainage District. A small part of the study area is covered by the IDB; this is located to the north of Melton Borough, in the Bottesford area.

6.4 Fluvial flood risk

Much of the fluvial flood risk in Leicestershire County and Leicester City is associated with the River Soar and its tributaries, as well as the River Welland, the River Avon and the River Sence. Parts of the main urban centres in the county such as Leicester City and Loughborough are located within the floodplain of the River Soar and its tributaries; parts of Market Harborough are located in the floodplain of the River Welland and its tributaries. There are also numerous ordinary watercourses that pose a flood risk in the area. However, the fluvial flood risk is not solely confined to cities and towns; several villages and rural areas are also at risk. Section 6.10 summarises the fluvial flood risk (as well as other sources of flooding) in each authority area.

Flooding may not be from one watercourse alone. Often the combination of watercourses and the interaction of two or more sources of out of bank flow across the floodplain can have profound implications for the extent of the risk. Notable areas where there are interactions with watercourses include:

- Around the River Soar, Grand Union Canal and the Wood Brook in the urban areas in Loughborough.
- Around the Broughton Astley Brook, Whetstone Brook, the River Sence (Soar) and the River Soar around the urban areas of Croft, Blaby, Whetstone and Narborough.
- At Melton Mowbray, several watercourses converge to form the River Wreake, and these rivers, streams and brooks must therefore be managed as a connected, cascading system.
- In North West Leicestershire District, areas to the north and east are vulnerable from the River Trent and the River Soar; both watercourses can flood independently and during wider events, both can present a risk simultaneously.

6.5 Surface water flood risk

Flooding from surface water runoff (or 'pluvial' flooding) is usually caused by intense rainfall that may only last a few hours, occurring often where the natural (or artificial) drainage system is unable to cope with the volume of water. Surface water flooding problems are inextricably linked to issues of poor drainage, or drainage blockage by debris, and sewer flooding.

6.5.1 Areas with known surface water flood risk

Surface water is one of the primary flood risks in the study area. Factors contributing to the surface water flood risk include:

- The local geology. For example, many local authorities in the study area have large areas underlain with clay deposits which, combined with the undulating topography, results in catchments responding quickly to rainfall events.

- The local topography. Surface water runoff from areas of high ground is known to have contributed to surface water flooding in Thorpe Astley, to the rear of Priestman Road, Tuffleys Way and Murby Way.
- High density of impervious surfaces, largely found in urban areas. This, combined with high intensity, localised rainfall events has the potential to cause localised surface water flooding. For example, Spinney Road and Thorpe Road in Melton Mowbray are reported to have flooded on three occasions since 2007.
- Insufficient capacity of the drainage system following heavy rainfall events. This is a known issue in Lutterworth, Great Glen, Kibworth, along Bardon Road in Coalville and has occurred in parts of Leicester City. Similarly, Long Clawson is reported to experience surface water flooding due to the village's culvert infrastructure. Insufficient capacity of the drainage system following heavy rainfall events was a historic and re-occurring issue in Market Harborough. Anglian Water completed a flood alleviation scheme in 2016 which is intended to reduce the risk of surface water flooding along Coventry Road, in Market Harborough. Flood defences and alleviation schemes are discussed further in Section 7. However, flooding to the town centre is reported to occur fairly regularly and should not be considered a historic matter only.
- Surface water runoff associated with certain agricultural practices. Certain arable farming practices are likely to increase this risk of surface water flooding and excessive loss of top soil.

6.5.2 Summary of the key findings from the Surface Water Management Plans

The 2012 Leicester City Council SWMP found:

- through historical flood records and national pluvial modelling, 36,900 properties were identified as being at risk across the City of Leicester, indicating that Leicester is at significant risk of surface water flooding;
- 18 Critical Drainage Areas were identified which denote an area or catchment where mitigation measures may be implemented to reduce flooding in that area or catchment;
- the surface water sewer network has the potential to increase the rate of discharge into watercourses during short duration intense storms;
- largely, privately owned and maintained surface water drainage networks may discharge into ordinary watercourses;
- there is the potential for a combined risk of surface water and pluvial flooding along areas of Gilores Brook, Ethel Brook, Hol Brook and Wash Brook; and,
- historical records indicate that flooding from sewers has occurred in Leicester, largely due to insufficient capacity in certain parts of the network.

The 2013 Loughborough SWMP found:

- 4,200 properties are at potential risk of surface water flooding, based on research conducted by Defra in 2009;
- Loughborough experienced significant surface water flooding in Easter 1998 – the severity of flooding makes this a nationally significant event in the PFRA;
- four Critical Drainage Areas were identified; and,
- at the time of the SWMP study, Severn Trent Water were assessing the feasibility of major rehabilitation of the entire sewer network in Loughborough.

The RoFfSW mapping for Leicestershire County and Leicester City can be found in Appendix A.

There are cases where the RoFfSW map does not reflect historic flood information. One such instance is around the east end of Oakham Road in the village of Somerby. Residents have reported that flood events occur in this area twice a year. A possible source of this flooding is from surface water runoff from fields or adjacent land. As part of site-specific Flood Risk Assessments, historic flood risk information should be considered in the assessment of flood risk, in conjunction with flood risk mapping datasets.

Section 6.10 summarises the surface water flood risk (as well as other sources of flooding) in each authority area.

6.6 Groundwater flood risk

6.6.1 Recorded incidents

In comparison to fluvial flooding, current understanding of the risks posed by groundwater flooding is limited and mapping of flood risk from groundwater sources is in its infancy. Under the Flood and Water Management Act (2010), LLFAs have powers to undertake risk management functions in relation to groundwater flood risk. Groundwater level monitoring records are available for areas on Major Aquifers. However, for lower lying valley areas, which can be susceptible to groundwater flooding caused by a high groundwater levels in mudstones, clays and superficial alluvial deposits, very few records are available. Additionally, there is increased risk of groundwater flooding where long reaches of watercourse are culverted because of elevated groundwater levels not being able to naturally pass into watercourses and be conveyed to less susceptible areas.

There are very few recorded incidents of groundwater flooding in the study area. The 2012 Level 2 Leicester City SFRA suggests that groundwater may have contributed to the flood events during 1983, 1984, 1987, 1989 and 1993 in Leicester City; however, this is not confirmed.

The historic flood information supplied by Leicester City Council identified seven incidents which may be attributed to groundwater flooding since 2011 (as shown in Table 6-1).

Table 6-1: Historic flood incidents potentially related to groundwater flooding

Date	Location	Post-code
June 2012	Cloverdale Road	LE5 1
December 2012	Hazelbank Close	LE4 0
December 2012	High View Close	LE4 9
March 2013	Goodwood Road	LE5 6
April 2013	Shanklin Drive	Not stated
June 2013	Evington Lane	LE5 5
July 2013	Padside Row	LE4 9

Source: Leicester City Council 2011-2017 flood records

In Melton Borough, the only confirmed records of groundwater flooding relate to incidents in Frisby and Melton Mobray following egression of groundwater through hillside fissures and generation of overland flow.

6.6.2 Potential groundwater flooding mechanisms

A desk-study review of previous SFRAs, SWMPs and historic flood information provided by the commissioning authorities has identified the following potential groundwater flooding mechanisms:

1. Groundwater flooding associated with Alluvium and River Terrace deposits where there is hydraulic connectivity with surface water i.e. when watercourses rise, this triggers a rise in groundwater levels.
2. Perched groundwater tables formed by natural rainfall recharge and artificial recharge. These can be found within River Terrace Deposits and sand lenses which are not hydraulically connected to surface water.
3. Rainfall recharge in perched water tables within the lenticular water bearing sand lenses within the Blue Lias formation and in the Mercia Mudstone formation. This can cause springs and seepages at their outcrops. In Long Clawson, it is noted that groundwater flooding associated with spring activity is a potential flood risk[4].
4. Significant and artificial modification of the ground (made ground deposits) which could cause flooding by the above mechanisms.
5. Coalfield mine-water rising. This can occur where the closure of a mine and the termination of associated activities such as water pumping, causes the mine void to refill with water. This is a risk in Oakthorpe and Donnisthorpe in north west Leicestershire, though there have been no recorded incidents of groundwater flooding relating to this.

4 Long Clawson Flood Risk Assessment and Flooding Reports: on behalf of the Long Clawson, Hose and Harby Neighbourhood Plan Group

6. There are several spring fed tributaries of the River Soar, located to the east and west of Leicester. The 2012 Leicester City Level 2 SFRA notes that historical incidents may be related to spring flows however, there is insufficient information to distinguish such events from pluvial or fluvial flooding events.

AStGW flooding has been provided and mapped for the study area; this can be found in Appendix A.

Section 6.10 summarises the groundwater flood risk (as well as other sources of flooding) in each authority area.

6.7 Flooding from artificial sources

6.7.1 Flooding from sewers

Sewer flooding occurs when intense rainfall overloads the sewer system capacity (surface water, foul or combined), and/or when sewers cannot discharge properly to watercourses due to high water levels. Sewer flooding can also be caused when problems such as blockages, collapses or equipment failure occur. Infiltration or entry of soil or groundwater into the sewer system via faults within the fabric of the sewerage system, is another cause of sewer flooding. Infiltration is often related to shallow groundwater, and may cause high flows for prolonged periods of time.

The 2012 Leicester City and the 2015 North West Leicestershire SFRAs note much of the sewer network dates to the Victorian era and the capacity and conditions of sections of the network is unknown.

However, since 1980, the Sewers for Adoption guidelines have meant that most new surface water sewers have been designed to have capacity for a 1 in 30-year rainfall event (3.3% AEP), although until recently this did not apply to smaller private systems. This means that, even where sewers are built to current specification, they are likely to be overwhelmed by larger events of the magnitude often considered when looking at river or surface water flooding. Existing sewers can also become overloaded as new development adds to the discharge to their catchment, or due to incremental increases in roofed and paved surfaces at the individual property scale (urban creep). Sewer flooding is therefore a problem that could occur in many locations across the study area.

Several historic records relate to sewer flooding. However, for areas where there were re-occurring issues maintenance work may have been undertaken by Anglian Water or Severn Trent Water since the flooding incidents occurred and therefore the risk may have been removed or reduced. As such, the historic record for sewer flooding represents a ‘snap-shot’ in time and is not necessarily a reflection of the current or future flood risk from sewers.

For confidentiality reasons, the data has been displayed on a 4-digit and 5-digit postcode basis.

Table 6-2: Severn Trent Water internal flooding records

Local Planning Authority	Postcode	No of incidents	Local Planning Authority	Postcode	No of incidents
Blaby District	LE10 3	2	Charnwood Borough	LE11 1	13
	LE19 3	1		LE11 3	1
	LE3 2	7		LE11 4	1
	LE3 3	4		LE11 2	1
	LE3 8	8		LE12 5	1
	LE8 5	5		LE12 7	2
	LE8 6	3		LE12 8	7
	LE9 4	5		LE12 9	2
Leicester City	LE1 1	1		LE4 3	1
	LE1 2	2		LE4 4	1
	LE1 5	1		LE4 8	2
	LE1 6	2		LE7 1	2
	LE2 8	11		LE7 4	9
	LE2 9	3		LE7 7	1
	LE2 1	20	Hinckley and Bosworth Borough	CV13 0	6
	LE2 2	1		CV13 6	3
	LE2 3	15		LE10 0	7
	LE2 5	4		LE10 1	7
	LE2 6	11		LE10 2	23
	LE2 7	2		LE6 0	6
	LE3 1	2		LE9 8	1
	LE3 5	5		LE9 9	5
	LE3 6	1	Melton Borough	LE13 0	2
	LE3 9	1		LE13 1	1
	LE4 0	1		LE14 3	2
	LE4 6	1		LE14 4	4
	LE5 0	1		NG13 0	2
	LE5 1	1	North West Leicestershire District	DE11 8	1
	LE5 2	8		DE12 7	2
	LE5 3	1		DE3 5	2
	LE5 4	1		DE74 2	3
	LE5 5	8		LE65 1	2
Harborough District	LE17 6	1		LE65 2	2
	LE7 9	3		LE67 2	4
Oadby and Wigston Borough	LE18 1	1		LE67 4	14
	LE18 3	1		LE67 5	4
	LE18 4	4		LE67 6	3
	LE2 4	5		LE67 8	1

Table 6-3: Anglian Water DG5 register

Local Planning Authority	Postcode	No of incidents
Harborough District	LE15 8	3
	LE15 9	3
	LE16 7	6
	LE16 9	4

6.7.2 Flooding from canals

Canals do not generally pose a direct flood risk as they are a regulated waterbody. The residual risk from canals tends to be associated with lower probability events such as overtopping and embankment failure (breach and sudden escape of the water retained in the canal channel).

The residual risk associated with canals is more difficult to determine as it depends on several factors including, for example, the source and magnitude of surface water runoff into the canal, the size of the canal, construction materials and level of maintenance. The probability of the risk of a breach is managed by continued maintenance.

Over-topping and breach

The level of water in canals is normally controlled by the level and size of weirs. When surface water enters a canal, the level of water rises. The water level may then reach a point in which it discharges from the canal through control structures such as weirs. If the capacity of these control structures is exceeded, or should they become blocked, overtopping may occur.

Breaches or embankment failure may be caused by several factors including:

- Culvert collapse
- Overtopping
- Animal burrowing

Flooding from a breach of a canal embankment is largely dictated by canal and ground levels, canal embankment construction, breach characteristics and the volume of water within the canal that can discharge into the lower lying areas behind the embankment. The volume of water released during a breach is dependent on the upstream pound length (i.e. the distance between locks) and how quickly the operating authorities can react to prevent further water loss, for example by the fitting of stop boards to restrict the length of the canal that can empty through the breach, or repair of the breach.

Recorded flood incidents from canals

There are three canals which flow through the study area:

- Grantham Canal;
- Grand Union Canal formed of the Welford Arm (Leicester Line), the Leicester Line and the Market Harborough Arm; and,
- Ashby Canal.

The Trent and Mersey Canal flows near the northern boundary of North West Leicestershire District.

The Canal and River Trust were consulted to identify breaches and overtopping from canals, within Leicestershire County and Leicester City. 11 incidents relating to breaches have been recorded across the study area from 1969 to 2010; most the incidents are associated with the failure of structures such as aqueducts, pipes, culverts, locks, sluices and weirs. 15 incidents relating to over-topping have been recorded across the study area from 2010 to 2013. One incident recorded in November 2012 describes interaction with the fluvial network, around the southern boundary of Harborough District, towards Welford; the River Avon is noted to have over-topped and entered Welford marina, at the top of the Welford Arm (Leicester Line). The canals have the potential to interact with other watercourses in the study area and have the potential to become flow paths.

In the 2015 North West Leicestershire SFRA, it is noted that the Grand Union Canal utilises the River Soar northwards of Leicester. Sections of the Grand Union Canal / River Soar are formed of artificial canals, canalised river sections and river navigation. Flooding was experienced at several locks along the River Soar in July 2007. The 2015 North West Leicestershire SFRA states that there no overland flow connections between the River Soar and Grand Union Canal; the risk posed by the Grand Union Canal / River Soar in North West Leicestershire District is localised to the canal network.

6.7.3 Flooding from reservoirs

Reservoirs with an impounded volume greater than 25,000 cubic metres are governed by the Reservoir Act 1975 and are listed on a register held by the Environment Agency. The level and standard of inspection and maintenance required under the Act means that the risk of flooding from reservoirs is relatively low. Recent changes to legislation under the Flood and Water Management Act require the Environment agency to designate the risk of flooding from these reservoirs. The Environment agency is currently progressing a 'Risk Designation' process so that the risk is formally determined.

Reservoir flooding is very different from other forms of flooding. It may happen with little or no warning and evacuation will need to happen immediately. The likelihood of such flooding is difficult

to estimate, but it is less likely than flooding from rivers or surface water. It may not be possible to seek refuge upstairs from floodwater as buildings could be unsafe or unstable due to the force of water from the reservoir breach or failure.

The risk of inundation to the Leicestershire County and Leicester City because of reservoir breach or failure of reservoirs within the area was assessed as part of the National Inundation Reservoir Mapping (NIRIM) study. Several reservoirs are located within the study area; however, there are also 20 reservoirs outside of the area whose inundation mapping is shown to affect the Leicestershire County and Leicester City. Maps of the flood extent can be found on the governments 'Long term flood risk assessment for locations in England' website.

Table 6-4: Reservoirs with potential risk to Leicestershire County and Leicester City

Reservoir	Location	Reservoir Owner	Environment Agency Area	Local Planning Authority reservoir extents affect	Reservoir located within the study area?
Ratcliffe on Soar Ash Lagoons	449458, 330084	E ON UK PLC	Environment Agency – East Midlands	North West Leicestershire District Council	No
Kingston Park Pond	450478, 327667	Kingston Park Farms Ltd	Environment Agency – East Midlands	North West Leicestershire District Council	No
Braunstone Park Storage Reservoir	456074, 302850	Environment Agency	Environment Agency – East Midlands	Leicester City Council and Charnwood Borough Council	Yes
Mallory Park Large Lake	444888, 299824	Mallory Park Motor Sport Ltd	Environment Agency – East Midlands	Hinckley and Bosworth Borough Council, Blaby District Council and Leicester City Council	Yes
Serpentine Lake	437878, 321538	Blunt	Environment Agency – East Midlands	North West Leicestershire District Council	Yes
EMA Gimbro Ponds (Winter and Summer)	443658, 325275	Nottingham East Midlands Airport Ltd	Environment Agency – East Midlands	North West Leicestershire District Council and Charnwood Borough Council	Yes
Blackbrook	445764, 317794	Severn Trent Water Authority	Environment Agency – East Midlands	North West Leicestershire District Council and Charnwood Borough Council	Yes
Thornton	447316, 307258	Severn Trent Water Authority	Environment Agency – East Midlands	Hinckley and Bosworth Borough Council, Blaby District Council, Leicester City Council and Charnwood Borough Council	Yes
Dakyn Road FSR	463764, 304841	Environment Agency	Environment Agency – East Midlands	Leicester City Council and Charnwood Borough Council	Yes

Reservoir	Location	Reservoir Owner	Environment Agency Area	Local Planning Authority reservoir extents affect	Reservoir located within the study area?
Swithland	455685, 314864	Severn Trent Water	Environment Agency – East Midlands	Charnwood Borough Council and North West Leicestershire District Council	Yes
Knighton Park FSR	460760, 300361	Environment Agency	Environment Agency – East Midlands	Oadby and Wigston Borough Council, Leicester City Council and Charnwood Borough Council	Yes
Hallgates No.4	453291, 311464	Severn Trent Water	Environment Agency – East Midlands	Charnwood Borough Council	Yes
Central East Area Balancing Pond	445759, 325484	Nottingham East Midlands Airport Ltd	Environment Agency – East Midlands	North West Leicestershire District Council and Charnwood Borough Council	Yes
Melbourne Pool	439137, 324695	Melbourne Estate	Environment Agency – East Midlands	North West Leicestershire District Council	No
Groby Pool	452393, 307911	Hanson Plc	Environment Agency – East Midlands	Hinckley and Bosworth Borough Council, Blaby District Council, Leicester City Council and Charnwood Borough Council	Yes
Nanpantan	450832, 317155	Severn Trent Water	Environment Agency – East Midlands	Charnwood Borough Council	Yes
Bosworth Marina Nr 2	438954, 303439	GJP Marina Developments Ltd	Environment Agency – West Midlands	Hinckley and Bosworth Borough Council	Yes
Oldbury No2	431639, 294462	Severn Trent Water	Environment Agency – West Midlands	Hinckley and Bosworth Borough Council	No
Merevale Park Estate	430080, 297160	Dugdale	Environment Agency – West Midlands	Hinckley and Bosworth Borough Council	No
Stanford	459586, 280323	Severn Trent Water Authority	Environment Agency – East Midlands and Lincolnshire and Northamptonshire	Harborough District Council	No
Oldbury No.1	431210, 294769	Severn Trent Water Authority	Environment Agency – West Midlands	Hinckley and Bosworth Borough Council	No
Bosworth Water Trust Amenity Lake	438169, 303008	Bosworth Water Trust	Environment Agency – West Midlands	Hinckley and Bosworth Borough Council	Yes

Reservoir	Location	Reservoir Owner	Environment Agency Area	Local Planning Authority reservoir extents affect	Reservoir located within the study area?
Willesley Lake	433751, 314475	Hart	Environment Agency – West Midlands	North West Leicestershire District Council	Yes
Glebe Farm (ID222)	436147, 301230	Caton	Environment Agency – West Midlands	Hinckley and Bosworth Borough Council	Yes
Seeswood Pool	433086, 290386	Warwickshire County Council	Environment Agency – West Midlands	Hinckley and Bosworth Borough Council	No
Medbourne Flood Storage Reservoir	479170, 294810	Environment Agency	Environment Agency – Lincolnshire and Northamptonshire	Harborough District Council	Yes
Stapleford Lake	481636, 318541	Gretton	Environment Agency – East Midlands	Melton Borough Council	Yes
Rolleston Lake	473734, 300287	Rolleston Hall Estates Ltd	Environment Agency – East Midlands	Harborough District Council	Yes
Eyebrook	485432, 294271	Tata Steel UK Limited	Environment Agency – Lincolnshire and Northamptonshire	Harborough District Council	Yes
Ragdale	465452, 320983	Severn Trent Water	Environment Agency – East Midlands	Charnwood Borough Council and Melton Borough Council	Yes
Brentingby Flood Storage Reservoir	477416, 318706	Environment Agency	Environment Agency – East Midlands	Charnwood Borough Council and Melton Borough Council	Yes
Welford	464666, 280905	Canal & River Trust	Environment Agency – East Midlands	Harborough District Council	No
Saddington	466420, 291493	Canal & River Trust	Environment Agency – East Midlands	Harborough District Council	Yes
Sulby	465200, 281160	Canal & River Trust	Environment Agency – East Midlands	Harborough District Council	No
Frisby Lake	469717, 318331	Environment Agency	Environment Agency – East Midlands	Charnwood Borough Council and Melton Borough Council	Yes
Naseby	466673, 277975	Canal & River Trust	Environment Agency – East Midlands and Lincolnshire and Northamptonshire	Harborough District Council	No
Scalford Brook Reservoir	475789, 320492	Environment Agency	Environment Agency – East Midlands	Charnwood Borough Council and Melton Borough Council	Yes
West Park and Harrington Drain FSR	447965, 333559	Environment Agency	Environment Agency – East Midlands	North West Leicestershire District Council	No

Reservoir	Location	Reservoir Owner	Environment Agency Area	Local Planning Authority reservoir extents affect	Reservoir located within the study area?
Cropston	455027, 311160	Severn Trent Water Authority	Environment Agency – East Midlands	North West Leicestershire District Council and Charnwood Borough Council	Yes
Foremark	432890, 324515	Severn Trent Water Authority	Environment Agency – East Midlands	North West Leicestershire District Council	No
Ogston	437946, 359890	Severn Trent Water Authority	Environment Agency – East Midlands	North West Leicestershire District Council	No
Church Wilne	446400, 332741	Severn Trent Water Authority	Environment Agency – East Midlands	North West Leicestershire District Council	No
Blithfield	407287, 322835	South Staffordshire Water Plc	Environment Agency – West Midlands	North West Leicestershire District Council	No
Breaston FSR	447226, 333125	Environment Agency	Environment Agency – West Midlands	North West Leicestershire District Council	No
Carsington	424224, 350598	Severn Trent Water Authority	Environment Agency – East Midlands	North West Leicestershire District Council	No
Howden	416984, 392443	Severn Trent Water Authority	Environment Agency – East Midlands and Yorkshire	North West Leicestershire District Council	No
Knipton	481855, 330832	Canal & River Trust	Environment Agency – East Midlands	Melton Borough Council	Yes
Staunton Harold	438107, 324306	Severn Trent Water Authority	Environment Agency – East Midlands	North West Leicestershire District Council	No
Belvoir Upper Lake	483037, 332953	The Belvoir Estate	Environment Agency – East Midlands	Melton Borough Council	Yes
Belvoir Lower Lake	483250, 333538	The Belvoir Estate	Environment Agency – East Midlands	Melton Borough Council	Yes

The maps represent a credible worst-case scenario. In these circumstances, it is the time to inundation, the depth of inundation, the duration of flooding and the velocity of flood flows that will be most influential.

The risk to development from reservoirs is residual but developers should consider reservoir flooding during the planning stage.

- Developers should seek to contact the reservoir owner to obtain information which may include
    - reservoir characteristics: type, dam height at outlet, area/volume, overflow location;
    - operation: discharge rates / maximum discharge;
    - discharge during emergency drawdown; and
    - inspection / maintenance regime.
- Developers should apply the sequential approach to locating development within the site. The following questions should be considered

- can risk be avoided through substituting less vulnerable uses or by amending the site lay-out?
- can it be demonstrated that less vulnerable uses for the site have been considered and reasonably discounted? and
- can layout be varied to reduce the number of people or flood risk vulnerability or building units located in higher risk parts of the site?

- Consult with relevant authorities regarding emergency plans in case of reservoir breach
- In addition to the risk of inundation those considering development in areas affected by breach events should also assess the potential hydraulic forces imposed by the rapid flood event and check that the proposed infrastructure fabric can withstand the loads imposed on the structures by a breach event.

6.8 Flood warning and emergency planning

6.8.1 Emergency planning

Emergency planning is one option to help manage flood related incidents. From a flood risk perspective, emergency planning can be broadly split into three phases: before, during and after a flood. The measures involve developing and maintaining arrangements to reduce, control or mitigate the impact and consequences of flooding and to improve the ability of people and property to absorb, respond to and recover from flooding.

6.8.2 NPPF

In development planning, a number of emergency planning activities are already **integrated** in national building control and planning policies e.g. the NPPF Flood Risk Vulnerability and Flood Zone 'Compatibility' table seeks to avoid inappropriate development in areas at risk from all sources of flooding. However; safety is a key consideration for any new development and includes residual risk of flooding, the availability of adequate flood warning systems for the development, safe access and egress routes and evacuation procedures.

The NPPF Planning Practice Guidance outlines how developers can ensure safe access and egress to and from development to demonstrate that development satisfies the second part of the Exception Test. As part of an FRA, the developer should review the acceptability of the proposed access in consultation with the Local Planning Authority (where appropriate) and the Environment Agency.

There are circumstances where a flood warning and evacuation plan[5] is required and / or advised:

- It is a requirement under the NPPF that a flood warning and evacuation plan is prepared for sites at risk of flooding used for holiday or short-let caravans and camping and are important at any site that has transient occupants (e.g. hostels and hotels) and for essential ancillary sleeping or residential accommodation for staff required by uses in this category [water-compatible development], subject to a specific warning and evacuation plan.
- The Environment Agency and DEFRAs standing advice for undertaking flood risk assessments for planning applications states that details of emergency escape plans will be required for any parts of the building that are below the estimate flood level.

It is recommended that Emergency Planners at the Local Planning Authority and / or Leicestershire County Council (where appropriate) are consulted prior to the production of any emergency flood plan. Advice from the emergency services may also need to be sought when producing an emergency flood plan, as part of the site-specific Flood Risk Assessment.

The Environment Agency do not normally comment on or approve the adequacy of flood emergency procedures accompanying development proposals and any comments are likely to be limited to delivering flood warnings covered by the Environment Agency's Flood Warning Service. The Environment Agency also advise LPAs to consider the emergency planning and rescue implications of new development, in all circumstances where warning and emergency response is fundamental to managing flood risk.

In addition to the flood warning and evacuation plan considerations listed in the NPPF / NPPG, it is advisable that developers also acknowledge the following:

5 Flood warning and evacuation plans may also be referred to as an emergency flood plan or flood response plan.

- How to manage the consequences of events that are un-foreseen or for which no warnings can be provided e.g. managing the residual risk of a breach.
- Proposed new development that places additional burden on the existing response capacity of the Councils will not normally be appropriate.
- Developers should encourage those owning or occupying developments, where flood warnings can be provided, to sign up to receive them. This applies even if the development is defended to a high standard.
- The vulnerability of site occupants.
- Situations may arise where occupants cannot be evacuated (e.g. prisons) or where it is safer to remain "in-situ" and / or move to a higher floor or safe refuge area (e.g. at risk of a breach). These allocations should be assessed against the outputs of the SFRA and where applicable, a site-specific Flood Risk Assessment to help develop emergency plans.

The Local Resilience Forum website covering Leicestershire County and Leicester City provides practical advice for residents, communities and businesses on preparing for emergencies (not exclusive to flooding). The LRF website provides a list of communities which have existing emergency plans and information on community flood wardens. The LRF website also contains emergency plan templates for residents, communities and businesses.

Further emergency planning information links:

- 2004 Civil Contingencies Act
- DEFRA (2014) National Flood Emergency Framework for England
- How to register with the Environment Agency's Flood Warnings Direct service
- National Flood Forum
- GOV.UK Make a Flood Plan guidance and templates
- FloodRe
- Local Resilience Forum website covering Leicestershire County and Leicester City

6.8.3 Flood warnings

Flood warnings can be derived and, along with evacuation plans, can inform emergency flood plans or flood response plans. The Environment Agency is the lead organisation for providing warnings of fluvial flooding (for watercourses classed as Main Rivers) and coastal flooding in England. Flood Warnings are supplied via the Floodline Warnings Directive (FWD) service, to homes and business within Flood Zones 2 and 3.

Within the study area, there are 16 flood alert areas (FAA) and 59 flood warning areas (FWA). These are shown in Appendix E. A list of FAAs in the study areas is shown in Table 6-5 and a list of the FWAs in the study area is shown in Table 6-6.

Table 6-5: Flood Alert Areas within Leicestershire County and Leicester City

Flood Alert Code	Flood Alert Name	Watercourse	Coverage
053WAF108WSK	Witham in South Kesteven	River Witham, Foston Beck	River Witham and its tributaries from South Witham to Claypole
055WAF134TWV	Welland Valley	River Welland, River Jordan	Welland Valley and River Jordan from Braybrooke to Stamford, including Braybrooke, Market Harborough, Welham, Harringworth, and Stamford
055WAF136TWT	Welland Tributaries	River Welland, Medbourne Brook, Great Easton Brook, Eye Brook, River Chater, River Gwash, Paston Brook, Werrington Brook, Brook Drain	Tributaries of the River Welland affecting Medbourne, Great Easton, Caldecott, Oakham, Ketton, and the north of Peterborough
033WAF201	Upper Avon River Swift and Clay Coton Brook	Avon, Swift, Claycoton	Low-lying land and roads between Stanford and Rugby including Lilbourne and Clay Coton areas
033WAF307	River Anker and River Sence	River Anker, River Sence	Low-lying land and roads between Nuneaton and Tamworth on the River Anker and between Temple Mill and Ratcliffe Culey on the River Sence
033WAF308	River Mease	Gilwiskaw Brook, River Mease	Low-lying land and roads between Ashby and Croxall
034WAF401	River Sence in Leicestershire	River Sence	River Sence and tributaries from Billesdon to the River Soar at Glen Parva
034WAF402	Upper Soar Catchment	River Soar	River Soar in Leicestershire including tributaries from Sharnford to the River Wreake confluence at Syston
034WAF403	Rothley Brook in Leicestershire	Rothley Brook	Rothley Brook and tributaries from Botcheston to the River Soar at Rothley
034WAF404	River Wreake in Leicestershire	River Wreake	River Wreake and tributaries from Stapleford to the River Soar at Syston
034WAF409	Lower Derwent in Derbyshire	River Derwent	River Derwent and tributaries from Rowsley to the River Trent at Shardlow
034WAF414	River Trent in Derbyshire	River Trent	River Trent and tributaries in Derbyshire from Newton Solney to Castle Donington
034WAF415	River Trent in Nottinghamshire	River Trent	River Trent in Nottinghamshire from Castle Donington to Cromwell Weir
034WAF419	River Devon and Smite in Leicestershire and Nottinghamshire	River Devon	River Devon, Smite and tributaries from Knipton to the River Trent at Newark on Trent
034WAF426	Loughborough Urban Watercourses	Black Brook	Black Brook, Wood Brook, Burleigh Brook, Grace Dieu Brook and other urban watercourses in Loughborough
034WAF428	Lower River Soar in Leicestershire	River Soar	Lower River Soar in Leicestershire including tributaries from Cossington to Redhill at the River Trent

Table 6-6: Flood Warning Areas within Leicestershire County and Leicester City

Flood Warning Code	Flood Warning Name	Watercourse	Coverage
055FWFPUWE02	River Welland in the market-square area of Market Harborough	River Welland	Surface water flooding in the market-square area of Market Harborough
055FWFPUWE04	Eye Brook in Caldecott	Eye Brook	Properties near the Eye Brook in Caldecott
055FWFUWEL01	River Welland in Market Harborough	River Welland	River Welland in Market Harborough including properties near the river in Yeomanry Court, St Marys Road, Britannia Walk, and Euro Business Park
055FWFUWEL03	River Jordan in Braybrooke and Little Bowden	River Jordan, West Brook	River Jordan in Braybrooke and Little Bowden including properties near the river on the far end of Newland Street in Braybrooke, and on Scotland Road and Rectory Lane in Little Bowden
055FWFUWEL05	River Welland and Tributaries in Welham	River Welland, Stonton Brook	River Welland and Tributaries in Welham including properties in Welham and farms on Stonton Brook
055FWFWELT01	Medbourne Brook in Medbourne	Medbourne Brook	Properties near the Medbourne Brook in Medbourne
055FWFWELT02	Great Easton Brook in Great Easton	Great Easton Brook	Great Easton Brook in Great Easton including properties near the river from Deepdale to Cross Bank
033FWF3ANKR005	River Anker at Mancetter, Witherley and Atherstone	River Anker	River Anker at Mancetter, Witherley and Atherstone including Lodge Close in Mancetter, Bridge Lane and Riverside in Witherley, Royal Meadow Drive, Ratcliffe Road and Aldermill Business Park in Atherstone
033FWF3MEASE01	Gilwiskaw Brook at Packington	Gilwiskaw Brook	Gilwiskaw Brook at Packington including Mill Street and Brook Close
033FWF3MEASE02	River Mease at Measham and Netherseal	River Mease	River Mease at Measham and Netherseal including Huntingdon Way, Mallard Close, Siskin Close, Wordsworth Way and Burns Close in Measham and Stretton Bridge and Mill Farm in Netherseal
033FWF3SENCE001	River Sence from Temple Mill to Sheepy Magna	River Sence	River Sence from Temple Mill to Sheepy Magna including Sibson Mill, Lovetts Bridge and Sheepy Parva
034FWFBBTHORACRE	Black Brook at Thorpe Acre	Black Brook	Black Brook at Thorpe Acre
034FWFDVBOTTSFRD	River Devon at Bottesford including Easthorpe, Muston	River Devon	River Devon at Bottesford including Easthorpe, Muston and Woolsthorpe

Flood Warning Code	Flood Warning Name	Watercourse	Coverage
	and Woolsthorpe		
034FWFGDWHITWICK	Grace Dieu Brook at Whitwick and Thringstone	Grace Dieu Brook	Grace Dieu Brook at Whitwick and Thringstone
034FWFROGLENFLD	Rothley Brook at Glenfield and Anstey	Rothley Brook	Rothley Brook at Glenfield and Anstey
034FWFROROTHLEY	Rothley Brook at Rothley	Rothley Brook	Rothley Brook at Rothley
034FWFSEBLABPAR	River Sence at Blaby and Glen Parva	River Sence	River Sence at Blaby and Glen Parva
034FWFSEGRTGLEN	River Sence at Great Glen	River Sence	River Sence at Great Glen
034FWFSOAYLESTNE	River Soar at Aylestone	River Soar	River Soar at Aylestone
034FWFSOBARRSOAR	River Soar at Barrow on Soar	River Soar	River Soar at Barrow on Soar
034FWFSOBELGRAVE	River Soar at Belgrave	River Soar	River Soar at Belgrave
034FWFSOBIRSWANP	River Soar at Birstall and Wanlip	River Soar	River Soar at Birstall, Wanlip and isolated propeties near Syston
034FWFSOBRUNSTNE	River Soar at Braunstone	River Soar	River Soar at Braunstone including Fosse Park
034FWFSOCOSSNGTN	River Soar at Cossington village, Mill and Grange	River Soar	River Soar at Cossington village, Mill and Grange
034FWFSOCOTES	River Soar at Cotes and Loughborough Moors	River Soar	River Soar at Cotes and Loughborough Moors
034FWFSOCROFT	River Soar at Croft	River Soar	River Soar at Croft
034FWFSOENDERBY	River Soar at Enderby	River Soar	River Soar at Enderby
034FWFSOKEGWORTH	River Soar at Kegworth	River Soar	River Soar at Kegworth
034FWFSOLEICFROG	River Soar at Frog Island and riverside areas of Leicester	River Soar	River Soar at Frog Island and riverside areas of Leicester
034FWFSOLEICSTER	River Soar at Leicester City	River Soar	River Soar at Leicester City
034FWFSOLITLTHRP	River Soar at Littlethorpe and Narborough	River Soar	River Soar at Littlethorpe and Narborough
034FWFSOLOUGHBRH	River Soar at Loughborough	River Soar	River Soar at Loughborough
034FWFSOMNTSORRL	River Soar at Mountsorrel	River Soar	River Soar at Mountsorrel
034FWFSONORMOOR	River Soar at Moor Lane in Normanton on Soar & Hathern Sports Ground	River Soar	River Soar at Moor Lane in Normanton on Soar and Hathern Sports Ground
034FWFSONORMSOAR	River Soar at Normanton on Soar	River Soar	River Soar at Normanton on Soar including Hathern Sports Ground area
034FWFSONRTHAYLE	River Soar at North Aylestone	River Wreake	River Soar at Aylestone Lock Industrial Estate and surrounding residential properties
034FWFSOQUORN	River Soar at Quorn	River Soar	River Soar at Quorn
034FWFSORATSOAR	River Soar at Ratcliffe on Soar	River Soar	River Soar at Ratcliffe on Soar including areas near the railway at Kingston on Soar
034FWFSORUSHMEAD	River Soar at Rushey Mead	River Soar	River Soar at Rushey Mead
034FWFSOSHRNFRD	River Soar at Sharnford including Croft Mill	River Soar	River Soar at Sharnford including Croft Mill
034FWFSOSILEBY	River Soar at Sileby	River Soar	River Soar at Sileby
034FWFSOSTOCKFRM	River Soar at Stocking Farm	River Soar	River Soar at Stocking Farm
034FWFSOTHURMSTN	River Soar at Thurmaston	River Soar	River Soar at Thurmaston
034FWFSOZOUCH	River Soar at Zouch Island	River Soar	River Soar at Zouch Island
034FWFTRCASDONKM	River Trent at Castle Donington Kings Mill Area	River Trent	River Trent at Castle Donington, Kings Mills Area
034FWFTRCASDONN	River Trent at Castle Donington including Hemington and Lockington	River Trent	River Trent at Castle Donington including Hemington and Lockington
034FWFTRCAVBRDG	River Trent at Cavendish Bridge	River Trent	River Trent at Cavendish Bridge
034FWFTRLOCKHEM	River Trent at Hemington Ponds, Hole and Fields area	River Trent	River Trent at Hemington Ponds, Hole and Fields area
034FWFTRSAWMARIN	River Trent at Sawley Marina, including Sawley Lock	River Trent	River Trent at Sawley Marina, including Sawley Lock
034FWFTRSHARDLW	River Trent at Shardlow	River Trent	River Trent at Shardlow including Great Wilne
034FWFWBWHETSTNE	Whetstone Brook at Whetstone	Whetstone Brook	Whetstone Brook at Whetstone
034FWFWOLOUGHB	Wood Brook at Loughborough	Wood Brook	Wood Brook at Loughborough
034FWFWRASFRDBY	River Wreake at Asfordby	River Wreake	River Wreake at Asfordby

Flood Warning Code	Flood Warning Name	Watercourse	Coverage
034FWFWRFRISWRKE	River Wreake at Frisby-on-the-Wreake	River Wreake	River Wreake at Frisby-on-the-Wreake
034FWFWRMELTNMOW	River Wreake at Melton Mowbray	River Wreake	River Wreake at Melton Mowbray
034FWFWRMILLS	River Wreake for mills at Hoby, Thrussington and Ratcliffe	River Wreake	River Wreake for mills at Hoby, Thrussington and Ratcliffe
034FWFWRRATHRUSS	River Wreake at Thrussington and Ratcliffe on the Wreake	River Wreake	River Wreake at Thrussington and Ratcliffe on the Wreake
034FWFWRRIVSYST	River Wreake for riverside properties near Syston	River Wreake	River Wreake for riverside properties near Syston
034FWFWRSYSTON	River Wreake at Syston	River Wreake	River Wreake at Syston

6.9 Cross boundary considerations

The topography of the study area means that watercourses either drain towards the centre of Leicestershire County and Leicester City, to the River Soar floodplain, or flow away from the study area, into surrounding catchments. Several watercourses also flow along the boundaries of the study area; these include, but are not limited to, sections of the River Welland, River Avon, River Smite, River Soar, River Trent, River Mease and River Sence. As such, future development, both within and outside the Leicestershire County and Leicester City can have the potential to affect flood risk to existing development and surrounding areas, depending on the effectiveness of SuDS and drainage implementation. Leicestershire County has boundaries with the following Local Authorities:

- Corby Borough;
- Daventry District;
- Erewash District;
- Kettering Borough;
- Lichfield District;
- Newark and Sherwood District;
- North Warwickshire;
- Nuneaton and Bedworth Borough;
- Rugby District;
- Rushcliffe Borough;
- Rutland;
- South Derbyshire District; and,
- South Kesteven District.

Neighbouring authorities were contacted and, where possible, Local Plans and SFRAs were reviewed to assess whether there are any proposed developments that may affect flood risk in the district. The proposed development information provided by neighbouring authorities consist of sites allocated within adopted Local Plans or proposed sites, considered as part of emerging Local Plans (which are not yet formally allocated or adopted). Details of any known cross-boundary flooding issues were also requested.

Several adopted or proposed site allocations fall adjacent to the study area boundary. However, the sites are either:

- located adjacent to watercourses which drain away from Leicestershire County and Leicester City and therefore unlikely to impact the fluvial flood risk within the study area; and / or,
- located on land which slopes away from Leicestershire County and Leicester City and therefore, due to the topography of the area, surface water runoff from the site is unlikely to flow into the study area, particularly if sustainable drainage measures are implemented at the sites.

There is nothing to suggest there will be any developments proposed in neighbouring authorities that would adversely affect flood risk within Leicestershire County and Leicester City. None of the neighbouring authorities reported any known cross boundary flooding issues.

Development control should ensure that the impact on receiving watercourses from development in Leicestershire County and Leicester City has been sufficiently considered during the planning stages and appropriate mitigation measures put in place to ensure there is no adverse impact on flood risk or water quality. Further, the Strategic Growth Plan provides opportunities for local authorities within Leicestershire County and Leicester City (including the Leicester City PUA) to continue co-operating and working together on flood risk matters and any known cross-boundary issues within the study area.

Section 11 builds on the theme of co-operation and cross-boundary working further and identifies opportunities to reduce flood risk across Leicestershire County and Leicester City.

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6.10 Summary of flood risk in each authority area

6.10.1 Blaby District

Source of flooding	Description
Fluvial	Fluvial flood risk in Blaby District is from the River Soar and its tributaries. There are also a number of smaller, un-named drains that join the River Soar and its tributaries in this area. Blaby District has a history of flooding, with the main source of flooding being from fluvial sources. Flood Zones show the undefended scenario. There are defences along sections of the Whetstone Brook, Cosby Brook and the River Soar with varying standards of protection. However, there remains a residual risk should the defences breach or fail. There is a Flood Alleviation Scheme along the Lubbesthorpe Brook which comprises river realignment / restoration to improve channel and floodplain capacity. There is also a Property Level Resilience Scheme in Sharnford. Flooding may not be from one watercourse alone and interaction between the watercourses has the potential to cause flooding. Interactions occur between the Broughton Astley Brook, Whetstone Brook, the River Sence (Soar) and the River Soar around the urban areas of Croft, Blaby, Whetstone and Narborough.
Surface water	Thorpe Astley has a history of surface water flooding, mostly via surface water runoff from the high ground to the rear of Priestman Road, Tuffleys Way and Murby Way. Mapping shows surface water flood risk in Blaby District generally follows similar flow paths to the River Soar and its tributaries, as well as several smaller drains. Surface water is also shown to pond in open spaces, gardens and roads. In urban areas, the risk is mainly confined to roads and gardens in the 3.3% AEP event. There are notable exceptions: • surface water follows drains south-east of the A47 / Leicester Forest Rugby Football Club towards the business parks east of Junction 21 of the M1; • surface water follows local roads through Glen Parva towards the Leicestershire Line (Grand Union Canal) and River Soar; and, • surface water follows the drain leading from Countesthorpe, across Hospital Lane to the Blaby By-Pass. However, properties tend to become at risk during events including and exceeding the 1% AEP event. Catchments in the district may respond quickly to rainfall events as extensive areas are underlain by clay.
Groundwater	The 2014 Joint SFRA describes how, due to the moderate or slowly permeable geology of the area, it is more likely that there will be higher percentages of runoff and therefore limited potential for ground water flood risk problems. The AStGW mapping indicates that parts of the district may be susceptible to groundwater flooding. Areas within the >=50% <75% or >=75% categories tend to be found along the valleys of watercourses and the locations of Secondary A aquifers (Superficial Deposits designation).
Sewers	There have been 37 records of internal flooding in Severn Trent Water's register. No date is given for when these occurred. Most of these occurred in the LE8 and LE3 postcode areas. he 2014 Joint SFRA states that there have been £200,000 invested in sewer improvements, undertaken by Severn Trent Water, to help prevent sewer flooding along Lubbesthorpe Road and Watergate Lane.
Reservoirs	The majority of the district is not at risk of inundation in the event of a reservoir failure. The mapping indicates that there are three reservoirs which present a risk; Mallory Park Large Lake, Thornton Reservoir and Groby Pool. The risk is largely confined to the valleys of the Thurlaston Brook, River Soar, Rothley Brook and Slate Brook and the extents predominantly affect rural land, rather than properties.
Other potential sources of flood risk and cross-boundary implications	The Leicestershire Line (Grand Union Canal) flows through a small section of Blaby District, around Glen Parva. Whilst no records of a breach or over-topping of the canal in Blaby District were found through this assessment, there remains a residual risk, should the canal breach or fail. Many of tributaries of the River Soar originate from outside of Blaby Borough. This may have important implications for the management of runoff and the transfer of risk as development in the upstream areas (either in one authority or in the other) could potentially have impacts downstream.

6.10.2 Charnwood Borough

Source of flooding	Description
Fluvial	Fluvial flood risk in Charnwood Borough is from the River Soar and its tributaries. Flood Zones show the undefended scenario. There are defences along sections of the River Soar, River Soar / Grand Union Canal, Rothley Brook, River Wreake, Sileby Brook, Quorn Brook, Wood Brook, Burleigh Brook, Black Brook and Hermitage Brook. There are Flood Alleviation Schemes along the River Soar and the River Wreake. However, there remains a residual risk should the defences breach or fail. Many of the urban settlements in the borough are located near a confluence of two or more watercourses and as such, flooding may not be from one watercourse alone and interaction between the watercourses has the potential to cause flooding. Interactions occur between the River Soar, Grand Union Canal and the Wood Brook in the urban area of Loughborough. In the February 2017 Environment Agency Flood and Coastal Erosion Risk Management (FCERM) Programme, a Flood Alleviation Scheme along the Swithland Brook will be undertaken to increase protection to 20 homes. This is forecast to be completed by April 2021.
Surface water	Historically, Charnwood Borough has experienced flooding from surface water in Loughborough in 1998 and parts of Swithland, Woodhouse Eaves, Rothley, Nanpantan and Newtown Linford in the summer of 2007. Mapping shows surface water flood risk generally follows similar flow paths to the River Soar and its tributaries, as well as several smaller drains to the north-east of the borough. The mapping indicates that surface water may originate as runoff from hillside areas to the north-east and south-west of the borough, towards the River Soar floodplain in Loughborough. Surface water is also shown to pond in open spaces, gardens and roads. Whilst the risk is mainly confined to roads and gardens in the 3.3% AEP event, certain flow paths are shown to affect properties. For example, Loughborough College is shown to be within and surrounded by surface water extents and surface water follows the valley of the Wood Brook, affecting areas around Forest Road and the town centre, during the 3.3% AEP event. However, properties tend to become at risk during events including and exceeding the 1% AEP event. Catchments in the borough may respond quickly to rainfall events as extensive areas are underlain by clay.
Groundwater	The 2014 Charnwood Borough SFRA Update describes how, due to the moderate or slowly permeable geology of the area, it is more likely that there will be higher percentages of runoff and therefore limited potential for ground water flood risk problems. The AStGW mapping indicates that areas within the >=50% <75% or >=75% categories, tend to be found along the valleys of River Soar and River Wreake and the locations of Secondary A aquifers (Superficial Deposits designation). Areas to the north-east of the borough which are underlain by Unproductive bedrock, tend to be in the < 25% category.
Sewers	The 2014 Charnwood Borough SFRA Update used Severn Trent Water's DG5 register; according to this, areas including Loughborough, Birstall, Shepshed and Rothley are prone to sewer flooding. At the time of the Loughborough SWMP study, Severn Trent Water were assessing the feasibility of major rehabilitation of the entire sewer network in Loughborough. There have been 44 records of internal flooding in Severn Trent Water's register. No date is given for the majority of the incidents. Most of these occurred in the LE7, LE11 and LE12 postcode areas.
Reservoirs	Parts of Charnwood Borough are at risk of flooding caused by a reservoir failure. The mapping indicates that there are 16 reservoirs which present a risk; Braunstone Park Storage Reservoir, EMA Gimbro Ponds, Black Brook Reservoir, Thornton Reservoir, Dakyn Road FSR, Swithland Reservoir, Knighton Park FSR, Hallgates No. 4, Central East Area Balancing Pool, Groby Pool, Nanpantan, Ragdale, Brentingby Flood Storage Reservoir, Frisby Lake, Scalford Brook Reservoir and Cropston Reservoir. The mapping indicates that the reservoir flood extents follow the valleys of the River Wreake, River Soar, Wood Brook, Black Brook and the Quorn Brook. As such, this presents a risk to parts of the main settlements in the borough, including Quorn, Barrow upon Soar and Loughborough in the event of any failure.
Other potential sources of flood risk and cross-boundary implications	The Grand Union Canal flows through the Charnwood Borough and follows the route of the River Soar. Along the course of the Grand Union Canal there are numerous locations where watercourses either run adjacent or underneath the canal. Two incidents of a breach on the Grand Union Canal have been recorded by the Canal and River Trust in Charnwood Borough because of third party works adjacent to the canal and a weir collapse. There remains a residual risk, should the Canal breach or fail. Further, there is complex interaction with watercourses and the Canal, in and around the eastern edge of Loughborough; during times of high flows, the Canal can act as an additional flow route and pose a significant risk of flooding in Loughborough. Many of tributaries of the River Soar originate from outside of Charnwood Borough. This may have important implications for the management of runoff and the transfer of risk as development in the upstream areas (either in one authority or in the other) could potentially have impacts downstream.

6.10.3 Harborough District

Source of flooding	Description
Fluvial	Fluvial flood risk in Harborough District is from several watercourses. The floodplains of the River Sence and River Welland are comparatively wide in the district, compared with the other watercourses whose floodplains are confined by steep-side valleys. There are also several un-named drains and smaller brooks throughout the district which present fluvial flood risks. Flood Zones show the undefended scenario. There are defences along an un-named watercourse nears its confluence with the Thurby Brook in Thurnby and along sections of the River Sence and Burton Brook in Great Glen. However, there remains a residual risk should the defences breach or fail. There are several flood related activities on-going or planned for the district which include: • de-culverting works in Broughton Astley to improve channel capacity; • a Property Level Flood Protection Scheme in Market Harborough; and, • works along the Scraptoft Brook (though it is not known if these will extend into Harborough District). Natural Flood Management options along the River Sence are being investigated.
Surface water	Several settlements have suffered surface water flooding including Market Harborough, Lutterworth, Great Glen and Kibworth. Market Harborough has frequently experienced surface water and sewer flooding following heavy rainfall events; a number of flood alleviation schemes have been implemented in the town, to help reduce the risk of surface water and sewer flooding. However, flooding to the town centre is reported to occur fairly regularly and should not be considered a historic matter only. Mapping shows surface water flood risk in Harborough District generally follows similar flow paths to the watercourses within the district. The mapping indicates that surface water may originate as runoff from hillside areas to the north-east and south-west of the district, towards periphery areas, around the district boundaries. Surface water is also shown to pond in open spaces, gardens and roads. Harborough District is predominantly rural. Whilst the risk is mainly confined to rural land, roads and gardens in the 3.3% AEP event, certain flow paths are shown to affect properties. For example, there are several overland surface water flow paths in Market Harborough during the 3.3% AEP event. However, properties tend to become at risk during events including and exceeding the 1% AEP event. Catchments in the district may respond quickly to rainfall events due to steep-sided topography and as extensive areas are underlain by clay. There is an existing Flood Alleviation Schemes in Broughton Astley and in 2005, Anglian Water constructed a storage tank beneath Commons Car Park in Market Harborough which has helped to alleviate surface water and sewer flooding. Anglian Water has also completed a flood alleviation scheme in 2016 which is intended to reduce the risk of surface water flooding along Coventry Road, in Market Harborough.
Groundwater	The AStGW mapping indicates that areas within the >=50% <75% or >=75% categories tend to be found along the valleys of River Welland, around the head waters of the River Swift and along tributaries which flow towards and into Blaby District. However, the majority of the district tends to be in the >=25% <50% or < 25% categories.
Sewers	Section 19 Flood Investigation Reports indicate that a cause of historic flooding to Market Harborough has been from intense rainfall which exceeded the design capacity of the 'public sewer' causing surface water flooding in the town centre. The previous 2009 SFRA for Harborough District identified Billesdon, Great Glen, Lutterworth and Market Harborough as locations with frequently historic sewer flooding. There have been 16 reports of internal flooding in Anglian Water's DG5 register and seven records of internal flooding in Severn Trent Water's register. There is an existing Flood Alleviation Scheme in Broughton Astley and in 2005, Anglian Water constructed a storage tank beneath Commons Car Park in Market Harborough which has help to alleviate surface water and sewer flooding. Anglian Water has also completed a flood alleviation scheme in 2016 which is intended to reduce the risk of surface water flooding along Coventry Road, in Market Harborough.
Reservoirs	The majority of the district is not at risk of inundation in the event of a reservoir failure. The mapping indicates that there are eight reservoirs which present a risk; Stanford Reservoir, Medbourne Flood Storage Reservoir, Rolleston Lake, Eyebrook Reservoir, Welford Reservoir, Saddington Reservoir, Sulby Reservoir and Naseby Reservoir. The mapping indicates that the reservoir flood extents follow the valleys of the River Avon, River Welland, Medbourne Brook and Langton Brook.
Other potential sources of flood risk and cross-boundary implications	The 2009 SFRA for Harborough District notes that the Upper Welland catchment is known to experience some seasonal water logging. Historic flooding in Harborough District is considered to be from a range of sources including fluvial, surface water, ground water and artificial sources. Harborough District has suffered frequent flooding; notable settlements affected include Market Harborough, Great Glen and Burton Overy. Section 19 Flood Investigation Reports indicated that a culvert blockage contributed to flooding experienced along Rugby Close, in Market Harborough during December 2013 and a culvert blockage beneath Main Street contributed to flooding experienced in Burton Overy in June 2014. The Leicester Line (Grand Union Canal), Welford Arm (Leicester Line) and Market Harborough Line (Grand Union Canal) flow through the district. There are three over-topping incidents and one breach incident recorded in the district. One incident in November 2012 was recorded to have been caused by the River Avon over-topping and entering the Canal network, around the southern boundary of the district, towards Welford. Interactions between the Canal network and fluvial watercourses have therefore been recorded. Further, there remains a residual risk, should a Canal breach or fail. The River Avon flows along the border with neighbouring Daventry District and likewise the River Welland crosses in and out of the border with Corby District. This may have important implications for the management of runoff and the transfer of risk as development in the upstream areas (either in one authority or in the other) could potentially have impacts downstream.

6.10.4 Hinckley and Bosworth Borough

Source of flooding	Description
Fluvial	Fluvial flood risk in Hinckley and Bosworth Borough is from the River Sence and its tributaries and the Rothley and Slate Brooks. There are also a number of smaller, un-named drains that join these watercourses in this area. Flood Zones show the undefended scenario. There are no raised flood defences in Hinckley and Bosworth Borough; however, GIS data from the Council indicates that there are flood prevention measures along the Sketchley Brook, Battling Brook and Harrow Brook in Hinckley. The 2014 Joint SFRA for Hinckley and Bosworth Borough Council also shows flood defences along the Witherley Brook, north of the village of Witherley. There is no further information as to what these comprise; there may be a residual risk should these measures fail. Flooding may not be from one watercourse alone and interaction between the watercourses has the potential to cause flooding. There are a number of interactions, particularly between the Broughton Astley Brook, Whetstone Brook and the River Sence (Soar).
Surface water	The borough has been affected by historic surface water flooding incidents. Section 19 Flood Investigation Reports indicate that the flooding to Sheepy Magna, Witherley and Shenton was partially caused by intense rainfall which resulted in surface water runoff and overland flow to low lying areas. - Mapping shows surface water flood risk in the borough generally follows similar flow paths to the watercourses. Surface water is also shown to pond in open spaces, gardens and roads. In urban areas, the risk is mainly confined to roads and gardens in the 3.3% AEP event. Properties tend to become at risk during events including and exceeding the 1% AEP event. Catchments in the borough may respond quickly to rainfall events as extensive areas are underlain by clay.
Groundwater	The 2014 Joint SFRA describes how, due to the moderate or slowly permeable geology of the area, it is more likely that there will be higher percentages of runoff and therefore limited potential for ground water flood risk problems. The AStGW mapping indicates that areas within the >=50% <75% or >=75% categories tend to be found along the valleys of watercourses and the locations of Secondary A aquifers (Superficial Deposits designation). The majority of the borough is shown to in the < 25% category.
Sewers	There have been 53 records of internal flooding in Severn Trent Water's register. No date is given for when most of these occurred. Most of these occurred in the LE10 postcode area. There is a Flood Alleviation Scheme along the Coventry Road, in Hinckley to address surface water flooding issues; this involved the installation of new sewer and on-line storage pipe network.
Reservoirs	The majority of the borough is not at risk of inundation in the event of a reservoir failure. The mapping indicates that there are ten reservoirs which present a risk; Mallory Park Large Lake, Thornton Reservoir, Groby Pool, Bosworth Marina Nr. 2, Oldbury No. 1 & 2, Merevale Park Estate, Bosworth Water Trush Amenity Lake, Glebe Farm (ID222) and Seeswood Pool. The mapping indicates that the risk is largely confined to the valleys of the Sence Brook, River Sence, River Anker and Rothley Brook, to name but a few and the extents predominantly affect rural land, rather than properties.
Other potential sources of flood risk and cross-boundary implications	The Ashby Canal flows through the borough. Two incidents of over-topping and four incidents of a breach have been recorded along the Canal. The breach incidents relate to asset failure (i.e. culvert failure). The Canal and River Trust over-topping data provides a description of the incident which queries whether the incidents indicate a critical point on the Canal for over-topping during heavy rainfall events (the location is around Upton Lane / Station Road in Stoke Golding). There also remains a residual risk, should the canal breach or fail. Many tributaries of the River Sence originate outside of the borough. The River Anker flows along a short section of the border with neighbouring North Warwickshire District. This may have important implications for the management of runoff and the transfer of risk as development in the upstream areas (either in one authority or in the other) could potentially have impacts downstream. There are several confluences across the district; levels in main rivers may affect levels further upstream, in tributaries. For example, the Section 19 Flood Investigation Reports into the June 2012 event at Mythe Lane in Witherley states that: *"when the highway outfall is below water level in the Witherley Brook, surface water food risk significantly increases. The level in the Witherley Brook is primarily governed by downstream levels in the River Anker as opposed to runoff from the Witherley catchment."*

6.10.5 Leicester City

Source of flooding	Description
Fluvial	Fluvial flood risk in Leicester City is from the River Soar and its tributaries. The floodplain of the River Soar is relatively wide through Leicester City, particularly around confluences with tributaries. Flood Zones show the undefended scenario. There are defences along sections of the River Soar, Saffron Brook, and Bushby Brook. However, there remains a residual risk should the defences breach or fail. As part of the Soar Natural Flood Management Project, there is an on-going scoping study into NFM the River Soar, specifically looking at the catchments of the Willow Brook, River Sence, Upper Soar and Upper River Eye. The report is due to be published in 2017 and will recommend opportunities for NFM. These are likely to include opportunities upstream of Leicester and Melton Mowbray which could potentially provide flood risk benefits in Leicester City. The Trent Rivers Trust has installed a number of small scale features across the Willow Brook and River Sence to hold water up and improve water quality.
Surface water	Surface water is a known and well documented risk to Leicester City; several recorded historic events have been partially attributed to surface water flooding. The 2012 SWMP for Leicester City identified the following known surface water hot spots: Toon Way, Northfields, Oakland Road, Leicester Royal Infirmary, Gilroes Brook and Alderman Richard Hallam, Nedham Street, Lomond Crescent, Dane Hills, Hol Brook and Portwey Brook. The RoFfSW mapping shows surface water flood risk in Leicester City generally follows similar flow paths to the River Soar and its tributaries. Several local roads are shown to be overland flow routes and experience surface water ponding during the 3.3% AEP event. However, properties tend to become at risk during events including and exceeding the 1% AEP event, throughout Leicester City, reflecting the urbanised nature of the City (i.e. significant areas of impervious surfaces). Leicester City Council undertook modelling of eight ordinary watercourses as part of the 2012 SWMP. In the February 2017 Environment Agency Flood and Coastal Erosion Risk Management (FCERM) Programme, there are several proposed schemes in Leicester City, aimed at alleviating flooding from surface water sources. These include: • Leicester Northfields Flood Alleviation Scheme; • Leicester Royal Infirmary Surface Water Flood Alleviation Scheme; • Leicester, Egginton Street Surface Water Flood Alleviation Scheme; • Leicester, Oakland Road Surface Water Flood Alleviation Scheme; and, • Leicester, Redhill Way Surface Water Flood Alleviation Scheme.
Groundwater	The AStGW mapping indicates that parts of Leicester City may potentially be susceptible to groundwater flooding. Areas within the >=50% <75% or >=75% categories tend to be found along the valleys of the River Soar, Willow Brook and Melton Brook and the locations of Secondary A aquifers (Superficial Deposits designation).
Sewers	Sewer flooding is a known and well documented risk to Leicester City; several recorded historic events have been partially attributed to sewer flooding. However, the 2012 SWMP for Leicester City has noted that maintenance work may have been undertaken by Severn Trent Water since the flooding incidents occurred and therefore the risk may have been removed or reduced significantly. The 2012 Level 2 SFRA for Leicester City states that many sewers in Leicester were built pre-1980 and as such, as likely to have a lower capacity. There have been 102 records of internal flooding in Severn Trent Water's register. Dates range from 1992 to 2000. Most of these occurred in the LE2 postcode area.
Reservoirs	The majority of Leicester City is not at risk of inundation in the event of a reservoir failure. The mapping indicates that there are six reservoirs which present a risk; Braunstone Park Storage Reservoir, Mallory Park Large Lake, Thornton Reservoir, Dakyn Road FSR, Knighton Park FSR and Groby Pool. The mapping indicates reservoir inundation extents follow the floodplains of the River Soar, Braunstone Brook, Saffron Brook, Willow Brook and Bushby Brook; urban areas are located within these extents.
Other potential sources of flood risk and cross-boundary implications	The 2012 SWMP notes that due to urban nature of Leicester City, there is a high level of interaction between the surface water sewer system and watercourses. The River Soar also interacts with the Grand Union Canal in Leicester. There have been two over-topping incidents and one breach incident along the Grand Union Canal in Leicester. The breach incident was caused by a weir collapse; there is no reported cause of the over-topping incidents. There remains a residual risk, should a Canal breach or fail. Many watercourses in Leicester City originate from outside of the City, in surrounding neighbouring authorities. This may have important implications for the management of runoff and the transfer of risk as development in the upstream areas (either in one authority or in the other) could potentially have impacts downstream. Further, if opportunities for natural flood management are realised, this has the potential to reduce the flood risk in Leicester City. Leicester City Council's Flood Risk Asset Register contains 1,027 assets which the council considers to significantly affect whether areas will flood in Leicester. Leicester City Council are currently considering whether to designate any assets within the city.

6.10.6 Melton Borough

Source of flooding	Description
Fluvial	Fluvial flood risk in Melton Borough is from the River Wreake (Eye) and its tributaries, as well as the River Devon, Wash Dyke, Dam Dyke and several smaller un-named drains located to the north of the borough. Some of the drains located to the north of the borough are maintained by the Trent Valley IDB. Melton Borough has a long and well documented history of fluvial flooding. Flood Zones show the undefended scenario. There are defences along sections of the River Wreake (Eye), Gaddesby Brook, Scalford Brook, Thorpe Brook, Welby Brook and the Asfordby Relief Channel. There are Flood Alleviation Schemes along the River Wreake, at Melton Mowbray and Breatingby. However, there remains a residual risk should the defences breach or fail. Flooding may not be from one watercourse alone and interaction between the watercourses has the potential to cause flooding. At Melton Mowbray, several watercourses converge to form the River Wreake.
Surface water	Historically, Melton Borough has experienced several flooding events related to surface water. A Section 19 Flood Investigation Report into the June 2012 flood event at Normanton identified intense rainfall, combined with drainage capacity issues, caused surface water flooding. Rural settlements across the borough have experienced surface water flooding including Somerby, Asfordby, Wymondham, Long Clawson, Hose and Harby. Mapping shows surface water flood risk in Melton Borough generally follows similar flow paths to watercourses and dry valleys with some isolated ponding located in low lying areas. The mapping indicates that surface water may originate as runoff from hillside areas to the north and south of Melton Mowbray, towards the River Wreake (Eye) and towards low-lying areas in the north of the borough. Surface water is also shown to pond in open spaces, gardens and roads. The risk is mainly confined to roads and gardens in the 3.3% AEP event and properties tend to be at risk during events including and exceeding the 1% AEP event.
Groundwater	The 2014 Melton SFRA identified recorded incidents of groundwater flooding in Frisby and Melton Mowbray, following the egression of groundwater through hillside fissures and the generation of overland flow. In Long Clawson, it is noted that groundwater flooding associated with spring activity is a potential flood risk. The AStGW mapping indicates that areas within the >=50% <75% or >=75% categories tend to be found along the valleys of River Wreake (Eye) and the drains in the low-lying areas to the north of the borough and the locations of Secondary A aquifers (Superficial Deposits designation). Areas of high ground to the north and south of Melton Mowbray tend to be less susceptible to groundwater as these areas are underlain by unproductive bedrock (i.e. < 25%).
Sewers	There have been nine records of internal flooding in Severn Trent Water's register. These occurred between 1994 and 2007 in Melton Mowbray, Bottlesford and Harby.
Reservoirs	The majority of Melton Borough is not at risk of flooding caused by a reservoir failure. The mapping indicates that there are eight reservoirs which present a risk; Stapleford Lake, Ragdale, Brentingby Flood Storage Reservoir, Frisby Lake, Scalford Brook Reservoir, Knipton, Belvoir Upper Lake and Belvoir Lower Lake. The mapping indicates that the reservoir flood extents follow the valleys of the River Wreake (Eye), the River Devon, the Kingston Brook, Ox Brook and un-named drains in and around Bottesford to the north of the borough and the Six Hill area to the west of the borough. Much of Bottesford is located within reservoir flood extents and parts of other urban settlements, including Melton Mowbray are at risk.
Other potential sources of flood risk and cross-boundary implications	The Grantham Canal flows through the north of the borough; there has been once incident of a breach and seven incidents relating to over-topping. Two incidents may have been caused by human activities (unconfirmed). There remains a residual risk, should the Canal breach or fail. The River Devon crosses in and out of the border with neighbouring Lincolnshire to the east and many of its tributaries are located outside of Melton Borough. This may have important implications for the management of runoff and the transfer of risk as development in the upstream areas (either in one county or in the other) could potentially have impacts downstream.

6.10.7 North West Leicestershire District

Source of flooding	Description
Fluvial	North West Leicestershire District has a well-documented history of fluvial flooding along the River Trent, River Soar, Grace Dieu Brook and Gilwiskaw Brook as well as several minor watercourses. Fluvial flood risk in North West Leicestershire District is from several watercourses including the River Trent, River Soar and River Mease and their tributaries. The floodplain in the northern corner of the district is notably wide and is associated with the confluence of the River Soar and River Trent; several un-named drains also discharge into the River Trent and River Soar in this area. This area may flood independently and in larger events, concurrently from the River Trent and River Soar. Flood Zones show the undefended scenario. There are defences along sections of the River Soar and River Trent to the north of the district and along a section of the Grace Dieu Brook in Agar Nook. However, there remains a residual risk should the defences breach or fail. Property Level Flood Protection schemes are proposed in Diseworth and Long Whatton under Leicestershire County Council's LFRMS and as listed in the February 2017 Environment Agency Flood and Coastal Erosion Risk Management (FCERM) Programme. The 2015 SFRA for North West Leicestershire District identified a flood storage area along the Gilwiskaw Brook which protects downstream areas. However, details for this flood storage area are unknown and it is not represented on the Environment Agency's Flood Map for Planning website. The 2015 SFRA also identifies defences along the Hemington Brook and Lockington Brook that are not represented on the Environment Agency's Flood Map for Planning website.
Surface water	Section 19 Flood Investigation Reports into the June 2012 event at Bardon Road in Coaville and Drome and Vercor Close and the November 2012 event at Moria identified the source of flooding as surface water. The capacity of the drainage network was also a noted cause of flooding. The 2015 SFRA for North West Leicestershire District identified Coalville, Measham, Blackfordby, Appleby Magna, Peggs Green and Castle Donington as areas at risk from surface water flooding (and potentially in combination with other sources) The Trent Rivers Trust has delivered a retro-fit SuDS scheme to the Leisure Centre in Measham and is in the early stages of scoping a second SuDS retro-fit project on land off Widgeon Drive in Measham. Mapping shows surface water flood risk in North West Leicestershire generally follows similar flow paths to watercourses in the district. Surface water is also shown to pond in open spaces, gardens and roads, particularly across urban settlements in the district. The risk is mainly confined to roads and gardens in the 3.3% AEP event; properties tend to become at risk during events including and exceeding the 1% AEP event.
Groundwater	The 2015 SFRA for North West Leicestershire District considered the risk of groundwater flooding to be low within the District. However, the report notes that groundwater can contribute to flooding from other sources. Rising groundwater associated within large-scale closures of coal mines, notably within Oakthorpe and Donnisthorpe could potentially cause flooding although no reports of flooding from this source have been recorded. The AStGW mapping indicates that much of the district within the >=50% <75% or >=75% categories tend to be found along the valleys of River Sense, River Mease, River Trent, Rive Soar, Grace Dieu Brook and Diseworth Brook and the locations of Secondary A aquifers (Superficial Deposits designation).
Sewers	In 2015, Severn Trent Water were investigating a potential scheme in Appleby Magna, to address sewer flooding; at the time of the SFRA, the scheme was currently in the feasibility stage for completion under AMP6 (2015-2020). There have been 36 records of internal flooding in Severn Trent Water's register. The occurred between 1989 and 2014. Most of these occurred in the LE67 postcode area.
Reservoirs	The majority of the district is not at risk from flooding caused by a reservoir failure. The mapping indicates that there are 19 reservoirs which present a risk; Ratcliffe on Soar Ash Lagoons, Kingston Park Pond, Serpentine Lake, EMA Gimbro Ponds, Blackbrook Reservoir, Swithland Reservoir, Central East Area Balancing Pond, Melbourne Pool, Willesley Lake, West Park and Harrington Drain FSR, Cropston Reservoir, Foremark Reservoir, Ogston Reservoir, Church Wilne Reservoir, Blithfield Reservoir, Breaston FSR, Carsington Reservoir, Howden Reservoir and Staunton Harold Reservoir. The mapping indicates that the reservoir flood extents follow the valleys of the Saltersford Brook and sections of the River Mease, Ramsley Brook, Diseworth Brook, River Soar, River Trent, Lockington Brook and Hemington Brook.
Other potential sources of flood risk and cross-boundary implications	The Grand Union Canal follows the River Soar course, along the north-east boundary of the district. The Ashby Canal is also located around Snarestone towards the south of the district. Whilst no records of a breach or over-topping of the canals in North West Leicestershire District were found through this assessment, there remains a residual risk, should the canal breach or fail. The 2015 SFRA for North West Leicestershire District notes that northwards from Leicester, the Grand Union Canal utilises the River Soar and for this section, flooding is comparatively common in Winter and was experienced at several locks along the River Soar in July 2007. There are no connections between the Grand Union Canal and the River Soar. The River Trent crosses in and out of the border with neighbouring South Derbyshire and Erewash Districts. This may have important implications for the management of runoff and the transfer of risk as development in the upstream areas (either in one county or in the other) could potentially have impacts downstream.

6.10.8 Oadby and Wigston Borough

Source of flooding	Description
Fluvial	Fluvial flood risk in Oadby and Wigston Borough is from the Wash Brook and River Sence, as well as un-named drains which discharge into the River Sence along the southern boundary of the district. The floodplain of the River Sence is predominantly rural through the borough; however, the floodplain of the Wash Brook and un-named drains which discharge into the River Sence cross through urban areas, presenting a risk to property. Flood Zones show the undefended scenario. There are no formal flood defences in the district.
Surface water	Mapping shows surface water flood risk in Oadby and Wigston Borough generally follows similar flow paths to the River Sence and its tributaries, as well as the Wash Brook and the drains which discharge into the River Sence to the south of the borough. Surface water is also shown to pond in open spaces, gardens and roads. Whilst the risk is mainly confined to roads and gardens in the 3.3% AEP event, certain flow paths are shown to affect properties. For example, there is a flow path from Kelmarsh Avenue to the railway line behind Little Hill Primary School, during the 3.3% AEP event. Surface water is shown to pond behind the railway lines indicating that railway embankment act as informal flood defences. However, properties tend to become at risk during events including and exceeding the 1% AEP event. Catchments in the borough may respond quickly to rainfall events as extensive areas are underlain by clay.
Groundwater	The 2014 Joint SFRA describes how, due to the moderate or slowly permeable geology of the area, it is more likely that there will be higher percentages of runoff and therefore limited potential for ground water flood risk problems. The AStGW mapping indicates that areas. within the >=50% <75% or >=75% categories tend to be found along the valleys of River Sence and Wash Brook valleys and the locations of Secondary A aquifers (Superficial Deposits designation).
Sewers	There have been 14 records of internal flooding in Severn Trent Water's register. These occurred in 1989, 1996 and 2016, in the LE18, LE24 and LE25 postcode areas.
Reservoirs	The majority of the district is not at risk from flooding caused by a reservoir failure. The mapping indicates that a small area, around the A5199, Brighton Avenue and Brighton Close is within the Knighton Park FSR flood extents.
Other potential sources of flood risk and cross-boundary implications	The Leicester Line (Grand Union Canal) flows near the southern boundary of the borough, near the River Sence. Whilst no records of a breach or over-topping of the canals in Oadby and Wigston Borough were found through this assessment, there remains a residual risk, should the canal breach or fail. Further, there is the potential for interaction with the Grand Union Canal and the River Sence in the borough.

7 Flood defences

7.1 Flood defences

There are many flood alleviation schemes (FAS) within Leicestershire County and Leicester City.

Flood alleviation schemes identified within the SFRA area may include formal defences, initiatives to improve drainage, and/or land management to reduce the risk of high velocity overland surface runoff.

7.2 Areas benefiting from defences

Appendix D shows the areas benefitting from defences in Leicestershire County and Leicester City as designated by the Environment Agency. The Environment Agency's Areas Benefitting from Defences dataset shows areas that benefit from flood defences in the event of a river flood with a 1% chance of happening in any one year. If the defences did not exist, these areas would be flooded. The dataset may not yet include areas benefitting from recently completed schemes.

At the time of preparing this SFRA, the areas benefiting from defences dataset was in the process of being updated. Developers are advised to contact the Environment Agency, at an early stage to check whether revised flood defence information has been published.

7.3 On-going flood alleviation schemes

One of the principal aims of this SFRA is to outline the present risk of fluvial flooding from watercourses across Leicestershire County and Leicester City that includes consideration of the effect of flood risk management measures (including flood banks and defences). The fluvial flood risk presented in the SFRA is of a strategic nature for the purpose of preparing evidence on possible growth options and locations for future development. In the cases where a site-specific risk assessment is required, detailed studies should seek to refine the current, broad, understanding of flood risk from all sources.

Consideration of the residual risk behind flood defences should be considered as part of detailed site-specific Flood Risk Assessments. The residual risk of flooding in an extreme flood event or from failure of defences should also be carefully considered.

Developers should also consider the standard of protection provided by defences and residual risk as part of a detailed FRA.

Standard of Protection
Flood defences are designed to give a specific standard of protection, reducing the risk of flooding to people and property in flood prone areas. For example, a flood defence with a 1% AEP standard of protection means that the flood risk in the defended area is reduced to a 1% chance of flooding in any given year.

It should be noted that the original 'design standard' referred to in this SFRA may not reflect the current standard of protection offered by the flood defences. The design standard of protection refers to the severity of the flood for which the defence was designed to offer protection from. The current or actual standard of protection refers to the severity of the flood for which defences currently offer protection from.

As such, although flood defences are designed to a standard of protection, over time, the actual standard of protection provided by the defence may decrease, for example due to deterioration in condition or increases in flood risk due to climate change. The design standard of protection may have been superseded by recent flood risk studies which could refine flood risk information and thus change the current standard of protection offered by defences.

7.3.1 Defence condition

Formal structural defences are given a rating based on a grading system for their condition. A summary of the grading system used by the Environment Agency for condition is provided in Table 7-1. This detail, in addition to descriptions and standard of protection for each, was provided by the Environment Agency for this SFRA which reports on the standard of protection using this information.

Table 7-1: Defence asset condition rating

Grade	Rating	Description
1	Very Good	Cosmetic defects that will have no effect on performance.
2	Good	Minor defects that will not reduce the overall performance of the asset.
3	Fair	Defects that could reduce the performance of the asset.
4	Poor	Defects that would significantly reduce the performance of the asset. Further investigation required.
5	Very Poor	Severe defects resulting in complete performance failure.

Source: Condition Assessment Manual – Environment Agency 2006

The condition of existing flood defences and whether they will continue to be maintained and/or improved in the future is an issue that needs to be considered as part of the risk based sequential approach and, in light of this, whether possible site options for development are appropriate and sustainable. In addition, detailed Flood Risk Assessments (FRAs) will need to thoroughly explore the condition of defences, especially where these defences are informal and demonstrate a wide variation of condition grades. It is important that these assets are maintained to a good condition and their function remains unimpaired.

A high-level overview of key defences across Leicestershire County and Leicester City, their condition and standard of protection, is included in the following sections.

7.4 Overview of existing flood defences in Leicestershire County and Leicester City

7.4.1 Environment Agency's Raised Flood Defences and Flood Storage Areas

The Environment Agency supplied a GIS file showing raised flood defences across the study area. This shows that there are several flood defences in Leicestershire County and Leicester City, specifically in Leicester City, Melton Mowbray and Loughborough. Other smaller and more rural settlements are also shown to have flood defences; these include, but are not limited to, Great Glen, Whetstone, Kegworth, Quorn and Rothley. In addition, there are several flood storage areas across the study area. Appendix D contains are series of maps showing the location of the flood defences, their design Standard of Protection and their current condition, as well as the location of flood storage areas. The mapping in Appendix D has only been provided for locations which have flood defences shown in the supplied Environment Agency raised flood defences GIS file.

No maps are provided for Hinckley and Bosworth Borough or Oadby and Wigston Borough as no defences are located in these council areas, as shown by the Environment Agency's supplied GIS file. However, the 2014 Joint SFRA which covers Hinckley and Bosworth Borough identifies flood defences along a section of the Witherley Brook to the north of Witherley and the 2013 Stour and Sketchley Brook Model report refers to defences at Brodrick Road (flood storage area) and the Longshoot (a flood wall); all of which are not represented in the Environment Agency's raised flood defences GIS dataset. An overview of existing defences per authority area is shown in Table 7-2.

Table 7-2: Environment Agency's raised flood defences and storage areas per authority area

Local Authority	Defences and storage areas description
Blaby District	There are defences along sections of: • the Whetstone Brook in Whetstone; • the Cosby Brook around Broughton Road / Chapel Lane in Cosby; and, • the River Soar, north of Sunny Dale. The design and actual standard of protection varies. The majority of the defences are considered to be either in a fair or good condition. However, the overall condition for some of the defences is unknown. There are no flood storage areas in Blaby District.
Charnwood Borough	There are several defences across Charnwood Borough. These can be found: • behind properties off Melton Road in Thurmaston next to the River Soar / Grand Union Canal; • along sections of the Rothley Brook through Rothley; • along a section of the River Wreake at Broome Lane, east of Ratcliffe on the Wreake; • along a section of the Sileby Brook in Sileby; • along sections of the Quorn Brook and River Soar through Quorn; • along sections of the River Soar west of Barrow upon Soar; • along sections of the Wood Brook, Burleigh Brook, Black Brook, Hermitage Brook and River Soar in Loughborough; • behind properties off Soarbank Way, parallel to the Grand Union Canal, in Loughborough; and, • along sections of the River Soar, east of Hathern. The design and actual standard of protection varies. The majority of defences are considered to be either in a fair or good condition. However, the defences along the Black Brook are classed as a poor condition. There is one flood storage area in Charnwood Borough, located next to the Fishpool Brook, behind Melton Road in Barrow upon Soar.

Local Authority	Defences and storage areas description
City of Leicester	There are defences along sections of: • the Saffron Brook; • Bushby Brook; and, • the River Soar. The design and actual standard of protection varies. The embankments associated with the flood storage area on the Saffron Brook have a design standard of protection of 1:1,000-years (0.1% AEP). However, the current standard of protection is shown to be 1:100-years (1% AEP) or unknown. Elsewhere, the design and actual standard of protection varies. The majority of the defences are considered to be either in a fair or good condition. However, the overall condition for some of the defences is unknown. There are three flood storage areas in Leicester City. One flood storage area is located along the Bushby Brook, downstream of its confluence with the Thurnby Brook. Another flood storage area is located off the Saffron Brook, upstream of A563 Palmerston Way in the Knighton area. The third flood storage area, sometimes referred to as the Braunstone Lakes flood storage area, is located along the Braunstone Brook, upstream of Braunstone Avenue in the Braunstone Town area.
Harborough District	There are defences along sections of: • the Burton Brook and River Sence towards their confluence at Great Glen; and, • an un-named watercourse near its confluence with the Thurnby Brook in Thurnby. The defences largely consist of embankments. Several of the defences in the Great Glen area have a 1:100-year design standard of protection. However, in places the current standard of protection is far lower than the design standard of protection. Elsewhere, the design and actual standard of protection varies. The majority of the defences are considered to be either in a fair or good condition. However, the overall condition for some of the defences is unknown. There are three flood storage areas across the district. One flood storage area is located along the Medbourne Brook, downstream of Hallaton Road and east of Medbourne Road. A second flood storage area is located upstream of Great Easton, around the confluence of two un-named watercourses. A third flood storage area is located on the River Jordan, upstream of the Little Bowden area of Market Harborough. Consultation with the Environment Agency has also identified • Defences along the River Welland in Market Harborough. This is not shown in the Environment Agency's supplied raised defences dataset and mapping in Appendix D as these defences are not owned or maintained by the Environment Agency. • A flood storage area on the River Jordan at Braybrooke (outside of the study area) which is likely to influence flood risk along the River Jordan in the district.

Local Authority	Defences and storage areas description
Hinckley and Bosworth Borough	There are no raised flood defences or flood storage areas in Hinckley and Bosworth Borough shown in the supplied GIS dataset. However, the 2014 Joint SFRA which covers Hinckley and Bosworth Borough identifies flood defences stating: *"the flood defence in Witherley is located to the north of the village, in the form of a bund running along the Witherley Brook and behind houses on Mythe Lane. If the level in the Witherley Brook are too high then highway drains from Mythe Lane and Atterton Lane are prone to backing up and flooding in this location."* Further, consultation with the Environment Agency has confirmed that there is an embankment towards the head of the Harrow Brook (where designated Main River).
Melton Borough	There are defences along sections of: • the Gaddesby Brook by Foxville Street in Ashby Folville; • the Scalford Brook, downstream of a flood storage area in Melton Mowbray; • the Thorpe Brook near the B676 Saxby Road and behind properties around the industrial estate along Acres Rise; and, • the River Wreake (Eye) around Brentingby; • the Welby Brook by The Valley; • the Asfordby Relief Channel in Asfordby; and, • the River Wreake, downstream of a flood storage area, north of Frisby on the Wreake. The design and actual standard of protection varies. The majority of the defences are considered to be either in a fair or good condition. However, the overall condition for some of the defences is unknown. There are three flood storage areas across the borough. A large flood storage area is located upstream of Melton Mowbray in Brentingby, along the River Wreak (forming part of the Flood Alleviation Scheme). A second flood storage area along the River Wreak is located at Frisby on the Wreake. The third flood storage area is located on the Scalford Brook, upstream of Melton Mowbray.
North West Leicestershire District	There are defences along sections of: • the River Soar, from Kegworth to the River Soar / River Trent confluence; • the River Trent along part of the northern boundary of the district; and, • the Grace Dieu Brook in Agar Nook. The defences are largely flood embankments. At Kegworth, the defences adjacent to Bridge Fields road and behind properties off Station Road have a 1:100-year (1% AEP) design standard of protection. Elsewhere, the design and actual standard of protection varies. The majority of the defences are considered to be either in a fair or good condition. However, the overall condition for some of the defences is unknown. There are no flood storage areas in North West Leicestershire District.
Oadby and Wigston Borough	There are no raised flood defences or flood storage areas in Oadby and Wigston Borough.

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7.4.2 Existing Flood Alleviation Schemes

Details of existing flood alleviation and / or risk management schemes across Leicestershire County and Leicester City are shown in Table 7-3.

Table 7-3: Existing Flood Alleviation and Risk Management Schemes

FAS	Description
Lubbesthorpe Brook FAS	Re-alignment and widening of ~500m of the watercourse channel. Bypass culvert constructed at Watergate Lane Bridge. In addition, £200,000 of sewer improvements have been undertaken by Severn Trent Water on Lubbesthorpe Road and Watergate Lane, to help prevent sewer flooding.
River Soar FAS	Constructed in the 1980-1990s, the FAS includes a series of works upstream of Quorn to reduce flood risk.
Melton Mowbray FAS – River Wreake	Completed in 2001, this scheme comprises an online storage facility to reduce flood risk along the River Wreake. The FAS has been designed to attenuate flows from the River Wreake up to the 1 in 100-year (1% AEP) flows, to the 1 in 5-year flows (20% AEP).
Melton Mowbray FAS – Brentingby	Complete in June 2003, this scheme provides a 1:100-years (1% AEP) standard of protection, providing flood alleviation to over 650 properties in the town. The scheme stores 3.7million cubic metres of water across 2.4km^2 and restricts the amount of flow through Melton Mowbray to a level that can be retained within the channel without any flooding to property during the design event.
Coventry Road, Hinckley FAS	£1.8m project undertaken by Severn Trent Water which involved the installation of 1,600m of new sewer and on-line storage pipework, to address surface water flooding issues.
Broughton Astley FAS	£19,000 project funded by the Environment Agency and Leicestershire County Council and which included the construction of 'leaky barriers' to delay the flow of storm water, the creation of ponds and tree-planting to provide new habitats for wildlife.
Market Harborough FAS	Anglian Water completed a flood alleviation scheme in 2016 which is intended to reduce the risk of surface water flooding along Coventry Road, in Market Harborough. 100 metres of new surface water sewers were constructed[6].

Further information on capital Flood Alleviation Schemes (e.g. the Medium-Term Plan) can be found on the government's website: https://www.gov.uk/.

7.4.3 Leicester City Council's Flood Risk Asset Database

Leicester City Council has compiled a Flood Risk Asset Register for Leicester under Section 21 of the FWMA (2010). Leicester City Council's Flood Risk Asset Register is available to download from the council's website. At the time of preparing this SFRA, there are 1,027 assets in the register. The assets include bridges, bridge piers, chambers, culverts, drains, fences, flap valves, headwalls, infalls, locks, outfalls, penstock, pumping stations, retaining walls, sluices, spillways, storm detention areas, trash screens and weirs. Although not all the assets are a formal flood defence, the council considers these assets to *"significantly affect whether areas will flood in Leicester"*[7].

An asset that is defined as having a significant effect on flood risk and therefore warrants inclusion on the Asset Register and Record is one that, should it fail, would have the potential to cause a 'locally significant' flooding event.

Before structures are added to the Asset Register, the relevant information about each asset such as ownership and condition are recorded. The list will then be updated periodically as Leicester City Council becomes aware of significant assets.

6 http://www.anglianwater.co.uk/news/tunnelling-work-underway-beneath-the-streets-of-market-harborough.aspx
7 https://www.leicester.gov.uk/your-environment/flooding-and-severe-weather/flood-risk-asset-register/

Assets on the online Flood Risk Asset Register may not all be owned or maintained by Leicester City Council. In addition, if an asset is listed on the register, this does not place any additional responsibilities on Leicester City Council for the asset's condition or performance.

The potential for flooding can be increased in areas where flood alleviation measures are not maintained regularly and/ or adequately. It is the responsibility of the riparian owner to maintain the watercourses or defences to a suitable standard. The Local Authority (for Ordinary Watercourses), the Environment Agency (for Main Rivers) and the IDB (for IDB Drains) have permissive powers to act should the riparian owner not satisfy their maintenance requirements.

Leicester City Council are currently considering whether to designate any assets within the city. If a feature or structure is designated, the owner will need to apply to Leicester City Council or another body for permission to alter or demolish it.

Other information

The 2009 SFRA for Harborough District noted that the risk of flooding to parts of Great Glen is witnessed to have been reduced by new water balancing arrangements, implemented as part of the recent A6 by-pass. Further, Anglian Water constructed a storage tank beneath the Commons Car Park in Market Harborough in June 2005 which has helped to alleviate flooding.

Hinckley and Bosworth Borough Council's GIS data shows that there are flood prevention measures along sections of the Sketchley Brook, Battling Brook and Harrow Brook in Hinckley.

7.5 Proposed schemes

7.5.1 Local Flood Risk Management Strategies

Several flood alleviation works are proposed in Leicestershire County and Leicester City. One of the main schemes is the Defra funded River Soar conveyance project which proposes to reduce the risk of flooding to approximately 4,700 properties in Leicester[8]. The scheme involves the creation of >1 hectare of new wetland habitat and the transformation of public open spaces. At the time of preparing this SFRA, the Environment Agency confirmed that phases 1 and 2 of the River Soar conveyance project were complete; the completed works provide an increased level of flood risk protection to over 1,500 properties. Phase 3 is due for completion in 2018 and will involve the installation of a flood relief culvert to Loughborough Road bridge and will increase the level of flood risk protection to a further 600 properties.

The 2015 Leicester City LFRMS provides examples of projects the authority proposes to deliver. This includes joint flood defence schemes for surface water and the main river network along the Willowbrook and tributaries, Braunstone Brook, Saffron Brook and Melton Brook. The LFRMS further proposes schemes along the Holbrook and Gilroes Brook, the Ethel Brook and Portwey Brook and at Northfields. It should be noted that these schemes are example projects which are proposed and may not necessarily be delivered.

The 2015 Action Plan accompanying the Leicestershire County Council LFRMS, identifies a series of flood defence and alleviation works including:

- De-culverting a watercourse in Broughton Astley to improve channel capacity
- Improve the channel capacity of the Scraptoft Brook and undertake works to improve the nature reserve
- Improve the channel capacity of the Scraptoft Brook and replace an existing highway culvert

Property level flood protection schemes are also proposed in:

- Diseworth & Long Whatton
- Market Harborough

Feasibility studies and investigations for attenuation schemes, raising existing defences, de-culverting works, flood mitigation measures, drainage improvements are also proposed across the county (refer to the 2015 Action Plan accompanying the Leicestershire County Council LFRMS for further detail).

Leicester City Council are also in the process of developing an Integrated Flood Risk Management Strategy (IFRMS). The IFRMS is identifying opportunities to reduce flood risk in four keys areas

8 River Soar and Grand Union Canal Partnership, 2016 / 2019 Action Plan: https://resources.leicestershire.gov.uk/sites/resource/files/field/pdf/2017/6/6/River_Soar_and_Grand_Union_Canal_Partnership.pdf

across the city: the Soar corridor, Willow Brook, Braunstone Brook and Saffron Brook. This IFRMS is planned to be published in December 2017.

8.1.1 Environment Agency Flood and Coastal Erosion Risk Management (FCERM) Programme – England

The Environment Agency FCERM Programme details schemes, strategies or maintenance activities that the Environment Agency or other flood risk management authorities will be undertaking. In Leicestershire County and Leicester City, the following schemes are planned:

- Swithland Brook Flood Alleviation Scheme, Leicestershire;
- Broughton Astley Flood Alleviation Scheme, Harborough, Leicestershire;
- Leicester Northfields Flood Alleviation Scheme;
- Leicester Royal Infirmary Surface Water Flood Alleviation Scheme;
- Leicester, Egginton Street Surface Water Flood Alleviation Scheme;
- Leicester, Oakland Road Surface Water Flood Alleviation Scheme;
- Leicester, Redhill Way Surface Water Flood Alleviation Scheme; and,
- Long Whatton and Diseworth Flood Alleviation Scheme, Leicestershire.

8.2 River Soar Catchment – projects

There are several projects concerning the River Soar catchment which are seeking to deliver a range of measures to alleviate flood risk. The Soar Natural Flood Management (NFM) Project is being delivered by the Trent Rivers Trust with support from the River Soar Catchment Partnership. There is an on-going scoping study into Natural Flood Management (NFM) along the River Soar, specifically looking at the catchments of the Willow Brook, River Sence, Upper Soar and Upper River Eye. The report is due to be published in 2017 and will recommend opportunities for NFM. These are likely to include opportunities upstream of Leicester and Melton Mowbray.

Technical studies concerning the feasibility of NFM on the Willow Brook and River Sence identified the following potential measures:

- *"Soil management to reduce runoff generation;*
- *Improved field underdrainage to reduce rapid runoff in unsaturated conditions;*
- *Measures to slow the flow in long, straight, steep, field ditches;*
- *Measures to temporary store flow in less productive areas (i.e. field corners etc); and,*
- *Measures to slow and store flow in wider channel reaches (especially Sence upstream of Great Glen)."*[9]

The above report put forwards recommendations to review these measures further and the measure may not necessarily be taken forward and implemented.

In addition, the Trent Rivers Trust has been working with landowners across the Willow Brook and River Sence catchments to support good farming practice and sustainable soil management to reduce the impact of farming downstream (i.e. diffuse pollution and flood risk). The Trent Rivers Trust has installed several small-scale features across the two catchments to hold water up and improve water quality.

A sediment fingerprinting study of the Willow Brook catchment is looking at the issues of sediment across the catchment from urban and rural settings and causing flood risk in urban areas of Leicester City. This study is on-going.

Further information on the above studies can be found at the Trent Rivers Trust website: http://www.trentriverstrust.org/site/SoarNFM.

7.7 River Mease Catchment – projects

The Trent Rivers Trust has delivered a retro-fit SuDS scheme to the Leisure Centre in Measham which uses the landscape to reduce flood risk and reduce pollution. The Trent Rivers Trust is in the early stages of scoping a second SuDS retro-fit project on land off Widgeon Drive in Measham.

9 River Sence and Willow Brook Natural Flood Management Scoping and Feasibility Study, SWCM / TRT Report, May 2017: http://www.trentriverstrust.org/site/sites/default/files/Willow%20Sence%20%20NFM%20scoping%20report%20FINAL%20for%20web.pdf

Discussion on surface water and SuDS can be found in Section 6.10.

7.8 Other information

The 2009 SFRA for Harborough District noted that works (including road drainage schemes) were proposed in Coventry Road in Market Harborough, South Churchill Road in Cranoe, Mill Lane in Smeeton Westerby and Burton Overy village centre to reduce and tackle flooding.

The 2015 North West Leicestershire SFRA noted that Severn Trent Water were investigating a potential scheme in Appleby Magna, to address sewer flooding; at the time of the SFRA, the scheme was currently in the feasibility stage for completion under AMP6 (2015-2020). A scheme at this location will only be taken forward if identified to be economically and technically viable.

7.9 Residual flood risk

Residual risk refers to the risks that remain in circumstances after measures have been taken to alleviate flooding (such as flood defences). It is important that these risks are quantified to confirm that the consequences can be safely managed. The residual risk can be:

- The effects of a flood with a magnitude greater than that for which the defences or management measures have been designed to alleviate (the 'design flood'). This can result in overtopping of flood banks, failure of flood gates to cope with the level of flow or failure of pumping systems to cope with the incoming discharges.
- Failure of the defences or flood risk management measures to perform their intended duty. This could be breach failure of flood embankments, failure of flood gates to operate in the intended manner or failure of pumping stations.

Defences in Leicestershire County and Leicester City vary in condition and standard of protection. In the event of a breach, depending on the extent and magnitude of the breach, water could rapidly inundate area behind defences with little warning. Although the majority of areas protected by defences are within the Environment Agency's Flood Warning Service, the service does not provide a warning in the event of a breach.

There is also the potential that the risk of defences overtopping in the future may increase due to increased flows due to climate change.

7.9.1 Implications for development

The assessment of residual risk demands that attention be given to the vulnerability of the receptors and the response to managing the resultant flood emergency. In this instance attention should be paid to the characteristics of flood emergencies and the roles and responsibilities during such events. Additionally, in the cases of breach or overtopping events, consideration should be given to the structural safety of the dwellings or structures that could be adversely affected by significant high flows or flood depths.

Developers should include an assessment of the residual risk where developments are in areas benefitting from defences. They should consider both the impact of breach, including the effect on safe access and egress, as well as potential for flood risk to increase in the future due to overtopping. Any improvements to defences should ensure they are in keeping with wider catchment policy. The residual risk should also be considered during the assessment of flood risk to opportunity areas in the SGP.

The breach modelling undertaken by the Environment Agency should be used as a starting point for breach modelling as part of detailed site-specific flood risk assessments. The assessments should identify rapid inundation zones, the speed of onset of flooding, the depth, hazard and extent of flood water.

CHAPTER 7 SUMMARY

Several communities benefit from flood defences and alleviation schemes in Leicestershire. Examples of alleviation measures found in Leicestershire include raised embankments, flood storage areas, sewer improvement initiatives and storage tanks. However, there remains a residual risk should the defences breach or fail.

The Environment Agency's raised flood defences GIS file indicates that there are notable differences between the design and current standard of protection and there are locations where defences are in a poor condition e.g. along the Black Brook in Loughborough.

There are also several assets which are considered to significantly affect whether areas will flood in Leicester and there are also other flood risk management initiatives such as property level flood protection schemes and retro-fits SuDS schemes. Whilst these may not be considered formal flood defences, these do play a role in the local management of flood risk.

There are several on-going schemes and projects to reduce the risk of flooding in Leicestershire comprising natural flood management initiatives along the River Soar catchment and flood alleviation schemes identified in Local Flood Risk Management Strategies and the Environment Agency's Flood and Coastal Erosion Risk Management Programme.

CHAPTER 7 RECOMMENDATIONS

Whilst areas benefit from defences and alleviation measures, there remains a residual risk. The residual risk can be:

- The effects of a flood with a magnitude greater than that for which the defences or management measures have been designed to alleviate (the 'design flood').
- Failure of the defences or flood risk management measures to perform their intended duty.

If opportunity growth areas identified in the SGP are taken forward and allocated for development, developers should consider the residual risk as part of a detailed site-specific flood risk assessment, where development is located in areas benefiting from defences. The assessment should consider the standard of protection by defences, their condition, impact of a breach and future over-topping.

Flood mitigation measures should only be considered if, after application of the Sequential Approach, sites cannot be located away from higher risk areas. If defences are constructed to protect a development site, it will need be demonstrated that the defences will not have a resulting negative impact on flood risk elsewhere, and that there is no net loss in floodplain storage. Any developments located within an area protected by flood defences, where the condition of those defences is 'fair' or 'poor', and where the standard of protection is not of the required standard, should be identified. Consideration needs to be given to how any necessary improvements could be funded, including the role of contributions secured via planning obligations'

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8 Cumulative impact of development / land use change

8.1 Introduction

When deciding strategic growth areas, consideration must be given to the potential cumulative impact of development on flood risk, as well as the impact of a change in land use. The nature of strategic growth areas means they may be in areas of previously undeveloped and rural land.

Increase in impermeable surfaces causes an increase in runoff; this has the potential to increase the chance of surface water flooding, if suitable mitigation measures, such as SuDS, are not put in place. Additionally, the increase in runoff may result in more flow entering watercourses and therefore has the potential to increase the risk of fluvial flooding downstream.

Consideration must also be given to the potential cumulative impact of the loss of floodplain because of development. The effect of the loss of floodplain storage should be assessed, at both the development and elsewhere within the catchment and, if required, the scale and scope of appropriate mitigation measures should be identified. Whilst the increase in runoff, or loss in floodplain storage, from individual developments may only have a minimal impact on flood risk, the cumulative effect of multiple developments may be more severe without appropriate mitigation measures.

The following sections describe the results of a high-level assessment of catchment responses to potential increases in development within the catchment.

8.2 Approach

Several sample locations have been selected to analyse the impact of a change in land use on the catchment response.

Table 8-1 lists the sample locations and reasons for choosing. A map of these locations is provided in Figure 8-1.

Table 8-1: Land use change assessment locations

Location	Description	ReFH urban description
0	Downstream on the River Sence. Large catchment. Located between South Wigston and Blaby.	Slightly urbanised
1	River Welland at Market Harborough. Small catchment. Market Harborough is in the lower reaches of the watercourse.	Essentially rural
2	Downstream on the Black Brook. Moderately sized catchment. Urban areas in the catchment include Shepshed and parts of Loughborough.	Moderately urbanised
3	Downstream of Saffron Brook. Small catchment, very urbanised. Flows through Oadby and Wigston and into Leicester.	Very heavily urbanised
4	Downstream on Rothley Brook. Larger catchment. Watercourse flows through Thurcaston and Rothley.	Moderately urbanised
5	Downstream on Melton Brook. Small catchment. Watercourse flows through predominantly rural land before entering Leicestershire.	Moderately urbanised
6	Downstream on Willow Brook. Urban watercourse flowing through Leicester.	Very heavily urbanised
7	Downstream on Lubbesthorpe Brook. Small catchment flowing through predominantly rural land, apart from the village of Narborough.	Moderately urbanised
8	Downstream on Cosby Brook. Small catchment flowing through predominantly rural land, apart from the village of Cosby.	Slightly urbanised
9	Downstream on Whetstone Brook. Small catchment flowing through predominantly rural land, apart from the village of Whetstone.	Slightly urbanised

Location	Description	ReFH urban description
10	Downstream on River Mease. Large catchment. Ashby-de-lla-Zouch, Packington and Measham are in the upper reaches.	Slightly urbanised
11	Downstream on the Wood Brook. Small catchment, flowing through the predominantly urban land of Loughborough.	Moderately urbanised
12	Downstream on the Quorn Brook. Smaller catchment, predominantly rural apart from the village of Quorn in the lower reaches.	Slightly urbanised
13	River Wreake. Large predominately rural catchment. Melton Mowbray is in the upper reaches.	Moderately urbanised
14	Downstream on the River Sence (Anker tributary). Large catchment. Flows through predominately rural land apart from Sheepy Magna.	Slightly urbanised

The scenarios used are

- Baseline (existing situation – no change made)
- 10% increase in urban extent within the catchment
- 25% increase in urban extent within the catchment
- 50% increase in urban extent within the catchment

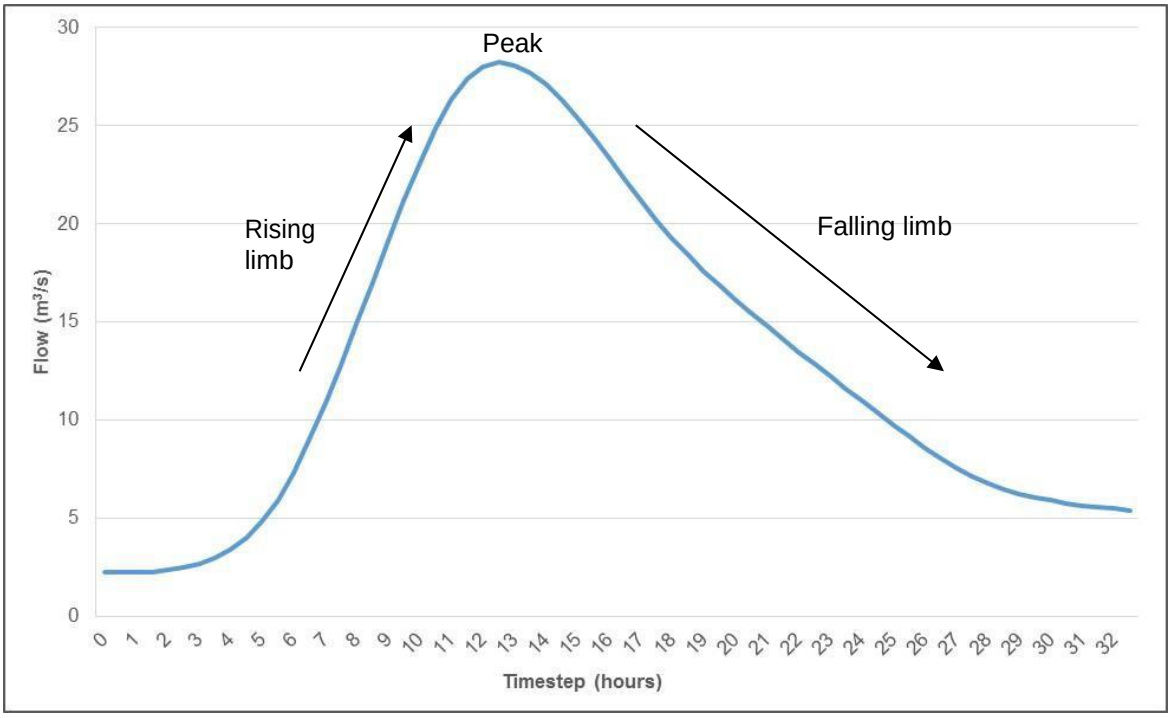
Indicative catchment response hydrographs have been produced using FEH catchment descriptors and run through the ReFH software for each location. These indicative hydrographs are based on a reference event intended to show the potential relative effects of runoff because of the increase in urban area within the catchment. A worst-case scenario has been used in which it has been assumed that no measures (e.g. SuDS) have been put in place to mitigate against increased runoff. The reference event is based on a flood with a 1% AEP.

The URBEXT values for the catchments were increased for the different scenarios and re-run in ReFH. The resulting hydrographs were then plotted against the present-day (baseline) hydrograph and compared to give an indication of the sensitivity of the watercourse to an increase in urban extent. It should be noted that these assessments were undertaken on the downstream extent of all the watercourses. Increases in urban land coverage is likely to have a more significant impact at a more local level and on the smaller tributaries of these watercourses.

An example of an indicative hydrograph is provided in Figure 8-1.

FEH (Flood Estimation Handbook) and associated software provides guidance on rainfall and river flood frequency estimates in the UK and are used to inform the hydrology / inflows which feed into hydraulic models. FEH is split into volumes. Volume 4, the rainfall-runoff method, has largely been superseded by **ReFH** (Revitalised Flood Hydrograph); this is an updated method which derives an inflow for a catchment or sub-catchment. ReFH uses catchment descriptors to inform inflow estimates; catchment descriptors represent physical and climatological characteristics of a catchment or sub-catchment. One of these catchment descriptors in the **URBEXT** value. The URBEXT value represents the proportion of urbanisation in a catchment or sub-catchment.

Figure 8-1: Example of indicative hydrograph



8.3 Effect of development / land use change on flood risk

In all cases, the increase in urban extent in the catchment results in an increase in peak flows, a steeper rising limb (i.e. a more rapid rate of rise) and a shorter duration. This indicates that not only will the peak flow be higher but flows will become 'flashier' – rising faster and over a shorter duration of time. Example indicative hydrographs for a heavily urbanised catchment, essentially rural catchment and moderately urbanised catchment are provided in Figure 8-2 to Figure 8-4 respectively. The hydrographs for all the locations are provided in Appendix I.

The degree to which this occurred varied between catchments. The smaller, urban catchments (locations 3 and 6) were much more sensitive to an increase in urban extent, with a noticeable increase in the steepness of the rising limb and peak flow when compared to larger, more rural catchments (location 1). The falling limb is also much steeper and the duration is shorter compared to the baseline scenario.

Essentially rural catchments see a very minor increase in the peak flow but the hydrograph shape stays the same.

Moderately urban catchments saw a similar response regardless of the catchment size (for example locations 4 and 5).

The results show watercourses are sensitive to an increase in the impermeable area because of development and change of land use, and highlight the importance of appropriate mitigation measures, such as SuDS, to ensure no detrimental impact on the flow regime of receiving watercourses and not exacerbate flood risk within the catchment. This is particularly important for areas where urban areas in the downstream catchment are already prone to flooding.

Figure 8-2: Example indicative hydrograph for a heavily urbanised catchment (location 3)

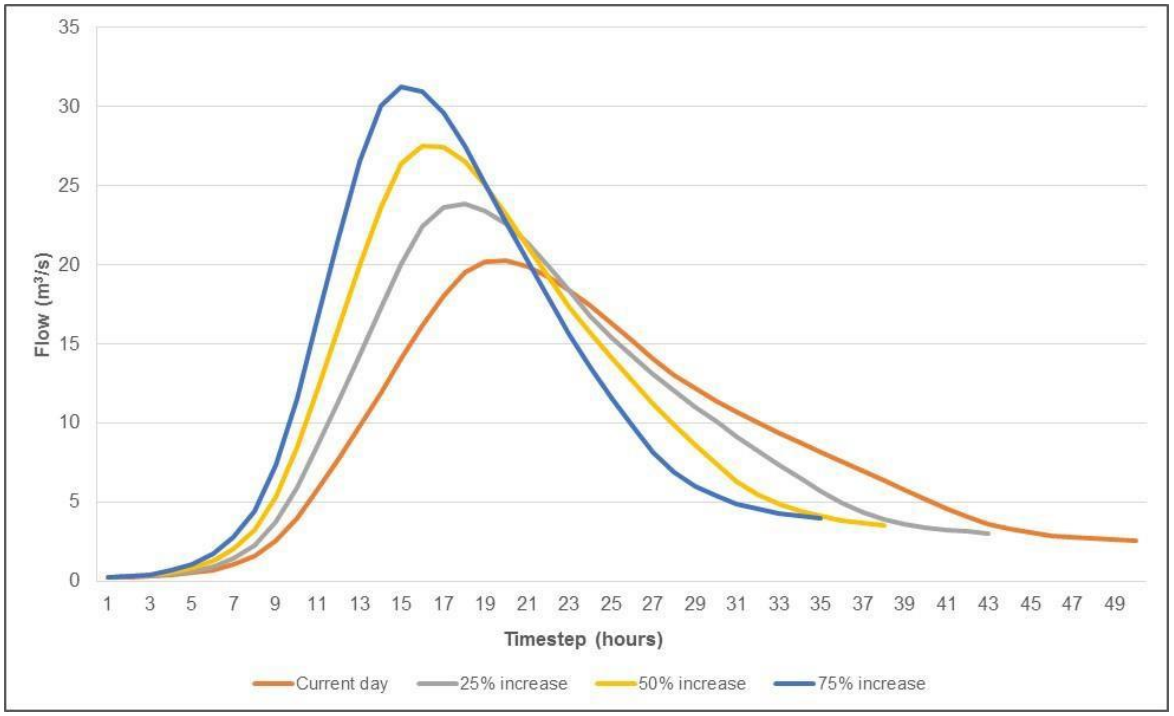


Figure 8-3: Example indicative hydrograph for an essentially rural catchment (location 1)

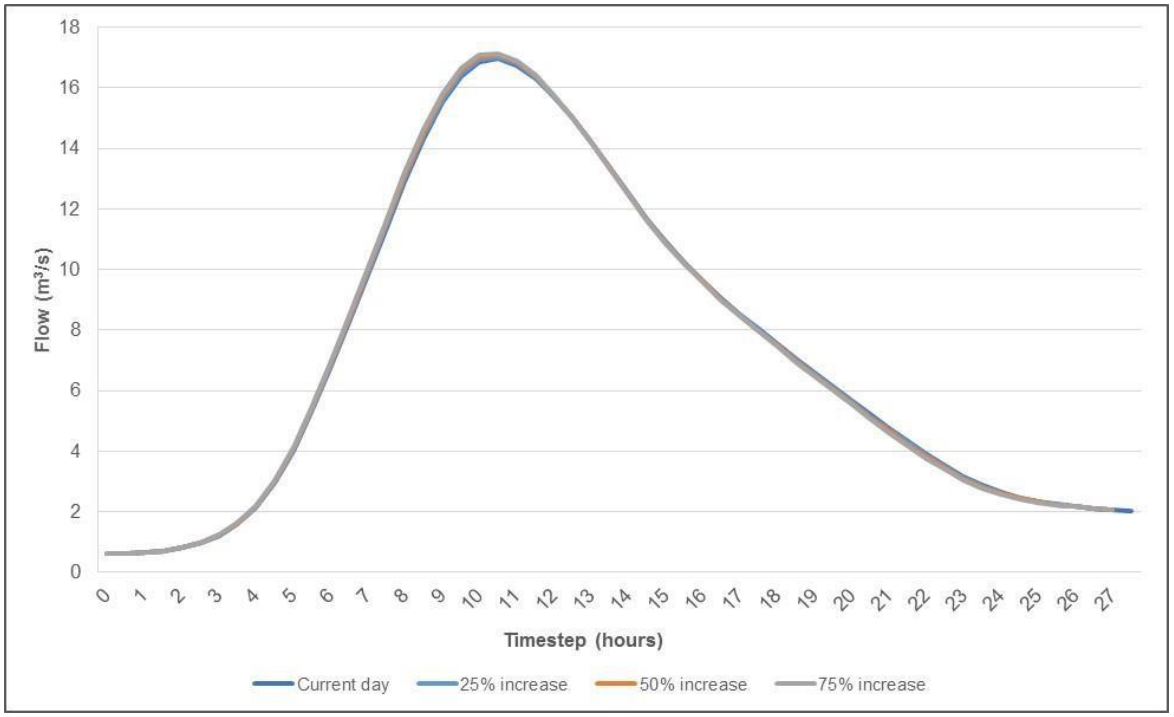
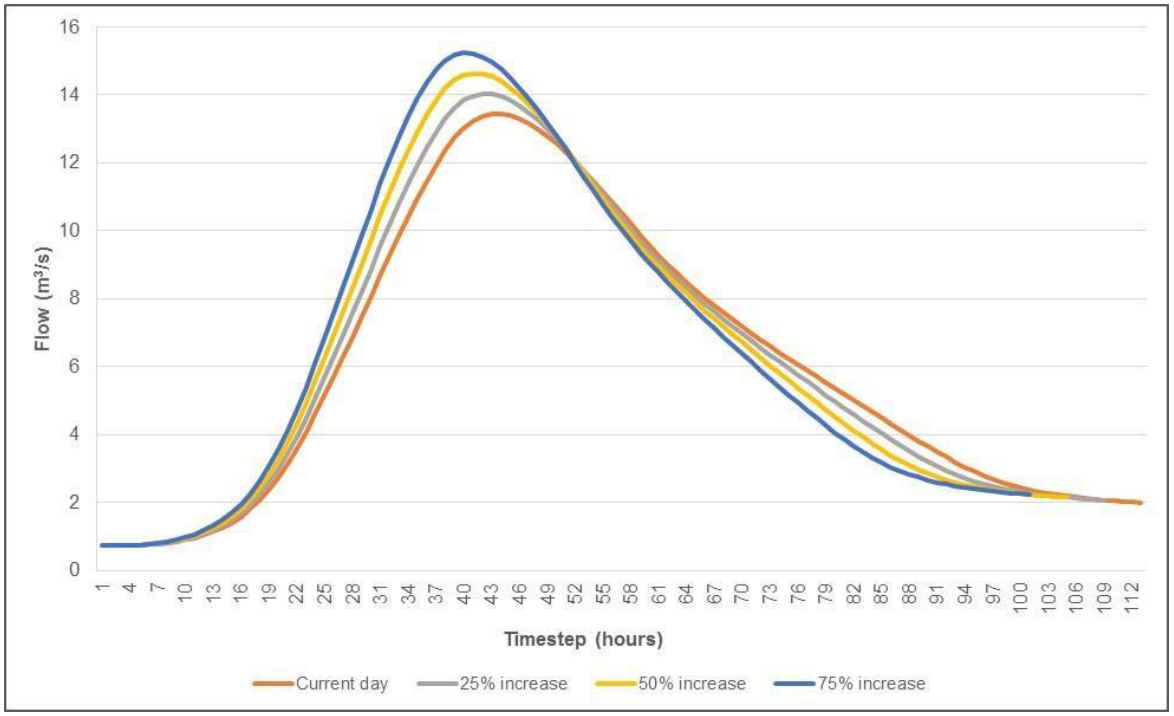


Figure 8-4: Example indicative hydrograph for a moderately urbanised catchment (location 5)



CHAPTER 8 SUMMARY

Changes in land use such as the increase in impermeable surfaces and resulting increase in runoff increases the chances of surface water flooding if suitable mitigation measures, such as SuDS, are not put in place. Additionally, the increase in runoff may result in more flow entering watercourses, increasing the risk of fluvial flooding downstream.

Development has the potential for loss of floodplain storage. Whilst the increase in runoff, or loss in floodplain storage, from individual developments may only have a minimal impact on flood risk, the cumulative effect of multiple developments may be more severe without appropriate mitigation measures.

A high-level assessment has been undertaken on catchment responses to potential increases in development within the catchment. The results show an increase in urban extent in the catchment resulting in an increase in peak flows a steeper rising limb and a shorter duration. This indicates that not only will the peak flow be higher but flows will become 'flashier'.

CHAPTER 8 RECOMMENDATIONS

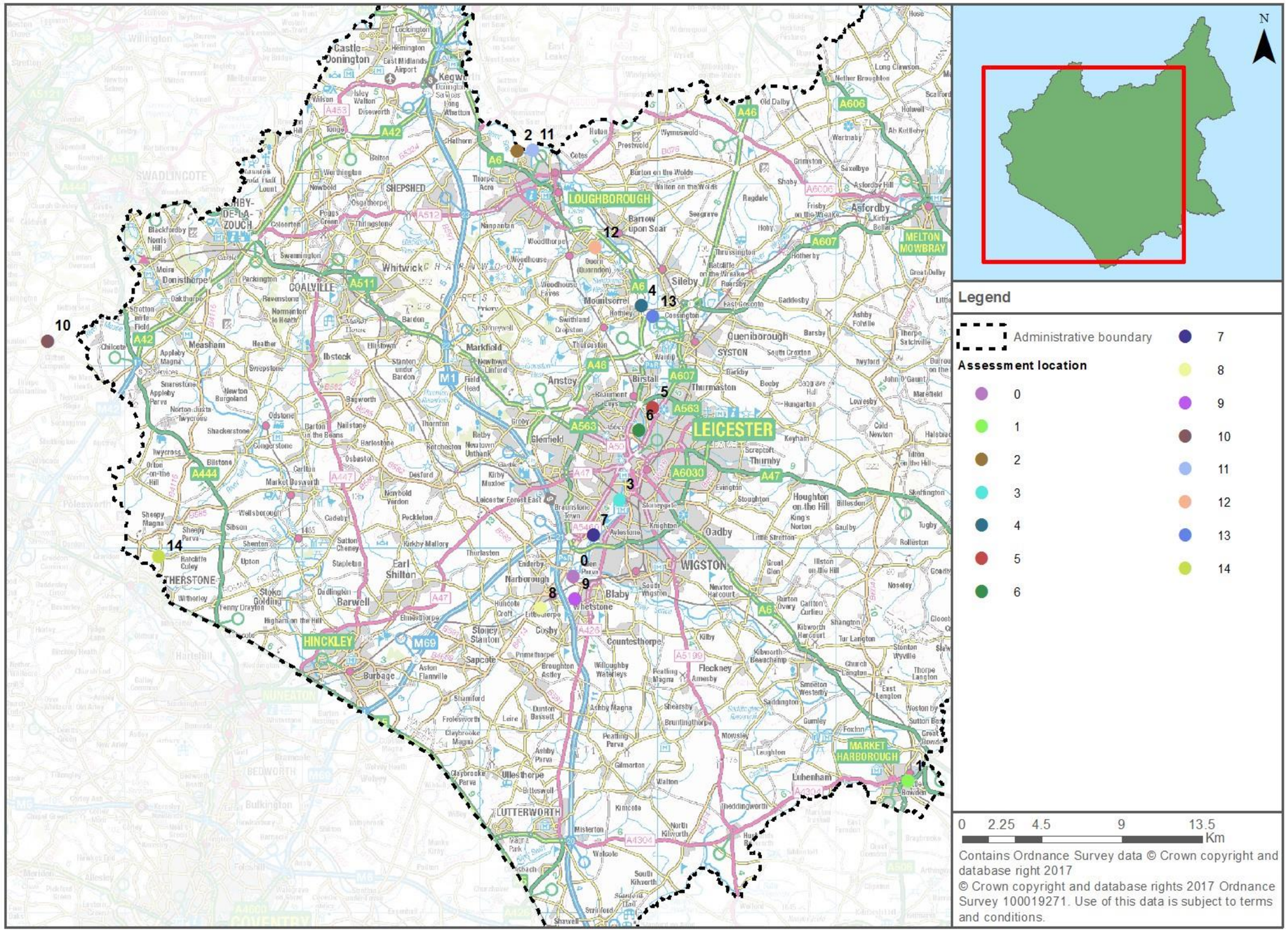
The cumulative impact of development and the effect of land use change should be considered at the planning application and development design stages. Appropriate mitigation measures should be identified and informed by an appropriate FRA, to ensure flood risk is not exacerbated, and in many cases the development should be used to reduce the flood risk. The application of SuDS should be used to help mitigate the impact of development and prevent increases in flood risk to third party lands.

When considering developing land within the proposed growth areas, consideration must be given to the potential cumulative impact of the loss of floodplain as a result of development. The effect of the loss of floodplain storage should be assessed, at both the development and elsewhere within the catchment and, if required, the scale and scope of appropriate mitigation should be identified. The application of SuDS should be used to help mitigate the impact of development and prevent increases in flood risk to third party lands.

Onsite attenuation schemes would need to be tested against the hydrographs of the receiving watercourse to ensure flows are not exacerbated downstream within the catchment.

Maintenance and upkeep of SuDS have been neglected in the past because of lack of clarity over where responsibility for it lies. Therefore, is it important that maintenance and upkeep for mitigation measures, such as SuDS, has been set out as part of a drainage strategy and that management funding for the lifetime of the development has been agreed.

Figure 8-5: Location of indicative hydrograph sample points



9 FRA requirements and flood risk management guidance

9.1 Over-arching principles

This SFRA focuses on delivering a strategic assessment of flood risk within Leicestershire County and Leicester City. The nature of the strategic growth areas means they are likely to be larger areas containing a number of different land uses. The Sequential approach to the location of development with the area should be used to place development in the areas of lowest risk.

Prior to any construction or development within a strategic growth area, site-specific assessments will need to be undertaken (where required) so all forms of flood risk at a site are fully addressed. It is the responsibility of the developer to provide an FRA with an application.

It should be acknowledged that a detailed FRA may show that a site is not appropriate for development of a particular vulnerability or even at all. Where the FRA shows that a site is not appropriate for a particular usage, a lower vulnerability classification may be appropriate.

9.2 Requirements for site-specific flood risk assessments

9.2.1 What are site-specific FRAs?

Site-specific FRAs are carried out by (or on behalf of) developers to assess flood risk to and from a site. They are submitted to LPAs with planning applications and should demonstrate how flood risk will be managed over the development's lifetime, taking into account climate change and vulnerability of users.

9.2.2 When are site-specific FRAs required?

Site specific FRAs are required in the following circumstances:

- Proposals of 1 hectare or greater in Flood Zone 1.
- Proposals for new development (including minor development and change of use) in Flood Zones 2 and 3.
- Proposals for new development (including minor development and change of use) in an area within Flood Zone 1 which has critical drainage problems (as notified to the LPA by the Environment Agency).
- Where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding.

A FRA may also be required for some specific situations:

- If the site may be at risk from the breach of a local defence, canals or reservoirs (even if the site is actually in Flood Zone 1)
- Where the site is intended to discharge to the catchment or assets of a water management authority which requires a site-specific FRA
- Where the site's drainage system may have an impact on an IDB's system
- Where evidence of historical or recent flood events have been passed to the LPA
- In an area of significant surface water flood risk.

9.2.3 Objectives of site specific FRAs

Site specific FRAs should be proportionate to the degree of flood risk, as well as appropriate to the scale, nature and location of the development. Site specific FRAs should establish:

- Whether a proposed development is likely to be affected by current or future flooding (i.e. climate change) from any source
- Whether the proposed development will be safe for its lifetime
- Whether a proposed development will increase flood risk elsewhere
- Whether the measures proposed to deal with the effects and risks are appropriate
- The evidence, if necessary, for the LPA to apply the Sequential Test

- Whether, if applicable, the development will be safe and pass the Exception Test, if applicable

FRAs for sites located in strategic growth areas should follow the approach recommended by the NPPF (and associated guidance) and guidance provided by the Environment Agency, the LLFAs and relevant local planning authority.

Guidance for local planning authorities for reviewing flood risk assessments submitted as part of planning applications has been published by Defra in 2015 – Flood Risk Assessment: Local Planning Authorities.

Developers should consult with the relevant local planning authorities, Lead Local Flood Authority and the Environment Agency (where relevant), at an early stage to discuss flood risk including requirements for site-specific FRAs, detailed hydraulic modelling, and drainage assessment and design. For example, there are watercourses where it was not possible to model the impacts of climate change (i.e. the River Welland) and developers may need to further investigate the flood risk as part of a site-specific FRA. Appendix H provides a list of all detailed hydraulic models used in this SFRA.

9.3 Flood risk management guidance – mitigation measures

Mitigation measures should be seen as a last resort to address flood risk issues. Consideration should first be given to minimising risk by planning sequentially across the strategic growth area and in individual sites within the growth area. Once risk has been minimised as far as possible, only then should mitigation measures be considered.

9.3.1 Site layout and design

Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development.

The NPPF states that a sequential, risk-based approach should be applied to try to locate more vulnerable land use away from Flood Zones 2 and 3, to higher ground, while more flood-compatible development (e.g. vehicular parking, recreational space) can be located in higher risk areas. However, vehicular parking in floodplains should be based on the nature of parking, flood depths and hazard including evacuation procedures and flood warning.

Waterside areas, or areas along known flow routes, can act as Green Infrastructure, being used for recreation, amenity and environmental purposes, allowing the preservation of flow routes and flood storage, and at the same time providing valuable social and environmental benefits contributing to other sustainability objectives. Landscaping should ensure safe access to higher ground from these areas, and avoid the creation of isolated islands as water levels rise.

Making space for water

The NPPF sets out a clear policy aim in Flood Zone 3 to create space for flooding by restoring functional floodplain.

All new development close to rivers should consider the opportunity presented to improve and enhance the river environment. Developments should look at opportunities for river restoration and enhancement as part of the development. Options include backwater creation, de-silting, in-channel habitat enhancement and removal of structures. When designed properly, such measures can have benefits such as reducing the costs of maintaining hard engineering structures, reducing flood risk, improving water quality and increasing biodiversity. Social benefits are also gained by increasing green space and access to the river. An example of where enhancements to the river environment are being implemented in on-going schemes is through the River Soar conveyance project which, in addition to providing increased levels of flood protection, involves the creation of >1 hectare of new wetland habitat and the transformation of public open spaces. Further information on the scheme can be found in Section 7.5.1.

The provision of a buffer strip can ‘make space for water’, allow additional capacity to accommodate climate change and ensure access to the watercourse, structures and defences is maintained for future maintenance purposes.

It also enables the avoidance of disturbing riverbanks, adversely impacting ecology and having to construct engineered riverbank protection. Building adjacent to riverbanks can also cause problems to the structural integrity of the riverbanks and the building itself, making future maintenance of the river much more difficult.

Culverted watercourses were often constructed to enable the efficient drainage of an area and allow land to become developable. However, culverted watercourses require regular maintenance to ensure that they function correctly. In most cases, they also require trash screens at their entrance to ensure they do not become blocked by large debris, further adding to the maintenance requirements. Culverting can also result in the loss of natural riverside and in-channel habitat through the direct loss of vegetation which creates complex habitats for a wide variety of plants and animals to thrive in. Culverts can also be impassable to some river animal species and fish. In some, mainly urban areas, culverted watercourses can become extremely polluted due to cross connections associated with developments and industry. Culverting can also alter the natural sediment transport regime resulting in displaced energy which can exacerbate or cause erosion upstream or downstream. Excessive erosion can weaken river banks and also results in excessive sediment in the watercourse which can be harmful to the plants and animals of the river environment.

Many artificial in-channel structures such as culverts are often redundant and / or serve little purpose and opportunities exist to remove them where feasible. De-culverting can bring many benefits including; reducing the need for regular maintenance and trash screens, reducing blockages and enhancing the river environment by providing a more varied habitat. In some cases, small sections of open channel can be beneficial for flood risk management allowing for flood water to disperse naturally and thus slowing the movement of flood water downstream. However, it also must be recognised that some artificial structures may have important functions or historical/cultural associations, which need to be considered carefully when planning and designing restoration work.

Under the Environmental Permitting Regulations (England and Wales) 2016, an environmental permit may be required for flood risk activities for work in, under, over or within 8 metres of any fluvial Main River, flood defence structure or culvert. Further information can be found in Section 2.9.3 and at: https://www.gov.uk/guidance/flood-risk-activities-environmental-permits.

Further information is provided in the **'Trash and Security Screen Guide 2009'**, published by the Environment Agency/ Defra, which should be used as evidence for any culvert assessment, improvement or structure retention.

9.3.2 Raised floor levels

In the event development is unable to be placed outside of Flood Zones 2 and 3, the raising of internal floor levels within the development avoids damage occurring to the interior, furnishings and electrics in times of flood.

If it has been agreed with the Environment Agency that, in a particular instance, the raising of floor levels is acceptable finished flood levels should be set above the 1% AEP event plus an allowance for climate change and an appropriate allowance for freeboard. The additional height that the floor level is raised above the maximum water level is referred to as the "freeboard". Additional freeboard may be required because of risks relating to blockages to the channel, culvert or bridge and should be considered as part of an FRA.

Allocating the ground floor of a building for less vulnerable, non-residential, use is an effective way of raising living space above flood levels.

Single storey buildings such as ground floor flats or bungalows are especially vulnerable to rapid rise of water (such as that experienced during a breach). This risk can be reduced by use of multiple storey construction and raised areas that provide an escape route. However, access and egress would still be an issue, particularly when flood duration covers many days. Through consultation with the Environment Agency, it is also advised that finished floor levels and mitigation measures for single storey developments (e.g. ground floor flats and bungalows) should be designed for the 0.1% AEP (1 in 1,000-year chance of flooding in any given year) flood event, where possible.

Similarly, the use of basements should be avoided. Habitable uses of basements within Flood Zone 3 should not be permitted, whilst basement dwellings in Flood Zone 2 will be required to pass the Exception Test.

Access should be situated 300mm above the design flood level and waterproof construction techniques used. Safe access and egress should be maintained for the lifetime of the development.

Safe access and egress should also be considered when appraising the residual risk posed by surface water drainage schemes. For example, if the highway forms part of the route of exceedance for surface water drainage, this should be considered in the assessment of safe access and egress.

9.3.3 Development and raised defences

Construction of localised raised floodwalls or embankments to protect new development is not a preferred option, as a residual risk of flooding will remain. Compensatory storage must be provided where raised defences remove storage from the floodplain. It would be preferable for schemes to involve an integrated flood risk management solution.

Temporary or demountable defences are not acceptable forms of flood protection for a new development but might be appropriate to address circumstances where the consequences of residual risk are severe but the time required to install the defences, for example in an overtopping scenario, would be realistic. In addition to the technical measures the proposals must include details of how the temporary measures will be erected and decommissioned, responsibility for maintenance and the cost of replacement when they deteriorate. The storage and accessibility of such structures must be considered.

9.3.4 Modification of ground levels

Modifying ground levels to raise the land above the required flood level is an effective way of reducing flood risk to a particular site in circumstances where the land does not act as conveyance for flood waters. However, care must be taken at locations where raising ground levels could adversely affect existing communities and property; in most areas of fluvial flood risk, raising land above the floodplain would reduce conveyance or flood storage in the floodplain and could adversely impact flood risk downstream or on neighbouring land.

All new development within the 1% AEP flood extent including an allowance for climate change (for the lifetime of the development) must not result in a net loss of flood storage capacity. Where possible, opportunities should be sought to achieve an increase in the provision of floodplain storage.

Where proposed development results in a change in building footprint, the developer should ensure that it does not impact upon the ability of the floodplain to store or convey water, and seek opportunities to provide floodplain betterment. Similarly, where ground levels are elevated to raise the development out of the floodplain, compensatory floodplain storage within areas that currently lie outside the floodplain should be provided to ensure that the total volume of the floodplain storage is not reduced.

For compensatory flood storage to be effective, it must be provided on a level for level, volume for volume basis on land which does not already flood and is within the site boundary. Where land is not within the site boundary, it must be in the immediate vicinity, in the applicant's ownership/control and linked to the site. Floodplain compensation should be considered in the context of the 1% annual probability (1 in 100 year) flood level including an allowance for climate change. When designing a scheme flood water must be able to flow in and out unaided. An FRA should demonstrate that there is no loss of flood storage capacity and include details of an appropriate maintenance regime to ensure mitigation continues to function for the life of the development. Guidance on how to address floodplain compensation is provided in Appendix A3 of the CIRIA Publication C624.

Raising ground levels can also deflect flood flows, so analyses should be performed to demonstrate that there are no adverse effects on third party land or property.

Raising levels can also create areas where surface water might pond during significant rainfall events. Any proposals to raise ground levels should be tested to ensure that it would not cause increased ponding or build-up of surface runoff on third party land.

9.3.5 Developer contributions

In some cases, and following the application of the sequential test, it may be necessary for the developer to make a contribution to the improvement of flood defence provision that would benefit both proposed new development and the existing local community. Developer contributions can also be made to maintenance and provision of flood risk management assets, flood warning and the reduction of surface water flooding (i.e. SuDS).

DEFRA's Flood and Coastal Risk Management Grant in Aid (FCRMGiA)[10] can be obtained by operating authorities to contribute towards the cost of a range of activities including flood risk management schemes that help reduce the risk of flooding and coastal erosion. Some schemes are only partly funded by FCRMGiA and therefore any shortfall in funds will need to be found from

10 Principles for implementing flood and coastal resilience funding partnerships (Environment Agency, 2012)

elsewhere when using Resilience Partnership Funding, for example local levy funding, local businesses or other parties benefitting from the scheme.

For new development in locations without existing defences, or where the development is the only beneficiary, the full costs of appropriate risk management measures for the life of the assets proposed must be funded by the developer.

However, the provision of funding by a developer for the cost of the necessary standard of protection from flooding does not mean the development is appropriate as other policy aims must also be met. Funding from developers should be explored prior to the granting of planning permission and in partnership with the Council and the Environment Agency.

The appropriate route for the consideration of strategic measures to address flood risk issues is the LFRMS. The LFRMS should describe the priorities with respect to local flood risk management, the measures to be taken, the timing and how they will be funded. It will be preferable to be able to demonstrate that strategic provisions are in accordance with the LFRMS, can be afforded and have an appropriate priority.

The Environment Agency is also committed to working in partnership with developers to reduce flood risk. Where assets are in need of improvement or a scheme can be implemented to reduce flood risk, the Environment Agency request that developers contact them to discuss potential solutions.

10.2.1 Emergency flood plans

Under the NPPF and NPPG, there are circumstances where a flood warning and evacuation plan is required and / or advised for new development (see Section 6.8 for further information). Emergency plans should not be used in isolation for new development; rather these should form part of a collection of measures designed to manage the residual risk of flooding. Such plans can help to manage site safety and identify access and egress arrangements in flood emergencies.

It is recommended that Emergency Planners at the Local Planning Authority and / or Leicestershire County Council (where appropriate) are consulted prior to the production of any emergency flood plan. Advice from the emergency services may also need to be sought when producing an emergency flood plan, as part of the site-specific Flood Risk Assessment. The Environment Agency do not normally comment on or approve the adequacy of flood emergency procedures accompanying development proposals and any comments are likely to be limited to delivering flood warnings covered by the Environment Agency's Flood Warning Service.

10.3 Flood risk management guidance – resistance measures

Measures designed to keep flood water out of properties and businesses.

There may be instances where flood risk to a development remains despite implementation of such planning measures as those outlined above. For example, where the use is water compatible, where an existing building is being changed, where residual risk remains behind defences, or where floor levels have been raised but there is still a risk at the 0.1% AEP scenario. In these cases, (and for existing development in the floodplain), additional measures can be put in place to reduce damage in a flood and increase the speed of recovery. These measures should not normally be relied on for new development as an appropriate mitigation method. Most of the measures should be regarded as reducing the rate at which flood water can enter a property during an event and considered an improvement on what could be achieved with sand bags. They are often deployed with small scale pumping equipment to control the flood water that does seep through these systems. The effectiveness of these forms of measures are often dependant on the availability of a reliable forecasting and warning system to user the measures are deployed in advance of an event. The following measures are often deployed:

Permanent barriers

Permanent barriers can include built up doorsteps, rendered brick walls and toughened glass barriers.

Temporary barriers

Temporary barriers consist of moveable flood defences which can be fitted into doorways and/or windows. The permanent fixings required to install these temporary defences should be discreet

and keep architectural impact to a minimum. On a smaller scale temporary snap on covers for airbricks and air vents can also be fitted to prevent the entrance of flood water.

Community resistance measures

These include demountable defences that can be deployed by local communities to reduce the risk of water ingress to a number of properties. The methods require the deployment of inflatable (usually with water) or temporary quick assembly barriers in conjunction with pumps to collect water that seeps through the systems during a flood.

9.5 Flood risk management guidance – resilience measures

Measures designed to reduce the impact of water that enters property and businesses.

Flood-resilient buildings are designed and constructed to reduce the impact of flood water entering the building. These measures aim to ensure no permanent damage is caused, the structural integrity of the building is not compromised and the clean up after the flood is easier. Interior design measures to reduce damage caused by flooding include:

- Electrical circuitry installed at a higher level with power cables being carried down from the ceiling rather than up from the floor level
- Water-resistant materials for floors, walls and fixtures
- Non-return valves to prevent waste water from being forced up bathroom and kitchen plugs, or lavatories
- Front doors that reduce ingress of water all the time with no further installation required. Such methods must consider hydrostatic pressure and that water may still come in through the floor. Such methods offer time and reduce damage but may not remove flood water from entering the house completely

It should be note that whilst these measures are designed to limit permanent damage to a property, prolonged periods of inundation may compromise the structural integrity of a building.

Resistance and resilience measures will be required if buildings are situated in the flood risk area. Such measures may include raising electrics and plug sockets and tiling the ground floor. An emergency flood plan may need to be prepared to help manage the residual risk of flooding.

9.6 Reducing flood risk from other sources

9.6.1 Groundwater

Groundwater flooding has a very different flood mechanism to any other and for this reason many conventional flood defence and mitigation methods are not suitable. The only way to fully reduce flood risk would be through building design (development form), ensuring floor levels are raised above the water levels caused by a 1% AEP plus climate change event, or where high ground water levels are known. Site design would also need to preserve any flow routes followed by the groundwater overland to ensure flood risk is not increased downstream.

Infiltration SuDS can cause increased groundwater levels and increase flood risk on or off of the site. Developers should provide evidence and ensure that this will not be a significant risk.

When redeveloping existing buildings, it may be acceptable to install pumps in basements as a resilience measure. However, for new development this is not considered an acceptable solution.

9.6.2 Surface water and sewer flooding

Developers should discuss public sewerage capacity with the water utility company at the earliest possible stage. It is important that a surface water drainage strategy shows that development will not make the risk worse, increase flood risk elsewhere, and that the drainage requirements regarding runoff rates and SuDS for new development are met. Anglian Water and the LLFA would also expect developers to clearly demonstrate how proposals follow the surface water hierarchy (Part H of the Building Regulations) and management train, with adequate evidence and reasoning, before proposing that surface water flows should be discharged to the public sewerage network.

If residual surface water flood risk remains, the likely flow routes and depths across the site should be modelled. The site should be designed so that these flow routes are preserved and building design should provide resilience against this residual risk.

When redeveloping existing buildings, the installation of some permanent or temporary flood-proofing and resilience measures could protect against both surface water and sewer flooding. Non-return valves prevent water entering the property from drains and sewers, providing they are maintained appropriately. Non-return valves can be installed within gravity sewers or drains within a property's private sewer upstream of the public sewerage system. These need to be carefully installed and must be regularly, and appropriately, maintained. Consideration must also be given to attenuation and flow ensuring that flows during the 100-year (1% AEP) plus climate change storm event are retained within the site if any flap valves shut. This must be demonstrated with suitable modelling techniques.

9.6.3 Sustainable Drainage Systems

Sustainable Drainage Systems (SuDS) re-create the benefits of natural drainage systems by integrating water management with urban form to create and enhance the public realm, streets and open spaces. The flexibility of SuDS components means that SuDS can apply in both the urban and rural context and in both natural and man-made environments.

SuDS allow the delivery of high quality surface water drainage whilst at the same time supporting urbanised areas in coping with severe rainfall. SuDS generally replace traditional underground, piped systems that gather runoff using grates or storm water drains. They control flows to prevent deluges during times of high rainfall and reduce the risk of flooding whilst also providing benefits for amenity and biodiversity. The SuDS approach keeps water on the surface as much as possible to avoid concentration and acceleration of flows in piped systems while also taking the opportunity to provide valuable amenity assets for local residents and increase the provision of green infrastructure in urban areas. Keeping water on the surface also means that any problems with the system are quicker and easier to identify than with a conventional system and are generally cheaper and more straightforward to rectify.

SuDS provide an opportunity to improve and connect habitat in urbanised environments, as well as playing an important role in delivering and reinforcing wider green infrastructure ambitions. SuDS can also deliver recreation and education opportunities.

SuDS must be considered at the outset, during preparation of the initial site conceptual layout to ensure that enough land is given to design spaces that will be an asset to the development rather than an after-thought. Advice on best practice is available from the LLFAs, the Environment Agency and the Construction Industry Research and Information Association (CIRIA).

More detailed guidance on the use of SuDS is provided in Section 10.

CHAPTER 9 SUMMARY AND RECOMMENDATIONS

This SFRA focuses on delivering a strategic assessment of flood risk within Leicestershire County and Leicester City. The Sequential approach to the location of development with the area should be used to place development in the areas of lowest risk.

Prior to any construction or development within a strategic growth area, site-specific assessments will need to be undertaken (where required) so all forms of flood risk at a site are fully addressed. It is the responsibility of the developer to provide an FRA with an application.

Mitigation measures should be a last resort to address flood risk issues. Consideration should first be given to minimising risk by planning sequentially across the strategic growth area and in individual sites within the growth area. Once risk has been minimised as far as possible, only then should mitigation measures be considered.

Where flood risk to a development remains, additional measures can be put in place to reduce damage in a flood and increase the speed of recovery. These measures should not normally be relied on for new development as an appropriate mitigation method.

Flood-resilient buildings are designed and constructed to reduce the impact of flood water entering the building. These measures aim to ensure no permanent damage is caused, the structural integrity of the building is not compromised and the clean up after the flood is easier. Interior design measures to reduce damage caused by flooding.

10 Surface water management and SuDS

10.1 What is meant by surface water flooding?

Surface water flooding describes flooding from sewers, drains, and ditches that occurs during heavy rainfall.

Surface water flooding includes

- pluvial flooding: flooding as a result of high intensity rainfall when water is ponding or flowing over the ground surface (overland surface runoff) before it either enters the underground drainage network or watercourse or cannot enter it because the network is full to capacity;
- sewer flooding: flooding that occurs when the capacity of underground water conveyance systems 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 which may cause water to back up and flood around buildings or in built up areas. Sewer flooding can also arise from operational issues such as blockages or collapses of parts of the sewer network; and
- overland flows entering the built-up area from the rural/urban fringe: includes overland flows originating from groundwater springs.

10.2 Role of the LLFA and Local Planning Authority in surface water management

From April 2015 local planning policies and decisions on planning applications relating to major development should ensure that SuDS for management of runoff are put in place. The approval of SuDS lies with the Local Planning Authority.

When considering planning applications, local planning authorities in Leicester City and Leicestershire County will seek advice from the relevant flood risk management bodies, principally the Lead Local Flood Authority, on the management of surface water, to satisfy themselves that the development's proposed minimum standards of operation are appropriate, and to ensure, through the use of planning conditions or planning obligations, that there are clear arrangements for on-going maintenance over the development's lifetime. Judgement on what SuDS system would be reasonably practicable will be through reference to Defra's Non-Statutory Technical Standards for SuDS and will take into account design and construction costs.

Developers should submit applications in accordance with the requirements of the DEFRA Non-Statutory Technical Standards for SuDS and in line with CIRIA C753 the SuDS Manual.

At the time of preparing this SFRA, Leicestershire County Council were in the process of preparing guidance relating to SuDS and surface water management. This guidance will need to be taken into account by developers in Leicestershire County, once published.

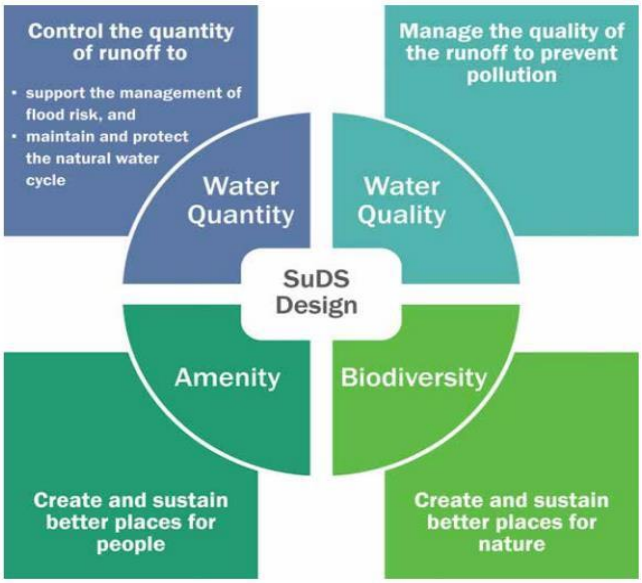
Developers in Leicester City will also need to take into account the Sustainable Drainage Guidance (February 2015) produced by Leicester City Council. Updated technical guidance relating to sustainable drainage is currently being prepared by Leicester City Council and will need to be taken into account by developers in Leicester City, once published.

Where necessary, consultations should be undertaken with the relevant LLFA to confirm the specific requirements in relation to post-development, surface water runoff management on-site.

Leicester City Council's Local Flood Risk Management Strategy states that *"much of the possible major development in the future will be upstream of Leicester and could potentially increase the flood risk in the city through increased surface water runoff."* The promotion of sustainable drainage and SuDS is therefore a key aspect of Leicester City's LFRMS, to mitigate this risk.

It is essential that developers consider sustainable drainage at an early stage of the development process – ideally at the master-planning stage. This will assist with the delivery of well designed, appropriate and effective SuDS. Proposals should also comply with the key SuDS principles regarding solutions that deliver multiple long-term benefits. These four principles are shown in Figure 10-1.

Figure 10-1: Four principles of SuDS design



Source: The SuDS Manual (C753) Ciria (2015)

10.3 Sustainable Drainage Systems (SuDS)

Sustainable Drainage Systems (SuDS) are designed to maximise the opportunities and benefits that can be secured from surface water management practices.

SuDS provide a means of dealing with the quantity and quality of surface water whilst offering additional benefits over traditional systems of improving amenity and biodiversity. The correct use of SuDS can also allow developments to counteract the negative impact that urbanisation has on the water cycle by promoting infiltration and replenishing ground water supplies. SuDS if properly designed can improve the quality of life within a development offering additional benefits such as:

- Improving air quality
- Regulating building temperatures
- Reducing noise
- Providing education opportunities
- Cost benefits over underground piped systems

Given the flexible nature of SuDS they can be used in most situations within new developments as well as being retrofitted into existing developments. For example, the Trent Rivers Trust has delivered a retro-fit SuDS scheme to the Leisure Centre in Measham and is in the early stages of scoping a second SuDS retro-fit project on land off Widgeon Drive in Measham. SuDS can also be designed to fit into the majority of spaces. For example, permeable paving could be used in parking spaces or rainwater gardens into traffic calming measures.

It is a requirement for all new major development proposals to ensure that sustainable drainage systems for management of runoff are put in place. Likewise, minor developments should also ensure sustainable systems for runoff management are provided. The developer is responsible for ensuring the design, construction and future/ongoing maintenance of such a scheme is carefully and clearly defined, and a clear and comprehensive understanding of the existing catchment hydrological processes and existing drainage arrangements is essential.

10.3.1 Types of SuDS Systems

There are many different SuDS components that can be implemented in attempts to mimic pre-development drainage (Figure 10-1). The suitability of the techniques will be dictated in part by the development proposal and site conditions. Advice on best practice is available from the Environment Agency and the Construction Industry Research and Information Association (CIRIA) e.g. the CIRIA SuDS Manual C753 (2015).

The DEFRA non-statutory technical standards for sustainable drainage systems (2015) has standards relating to flood risk outside of the development (S1), peak flow control (S2 and S3),

volume control (S4, S5 and S6), flood risk within the development (S7, S8 and S9), structural integrity (S10 and S11), designing for maintenance considerations (S12) and construction (S13 and S14).

Leicester City Council has produced SuDS guidance which includes information on different types of SuDS systems detailing practical issues, solutions and design considerations.

Table 10-1: Examples of SuDS components and potential benefits

SuDS Technique	Flood Reduction	Water Quality Treatment & Enhancement	Landscape and Wildlife Benefit
Living roofs	✓	✓	✓
Basins and ponds	✓	✓	✓
Constructed wetlands	✓	✓	✓
Balancing ponds	✓	✓	✓
Detention basins	✓	✓	✓
Retention ponds	✓	✓	✓
Filter strips and swales	✓	✓	✓
Infiltration devices	✓	✓	✓
Soakaways	✓	✓	✓
Infiltration trenches and basins	✓	✓	✓
Permeable surfaces and filter drains	✓	✓	
Gravelled areas	✓	✓	
Solid paving blocks	✓	✓	
Porous pavements	✓	✓	
Tanked systems	✓		
Over-sized pipes/tanks	✓		
Storm cells	✓		

10.3.2 Treatment

A key part of the four pillars of SuDS is to provide the maximum improvement to water quality through the use of the “SuDS management train”. To maximise the treatment within SuDS, CIRIA recommends the following good practice is implemented in the treatment process:

1. **Manage surface water runoff close to source:** This makes treatment easier due to the slower velocities and also helps isolate incidents rather than transport pollutants over a large area.
2. **Treat surface water runoff on the surface:** This allows treatment performance to be more easily inspected and managed. Sources of pollution and potential flood risk is also more easily identified. It also helps with future maintenance work and identifying damaged or failed features.
3. **Treat a range of contaminants:** SuDS should be chosen and designed to deal with the likely contaminants from a development and be able to reduce them to acceptably low levels.
4. **Minimise the risk of sediment remobilisation:** SuDS should be designed to prevent sediments being washed into receiving water bodies or systems during events greater than what the feature may have been designed.
5. **Minimise the impact of spill:** Designing SuDS to be able to trap spills close to the source or provide robust treatment along several features in series.

The number of treatment stages required depends primarily on the source of the runoff. A drainage strategy will need to demonstrate that an appropriate number of treatment stages are delivered.

Where reasonably practical, all drainage proposals should follow the SuDS discharge hierarchy and management train which prioritises infiltration at source first. How proposals follow this hierarchy

and management train should clearly be demonstrated, with adequate evidence and reasoning. If necessary, adequate evidence and explanation concerning why infiltration methods are not considered to be feasible and why methods lower down the hierarchy are considered to be feasible, may need to be provided with drainage proposals.

10.3.3 SWMP recommendations relating to SuDS

The 2012 Leicester City SWMP identified several opportunities for linking and incorporating SuDS and Green Infrastructure (GI) as mechanisms to reduce surface water runoff and to store flood water. It recommends exploring areas upstream of flood risk areas, where it may be possible to reduce flood risk through GI and take opportunities where these exist. GI opportunities have been discussed further in Section 11.5.

Phase III of the 2013 Loughborough SWMP appraised structural and non-structural measures to alleviate flood risks to each of the four Critical Drainage Areas, identified in the Phase II assessment. Structural measures considered in the SWMP included engineering interventions that could be implemented at the source and the pathways of the flooding. Examples include green roofs, soakaways, swales, permeable paving, rainwater harvesting, detention basins, capacity of drainage systems and the separation of foul and surface water sewers etc. Non-structural measures considered in the SWMP included measures to be considered by persons and organisations affected by flooding (termed 'receptors'). Examples include planning policies to influence development, social change, education and awareness and improved maintenance regimes etc.

In addition, broadscale options across Loughborough were identified; options include:

- ensure local planning policies were aligned with National Standards for SuDS;
- promote rainwater harvesting in new and existing development; and,
- consider opportunities to promote the use of water butts in new and existing development.

10.3.4 SuDS Management

SuDS components should not be used individually but as a series of features in an interconnected system designed to capture water at the source and convey it to a discharge location. SuDS components should be selected based on design criteria and how surface water management is to be integrated within the development and landscaping setting. By using a number of SuDS components in series it is possible to reduce the flow and volume of runoff as it passes through the system as well as minimising pollutants which may be generated by a development.

Page 20 of the Sustainable Drainage Guidance (February 2015) produced by Leicester City Council includes information on the maintenance of SuDS.

Where developers and applicants are considering applying to Anglian Water to adopt SuDS features, reference should be made to Anglian Water's SuDS handbook. Further information can be found on Anglian Water's website at: http://www.anglianwater.co.uk/developers/suds.aspx

10.3.5 Overcoming SuDS constraints

The design of a SuDS system will be influenced by a number of physical and policy constraints. These should be taken into account and reflected upon during the conceptual, outline and detailed stages of SuDS design. Table 10-2 details some possible constraints and how they may be overcome and includes information from both the SuDS Manual (C753). Guidance should also be sought from the Environment Agency.

Table 10-2: Examples of SuDS constraints and possible solutions

Constraint	Solution
Land availability	SuDS can be designed to fit into small areas by utilising different systems. For example, features such as permeable paving and green roofs can be used in urban areas where space may be limited.
Contaminated soil or groundwater below site	SuDS can be placed and designed to overcome issues with contaminated groundwater or soil. Shallow surface SuDS can be used to minimise disturbance to the underlying soil. The use of infiltration should also be investigated as it may be possible in some locations within the site. If infiltration is not possible linings can be used with features to prevent infiltration.

Constraint	Solution
High groundwater levels	Non-infiltrating features can be used. Features can be lined with an impermeable liner or clay to prevent the egress of water into the feature. Additional, shallow features can be utilised which are above the groundwater table.
Steep slopes	Check dams can be used to slow flows. Additionally, features can form a terraced system with additional SuDS components such as ponds used to slow flows.
Shallow slopes	Use of shallow surface features to allow a sufficient gradient. If the gradient is still too shallow pumped systems can be considered as a last resort.
Ground instability	Geotechnical site investigation should be done to determine the extent of unstable soil and indicate whether infiltration would be suitable or not.
Sites with deep backfill	Infiltration should be avoided unless the soil can be demonstrated to be sufficiently compacted. Some features such as swales are more adaptable to potential surface settlement.
Open space in floodplain zones	Design decisions should take into account the likely high water table and possible high flows and water levels. Features should also seek to not reduce the capacity of the floodplain and take into consideration the influence that a watercourse may have on a system. Factors such as siltation after a flood event should also be taken into account during the design phase.
Future adoption and maintenance	Local Planning Authority should ensure development proposals, through the use of planning conditions or planning obligations, have clear arrangements for on-going maintenance over the development's lifetime.

Infiltration drainage techniques in Leicestershire County and Leicester City may be constrained due to the local geology (i.e. clay underlain parts of the study area), groundwater vulnerability and / or the presence of Groundwater Source Protection Zones (SPZs). For proposed developments, it is imperative that a site-specific infiltration test is conducted early on as part of the design of the development, to confirm whether the water table is low enough to allow for SuDS techniques that are designed to encourage infiltration. Infiltration should be considered with caution within areas of possible subsidence or sinkholes.

Where sites lie within or close to Groundwater SPZs, NVZs or aquifers there may be a requirement for a form of pre-treatment prior to infiltration. Guidance can be found in the CIRIA SuDS manual on the level of water quality treatment required for drainage via infiltration. Further restrictions may still be applicable and guidance should be sought from the LLFA. Where potentially polluting activities are proposed, the Environment Agency should also be consulted.

10.4 Other surface water considerations

10.4.1 Groundwater Source Protection Zones

In addition to the AStGW data the Environment Agency also defines Groundwater Source Protection Zones in the vicinity of groundwater abstraction points. These areas are defined to protect areas of groundwater that are used for potable supply, including public/private potable supply, or for use in the production of commercial food and drinks. The Groundwater SPZ requires attenuated storage of runoff to prevent infiltration and contamination. The definition of each zone is shown below:

- Zone 1 (Inner Protection Zone) – Most sensitive zone: defined as the 50-day travel time from any point below the water table to the source. This zone has a minimum radius of 50 metres
- Zone 2 (Outer Protection Zone) – Also sensitive to contamination: defined by a 400-day travel time from a point below the water table. This zone has a minimum radius around the source, depending on the size of the abstraction
- Zone 3 (Total Catchment) - Defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source. In confined aquifers, the source catchment may be displaced some distance from the source.
- Zone 4 (Zone of special interest) – A fourth zone SPZ4 or 'Zone of Special Interest' usually represents a surface water catchment which drains into the aquifer feeding the groundwater supply (i.e. catchment draining to a disappearing stream).

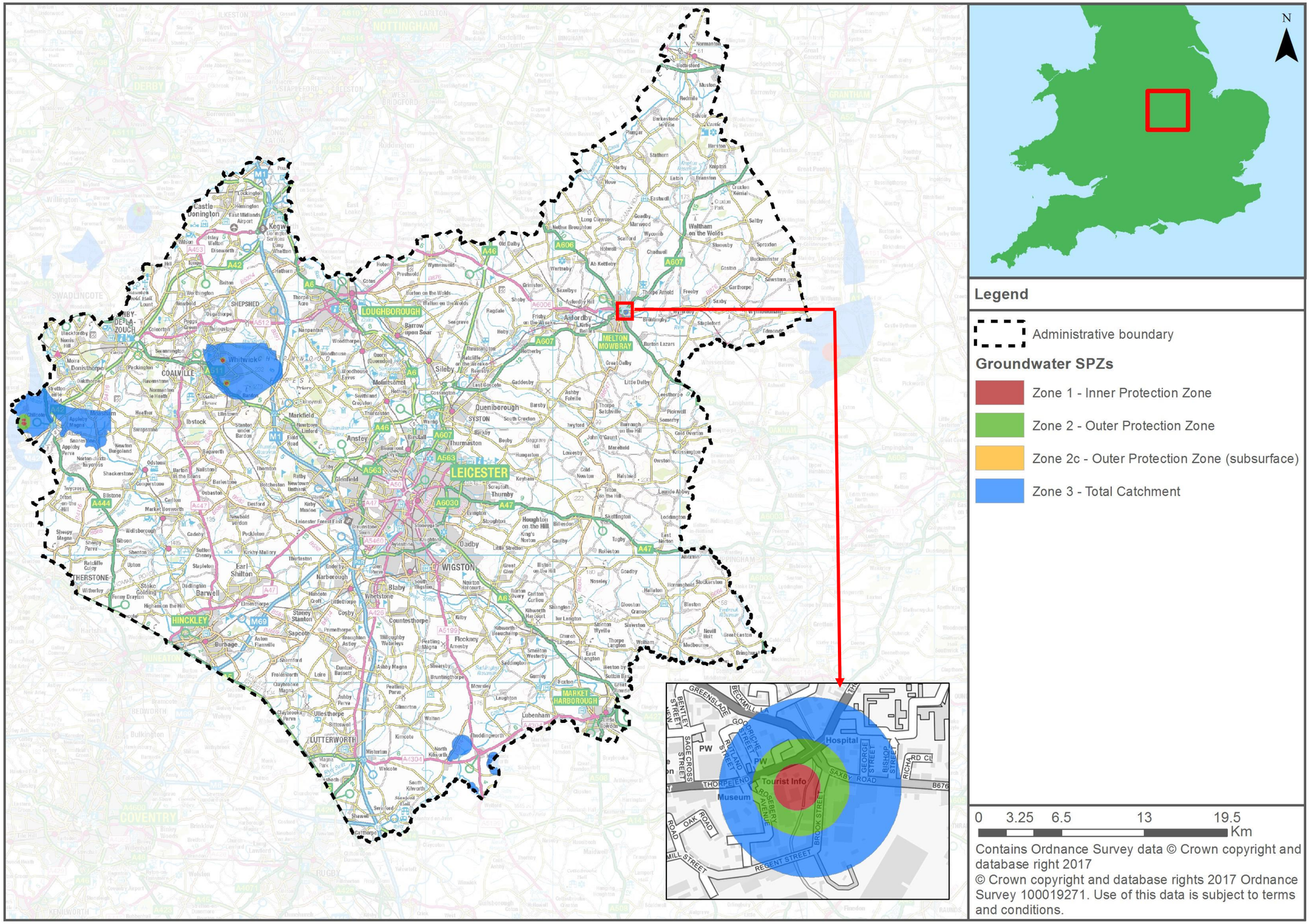
Groundwater SPZs may have implications for the type of SuDS system used depending on which zone the development falls within. For example, infiltration SuDS are generally accepted within Zone 3, whereas in Zones 1 or 3, the Environment Agency will need to be consulted and infiltration SuDS may only be accepted if correct treatments and permits are put in place.

Groundwater SPZs are located in the following areas:

- Eastern area of Melton Mowbray;
- Land to the north-west, south-east and south of Husbands Bosworth in Harborough District;
- The Whitwick and Greenhill areas of Coalville; and
- Land to the south-west of North West Leicestershire District, around Appleby Magna.

The locations of these GPSZs are shown in Figure 10-2.

Figure 10-2: Groundwater Source Protection Zones



10.4.2 Nitrate Vulnerability Zones

Nitrate Vulnerable Zones (NVZs) are areas designated as being at risk from agricultural nitrate pollution. Nitrate levels in waterbodies are affected by surface water runoff from surrounding agricultural land entering receiving waterbodies. The level of nitrate contamination will potentially influence the choice of SuDS and should be assessed as part of the design process.

The existing Nitrate Vulnerability Zones are those zones which apply from 1 January 2013. The whole of the Leicestershire County and Leicester City is classed as a surface water NVZ, with exception of a small areas of land south of Castle Donington, in North West Leicestershire District. In addition, much of North West Leicestershire District and the eastern part of Melton Borough, are classed as a groundwater NVZ.

The proposed (2017 – 2020) Nitrate Vulnerability zones are those which are proposed to apply in 2017. The surface water NVZ and groundwater NVZ extents are broadly consistent with the existing NVZs. In addition, there are Eutrophic NVZ areas, around Markfield in Charnwood Borough and south-east of Lutterworth, towards the southern boundary of Harborough District.

Nitrate Vulnerability Zones in the study area are available to view on the Environment Agency's website: http://apps.environment-agency.gov.uk/wiyby/141443.aspx.

CHAPTER 10
SUMMARY

SuDS provide a means of dealing with the quantity and quality of surface water whilst offering additional benefits over traditional systems of improving amenity and biodiversity.

There are various types of SuDS systems; the design will be influenced by several physical and policy constraints.

Leicestershire County Council and Leicester City Council were made statutory consultees on the management of surface water and, as a result, will be required to provide technical advice on surface water drainage strategies and designs put forward for major development proposals that fall within their respective administrative areas.

CHAPTER 10 RECCOMENDATIONS

Planners should be aware of local requirements set by the Lead Local Flood Authority for surface water management. Wherever possible, sustainable drainage (SuDS) should be promoted. If sites are identified in the proposed growth areas and allocated for development:

- It should be demonstrated through a Surface Water Drainage Strategy or as part of a site-specific Flood Risk Assessment, that the proposed drainage scheme, and site layout and design, will prevent properties from flooding from surface water. A detailed site-specific assessment of SuDS would be needed to incorporate SuDS successfully into the development proposals and where possible, seek to identify betterment. All development should adopt source control SuDS techniques to reduce the risk of frequent low impact flooding due to post-development runoff.
- Developers should submit applications in accordance with the requirements of the DEFRA Non-Statutory Technical Standards for SuDS.
- Where reasonably practical, all drainage proposals should follow the SuDS discharge hierarchy and management train which prioritises infiltration at source first. How proposals follow this hierarchy and management train should clearly be demonstrated, with adequate evidence and reasoning. If necessary, adequate evidence and explanation concerning why infiltration methods are not considered to be feasible and why methods lower down the hierarchy are considered to be feasible, may need to be provided with drainage proposals.
- For proposed developments, it is imperative that a site-specific infiltration test is conducted early on as part of the design of the development, to confirm whether the water table is low enough to allow for SuDS techniques that are designed to encourage infiltration and to confirm the adequacy of infiltration rates.
- Where sites lie within or close to Groundwater Source Protection Zones or aquifers, there may be a requirement for a form of pre-treatment prior to infiltration.
- Consideration must also be given to residual risk and maintenance of sustainable drainage and surface water systems. Developers should produce a maintenance plan for SuDS, stating who will own and who will maintain the proposed SuDS scheme.
- SuDS proposals should contain an adequate number of treatments stages to ensure any pollutants are dealt with on site and do not have a detrimental impact on receiving waterbodies.
- The promotion and adoption of water efficient practices in new development will help to manage water resources and work towards sustainable development and will help to reduce any increase in pressure on existing water and wastewater infrastructure.
- Opportunities for SuDS to link with green infrastructure should be investigated and where appropriate, taken forward.

11 Opportunities to reduce flood risk

11.1 Introduction

Areas identified for strategic growth have the potential to offer opportunities to reduce flood risk across Leicestershire County and Leicester City. With careful planning of site layout and consideration to the wider area, flood risk could be reduced both at the site level and elsewhere within Leicestershire County and Leicester City.

Leicestershire County and Leicester City are covered by a number of different CFMP policy options. In summary, the CFMPs policies indicate that intervention measures will be used across Leicestershire and Leicester City to manage the risk of flooding. Flood risk will either be managed at current levels (now and / or in the future) or reduced (now and / or in the future). CFMPs are discussed further in Section 2.6. It is important that any flood risk solutions are consistent with the wider catchment policy for the area of interest.

It is also important that opportunities to reduce risk in Leicestershire County and Leicester City are consistent with the wider approaches identified in the FRMPs. Appendix C of the Anglian FRMP identifies six actions concerning the River Welland catchment and Leicestershire. Appendix C of the Humber FRMP identifies 20 actions across the Leicester City Principal Urban Area (PUA). FRMPs are discussed further in Section 2.2.3.

The following sections outline different options which could be considered for strategic flood risk solutions in strategic growth areas. Appendix F consider strategic flood risk solutions within the emerging SGP proposed growth areas.

11.2 Flood Storage Schemes

Flood storage schemes aim to reduce the flows passed downriver to mitigate downstream flooding. Development increases the impermeable area within a catchment, creating additional and faster runoff into watercourses. Flood storage schemes aim to detain this additional runoff, releasing it downstream at a slower rate, to avoid any increase in flood depths and/or frequency downstream. Methods to provide these schemes include[11]:

- enlarging the river channel;
- raising the riverbanks; and/or
- constructing flood banks set back from the river.

If strategic growth areas take the form of a strategic urban extension, flood storage schemes in the upper reaches of watercourses that go on to flow through the urban area have the advantage that they will also benefit the urban area downstream, not just the strategic growth site.

Strategic growth areas that fall within the following CFMP policy units would be ideal areas to consider flood storage schemes as the provision of flood storage would be consistent with the CFMP policy applied to these units (Policy 6)

- **River Trent CFMP, Policy Unit 6 (Mid Staffs and Lower Tame)**
- **River Trent CFMP, Policy Unit 8 (Rural Leicestershire)**
- **River Severn CFMP, Policy Unit 7 (Upper Avon)**

11.3 Catchment and floodplain restoration

Compared to flood defences and flood storage, floodplain restoration represents the most sustainable form of strategic flood risk solution. It allows watercourses to return to a more naturalised state, and creates space for naturally functioning floodplains working with natural processes.

Restoring floodplain is difficult in previously developed areas when development cannot be rolled back. However, strategic growth areas provide an opportunity to not only protect existing floodplain but also restore connectivity in areas where it may have been lost. This may be through a number of measures such as

11 http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide/Chapter10.aspx?pagenum=2

- Promoting existing and future brownfield sites that are adjacent to watercourses to naturalise banks as much as possible. Buffer areas around watercourses provide an opportunity to restore parts of the floodplain
- Removal of redundant structures to reconnect the watercourse and the floodplain. There are a number of culverted sections of watercourse located throughout the district which if returned to a more natural state would potentially reduce flood risk to the local area
- Apply the Sequential Approach to avoid new development within currently undefended floodplain

For those sites considered within Strategic Growth Plan that have watercourses flowing through or past them, the sequential approach should be used to locate development away from these watercourses. This will ensure the watercourses retain their connectivity to the floodplain.

11.3.1 Structure Removal and / or modification (e.g. Weirs), de-culverting

Structures, both within watercourses and adjacent to them can have significant impacts upon rivers including alterations to the geomorphology and hydraulics of the channel through water impoundment and altering sediment transfer regimes, which over time can significantly impact the channel profile including bed and bank levels, alterations to flow regime and interruption of biological connectivity, including the passage of fish and invertebrates.

Many artificial in-channel structures (examples include weirs and culverts) are often redundant and / or serve little purpose and opportunities exist to remove them where feasible. The need to do this is heightened by climate change, for which restoring natural river processes, habitats and connectivity are vital adaptation measures. However, it also must be recognised that some artificial structures may have important functions or historical/cultural associations, which need to be considered carefully when planning and designing restoration work.

In the case of weirs, whilst weir removal should be investigated in the first instance, in some cases it may be necessary to modify a weir rather than remove it, for example by lowering the weir crest level or adding a fish pass. This will allow more natural water level variations upstream of the weir and remove a barrier to fish migration.

With careful early planning, watercourses can be made a feature of the site and ownership and maintenance should be considered early. De-culverting of a watercourse, to open it up and make it a feature of the site to allow for flood storage and betterment downstream, should be considered for all sites with culverted watercourses within their boundary.

Further information is provided in the 'Trash and Security Screen Guide 2009'[12], published by the Environment Agency/ Defra, which should be used as evidence for any culvert assessment, improvement or structure retention.

11.3.2 Re-naturalisation

There is potential to re-naturalise a watercourse by re-profiling the channel, removing hard defences, re-connecting the channel with its floodplain and introducing a more natural morphology (particularly in instances where a watercourse has historically been modified through hard bed modification). Detailed assessments and planning would need to be undertaken to gain a greater understanding of the response to any proposed channel modification.

11.3.3 Links with FRMPs

Appendix C of the Humber FRMP identifies 20 actions across the Leicester City Principal Urban Area (PUA). This identified two actions relating to catchment and floodplain restoration:

- Re-naturalisation of watercourses has been identified as a potential option across the Leicester City PUA; and,
- Improve flood flow conveyance in Leicester, by opening up sections of the floodplain and desilting structures to encourage unobstructed flood flow.

12 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/291172/scho1109brhf-e-e.pdf

11.4 Natural flood management

Strategic growth areas provide opportunities to work with natural processes to reduce flood and erosion risk, benefit the natural environment and reduce costs of schemes. Natural flood management (NFM) requires integrated catchment management and involves those who use and shape the land. It also requires partnership working with neighbouring authorities, organisations and water management bodies.

Conventional flood prevention schemes may be preferred, but consideration of 're-wilding' rivers upstream could provide cost efficiencies as well as considering multiple sources of flood risk; for example, reducing peak flows upstream such as through felling trees into streams or building earth banks to capture runoff, could be cheaper and smaller-scale measures than implementing flood walls for example. With flood prevention schemes, consideration needs to be given to the impact that flood prevention has on the WFD status of watercourses. It is important that any potential schemes do not have a negative impact on the ecological and chemical status of waterbodies.

Natural flood management should be considered for strategic growth areas in the upper reaches of watercourses.

The Environment Agency have NFM projects in development for the headwater catchments of the Willow Brook and River Sence. Plans for strategic growth in these areas should consider and consult with the Environment Agency at an early stage to determine whether the development provides the opportunity for an alternative solution than NFM which may also benefit existing development downstream.

Alternatively, if development occurs after the Environment Agency scheme has been implemented, it should be ensured that the development will have no adverse impact on the scheme.

11.5 Green infrastructure

Green Infrastructure (GI) is a planned and managed network of natural environmental components and green spaces that intersperse and connect the urban centres, suburbs and rural fringe and consist of:

- Open spaces – parks, woodland, nature reserves, lakes
- Linkages – River corridors and canals, and pathways, cycle routes and greenways
- Networks of "urban green" – private gardens, street trees, verges and green roofs.

The identification and planning of GI is critical to sustainable growth. It merits forward planning and investment as much as other socio-economic priorities such as health, transport, education and economic development. GI is also central to climate change action and is a recurring theme in planning policy. With regards to flood risk, green spaces can be used to manage storm flows and free up water storage capacity in existing infrastructure to reduce risk of damage to urban property, particularly in city centres and vulnerable urban regeneration areas; the 2012 Leicester City SWMP identified several opportunities for linking and incorporating SuDS and GI. Green infrastructure can also improve accessibility to waterways and improve water quality, supporting regeneration and improving opportunity for leisure, economic activity and biodiversity.

11.5.1 Green infrastructure strategies

A county-wide GI study is on-going and the findings were not available at the time of preparing this SFRA. This sub-section reviews existing GI strategies and studies in the study area.

The 6 'C's Green Infrastructure Strategy (2010)

The 6 'C"s sub-region includes the three cities of Derby, Leicester and Nottingham and the three counties of Derbyshire, Leicestershire and Nottinghamshire. A Green Infrastructure Strategy for the sub-region was published in 2010, with the aim to provide a GI Strategy to *"help inspire stakeholder involvement, and focus action on the ground where it is most needed and would achieve most benefit".*

Volume 1 of the Green Infrastructure Strategy outlines the aims and objectives of the strategy, providing an overview of GI assets. The spatial priorities are sub-regional GI corridors, urban fringe GI enhancement zones and city-scale GI corridors.

Volume 5 of the Green Infrastructure Strategy covers Leicester City and sub-regional areas, extending into Leicestershire County; it includes six key sub-regional corridors that were identified and that reflect significant wildlife habitat corridors/areas that link with strategic GI in surrounding

areas. The sub-regional corridors include: the National Forest and Charnwood Forest, Soar Strategic River Corridor, Wreake Strategic River Corridor, Leighfield Forest, Sence Strategic Corridor and the Grand Union Canal and Welland Strategic River Corridor. The study identified that these have the potential to deliver flood risk mitigation, enhancement of water management and other natural processes e.g. through appropriate land management along the Soar Strategic River Corridor, the Wreake Strategic River Corridor, the Sence Strategic Corridor and Grand Union Canal and the Welland Strategic River Corridor.

Urban fringe GI enhancement zones were identified in Swadlincote, Leicester, Coalville, Hinckley, Loughborough, Market Harborough and Melton Mowbray. A city-scale GI corridor was identified in Leicester and includes key elements of the urban fringe GI enhancement zones. The Leicester City Level 2 SFRA further notes that four main strategic GI assets have been identified in the Leicester City GI corridor including: Soar Strategic River Corridor, Soar Floodplain in Southwest Leicester, North West Leicester Urban Fringe and South East Leicester Urban Fringe.

Charnwood Urban Fringe Green Infrastructure Enhancement Zone and Areas of Local Separation (2016)

One aspect of this 2016 study was to provide evidence to defined boundaries of Urban Fringe Green Infrastructure Enhancement Zones. The assessment focused on defined areas, to review existing weakness and enhancement opportunities. The areas included:

- North East Leicester (Thurmaston/Hamilton/Barkby Thorpe/Syston);
- Watermead Country Park North (Birstall/Thurmaston);
- North West Leicester (Anstey/Cropston/Thurcaston);
- Shepshed/Loughborough; and,
- East Loughborough.

Opportunities to enhance GI were identified in these areas. One enhancement related to flood risk. The study identified that environmental functions of natural features could be enhanced to provide better flood alleviation and gave the example of Melton Brook in the assessment area reference GIEZ-1.

Harborough Open Spaces Strategy 2016 to 2021

This strategy, published in 2016, details how the Council wants to improve and develop open spaces. The strategy acknowledges the role that open space can have in flood risk and states that open spaces should contribute towards reduce flood risk and the effects of climate change. For example, open spaces in urban areas can provide natural drainage systems to reduce flooding. The Open Spaces Strategy aims to help mitigate against flood risk by creating areas for detention of runoff from new development i.e. SuDS.

River Soar and Grand Union Canal Partnership

The River Soar and Grand Union Canal Partnership is made up of representative from public authorities, statutory bodies and charitable and voluntary organisations. The partnership considers how it can promote long term regeneration and suitability of the River Soar and Grand Union Canal corridor. This corridor extents across much of the Leicester City Principal Urban Area, from Birstall and Thurmaston in the north of South Wigston in the south. The 2016 – 2019 Action Plan details this vision. It highlights the River Soar Flood Alleviation Scheme as an example of how improvements to green infrastructure will help to reduce the risk of flooding to approximately 4,700 properties in Leicester. The Partnership will continue to seek opportunities to enhance the river corridor arising from flood management works.

CHAPTER 11
SUMMARY

The Strategic Growth Plan provides opportunities to reduce flood risk across the study area, both at a site level and elsewhere within Leicestershire County and Leicester City. Opportunities include:

- Flood storage schemes – particularly in the upper reaches of watercourses that go on to flow through the urban area
- Catchment and floodplain restoration – protection of existing floodplains and restore connectivity in areas where it may have been lost
- Natural flood management – several on-going and proposed flood alleviation schemes in the study area involve natural flood management techniques
- Other measures - structure removal / modification and re-naturalisation.

Any measures should be consistent with the wider CFMP of interest.

River corridors identified as functional floodplains are an excellent linkage of GI and can provide storage during a flood event.

CHAPTER 11 RECCOMENDATIONS

The commissioning authorities should consider the strategic flood risk solutions proposed in this SFRA and where necessary, consult with other Risk Management Authorities, to identify whether these warrant further investigation and consideration.

There are several opportunities where strategic flood risk solutions can be incorporated into the potential growth areas to provide flood risk betterment to the site and downstream, particularly the creation of upstream storage areas. However, this is not a solution for everywhere. Upstream storage should be investigated fully before being adopted as a solution.

Plans for strategic growth in these areas should consider and consult with the Environment Agency at an early stage to determine whether the development provides the opportunity for an alternative solution than NFM which may also benefit existing development downstream.

For successful flood risk management, it is recommended that the commissioning authorities continue to adopt a catchment partnership working approach in tackling flood risk and environmental management.

Where possible, developers should identify and work with partners to explore all avenues for improving the wider riparian environment.

For those sites considered within Strategic Growth Plan that have watercourses flowing through or past them, the sequential approach should be used to locate development away from these watercourses. This will ensure the watercourses retain their connectivity to the floodplain.

The evidence base provided in this SFRA can be used to help inform the on-going county wide Green Infrastructure study and any GI strategies prepared for the study area. Areas identified within the urban environment or upstream of a critical surface water flood area should be incorporated into authorities' GI strategies. Opening up land to create flow paths or flood storage areas can help protect current and future property. In certain circumstances runoff from green space can cause flooding in developed areas. This should be considered through further detailed work in a Surface Water Management Plan.

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12 Not Available

12.1 Introduction

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13 Summary

13.1 Appraisal of flood risk

- There have been several recorded flood incidents across Leicestershire County and Leicester City, from a combination of sources. Prominent sources of flooding are fluvial, surface water, sewer and flood incidents associated with water infrastructure issues such as culvert blockages or insufficient capacity in the sewer network.
- Much of the fluvial flood risk in the study area is associated with the River Soar and its tributaries, as well as the River Welland, the River Avon and the River Sence. There are also numerous ordinary watercourses that pose a flood risk in the area. Often the combination of watercourses and the interaction of two or more sources of out of bank flow across the floodplain can have profound implications for the extent of the risk.
- Surface water is one of the primary flood risks in the study area. Several urban areas and rural settlements have a well-documented history of surface water flooding and the Risk of Flooding from Surface Water (RoFfSW) mapping shows a number of prominent overland flow routes, following topographical flow paths of existing watercourses or dry valleys and local road infrastructure with some isolated ponding located in low-lying areas.
- The sewers are managed by two Water and Sewerage Companies; Anglian Water and Severn Trent Water. Previous SFRAs note much of the sewer network dates to the Victorian era and the capacity and conditions of sections of the network is unknown.

  Several historic records relate to sewer flooding. However, for areas where there were re-occurring issues maintenance work may have been undertaken and the risk may have been removed or reduced.
- There are very few recorded incidents of groundwater flooding in the study area. A desk-study review of existing assessments and documents has identified six potential groundwater flooding mechanisms in Leicester City and Leicestershire County.
- There are no records of flooding from reservoirs impacting properties inside the study area.
- There are three canals in the study area: Grantham Canal, Grand Union Canal and Ashby Canal. 26 records of a canal overtopping have been recorded across the study area from 1969 to 2013.
- Currently there are 16 Flood Alert Areas and 59 Flood Warning Areas (FWAs) covering the study area.

13.2 Flood defences

- A high-level review of existing flood defences was undertaken and found several communities benefit from flood defences and alleviation schemes in Leicestershire County and Leicester City.
- The Environment Agency's Raised Flood Defences dataset indicates that there are notable differences between the design and current standard of protection and there are locations where defences are considered to be in a poor condition.
- There are also several assets which are considered to significantly affect whether areas will flood in Leicester and there are also other flood risk management initiatives such as property level flood protection schemes and retro-fits SuDS schemes.
- There are several on-going schemes and projects to reduce the risk of flooding in Leicestershire comprising natural flood management initiatives.
- Where areas benefit from defences and alleviation measures, there remains a residual risk, should the defences breach or fail.

13.3 Relevant studies

- There are many relevant regional and local key studies which complement the SFRA and have been considered, such as the Catchment Flood Management Plan, River Basin Management Plan, Preliminary Flood Risk Assessments and Local Flood Risk Management Strategies. Other policy considerations have also been incorporated, such as sustainable development principles, climate change and flood risk management

14 Recommendations

14.1 Development and planning considerations

14.1.1 Identifying potential growth areas and future development

- The sequential approach to development and flood risk should be adopted, directing new development to areas of lowest risk.
- It is recommended that the climate change modelling and mapping in this SFRA is taken into consideration when identifying sites for development in the proposed growth areas.
- The potential growth area summary tables provide an indication on where flood risk may need to be investigated in more detail as part of a site-specific Flood Risk Assessment. This may include areas where:
    - The Environment Agency's Flood Zone maps do not cover the watercourse. Environment Agency mapping of Flood Zones covers watercourses with a catchment area greater than 3km^2 (Rivers and Sea). If a watercourse or drain is shown on OS mapping but is not covered by a Flood Zone, this does not mean there is no potential flood risk.
    - Locations where surface water flooding is the predominant flood risk could be investigated further by use of surface water hydraulic modelling, or in combination with fluvial modelling, to assess the interactions between the two in more detail. Similarly, for any locations which suffer from sewer flooding or sewer capacity issues; this data can be incorporated into hydraulic models to more accurately represent the surface water system.
    - Any developments shown to be at residual flood risk, for example from a breach or overtopping scenario (e.g. reservoir, canal, perched watercourse), may require modelling.

14.1.2 Site-specific Flood Risk Assessments

- The Level 1 SFRA including the potential growth area summary tables are not intended to replace site-specific FRAs. Site-specific FRAs are required by developers to provide a greater level of detail on flood risk and any protection provided by defences and, where necessary, demonstrate the development passes the Exception Test.
- Developers should consult with the relevant LPA, Lead Local Flood Authority and the Environment Agency (where relevant), at an early stage to discuss flood risk including requirements for site-specific FRAs, detailed hydraulic modelling, and drainage assessment and design. For example, there are watercourses where it was not possible to model the impacts of climate change (i.e. the River Welland) and developers may need to further investigate the flood risk as part of a site-specific FRA. Appendix H provides a list of all detailed hydraulic models used in this SFRA.
- New development and re-development of land should wherever possible seek opportunities to reduce overall level of flood risk at the site.

14.1.3 Surface water management and SuDS

- Planners should be aware of local requirements set by the Lead Local Flood Authorities for surface water management for major and minor developments and ensure development proposals and applications are compliant with the LLFAs policy and specific requirements. Where necessary, consultations should be undertaken with the relevant LLFA to confirm the specific requirements in relation to post-development, surface water runoff management on-site.
- Developers should submit applications in accordance with the requirements of the DEFRA Non-Statutory Technical Standards for SuDS and in line with CIRIA C753 the SuDS Manual.
- Where reasonably practical, all drainage proposals should follow the SuDS discharge hierarchy and management train which prioritises infiltration at source first. How proposals follow this hierarchy and management train should clearly be demonstrated, with adequate evidence and reasoning. If necessary, adequate evidence and explanation concerning why

infiltration methods are not considered to be feasible and why methods lower down the hierarchy are considered to be feasible, may need to be provided with drainage proposals.

- All new development should aim to minimise areas of impermeable ground to reduce surface water runoff and sustainable drainage systems (SuDS) should be used on all new development, unless it is proved unfeasible. SuDS which provide multiple benefits should be maximised.
- It should be demonstrated through a Surface Water Drainage Strategy or as part of a site-specific Flood Risk Assessment, that the proposed drainage scheme, and site layout and design, will prevent properties from flooding from surface water. A detailed site-specific assessment of SuDS would be needed to incorporate SuDS successfully into the development proposals and where possible, seek to identify betterment. All development should adopt source control SuDS techniques to reduce the risk of frequent low impact flooding due to post-development runoff.
- For proposed developments, it is imperative that a site-specific infiltration test is conducted early on as part of the design of the development, to confirm whether the water table is low enough to allow for SuDS techniques that are designed to encourage infiltration and to confirm the adequacy of infiltration rates.
- Where sites lie within or close to Groundwater Source Protection Zones or aquifers, there may be a requirement for a form of pre-treatment prior to infiltration. Further guidance can be found in the CIRIA SuDS manual on the level of water quality treatment required for drainage via infiltration.
- Consideration must also be given to residual risk and maintenance of sustainable drainage and surface water systems. Developers should produce a maintenance plan for SuDS, stating who will own and who will maintain the proposed SuDS scheme.
- SuDS proposals should contain an adequate number of treatments stages to ensure any pollutants are dealt with on site and do not have a detrimental impact on receiving waterbodies.
- The promotion and adoption of water efficient practices in new development will help to manage water resources and work towards sustainable development and will help to reduce any increase in pressure on existing water and wastewater infrastructure.
- Opportunities for SuDS to link with green infrastructure should be investigated and where appropriate, taken forward.

14.1.4 Infrastructure and safe access

Safe access and egress at sites will need to be demonstrated by the developer; the development should be higher than the 1 in 100-year (1% AEP) flood level, plus an allowance for climate change, and emergency vehicular access should be possible during times of flood. Finished Floor Levels should be above the 1 in 100-year (1% AEP) flood level, plus an allowance for climate change and an appropriate allowance for freeboard. The additional height that the floor level is raised above the maximum water level is referred to as the "freeboard".

Safe access and egress should also be considered when appraising the residual risk posed by surface water drainage schemes. For example, if the highway forms part of the route of exceedance for surface water drainage, this should be considered in the assessment of safe access and egress.

14.1.5 Residual risk

Any developments located within an area protected by flood defences, where the condition of those defences is 'fair' or 'poor', or where the standard of protection is not of the required standard should be identified.

Development located in an area benefiting from defences and / or located behind a defence will require breach and overtopping analysis to be undertaken as part of a site-specific FRA.

Resistance and resilience measures will be required if buildings are situated in the flood risk area. Such measures may include raising electrics and plug sockets and tiling the ground floor. An emergency flood plan may need to be prepared to help manage the residual risk of flooding. As applicable in all cases of flood risk, opportunities to enhance green infrastructure and reduce flood risk by making space for water should be sought.

14.1.6 Cumulative impact and land use change considerations

- The cumulative impact of development and the effect of land use change should be considered at the planning application and development design stages. Appropriate mitigation measures should be identified and informed by an appropriate FRA, to ensure flood risk is not exacerbated, and in many cases the development should be used to improve the flood risk. The application of SuDS should be used to help mitigate the impact of development and prevent increases in flood risk to third party lands.
- Onsite attenuation schemes would need to be tested against the hydrographs of the unnamed drain to ensure flows are not exacerbated downstream within the catchment.
- Maintenance and upkeep of SuDS have been neglected in the past because of lack of clarity over where responsibility for it lies. Therefore, is it important that maintenance and upkeep for mitigation measures, such as SuDS, has been set out as part of a drainage strategy and that management funding for the lifetime of the development has been agreed

14.2 Future flood management in Leicester City and Leicestershire County

14.2.1 Green Infrastructure and WFD

Developments should demonstrate opportunities to create, enhance and link green assets. This can provide multiple benefits across several disciplines including flood risk and biodiversity/ ecology and may provide opportunities to use the land for an amenity and recreational purposes. Development that may adversely affect green infrastructure assets should not be permitted.

14.2.2 Strategic flood risk solutions

The information provided in the SFRA should be used as a basis for investigating potential strategic flood risk solutions within Leicestershire County and Leicester City. Opportunities could consist of the following:

- Floodplain restoration
- Upstream storage schemes
- Opening up culverts, weir removal, and river restoration.

Plans for strategic growth in areas earmarked by the Environment Agency for NFM should consider and consult with the Environment Agency at an early stage to determine whether the development provides the opportunity for an alternative solution than NFM which may also benefit existing development downstream.

Where possible, developers should identify and work with partners to explore all avenues for improving the wider riparian environment.

14.2.3 Cross-boundary partnership working

The SGP is an excellent example of cross-boundary partnership working amongst local authorities in Leicestershire County and Leicester City. For successful future flood risk management, it is recommended that local planning authorities adopt a catchment partnership working approach in tackling flood risk and environmental management. It is also recommended that local planning authorities continue to work with their partners and other risk management authorities to strengthen the direction of future flood risk management and flood risk solutions.

14.3 Use of Strategic Flood Risk Assessment data

The Strategic Flood Risk Assessment has been developed using the best available information, supplied at the time of preparation. This relates both to the current risk of flooding from rivers, and the potential impacts of future climate change.

This SFRA is a high level strategic document. The datasets used to inform this SFRA may periodically be updated and following the publication of this SFRA, new information on flood risk may be provided by Risk Management Authorities.

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Appendices

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A Mapping of all sources of flood risk

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B Historic flood records in Leicestershire County and Leicester City

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C Watercourses in Leicestershire County and Leicester City

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D Flood Defences

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E Flood Warning and Flood Alert Coverage

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F Not Available

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G Sequential and Exception Test flow charts

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H Technical summary

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I Land use change indicative hydrographs

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