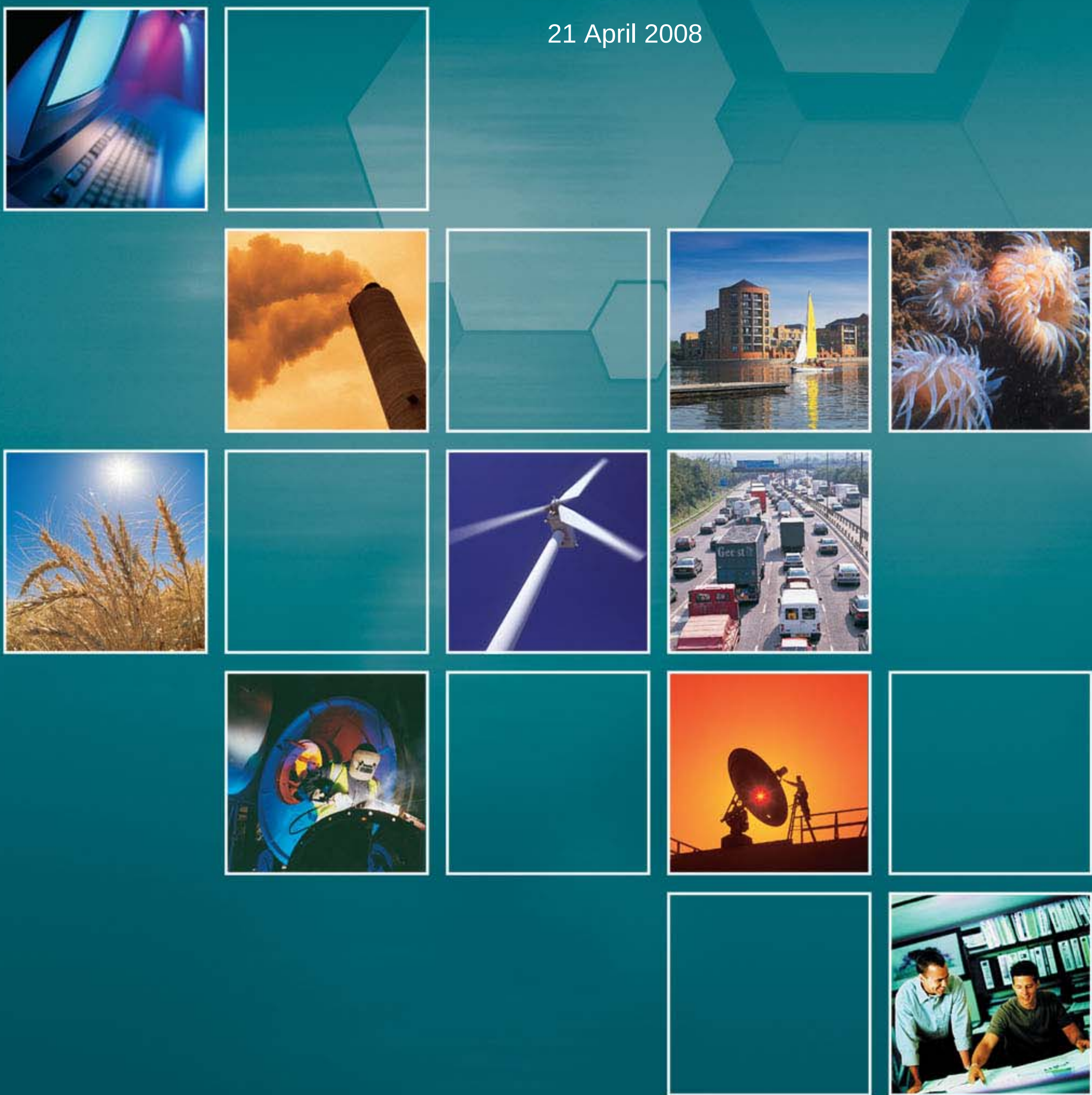
Charnwood Borough Council

Charnwood Strategic Flood Risk Assessment

Final Report

21 April 2008



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Report for

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Executive Summary

Purpose of this Report

Charnwood Borough Council is currently in the process of developing its Local Development Framework (LDF) with a view to planning for their future development needs. This process is driven by the Regional Plan which will specify future development needs over the next 20 years. This presents an opportunity to plan for sustainable development that is located and designed to reduce flood risk.

The Strategic Flood Risk Assessment (SFRA) is intended to inform the LDF and Sustainability Appraisal (SA) with respect to local flood risk issues and the location of future development in the Borough. In line with the general approach of all SFRAs, a sequential, risk-based approach to assessing development and flood risk has been taken for the borough. This is in line with the guidance outlined in Planning Policy Statement 25 (PPS25) *"Development and Flood Risk"* (and its predecessor Planning Policy Guidance 25) and the new PPS25 Practice Guide. The Environment Agency has been represented on the steering group for this project and has commented at every stage of the SFRA's preparation.

During the project the SFRA was extended to include a consideration of Leicestershire County Council's Minerals and Waste Development Frameworks and in particular flood risk issues associated with potential waste and minerals sites located in Charnwood, which are being considered by the County Council.

SFRA Process

In line with the general approach of all SFRAs, a sequential, risk-based approach to assessing development and flood risk was undertaken, in accordance with the guidance outlined in PPS25 *Development and Flood Risk*. The PPS25 Sequential Test has been applied using a tiered approach to assess all potential sources of flood risk based on a range of both local and broad-scale information relating to flood risk.

The overriding aim of the PPS25 Sequential Test is to manage flood risk by ensuring that all new development is located in areas of lowest flood risk. Where this is not possible and there is appropriate justification, PPS25 aims to ensure there are sufficient mitigations to prevent an unacceptable increase in flood risk to people and property. It is primarily based on the Environment Agency flood zones, which delineate areas by their level of risk due to river flooding. Based on the Borough's future development needs and the potential locations for future development identified, it was found that there was sufficient land in Zone 1 (i.e. areas with a low probability of flooding) to preclude the need to place new greenfield development in any of the higher risk flood zones. Secondary sources of flooding were also considered (including fluvial risk due to minor watercourses, groundwater, overland flow, structural blockages and sewer flooding) to refine the prioritisation of sites with the least risk of flooding. Guidance for the Council's planners on the application of the Sequential and Exception Tests has been produced in relation to the flood risk to people and property within Charnwood.

It is important to note that the SFRA does not undertake the Sequential Test. The SFRA's role is to inform the council's planners and enable them to undertake the Sequential Test as part of the LDF process. A SFRA identifies, and where possible, quantifies flood risk to provide a local authority specific flood-risk evidence base. This should be used by planners to, as far as practicable, avoid placing new development in areas of flood risk and in seeking solutions that reduce flood risk to existing development.

Underlying Assumptions

The prioritisation of sites as part of this SFRA does not remove the need for a more detailed assessment (in the form of a Flood Risk Assessment) for sites selected for future development. This includes a need to consider all mechanisms of flooding as flood risk is never eliminated completely. The sites identified for prioritisation are merely considered to have the lowest risk of the areas of search, not zero risk.

It is recognised that the final selection of sites for future development will depend on a range of planning pressures. As with all new development, the guidance in PPS25 will help to determine whether development may be permitted, including a requirement to satisfy the criteria of a Flood Risk Assessment.

Conclusions and Recommendations

Due to its situation adjacent to the confluences of the River Soar with its tributaries the River Wreake, Rothley Brook and Black Brook a large swathe of Charnwood is potentially at risk from fluvial flooding. The source of these watercourses is located outside of Charnwood; as such the management of runoff from development in these upstream districts could potentially have significant impacts within Charnwood. The close association of historical development with flat land adjacent to rivers which provided water, transport and energy has in places left a legacy of development at risk of flooding.

The Charnwood SFRA is designed to accompany the Charnwood LDF and the Mineral and Waste Development Frameworks and ensure that future development is planned and designed in a way that avoids future increases in flood risk, and where possible contributes to a reduction in the degree of existing flood risk. As such the SFRA has delineated the functional floodplain (Flood Zone 3b - 5% or greater probability of flooding in a given year), supplemented the existing Flood zone 3a outline with additional information, and assessed the potential changes in flood depths and extents due to a 20% increase in peak flows (climate change) scenario.

Hydraulic modelling carried out in support of the Charnwood SFRA has shown that Flood Zone 3b (the functional floodplain) for the River Soar and River Wreake is almost as spatially extensive as the Flood Zone 3a. The extent of the SFRA Flood Zone 3a although indicating some additional areas potentially at risk, shows no great divergence from the EA Flood Zone 3. Investigation of the impacts of a 20% increase in flows scenario, has indicated that watercourses in the borough primarily respond in terms of a depth increase, rather than in an increased extent of Flood Zone 3a. This occurs due to local topography; since relatively steep sides to the floodplain allow depth to increase without the overall floodplain extent increasing. Depth increases due to a 20% increase in peak flows are particularly notable upstream of structures which constrict the channel, on all the main rivers, but especially on the Rothley Brook. If any future development is (after passing the Sequential and Exception Test) to occur in Flood Zone 3a changes in flood depth must be adequately considered. Increasing flood depths will also mean that present development particularly in areas of highest risk, will become at increased risk of flooding, necessitating either new flood defences or property specific flood proofing.

Detailed figures illustrating flood risk across the borough are included in the report, after Sections 4 and 5. Table 4.3 provides a short introduction to each figure and states which figures should be used by Development Control in determining if a FRA is required and the level of detail.

This SFRA has been developed specifically for Charnwood Borough to assess flood risk in the Borough, and specifically to the potential areas of development in accordance with PPS25. These areas have been prioritised according to their flood risk. The level of assessed flood risk to each site should be used by the council's planners to undertake the Sequential Test when allocating future development and to form the basis for requesting detailed Flood Risk Assessments.

In terms of future development the broad areas where future Sustainable Urban Extensions (SUEs) may be located in Charnwood are located in Flood Zone 1 (less than 0.1% probability of flooding from fluvial sources). Ensuring that new development is set back from the limited areas of Flood Zone 3a and 2 alongside rivers which pass through and adjacent to these development areas will ensure direct flood risk to new development is minimised. For these SUEs the key issues are ensuring that surface water runoff is properly managed and that providing transport links for new development.

The large scale of future development would, if not properly managed, produce an unacceptable increase in flood risk. Defra's current Integrated Urban Drainage (IUD) pilots have shown the value of taking a holistic approach to the management of surface water from development. It is therefore recommended that a Surface Water Management Plan (SWMP) should be produced for each SUE (section 8.7.2), ensuring that drainage is considered strategically during site masterplanning, followed by more specific design as segments are brought forward for development. Surface water runoff from new developments should be adequately managed through the use of Sustainable Drainage Systems (SuDS). These systems should be designed to ensure that the rates and volumes of runoff are kept at greenfield levels and will prevent increases in the flood risk to existing development downstream. In this way, SuDS mimic the natural drainage pattern and help to ensure that the hydrological cycle is not altered.

If progressed, after passing through the Sequential Test, proposals for improved transport links to development east of Loughborough need to satisfy the Exception Test and be designed carefully to ensure that they a) remain operational during flooding and b) do not increase the flood risk to others, such as by causing upstream afflux and thus changing flood depths or redirecting flood flow paths.

Within Charnwood, particularly in Loughborough several brownfield sites exist which are located in areas of significant flood risk. The Sequential Test and Exception Test processes must be used to ensure that, when proposed, the redevelopment of these sites is appropriate. Whilst redevelopment may be desirable on regeneration and sustainability grounds, these sites have significant flood risk issues and it will be necessary for the council, the developer and the Environment Agency to work closely in order to develop a suitable development scheme which successfully addresses flood risk. Practical solutions may not be available for all sites, and it may be necessary to sacrifice some sites to allow the redevelopment of others.

The SFRA should be treated as a living document with provision made for regularly updating the SFRA particularly where new information and guidance on flood risk and climate change becomes available. Significant amounts of information were collated in the preparation of the Charnwood SFRA. These sources of information were instrumental in informing the assessment of flood risks, particularly with respect to sources of flooding that are not managed by the Environment Agency. It is highly recommended that this information relating to actual flood events is expanded and updated as new information arises, to build and maximise the knowledge of flood risk issues local to Charnwood Borough.

Whilst the SFRA has been commissioned to support the LDF and Minerals and waste Development Frameworks process, the SFRA should also be able to a) aid the council in identifying potential strategic flood risk solutions, b) support the development control process by providing a compiled source of flood risk information and c) support the councils' emergency planning for flood incidents. For development control, a set of guidance notes for developers is recommended to complement the findings of the Charnwood SFRA, in addition an example Supplementary Planning Document is provided in Section 7. It is important to reinforce the message that detailed Flood Risk Assessments are still essential for specific sites selected for development.

Contents

Glossary

Design Flood Event	Flood event that has a given probability of occurrence and is used to design flood defences or alleviation schemes, or produce flood risk maps.
Exception Test	The PPS25 Exception Test is the process by which departures from the Sequential Test (see entry below) may be justified where it is necessary to meet the wider aims of sustainable development[1].
Flood Defence	Man made structure - embankment, bund, sluice gate, reservoir, barrier - designed to prevent flooding of areas adjacent to the defence.
Flood Resilience	Measures which ensure that a property situated on the floodplain is not damaged during a flood event. They are mainly related to preventing floodwater from entering the property or ensuring that if water was to enter the property, no damage would be caused. In broader terms, Flood Resilience is the ability of a community/society to withstand the impacts of flooding.
Flood Resistance	Measures which reduce the amount of water entering a building during a flood. It is important to note that these measures are fallible as they may involve the insertion of protective barriers (in doorways) by occupiers; water pressure also limits the flood-depth in which they can be applied.
Floodplain	Flat, low lying topographic area adjacent to rivers, the coast and estuaries liable to flooding.
Hydraulic	Related to the flow of water.
Inundation	Overflowing of water onto land that is normally dry. In the case of Charnwood, causes of inundation could include (but not necessarily be limited to) rivers, groundwater, overland flow, culvert blockages, structural failures, and sewer flooding.
Local Development	The Local Development Framework (LDF) is at the heart of the new planning system introduced by the Planning and Compulsory Purchase Act 2004[2]. The LDF

[1] *PPS25 Development and Flood Risk*, Communities and Local Government, December 2006.

[2] *PPS 12 Local Development Frameworks*, Office of the Deputy Prime Minister, 2004.

Framework — will comprise Local Development Documents (LDDs), including the Development Plan Documents (DPDs) (statutory planning documents) and Supplementary Planning Documents which expand on policies or provide greater detail. The Development Plan Documents may include a Core Strategy, site specific allocations and an adopted proposals map.

Planning Obligations — Planning Obligations (or s106 agreements) are private agreements negotiated as part of planning applications between local planning authorities and developers which are intended to make acceptable development that would otherwise be unacceptable in planning terms[3].

Planning Policy Guidance and Statements for England — Planning Policy Guidance Notes (PPGs) and their replacements Planning Policy Statements (PPSs) are prepared by the government after public consultation to explain statutory provisions and provide guidance to local authorities and others on planning policy and the operation of the planning system.They also explain the relationship between planning policies and other policies which have an important bearing on issues of development and land use.Local authorities must take their contents into account in preparing their development plans. The guidance may also be relevant to decisions on individual planning applications and appeals.

Residual Risk — Flood risk associated with areas afforded protection from flood defences or alleviation schemes. The residual risk is the remaining risk of flooding due to exceedence of the design flood event (see entry above) or the failure of the scheme itself (structural or operational).

Regional Spatial Strategy — Following the enactment of the Planning and Compulsory Purchase Act 2004, Regional Planning Guidance (RPG) has become part of the statutory development plan and has been re-named as a Regional Spatial Strategy (RSS). It covers the scale and distribution of new housing, priorities for the environment, transport, infrastructure, economic development, agriculture, minerals extraction, waste treatment and disposal.

Sequential Test — The PPS25 Sequential Test refers to the process of determining the suitability of land for development in flood risk areas, central to the PPS25 guidance, and to be applied to all levels of the planning process[4].

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[3] *Draft Revised Circular on Planning Obligations (Consultation Document)*, Office of the Deputy Prime Minister, November 2004

[4] *PPS25 Development and Flood Risk*, Communities and Local Government, December 2006

Supplementary Planning Document	Supplementary Planning Documents expand policies set out in a development plan document or provide additional detail on both thematic and site specific matters. They are not subject to independent examination and therefore do not form part of the statutory development plan, nor are they used to allocate land.
UK Climate Impacts Programme 02 Scenarios	UK climate change scenarios are often used to assess the potential impact of climate change in the UK based on different global emission scenarios. Four UKCIP02 scenarios have been derived from climate model runs at the Hadley Centre and are described in detail in the UKCIP02 Scientific Report. Each of the climate scenarios is based on a different global emissions scenario that was developed for the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios.

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Abbreviations

ABI	Association of British Insurers
AOD	Above Ordnance Datum
BW	British Waterways
CBC	Charnwood Borough Council
CFMP	Catchment Flood Management Plan
CIRIA	Construction Industry Research and Information Association
CLG	Communities and Local Government
CSO	Combined Sewer Overflow
DEFRA	Department for the Environment, Food and Rural Affairs
DPD	Development Plan Documents
DTM	Digital Terrain Model
EA	Environment Agency
ESS	Environmental Stewardship Scheme
FEH	Flood Estimation Handbook
FRA	Flood Risk Assessment
GIS	Geographical Information System
IDB	Internal Drainage Board
ISIS	1D hydraulic modelling software, used in flood modelling.
JFLOW	JFLOW (2D basic flood modelling software package)
LDD	Local Development Document

LDF	Local Development Framework
LDS	Local Development Scheme
LPA	Local Planning Authority
NAIDB	Newark Area Internal Drainage Board
ODPM	Office of the Deputy Prime Minister
OW	Ordinary Watercourses
PAG 2	Project Appraisal Guidance 2
PPG	Planning Policy Guidance
PPS	Planning Policy Statement
RFRA	Regional Flood Risk Assessment
RPB	Regional Planning Bodies
RSS	Regional Spatial Strategy
SFRA	Strategic Flood Risk Assessment
STW	Severn Trent Water
SuDS	Sustainable Drainage Systems
UKCIP	United Kingdom Climate Impact Programme

1. Introduction

1.1 Background

Future development needs in Charnwood Borough have been broadly outlined in the East Midlands Regional Plan, and Charnwood Borough Council is now considering these needs at a local level in the emerging Charnwood Local Development Framework (LDF). The LDF presents an opportunity to plan sustainable development that is located and designed to reduce flood risk. The importance of flood risk and its implications for development in the locality is supported by a history of significant flood events in the Borough which has caused properties in the River Soar catchment to be inundated, most recently in the Loughborough area in 1998. Flooding has also been associated with smaller watercourses in the Borough such as the Barkby Brook in Syston and the Sileby Brook, Sileby.

1.2 Scope and Objectives

Charnwood Borough Council appointed Entec in March 2007 to undertake a Strategic Flood Risk Assessment (SFRA) of the Borough to inform the LDF and Mineral and Waste Development Frameworks. The primary goal of the SFRA is to assess the flood risk of potential areas of development in order to inform the application, by the council's planners, of the sequential test outlined in Planning Policy Statement 25 (PPS25) Development and Flood Risk. The SFRA is also intended to provide those involved in the planning and control of development in the Borough with a better understanding of flood risk issues throughout the Borough. This SFRA was produced in close liaison with Environment Agency staff, who were consulted throughout the SFRA process.

1.3 Structure of the Report

This report comprises the following sections:

- Section 1 describes the background, scope and objectives of the Charnwood SFRA;
- Section 2 summarises the planning context for development and management of flood risk in Charnwood Borough which is a key driver of the SFRA;
- Section 3 outlines the general approach of SFRAs and how this has been applied in Charnwood Borough;
- Section 4 provides an overview of flood risk in the Borough including potential sources of flood risk, historical flood events and flood alleviation schemes, and the potential impacts of residual risk, climate change and uncertainty on the SFRA;
- Section 5 assesses the flood risk to potential areas of development to guide development prioritisation. It should be used by the Council's planners in the application of the PPS25 Sequential Test;

- Section 6 discusses aspects of flood risk in the Borough relevant to Leicestershire County Councils' Minerals and Waste Development Frameworks;

- Section 7 outlines flood risk mitigation measures to control flood risk whilst allowing development in the Borough;

- Section 8 concludes the SFRA and provides recommendations for the application of the SFRA findings in the LDF as well as the Development Control process;

- Section 9 lists references.

2. The Planning Framework

2.1 Introduction

This SFRA has been undertaken to assess flood risks throughout Charnwood Borough, and in particular the flood risks associated with areas being considered for future development as part of the emerging Local Development Framework. In addition, there are higher level documents which have to be taken into account including the East Midlands Regional Spatial Strategy, and the Leicestershire, Leicester and Rutland Structure Plan, together with national planning legislation and policy guidance.

The planning process is driven by legislation and guidance developed at a national, regional and local level, with flood risk being only one of many aspects to consider when making decisions relating to land use. The aim of the SFRA is to provide the necessary information on flood risk to enable the PPS25 sequential test to be carried out and thereby provide a robust basis for steering future, sustainable development through the planning process.

The planning background to the SFRA is discussed in more detail in Appendix A. The key outcomes affecting potential future development in Charnwood are outlined in Section 2.2.

2.2 Potential Development and Flood Risk in Charnwood

Most new development is expected to take place on brownfield sites in urban areas and in sustainable urban extensions (SUEs) adjacent to the Principle Urban Area of Leicester and the Sub-Regional Centre of Loughborough/Shepshed, in accordance with the emerging Regional Plan's urban concentration policy.

Potential development locations at Loughborough include:

- Within Loughborough Town Centre;
- West of Shepshed;
- West of Loughborough;
- South of Loughborough;
- East of Loughborough (east of the River Soar);
- North of Loughborough towards Hathern; and
- Wymeswold Airfield.

Major investment in a new distributor road would be required to support any large new development east of Loughborough (East of Loughborough or Wymeswold Airfield SUEs) and allow improvements to Loughborough Town Centre;

Potential development locations adjacent to the Leicester PUA are as follows:

- East of Thurmaston and North of Hamilton;
- North of Birstall; and
- Adjacent to Glenfield within Charnwood south of Anstey.

Future development may also occur at:

- Other sites identified in the Housing Land Availability Assessment throughout the Borough; and
- Loughborough Science Park (New Ashby Road).

Other important considerations are

- a preference to redevelop brownfield sites over greenfield land where possible, and
- the proposal for a Loughborough Town Centre inner relief road and new access and support roads for the above developments.
- Figure 2.1 shows the broad areas under investigation for locating future major development.
- Development of several sites within the Borough for Minerals and Waste use is proposed by Leicestershire County Council (discussed in Section 6);

2.3 Conclusions

In accommodating future development in Charnwood Borough, there is a range of planning policies to consider and balance on a national, regional and local level. Future development needs will be specified in the Regional Plan and will be refined on a local level in the emerging LDF.

PPS25 provides the overarching national guidance with respect to development and flood risk, emphasising the need to effectively manage flood risk within the planning system, rather than relying on reactive solutions to flooding. This includes a responsibility for LPAs to reduce flood risk to people and property as a result of new development. It also identifies the preparation of SFRAs as a key process in the understanding and management of flood risk for planning purposes.

Within Charnwood managing flood risk poses significant issues in terms of accommodating new development, managing runoff from the proposed SUEs, the routing of supporting distributor roads, and the potential redevelopment of brownfield and windfall sites located in areas of flood risk. Charnwood Borough Council will have to weigh up flood risk against other constraints, when deciding on preferred development options to facilitate the socio-economic needs of a community.

In some cases it will not be possible to avoid flood risk areas for new development. In these cases e.g. the redevelopment of brownfield and windfall sites located in areas of high flood risk, the development will need to be fully justified through the Sequential and Exception Tests. The Exception Test includes a requirement to demonstrate adequate mitigation of flood risk to allow for the new development. In other cases alternative land-uses and development options such as the relocation of existing development may have to be considered.

3. Strategic Flood Risk Assessments

3.1 Background

Historically, the management of flood risk in the UK has been undertaken in a somewhat reactive manner, addressing problems on an ‘as needed’ basis in response to a flooding event. It was recognised by Government that, in general, this was not a particularly cost effective approach and often failed to consider individual problem areas within the ‘bigger picture’ of the wider hydrological system.

The Environment Agency has therefore committed to a rolling programme of flood risk assessment (mapping) and strategic flood risk management investigations, including Catchment Flood Management Plans (CFMPs) and PAG2 Flood Risk Management Strategies[5] within fluvial (river) systems. These studies take a catchment-wide approach, identifying where flooding is known and/or perceived to be an existing problem, how this flooding regime may alter in future years as a result of climate and land use change, and how flooding can be managed cost effectively and sustainably over the next 50 to 100 years.

On a local planning level, SFRAs consider the flood risk within the local area and, when used by LPAs such as Charnwood to inform the PPS25 Sequential Test and Exception Test, allow development to be allocated preferentially to the areas of lowest flood risk. Advice given within the SFRA should fit within the broader catchment scale recommendations of the CFMP and be consistent with CFMP objectives and policies. More detailed Flood Risk Assessments (FRAs) are required for individual sites when and if they are developed.

3.2 General Approach

3.2.1 Introduction

The SFRA is a planning tool. It is an assessment of flood risk to inform the spatial planning process, and therefore the degree of detail and accuracy should be commensurate with this objective.

A pragmatic and risk-based approach is recommended. The assessment of flood risk within a Borough should be targeted to those areas where development pressure is proposed within current planning horizons. Furthermore, the accuracy sought with respect to the delineation of flood risk should be sufficient to ensure confidence in the findings and recommendations of the SFRA, and it should also be reasonable within the context of the intended end use of the document to inform the allocation of sites within the LDF.

[5] *FCDPAG2 Strategic Planning and Appraisal*, part of the series *Flood and Coastal Defence Project Appraisal Guidance*, DEFRA, April 2001.

The LPA, supported by advice from the Environment Agency, must ensure flood risk is managed appropriately and effectively during the planning process. To facilitate this, and to inform the planning process, the CLG expects LPAs to undertake a sequential flood risk test when planning development as outlined in PPS25. Paragraph 14 of PPS25 states that:

> *"A sequential risk-based approach to determining the suitability of land for development in flood risk areas is central to the policy statement and should be applied at all levels of the planning process."*

3.2.2 The PPS25 Sequential Test and Exception Test

PPS25 sets out a robust approach to the Sequential Test which the SFRA should inform in order to ensure that the test is applied against a thorough understanding of local flood risk. It is based on Environment Agency flood zones, which delineate areas by their level of risk due to river and sea flooding. Table 3.1 summarises these zones.

Table 3.1 PPS25 Flood Risk Zones

Flood Zone	Criteria	Appropriate Land Use Vulnerability [1]
Zone 1 Low Probability	Land with a < 0.1% chance of river and sea flooding in any year.	All land uses
Zone 2 Medium Probability	Land with between a 1% and 0.1% chance of river flooding or between a 0.5% and 0.1% chance of sea flooding in any year.	Water compatible, less vulnerable and more vulnerable land uses Highly vulnerable land uses **only** if the Exception Test is passed
Zone 3a High Probability	Land with a > 1% chance of river flooding or a > 0.5% chance of sea flooding in any year.	Water compatible and less vulnerable land uses More vulnerable land uses and essential infrastructure **only** if the Exception Test is passed **No** highly vulnerable land uses
Zone 3b Functional Floodplain	Land where water has to flow or be stored in times of flood. Either land with a > 5% chance of flooding in a given year, land that is designed to flood in an extreme flood and water conveyance routes.	Water compatible land use Essential infrastructure **only** if it must be in this location and the Exception Test is passed **No** less vulnerable, more vulnerable or highly vulnerable land uses

[1] See Appendix B for land use vulnerability classification.

The overriding aim of the Sequential Test is to steer all new development to the lowest flood risk zone (i.e. Zone 1). Where it is not possible to locate development in Zone 1, development may be considered in Zone 2 and then Zone 3a if there is no available alternative in a lower risk zone. The Sequential Test constrains such development based on the vulnerability of the proposed land use, with the more vulnerable land uses restricted to zones of lower risk. Table 3.1 indicates the appropriate land use vulnerabilities for each zone. Appendix B (of this report) lists land uses according to the vulnerability classification used in the Sequential Test.

Depending on the land use vulnerability, there may be a further requirement to satisfy the Exception Test outlined in PPS25 prior to development in these higher risk zones (as indicated in Table 3.1), paragraph D9 states that "For the Exception Test to be passed:

a) *it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by an SFRA where one has been prepared.*

b) *the development should be on developable previously-developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously-developed land;*

c) *A flood risk assessment must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall*

The Exception Test should only be applied after the Sequential Test has been used to demonstrate that no sites with a lower flood risk are available. Both tests should be applied as early in the Planning Process as possible, and should not be used simply as a tool to retrospectively justify 'highly vulnerable development' in PPS25 Zone 2, or 'less vulnerable'; 'more vulnerable'; and 'highly vulnerable' in PPS25 Zone 3a.

Where development is planned in the higher risk zones, flood management and mitigation measures will likely be required to reduce risks to an acceptable level. Types of measures could range from traditional flood defences and flood alleviation schemes, to flood resistant and resilient design, and emergency plans. Where either existing or proposed measures are in place, the Sequential Test requires a demonstration that the residual flood risk (i.e. after taking the management and mitigation measures into account) is acceptable. In addition, the potential for climate change to impact on flood risk must also be considered.

Development in all zones, both low and high risk, must also consider flood risks other than those due to river and sea flooding (e.g. groundwater, overland flow and sewer flooding) and apply a sequential approach to these risks if present. In addition, the implications the development has for flood risk elsewhere due to its drainage and runoff must also be considered.

The application of the Sequential Test (taking land use vulnerability into account) together with the Exception Test forms a rigorous process for assessing and prioritising the location of planned development with respect to flood risk. If required, the Sequential Test can be undertaken as an iterative process, using greater resolution and understanding of the flood risks, and after testing how effective any management or mitigation measures might be. The flood risk issues associated with the preferred development sites identified through the SFRA should be examined in more detail as and when a site-specific Flood Risk Assessment (FRA) is produced as part of the planning application.

3.3 Approach for Charnwood Borough

The following key factors determined how the SFRA approach was tailored for Charnwood Borough:

- Potential greenfield development in the key zones surrounding Loughborough and adjacent to the Leicester (PUA);
- Potential future ‘infill’ development of brownfield sites, identified by the HLAA (see Section 2);
- A recent history of significant fluvial flood events along the Borough’s main watercourses, but also known incidents of flooding due to other mechanisms, in particular blockages or insufficient capacities of culverts and bridges;
- A number of flood alleviation schemes planned and/ or implemented, including a major flood alleviation dam at Brentingby, on the Wreake in the neighbouring borough of Melton.

As the principal aim of the Sequential Test is to locate development in the lowest flood risk zone, the Charnwood SFRA emphasises the steering of all future development to Zone 1 which is appropriate for all categories of land use vulnerability.

Where no suitable alternative is available, there may be some scope for locating development in higher risk flood zones depending on the vulnerability of the proposed land use. Table 3.2 shows the PPS25 criteria with respect to the vulnerability of planned development in Charnwood Borough and appropriate levels of flood risk; Appendix B gives the full details of acceptable land uses for these vulnerability classifications.

Regardless of vulnerability, PPS25 indicates that greenfield development proposed in Zones 2 and 3a must demonstrate that there is no reasonable greenfield alternative available in a lower flood risk zone. Charnwood Borough Council will require this sequential approach to be undertaken and preference will be given to sites in Flood Zone 1.

For the redevelopment of brownfield and windfall/infill sites within areas of flood risk the Sequential Test must first be passed before the Exception Test can be attempted. In addition, all major developments must meet other requirements (for example avoid the generation of excess surface water runoff that adversely affects Third Parties) through a detailed FRA that meets the requirements of PPS25 and the EA Flood Risk Matrix guidance given at:

http://www.pipernetworking.com/floodrisk/matrix.html.

Table 3.2 Location of Planned Development According to Vulnerability

Planned Development	Zone 1 Low Probability	Zone 2 Medium Probability	Zone 3a High Probability	Zone 3b Functional Floodplain
Highly Vulnerable	Yes	Yes, if Exception Test is passed	No	No
More Vulnerable	Yes	Yes	If Exception Test is passed	No
Less Vulnerable	Yes	Yes	Yes	No
Water Compatible Infrastructure	Yes	Yes	Yes	Yes
Essential Infrastructure	Yes	Yes	If Exception Test is passed	If Exception Test is passed

Based on PPS25 Table D.2, residential development is classified as a 'more vulnerable' land use classification. This means that this development should be directed sequentially as far as feasibly possible to Flood Zone 1, then to Flood Zone 2. The Exception Test is required to be passed to justify placing 'More Vulnerable' development in Flood Zone 3a. PPS25 states that overall in these Flood Zones, developers and local authorities should aim to: *"reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate applications of sustainable drainage techniques"*. The majority of development proposed in Charnwood, comprising the residential element of the SUEs will fall into the 'More Vulnerable' category.

PPS25 Table D.2 indicates that most development for business use will come under the 'Less Vulnerable' classification (where not included in the 'More Vulnerable' classification). This means that this development should be directed sequentially as far as feasibly possible to Flood Zone 1, then to Flood Zone 2 then to Flood Zone 3a. PPS25 states that overall in these Flood Zones, developers and local authorities should aim to: *"reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate applications of sustainable drainage techniques"*. An exception is where an installation requires hazardous substances consent, in which case it is classed as 'Highly Vulnerable', in which case these should be located in Flood Zone 1, with an Exception Test required to justify placing them in Flood Zone 2.

Leicestershire County Council's assessment of transportation infrastructure to support development includes proposals for an eastern distributor road. However, the location of supporting infrastructure (such as distributor roads) needs to follow the Sequential Test process, and must consider the options for routes through areas of lower flood risk. At present more work is required to show that the sequential approach has been followed in selecting the preferred eastern route. If a route through areas of flood risk is selected, then the Exception Test must be fully satisfied.

To classify the distributor road as 'Essential Infrastructure', justification for routing the road through the floodplain will be required. The Exception Test as outlined in PPS25 para D.9 would then need to be passed. The proposal to build new development across the River Soar, east of Loughborough (proposed East of Loughborough and/or Wymeswold Airfield SUEs), does not alone provide sufficient justification for the road. It will be necessary to demonstrate through the sequential test that alternative locations for potential Loughborough SUEs are less suitable.

The 'essential infrastructure' classification for any new distributor road, would require that it remains operational and safe at times of flooding at present, and under a scenario of 20% increase in flows as a climate change scenario. Furthermore any scheme needs to be planned and engineered such that there is: a) no loss of floodplain storage; b) no unacceptable afflux (increase in flood depth upstream of structures due to conveyance constrictions); and that c) no new floodwater pathways are created.

To inform the LDF and the strategic planning process, the primary (fluvial) flood risk, by means of the Environment Agency's flood zones, have been used by Charnwood Borough Council as a constraint for informing its choice of preferred growth areas. Broad areas in Flood Zone 1 were identified as most preferable for future development. This SFRA further informs potential development options through more detailed modelling of flood risk areas, including a climate change scenario, and through assessment of the secondary sources of flooding. An appraisal of the flood risk at each site identified in the HLAA, which by their nature may be in Flood Zones 3a and 2 and may in future be progressed for development, is also included.

Based on the Borough's future development needs and the potential areas of development identified, there is sufficient land in Zone 1 to preclude the need to direct strategic new development to any of the higher risk flood zones.

As a result, the SFRA has focussed on characterising flood risk (including non-fluvial sources) throughout the Borough and the potential areas of development in particular, and includes the use of hydraulic modelling to more accurately refine and delineate the higher risk flood zones (e.g. Zone 3a, Zone 3b, extent of Zone 3a with 20% increase in peak flows etc). This has been undertaken with the aim of producing an SFRA tailored to best inform the LDF with respect to the location of future development in Charnwood Borough, and to provide a guide to local flood risk issues which will then inform the more detailed FRAs for selected development sites.

4. Overview of Flood Risk

4.1 Introduction

Flood risk throughout the borough has been characterised based on all available sources of information. This has included consideration of both primary (fluvial) flooding, as well as other secondary sources of flooding. This has largely been based on the Flood Zone extents modelled as part of the SFRA exercise, combined with the Environment Agency's Flood Zones, together with historical flood records to capture information on secondary sources of flooding where available. The SFRA thus provides an indication of the varied nature of flood risk throughout the borough,

4.2 Topography and Hydrology

The topography of Charnwood can be split into three units, the raised area of Charnwood Forest in the west, the central low-lying south-north floodplain of the River Soar and the raised area of the Wolds to the east. Elevations range between 34m AOD on the River Soar floodplain northeast of Hathern in the north to 248m AOD at Beacon Hill in the west, whilst the topography of the wolds in the east of the borough is more subdued, reaching an elevation of 134m AOD at Six Hills. Slopes of around 1 in 7 are characteristic of the Charnwood Forest area in the west, while slopes of around 1 in 20 are to be found in the Wolds to the east.

The Soar FRMS provide useful background information on the catchment, which is summarised below. Charnwood Borough receives between 750 and 625mm of rain on average a year. Rainfall is highest over the hills of Charnwood Forest in the west, and decreases eastwards towards the Wolds.

Watercourses draining the Charnwood Forest tend to be faster responding than the watercourses draining the Wolds to the east. In the south of the borough the Soar is joined by the River Wreake and the Rothley Brook. Flood levels in the lower Soar north of this confluence are strongly influenced by the coincidence of peaks on the three watercourses, water levels rising most rapidly if the flood peaks from all three watercourses coincide.

Regionally, Charnwood is considered to have limited groundwater sources, but minor aquifers may be of local significance.

Swithland, Cropston and Black Brook Reservoirs provide storage for public water supply, with additional Public Water Supply needs being imported into the Soar catchment from the River Dove. Nanpantan Reservoir was originally used for Loughborough's drinking water supply. These reservoirs are not operated for flood attenuation and therefore may be full in winter, thereby providing no flow attenuation during flood events. The potential exists to use Nanpantan reservoir for flood attenuation in the future.

4.3 Primary Sources of Flooding

4.3.1 Fluvial Flooding

The watercourses throughout the Borough pose a potential flood risk to both existing and future development, particularly development near the extensive floodplains of the larger, lower gradient rivers (Soar, Wreake and Rothley Brook), which the rivers naturally occupy during periods of high flow. Floods may also be caused by obstructions to flow, such as constrictive bridges or blockage by large debris (e.g. trees, debris etc) such as the partial blockage of the railway bridge over the Eye/Wreake by a skip which occurred in nearby Melton Mowbray in 1998.

Table 4.1 lists the watercourses in Charnwood Borough and includes main rivers, ordinary watercourses (OWs) and the Grand Union Canal (Leicester Branch).

The watercourses are shown in Figure 4.1. Not all of these watercourses are included in the Environment Agency's flood zones, illustrating the need to assess site specific watercourses when carrying out detailed FRAs.

Table 4.1 Watercourses in Charnwood Borough

River	Classification	Responsibility	Description (Source, Location, Geology, Hydrology etc)
River Soar	MR	EA	Source in south Leicestershire / north Warwickshire, the catchment collects water from a wide primarily rural catchment before passing through urban Leicester, where it receives urban runoff. Major tributaries the River Wreake and Rothley Brook join the Soar in Charnwood. Flows north to the Trent in Rushcliffe. Catchment is mainly clay and alluvium, responsive to rainfall events.
River Wreake	MR	EA	Limestone aquifer source at Waltham on the Wolds, flows south and then west through Melton and Charnwood to the Soar. Catchment is mainly clay and alluvium, responsive to rainfall events.
Rothley Brook	MR	EA	Source in Charnwood Forest, flows east through NW Leicestershire into Charnwood to the River Soar. Catchment is mainly clay and alluvium, with isolated areas of igneous and metamorphic rock, rapid response to rainfall events.
Black Brook (inc. Grace Dieu Brook)	MR	EA	Source in Charnwood Forest, flows east through NW Leicestershire into Charnwood to the River Soar. Catchment is mainly clay and alluvium, with isolated areas of igneous and metamorphic rock, rapid response to rainfall events.
Burleigh Brook (inc. Shortcliffe Brook)	MR/OW	EA/CBC	Source in Charnwood Forest, flows east through Loughborough to the River Soar. Lower catchment in mainly urbanised. Drop-culvert structure takes watercourse under the GU Canal. Rapid response to rainfall events.
Wood Brook	MR/OW	EA/CBC	Source in Charnwood Forest, flows east through Loughborough to the River Soar. Catchment in mainly urbanised. Drop-culvert structure takes watercourse under the GU Canal. Rapid response to rainfall events.
Quorn Brook (inc. Poultney and Swithland Brooks and the River Lin)	MR/OW	EA/CBC	Source in Charnwood Forest, comprises three main tributaries, River Lin flows into Cropston Reservoir and then with the Swithland Brook into Swithland Reservoir. The Poultney Brook joins the Quorn Brook downstream of the reservoirs in Quorn, before the watercourse enters the Soar. Catchment is mainly clay and alluvium, with isolated areas of igneous and metamorphic rock, rapid response to rainfall events, which may be attenuated depending on storage available in reservoirs
Sic Brook	OW	CBC	Short watercourse draining east through Mountsorrel to the River Soar.
Anstey, Leicester Road Culvert	MR	CBC	Watercourse culverted under ‘The Nook’. Recent culvert replacement scheme.
Thurmaston Dyke	OW	CBC	Short watercourse draining west through Thurmaston, from the area east of the Leicester railway line embankment, west passing nr Ferndale Rd to the River Soar. Culverted in places. Urban catchment.

Table 4.1 (continued) Watercourses in Charnwood Borough

River	Classification	Responsibility	Description (Source, Location, Geology, Hydrology etc)
Barkby Brook	MR/OW	CBC	Source in Market Harborough, flows north west through Charnwood to the River Wreake northwest of Syston. Catchment is rural, and comprised of clays and alluvium. Potentially rapid response to rainfall events.
Queniborough Brook (inc. Gaddesby Brook and Parish Dyke)	MR/OW	EA/CBC	Source in Market Harborough / Melton, flows north west through Charnwood to the River Wreake northwest of Queniborough. Catchment is rural, and comprised of clays and alluvium. Potentially rapid response to rainfall events.
Rearsby Brook	MR/OW	EA/CBC	Source in Melton, flows west through Charnwood to the River Wreake west of Rearsby. Catchment is rural, and comprised of clays and alluvium. Potentially rapid response to rainfall events.
Thrussington Brook	MR/OW	EA/CBC	Short watercourse draining south through Thrussington to the River Wreake.
Cossington Brook and Platts Lane Culvert	OW	CBC	Flows southwest through Cossington to the River Soar. Catchment is rural, and comprised of clays and alluvium. Potentially rapid response to rainfall events.
Sileby Brook	MR /OW	EA/CBC	Flows southwest through Sileby to the River Soar. Catchment is rural, and comprised of clays and alluvium. Potentially rapid response to rainfall events.
Barrow Brook	OW	CBC	Flows southwest to the River Soar. Catchment is rural, and comprised of clays and alluvium. Potentially rapid response to rainfall events.
Fishpool Brook	MR/OW	EA/CBC	Flows southwest through Barrow Upon Soar to the River Soar. Catchment is rural, and comprised of clays and alluvium. Potentially rapid response to rainfall events.
Walton, Burton Brook and unnamed watercourse between Hoton and the Soar	OW	CBC	Flows west to the River Soar. Catchments are rural, and comprised of clays and alluvium. Potentially rapid response to rainfall events.
Kings Brook and River Mantle	MR/OW	EA/CBC	Flows west to the River Soar. Wymeswold situated on the River Mantle. Catchments are rural, and comprised of clays and alluvium. Potentially rapid response to rainfall events.
Grand Union Canal	Canal	BW	Canal passes north-south through the centre of Charnwood and is interlinked with the River Soar.

Abbreviations: EA - Environment Agency, CBC - Charnwood Borough Council, BW - British Waterways.
MR – Main River, OW – Ordinary Watercourse

4.3.2 Fluvial Flood Risk

The Environment Agency published the Flood Zones Map in 2004. A key component of this is the flood zones which classify the whole of England into three zones based on the level of risk due to flooding from rivers and the sea. The zones reflect the risk categories in PPS25 to enable planning authorities to apply the sequential test for planned development. With respect to fluvial flooding, the zones are defined as follows:

- **Zone 1 Low Probability**: Less than 0.1% chance (1 in 1000) of flooding in any year;
- **Zone 2 Medium Probability**: Greater than 0.1% (1 in 1000) but less than 1% (1 in 100) chance of flooding in any year;
- **Zone 3 High Probability**: Greater than 1% (1 in 100) chance of flooding in any year.

Figure 4.2 shows the extent of these zones within Charnwood Borough. The flood zones are based on a Digital Terrain Model (DTM) derived from aerial survey and flow estimates from the Flood Estimation Handbook (FEH). JFLOW, a two-dimensional raster floodplain model was used to generate the flood outlines for all catchments over 3 km^2. It is important to note that the flood outlines do not account for structures in the floodplain such as defences, bridges, culverts and embankments which may have significant local effects on the flood zones. JFLOW is not a hydraulic model, and does not represent the routing of floodwater in hydro-dynamic terms, but rather routes a volume of flood water through a grid of cells across topography. For this reason, there can be discrepancies between flood extents produced with JFLOW and those produced by hydraulic modelling.

The flood zones were produced as a national exercise and therefore only provide a broad indication of fluvial flood risk within the above constraints. In some areas, where more detailed modelling is available and is based on a consistent methodology, this information has been included in the derivation of the current flood zones. The Environment Agency will continuously update the Flood Zone Map as more detailed modelling and actual flood risk information becomes available.

Hydraulic models for the Rivers Soar and Wreake and the Rothley, Black, Burleigh, Wood and Barkby Brooks have been used to define the functional floodplain (3b), High Risk (3a), and the High Risk plus 20% increase in peak flows climate change scenario (3a+CC) extents.

Table 4.2 summarises the approximate areal extent of areas at risk of flooding in Charnwood (details of how the SFRA flood zones were delineated are included in Appendix C), based on the EA Flood Zones and the modelling carried out as part of the SFRA. The following points should be noted

- The SFRA Flood Zone 3 (3a+3b) covers an additional 5km^2 of the Borough when compared with EA Flood Zone 3;

- SFRA Flood Zone 3a with climate change provides an indication of the sensitivity of the area of the flood zone to an increase of 20% in flood flows. This shows that in future a further 0.5km^2 is potentially at risk;
- SFRA Flood Zone 3b is almost as extensive as SFRA Flood Zone 3a. The areas shown in Table 4.2 for Flood Zone 3b only include the main modelled watercourses in the Borough, and in reality this proportion will be slightly larger, if the areas of Flood Zone 3b along minor watercourses were included;
- Table 4.3 provides a summary and brief description of the flood extent figures included in this report. The functional floodplain (Flood Zone 3b) has only been modelled along watercourses for which a hydraulic model was available. Should the need arise, it will be up to the developer to undertake the required hydraulic modelling to define the appropriate fluvial flood zones.

Table 4.2 Areal Extent of Flood Zones in Charnwood

Flood Zone	Area (km^2)	Percentage of Borough
Charnwood Borough	249	-
EA Flood Zone 3	33.63	13.51
EA Flood Zone 2	6.75	2.71
SFRA Flood Zone 3b	24.04	9.66
SFRA Flood Zone 3a	15.69	6.30
SFRA Flood Zone 3a+3b	39.74	15.96
SFRA Flood Zone 3a + CC	16.40	6.59
SFRA Flood Zone 3 + CC	40.45	16.24

Finally, it must be noted that the Environment Agency flood zones, and the modelling carried out for this SFRA do not provide any indication of flood risk due to minor watercourses (i.e. with catchments of less than 3 km^2) or other, secondary sources of flooding including groundwater, overland flow and sewer flooding. These other flood risks have been characterised for Charnwood Borough as part of this SFRA and identified at a local level for the areas of search. They too must be considered and addressed in further detail at the FRA stage of proposed development.

Where development is proposed in or near the boundaries of the higher risk flood zones (i.e. Zones 2 and 3a), more detailed modelling will be required at the FRA stage to determine the floodplain extent and design flood levels more accurately. This should also investigate the effects of climate change on flood risk. The SFRA report has identified river models that have been developed for watercourses in Charnwood Borough (see Appendix C). To inform the FRA of proposed developments these models, and in specific cases, bespoke hydraulic models may be required to assess the fluvial flood risk.

By combining the areas indicated as having flooded historically, the EA Flood Zones and detailed hydraulic modelling outlines, the SFRA Flood Zones provide a more conservative zoning tool for identifying areas where flood risk needs to be considered in greater detail. Appendix C details the hydraulic modelling and projection carried out to produce flood zones detailing the Flood Risk in Charnwood in greater detail. **Section 6** of the Appendix C details the modelled flood levels.

Table 4.3 Flood Modelling Figures – Details of Contents

Figure Title	Contents
Figure 4.3 – River Soar – Comparison of Flood Zone 3a Extents	Comparison of the EA Flood Zone 3 (1% event) with output of the River Soar Hydraulic Models for the 1% flood event
Figure 4.4 – River Soar - Flood Zones 3b, 3a and 3a plus Climate Change	Extent of the Charnwood SFRA flood zones for the River Soar. Zoning produced as set out in Appendix C
Figure 4.5 - Modelled Flood Depths along the River Soar	Flood depth for the 1% flood extent along the River Soar
Figure 4.6 - River Soar model outline - Climate Change Comparison	Comparison of model Flood Zone 3a and model Flood Zone 3a+ climate change outlines
Figure 4.7 - River Wreake and Barkby Brook - Comparison of Flood Zone 3a Extents	Comparison of the EA Flood Zone 3 (1% event) with output of the River Wreake and Barkby Brook Hydraulic Models for the 1% flood event
Figure 4.8 - River Wreake (and Barkby Brook) - Flood Zones 3b, 3a and 3a plus Climate Change – Defended (with Brentingby)	Extent of the Charnwood SFRA flood zones for the River Wreake – **with** online storage at Brentingby. Zoning produced as set out in Appendix C
Figure 4.9 - River Wreake (and Barkby Brook) - Flood Zones 3b, 3a and 3a plus Climate Change – Undefended (without Brentingby)	Extent of the Charnwood SFRA flood zones for the River Wreake – **without** online storage at Brentingby. Zoning produced as set out in Appendix C
Figure 4.10 - Modelled Flood Depths along the River Wreake and Barkby Brook	Flood depth for the 1% flood extent along the River Wreake and Barkby Brook
Figure 4.11 - River Wreake model outline - Climate Change Comparison	Comparison of model Flood Zone 3a and model Flood Zone 3a+ climate change outlines
Figure 4.12 - Rothley Brook - Comparison of Flood Zone 3a Extents	Comparison of the EA Flood Zone 3 (1% event) with output of the Rothley Brook Hydraulic Model for the 1% flood event
Figure 4.13 - Rothley Brook - Flood Zones 3b, 3a and 3a plus	Extent of the Charnwood SFRA flood zones for Rothley Brook. Zoning produced as set out in Appendix C
Figure 4.14 – Modelled Flood Depths along the Rothley Brook	Flood depth for the 1% flood extent along the Rothley Brook
Figure 4.15 – Rothley Brook model outline - Climate Change Comparison	Comparison of model Flood Zone 3a and model Flood Zone 3a+ climate change outlines
Figure 4.16 - Black Brook, Burleigh Brook and Wood Brook - Comparison of Flood Zone 3a Extents	Comparison of the EA Flood Zone 3 (1% event) with output of the Black Brook, Burleigh Brook and Wood Brook Hydraulic Models for the 1% flood event

Table 4.3 (continued) Flood Modelling Figures – Details of Contents

Figure Title	Contents
Figure 4.17 - Black Brook, Burleigh Brook and Wood Brook - Flood Zones 3b, 3a and 3a plus Climate Change	Extent of the Charnwood SFRA flood zones for the Black Brook, Burleigh Brook and Wood Brook. Zoning produced as set out in Appendix C
Figure 4.18 - Modelled Flood Depths along the River Soar, Burleigh Brook and Wood Brook at Loughborough	Flood depth for the 1% flood on the River Soar, Burleigh Brook and Wood Brook at Loughborough
Figure 4.19 – Black Brook, Burleigh Brook and Wood Brook model outline - Climate Change Comparison	Comparison of model Flood Zone 3a and model Flood Zone 3a+ climate change outlines

For the purposes of Development Control, Figures 4.4, 4.9, 4.13 and 4.17 should be used in triggering the requirement for a FRA. Cross reference between the flood zone shown in these figures and the Environment Agency's Flood Risk Matrix will detail the scope of the required FRA.

4.3.3 River Soar

Figure 4.3 compares the EA's Flood Zone 3 (1% or greater risk of fluvial flooding in a given year) with the SFRA Flood Zone 3a (created by amalgamating hydraulic modelling results and historical information with the extent of EA's Flood Zone 3) for the River Soar. By including this additional information additional areas potentially at risk have been identified. The additional areas identified using hydraulic modelling were:

- Quorn;
- Loughborough – industrial estates north of Belton Road West Extension;
- Loughborough – west of Meadow Lane between Bottleacre Lane and the railway line;
- Loughborough – Morley Street and the southern area of Falcon Street;
- Western edge of Thurmaston;
- Land between Birstall and Wanlip;
- Sewage Works north of Wanlip;
- Western fringe of Sileby; and
- North-eastern fringe of Mountsorrel.

Additional areas identified using the historical flood map were:

- Areas of the Soar Valley south of the Wreake confluence;
- Area south of Syston Road, Cossington adjacent to Wreake confluence;

- Eastern area of Derby Road Industrial Estate; and
- Dishley Grange.

Figure 4.4 shows the PPS25 Flood Zones 3b, 3a and 3a+20% increase in peak flows (climate change scenario) for the River Soar. The limited increases in floodplain extent due to a 20% increase in peak flows can be seen on both figures. The effect of a 20% increase in peak flows is primarily a depth increase. This occurs due to local topography; since relatively steep sides to the floodplain allow depth to increase without the overall floodplain extent increasing.

Figure 4.5 shows the flood depths along the River Soar for the 1% flood extent. Particularly deep flood depths (1.5m +) occur

- on the Soar floodplain between the A46 and the Cossington Lane/Syston Road crossings;
- north of Mountsorrel;
- adjacent to the former Loughborough tip, and
- north of Hathern.

Elsewhere flood depths are shallower, around the eastern periphery of Loughborough depths being typically 0.5m – 1m. The flood depths shown in Figure 4.5 are based on raw model output, the black outline of SFRA Flood Zone 3a indicates the areas that have been included in the final SFRA Flood Zone 3a (reasons for editing are detailed in Appendix C).

An analysis of a 20% increase in peak flows (Table 4.3 and Appendix C - Table 6.1), indicates that flood levels during the 1% event could increase significantly in future. Depth increases of up to 0.38m occur at Wanlip near the Wreake confluence, in the stretch between the A46 bridge and the Cossington Lane/Syston Road bridge. At Cotes, (the greatest flood depth increase near Loughborough) flood levels are indicated as potentially increasing by up to 0.24m. In terms of flood extent, a limited increase in extent is indicated by the River Soar hydraulic model (see Figure 4.6); under the +20% peak flows climate change scenario, Flood Zone 3a expands slightly. In Loughborough this is further into the area between Meadow Lane and Nottingham Road and along the south-western fringe of the Soar floodplain north of The Wharf.

Table 4.4 River Soar 20% increase in peak flows scenario- Climate Change Sensitivity

	1% event + 20% Increase in Flows	1% Flood Water Surface Elevation	1%+CC Flood Water Surface Elevation
Mean Depth Increase	0.17m		
Maximum Depth Increase	0.38m		
Depth Increase at Wreake-Soar confluence	0.38m	48.68m AOD	49.06m AOD
Depth Increase at Cotes	0.24m	38.84m AOD	39.08m AOD

4.3.4 River Wreake and Barkby Brook

Figure 4.7 compares the EA's Flood Zone 3 (1% or greater risk of fluvial flooding in a given year) with the SFRA Flood Zone 3a (created by amalgamating hydraulic modelling results and historical information with the extent of EA's Flood Zone 3) for the River Wreake and Barkby Brook. By including this additional information additional areas potentially at risk have been identified, through hydraulic modelling, these areas were:

- Land north of Rearsby, southeast of railway line;
- Land north of Syston, southeast of railway line; and
- Land north of Syston Railway Station, including the triangle between railway lines and land to the east.

Through the historical flood map:

- General infilling of the modelled flood extent.

Figure 4.8 and 4.9 show the PPS25 Flood Zones 3b, 3a and 3a+climate change for the River Wreake under the defended and undefended situations respectively and the Barkby Brook. The difference in the extent of Flood Zone 3b (functional floodplain) can be seen with and without online storage at Brentingby (upstream of Melton Mowbray in the neighbouring borough of Melton). Flood Zones 3a and 3a+CC do not appear to change in extent, partially due to the historical data with which they have been supplemented – instead a depth increase occurs. The limited increases in floodplain extent due to a 20% increase in peak flows can be seen on both figures. The effect of a 20% increase in peak flows primarily causes a depth increase. This occurs due to local topography; since relatively steep sides to the floodplain allow depth to increase without the overall floodplain extent increasing. For both defended and undefended situations, Flood Zone 3b (functional floodplain) is extensive, covering the majority of the area covered by Flood Zone 3a. As a precautionary approach (and since there is limited difference in extents) the Flood Zone 3b without online Storage at Brentingby has been used as the final Flood Zone 3b outline.

In terms of depth the operation of Brentingby reduces the 1% flood level along the River Wreake by a mean of 0.3m and in particular, by up to 0.6m north of East Goscote and by 0.3m north of Syston.

Figure 4.10 shows the flood depths along the River Wreake for the 1% undefended (no Brentingby) situation. Particularly deep flood depths (1.5m +) occur on the Wreake floodplain upstream of Rearsby and southwest of the A607 crossing and north of Syston. Elsewhere flood depths are shallower, typically around 0.5m – 1m. The flood depths shown in Figure 4.10 are based on raw model output, the black outline of SFRA Flood Zone 3a indicates the areas that have been included in the final SFRA Flood Zone 3a (reasons for editing are detailed in Appendix C).

An analysis of the effects of a 20% increase in peak flows (Table 4.5 and Appendix C - Table 6.2), indicates that flood levels during the 1% event could increase considerably in future without the online storage at Brentingby, the mean increase is 0.21m with and without Brentingby operating. Maximum depth increases are 0.37m with Brentingby and 0.39m without Brentingby. In terms of flood extent, a limited increase in extent is indicated by the River Wreake hydraulic model (see Figure 4.11); under the +20% flows climate change scenario, Flood Zone 3a expands slightly, particularly in the area north of East Goscote and northwest of Syston. Flood Zone 3a for the Barkby Brook increases in extent north of Syston Station within the triangular area between railway tracks and the area to the east.

Table 4.5 River Wreake 20% Increase in Peak Flows Scenario- Climate Change Sensitivity

	1% event + 20% Increase in Flows - with Melton FAS (Brentingby)	1% event + 20% Increase in Flows - without Melton FAS (Brentingby)
Mean Depth Increase	0.21m	0.21m
Maximum Depth Increase	0.37m	0.39m

4.3.5 Rothley Brook

Figure 4.12 compares the EA's Flood Zone 3 (1% or greater risk of fluvial flooding in a given year) with the SFRA Flood Zone 3a (created by amalgamating hydraulic modelling results and historical information with the extent of EA's Flood Zone 3) for the Rothley Brook. By including this additional information additional areas potentially at risk have been identified, through hydraulic modelling, these areas were:

- Rothley, adjacent to the Rothley Brook;
- Upstream of Leicester Road bridge, Thurcaston;
- Sewage Works between Anstey and Thurcaston;
- Upstream of the Leicester Road Bridge, Anstey; and

- Land downstream of the A46 bridge.

Through the historical flood map:

- Land downstream of the Great Central Railway up to the Soar confluence;
- Sewage Works between Anstey and Thurcaston;
- Upstream of the Leicester Road Bridge, Anstey; and
- Land downstream of the A46 bridge.

Figure 4.13 shows the PPS25 Flood Zones 3b, 3a and 3a+20% increase in peak flows (climate change scenario) for the Rothley Brook. The limited increases in floodplain extent due to a 20% increase in peak flows can be seen on both figures. The effect of a 20% increase in peak flows is primarily a depth increase. This occurs due to local topography; since relatively steep sides to the floodplain allow depth to increase without the overall floodplain extent increasing.

Figure 4.14 shows the flood depths along the Rothley Brook for the 1% flood extent. Particularly large flood depths (1.5m +) occur along the Rothley Brook upstream of river crossings. Elsewhere flood depths are shallower, depths being typically 0.5m – 1m. The flood depths shown in Figure 4.14 are based on raw model output, the black outline of SFRA Flood Zone 3a indicates the areas that have been included in the final SFRA Flood Zone 3a (reasons for editing are detailed in Appendix C).

Modelling with a 20% increase in peak flows (Table 4.6 and Appendix C - Table 6.3), indicates that flood levels during the 1% event could increase significantly in future. Depth increases by a mean of 0.36m, but increases of up to 0.67m occur at other locations along the Rothley brook, principally upstream of bridge structures. At Rothley, river levels may increase by 0.20m. In terms of flood extent, a limited increase in extent is indicated by the Rothley Brook hydraulic model (see Figure 4.15); under the +20% flows climate change scenario, Flood Zone 3a expands slightly along the entire length of the brook, particularly upstream of bridges and structures.

Table 4.6 Rothley Brook 20% Increase in Peak Flows Scenario- Climate Change Sensitivity

	1% Event + 20% Increase in Flows	1% Flood Water Surface Elevation	1%+CC Flood Water Surface Elevation
Mean Depth Increase	0.36m		
Maximum Depth Increase	0.67m		
Depth Increase at upstream of Leicester Road bridge, Anstey	0.67m	62.21m AOD	62.89m AOD
Depth Increase at upstream of Medieval bridge, Anstey	0.51m	60.71m AOD	61.22m AOD
Depth Increase at upstream of Great Central Railway Bridge	0.55m	51.81m AOD	52.36m AOD
Depth increase upstream of Hallfields Lane, Rothley	0.20m	48.48m AOD	48.68m AOD

4.3.6 Loughborough - Black Brook, Burleigh Brook and Wood Brook

Plates 4.1 – 4.8 show the Wood, Burleigh and Black Brooks and give an indication of associated flood risks.

Figure 4.16 compares the EA's Flood Zone 3 (1% or greater risk of fluvial flooding in a given year) with the SFRA Flood Zone 3a (created by amalgamating hydraulic modelling results and historical information with the extent of EA's Flood Zone 3) for the Black Brook, Burleigh Brook and Wood Brook. By including this additional information additional areas potentially at risk have been identified, through hydraulic modelling, these areas were:

- Black Brook – broad area of farmland alongside Black Brook upstream of Loughborough;
- Black Brook - Land upstream of Buckingham Drive, Thorpe Acre;
- Black Brook - Land between Maxwell Drive and the Black Brook in Thorpe Acre;
- Burleigh Brook – Flood Zone between Albany Street (Alan Moss Road) and the Grand Union Canal; and
- Wood Brook – Land at Limehurst Avenue.

Through the historical flood map:

- Land alongside the Black Brook upstream of Loughborough; and
- Land south of the Black Brook in Thorpe Acre, extending towards the A6/Willow Brook;

Additionally, the area of EA Flood Zone 3 located between the Black and Burleigh Brook was removed from the SFRA Flood Zone 3a extent. Examination of the EA Flood Map shows that the lower course of the Burleigh Brook has not been picked up in the coarse-scale JFLOW modelling of the area; therefore instead of water moving east towards the River Soar, it has been routed north towards the Black Brook. Furthermore examination of output extents from the Black Brook hydraulic model indicate that flood water from the Black Brook does not pass south to the Burleigh Brook. Local knowledge and the examination of topographical data indicate that there is a low ridge of land running between the two watercourses. Therefore this area was cut from the SFRA Flood Map, and the extents of the 1% flood event produced by the Black Brook and Burleigh Brook hydraulic models used to define the new edges of Flood Zone 3a for both watercourses (see Appendix C for more detail).

Figure 4.17 shows the PPS25 Flood Zones 3b, 3a and 3a+20% increase in peak flows (climate change) scenario for the Black Brook, Burleigh Brook and Wood Brook. The limited increases in floodplain extent due to a 20% increase in peak flows can be seen on both figures. The effect of a 20% increase in peak flows is primarily a depth increase. This occurs due to local topography; since relatively steep sides to the floodplain allow depth to increase without the overall floodplain extent increasing.

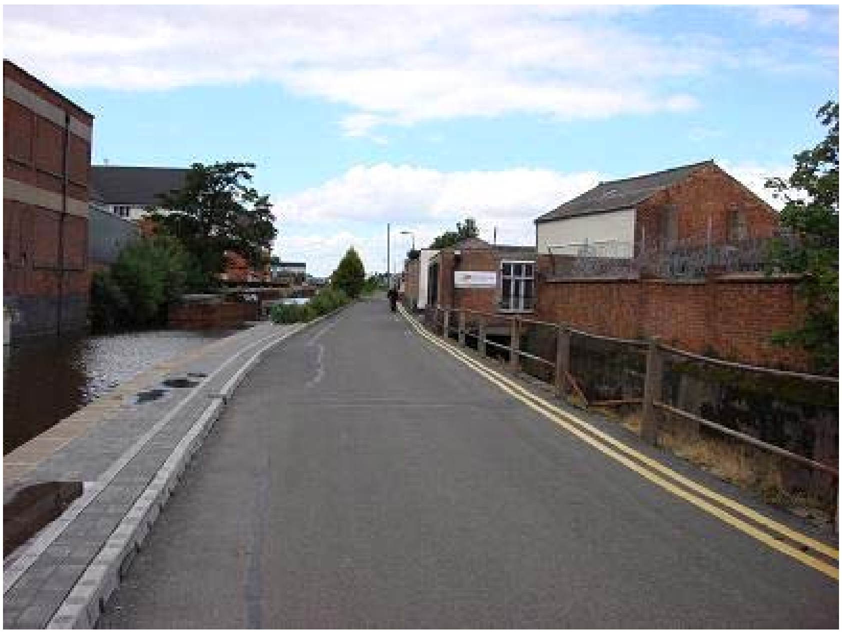
Figure 4.18 shows the flood depths along the Burleigh Brook and Wood Brook for the 1% flood extent. Particularly deep flood depths (1.5m +) occur on the Soar floodplain adjacent to the former Loughborough tip, and upstream of Quorn. Elsewhere flood depths are shallower, around the eastern periphery of Loughborough depths being typically 0.5m – 1m. Flood depths associated with the Burleigh and Wood Brooks away from the channel, are generally shallow (0.5 – 1m). The flood depths shown in Figure 4.18 are based on raw model output, the black outline of SFRA Flood Zone 3a indicates the areas that have been included in the final SFRA Flood Zone 3a (reasons for editing are detailed in Appendix C).

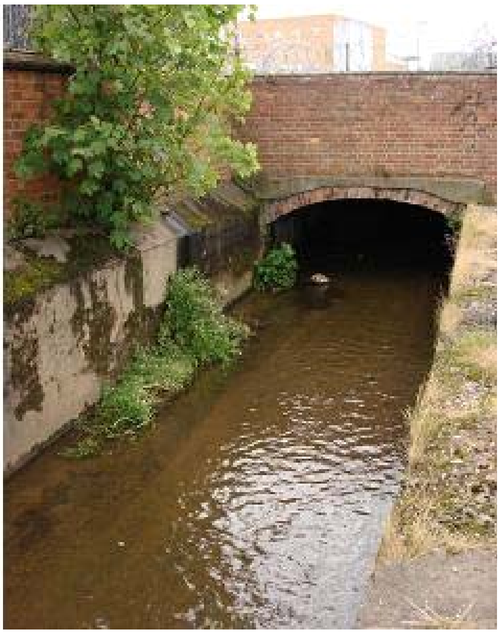
Modelling for a 20% increase in peak flows carried out as part of the Black Brook SFRM exercise (Table 4.7 and Appendix C - Table 6.4). The supplied data indicates that flood levels during the 1% event (for the Defended watercourse) for the reach below the confluence with the Grace Dieu Brook could increase by on average 0.10m, with localised increases of up to 0.38m. Even under the 20% increase in peak flows scenario (climate change), defences in Thorpe Acre are not indicated as breaching. In terms of flood extent, a limited increase in extent is indicated by the Black Brook hydraulic model (see Figure 4.19); under the +20% peak flows scenario, Flood Zone 3a expands slightly. A particularly large increase in extent occurs into the area of open space (fishing lakes) upstream (west) of Mount Grace Road in Thorpe Acre, maintaining this area for flood storage is therefore crucial. For the Burleigh Brook hydraulic modelling indicates the Flood Extents show limited increases due to a 20% increase in peak flows along most of the watercourse, increases in Flood Zone 3a are most pronounced around the Derby Road/Belton Road area. For the Wood Brook hydraulic modelling indicates the Flood Extents east of Sandalwood Road along Forest Road to east of Epinal Way, south of Browns Lane and the area around Limehurst Avenue are particularly sensitive to the 20% increase in peak flows (climate change) scenario. The potential for flood storage (section 6.8.1) could be a mitigation option, and should be fully investigated, with potential flood storage areas protected from development.

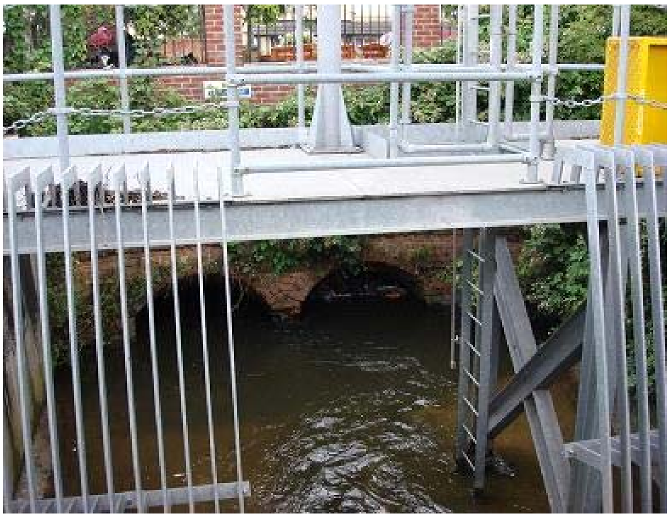
Table 4.7 Black Brook 20% Increase in Peak Flows Scenario- Climate Change Sensitivity (Data from Black Brook SFRM study)

	1% event + 20% increase in flows	1% Flood Water Surface Elevation	1%+CC Flood Water Surface Elevation
Mean Depth Increase	0.10m		
Maximum Depth Increase	0.38m		
Depth Increase at downstream of Black Brook – Grace Dieu Brook confluence	0.04m	49.30m AOD	49.34m AOD
Depth Increase for land between Mount Grace Road and Buckingham Drive	0.21m	42.85m AOD	43.05m AOD
Depth Increase nr Swithland Close (Buckingham Drive)	0.38m	42.26m AOD	42.64m AOD
Depth increase upstream of A6 bridge	0.16m	37.59m AOD	37.75m AOD

Plate 4.1 - 4.4 Wood Brook in Loughborough adjacent to the Grand Union Canal

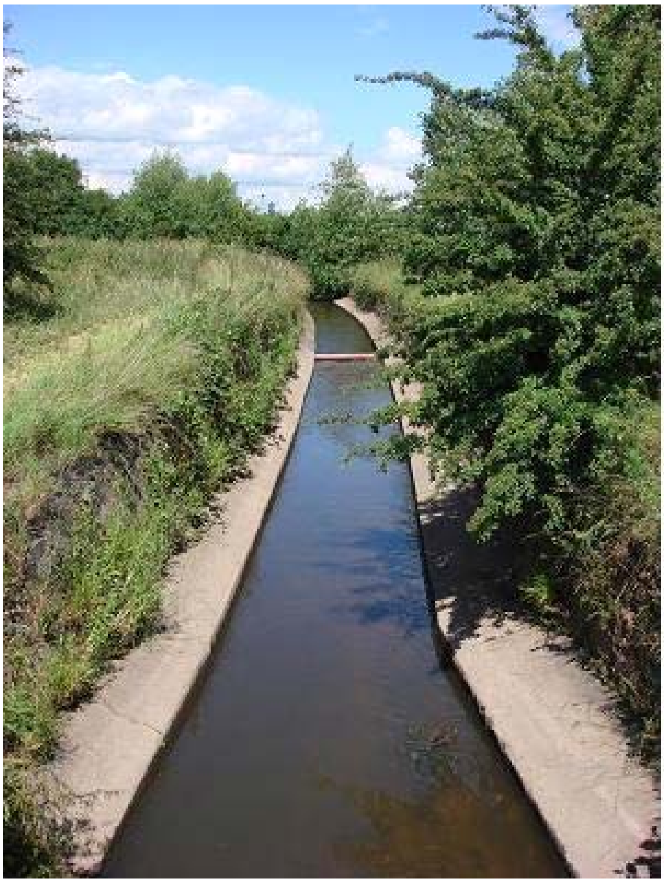






From top-left, clockwise, Plate 4.1 shows the view to the north along Canalside, with The Wharf on the left and the Wood Brook on the right, during dry weather the Brook is lower than the canal; Plate 4.2 shows a typical culvert across the Wood Brook at Canalside; Plate 4.3 shows debris build up on the debris screen upstream of the siphon under the Grand Union Canal; and Plate 4.4 shows the entrances to the siphon.

Plates 4.5 – 4.6   Burleigh Brook in Loughborough



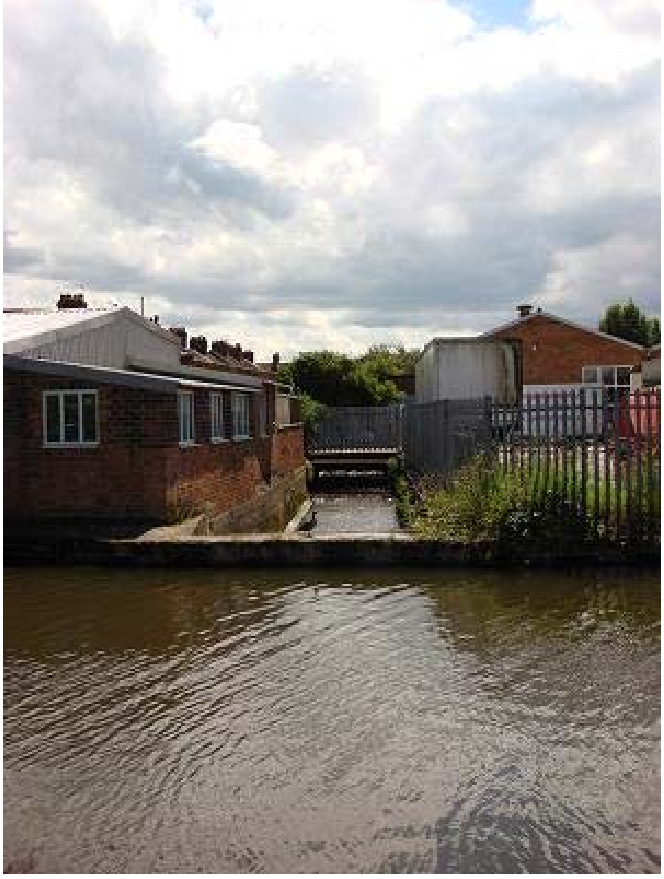


Plate 4.5 (left hand image) shows the downstream view (eastwards) along the Burleigh Brook from Canalside – note concrete bed; and Plate 4.6 (right hand image) shows the upstream view – note encroaching development and confined artificial channel and banks.

Plates 4.7 – 4.8 Black Brook in Loughborough at Thorpe Acre

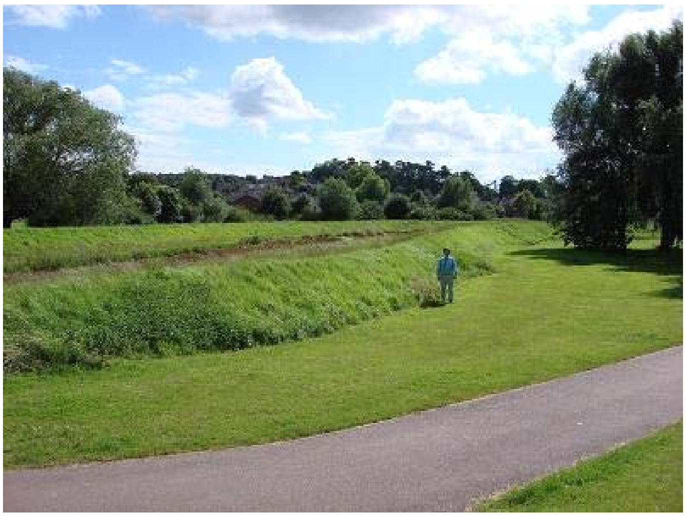
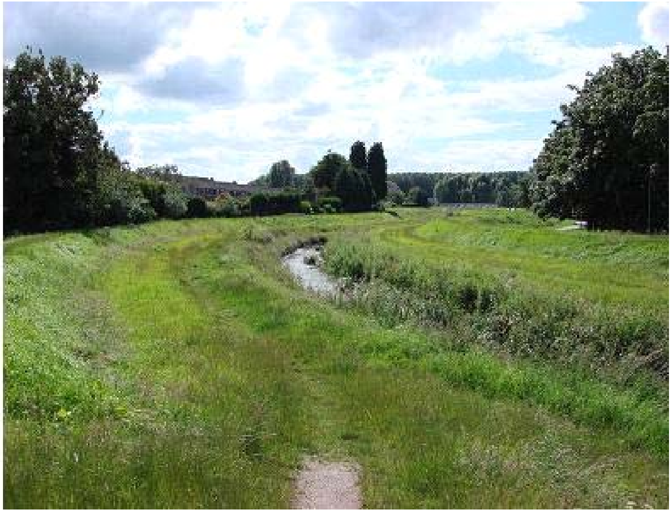



Plate 4.7 (left hand image) shows the height of the embankments along the Burleigh Brook at Thorpe Acre (view is to the southwest); note person for scale; and Plate 4.8 (right hand image) shows a typical view of the two-stage channel between the flood embankments.

4.4 Velocity of Floodwater

The 1-D models available for watercourses in Charnwood preclude the prediction of velocities in areas of flooding such as floodplains, where a 2-D model would be required to estimate velocities. In addition specific breach models would be required of embanked watercourses, such as the Black Brook at Thorpe Acre, to estimate velocities in the vicinity of a potential breach.

However, in qualitative terms it is possible to consider the areas with the where risk to life will be greatest. Areas of deeper water will present the most risk; out-of-bank flow from rivers tends to flow following the path of least resistance producing high velocities where flow is concentrated – such as across the floodplain between each side of a river meander, or in urban areas following roads. Structures that constrict flood flows causing upstream afflux will also cause flood water to accelerate creating faster velocities immediately downstream. The fact that floodwater will generally be sediment laden and opaque means that obstacles and holes at ground level will not be visible and increases the risk of injury.

The Defra report FD2320 *"Flood Risk Assessment Guidance for New Development"* (in particular Sections 12 and 13) provides details of methods to assess the potential risk to people from moving flood water. Development adjacent to raised defences should be discouraged, since these areas have a high residual risk of flooding due to the rapid inundation that would occur if defences failed or were exceeded during a flood situation. Where possible, new development should be located elsewhere. However, where the Sequential and Exception

Tests have been met, the FRA for new development behind raised defences, will require a breach/overtopping analysis to quantitatively inform the site and building design.

Areas immediately behind defences in Charnwood (see Section 4.7) should be considered to be a "High Flood Hazard Zone' – whilst the defences significantly reduce flood risk in these areas, the potential for flooding due to defence failure or the overtopping of defences remains. During these scenarios floodwater can reach dangerously high velocities causing a risk to life as well as causing erosion and structural damage.

4.5 Historical Flooding

4.5.1 Flood Events

Charnwood Borough has a long history of flood events, including several events in recent history which saw properties inundated throughout the Borough, in some cases on several occasions. Table 4.8 shows details of historic flood events based on the UK Hydrochronology website[6].

Table 4.8 Charnwood Flood History

Year	Details
Feb. 1795	'The great flood' in Leicester and vicinity
Feb. 1799	Failure of the Black Brook reservoir – catastrophic flooding along lower Black Brook
Nov. 1852	Great flood on the Wreake and Soar ("deepest for 50 years")
Jun. 1871	Flooding of the Soar valley from prolonged rainfall
Jul. 1875	Properties in Leicester flooded to 0.6m depth by the River Soar, River Wreake also in flood.
Jan. 1877	Flood along the River Wreake
Jul. 1880	Severe flooding around Loughborough with damage to houses and infrastructure
Jul. 1880	Barkby Brook rose 4m during flooding
Oct. 1880	Flood along the River Wreake,
Oct. 1882	Flood along the River Wreake
Oct. 1885	Flood along the River Wreake
May 1886	Heavy rainfall caused flooding along the River Soar
Jan. 1895	Heavy rain/snow fall caused flooding along the River Wreake
Jul. 1896	Flood along the River Wreake

[6] Hydrochronology website: http://134.36.96.5/default.htm

Table 4.8 (continued) Charnwood Flood History

Year	Details
Feb. 1897	Flooding in Loughborough after heavy rainfall, flooding along River Wreake.
Dec. 1900	Heavy rainfall caused localised flooding around Leicester
? 1903	Severe flooding of the River Soar
Nov. 1906	Flooding along the River Soar 1-2m deep across floodplain
Jul. 1915	Flooding along the Soar valley
Jan. 1926	Soar Valley – "worst flooding in 40 years" – Melton Mowbray to Syston severely affected
1932	Severe flooding of the Soar Valley
1947	Severe flooding of the Soar Valley, Queniborough Brook
Dec. 1948	Flooding along the River Soar - 5.5cm of rainfall recorded in a day at Prestwold Hall
Dec. 1954	Severe flooding of the Soar Valley
1975	Flooding of the River Wreake and Rothley Brook
1977	Severe flooding of the River Wreake (also Rothley Brook)
1979	Flooding of the River Wreake and Rothley Brook
1981, 1982, 1987, 1989, 1992 and 1993	Flooding of the River Soar
Apr. 1998	Severe flooding in Charnwood, principally along the Wreake, and then the Soar below its confluence with the Wreake
Jan. 1999	Heavy rainfall and localised flooding. Damage to railway embankment at Rothley
Dec. 2002	High river levels along the Soar, Wreake and Rothley Brook.

The recent Soar/Wreake floods between Easter 1998 and January 1999 provide a valuable insight into flood risk in Charnwood Borough. Information from the Environment Agency has been used to help guide the understanding of flood risks posed to development in the Borough. Leicestershire was not badly affected by the extreme rainfall which caused flooding across large parts of the UK during the summer of 2007. However, whilst flooding along the main watercourses in the Borough was limited, notable flooding due to overland flow occurred in the settlements around Charnwood Forest in the west of the Borough.

4.5.2 Environment Agency Historical Flood Maps

As part of the Flood Map, the Environment Agency compiles the Historic Flood Map which depicts the maximum extent of all observed fluvial (and tidal) flood events. This can be based on a range of information sources, including aerial photography, flood surveys, questionnaires, interviews etc. Figure 4.16 shows the historical flood extents for Charnwood Borough. These are based on the known extents of previous floods; two layers are shown one showing the extents of the 1947 flood for the Queniborough Brook and the 1977 flood for the Soar, Wreake and Rothley and Black Brooks. A second layer shows the extent of the Easter 1998 flood on the River Wreake (estimated as having a 2.3% annual probability - see Section 4.3.1). The events represent particular rainfall and antecedent hydrological and hydraulic conditions, and provide a guide to the locations and extents at risk from flooding; future flood events may occur in different locations and produce different flood extents.

Historic Flood outlines were only available for the main watercourses within the Borough. The absence of a recorded historic flood outline does not necessarily indicate that flooding has not occurred in the past.

4.6 Secondary Sources of Flooding

Secondary sources of flooding can present significant flood risks to development. PPS25 emphasises the need to consider these other sources of flooding both at the strategic and site level when planning development. It is important to consider secondary sources of flooding for all development locations, not just that in Flood Zone 3a.

4.6.1 Groundwater

Raised groundwater levels caused by prolonged periods of rainfall can result in flooding. New springs may appear in locations previously thought to be safe. Groundwater may not be perceived to be a major factor contributing to flood risk, but over 1000 homes and businesses were affected in the UK in the winter of 2000/2001, mainly over chalk geology in the south of England. Once groundwater flooding occurs, it may take a long time for groundwater levels to fall and flooding to abate. The River Trent CFMP (Environment Agency, 2007) states that groundwater flooding is considered to be only a minor issue within the Trent catchment. Furthermore the groundwater flooding report “Initial Statement (non-chalk Aquifers) Final Report” (Environment Agency, 2006) notes that no verified sources of groundwater flooding have been identified on the permo-triassic sandstones.

In the west areas of harder Precambrian and Ordovician metamorphic/igneous geology around Charnwood Forest generally without boulder clay drift are present. Along the Soar valley Triassic Mercia Mudstone (predominantly red clays and marls with occasional sandstone, siltstone and gypsum interbedding) is overlain with alluvium (gravel, sand and silt deposits) along the soar floodplain with gravel terrace deposits along the valley sides. In the east, much of Charnwood Borough is underlain by a succession of Triassic Mercia Mudstone with intermittent layers of gypsum, the Tea-Green Marl, Shales, Hydraulic Limestone, and Lias Clays, covered by a thick layer of Pleistocene glacial boulder clay drift. Alluvium occupies the valley bottoms of the River Soar, Wreake, Rothley Brook and the lower reaches of other watercourses in the Borough. This moderate to slowly permeable geology is likely to produce a high percentage runoff, with limited potential for groundwater flooding problems, except in areas where historic dewatering has occurred for mining and mineral extraction purposes. There is a limited potential for groundwater flooding associated with the small exposures of river terrace gravels between the clay hillsides and alluvium deposits in the Soar and Wreake river valleys, especially after prolonged seasonal rainfall.

The majority of the catchment is classified as a *Non-Aquifer (negligibly permeable)*[7] due to the presence of low permeability boulder clay drift geology and underlying clay solid geology. A 2km^2 area southwest of Shepshed is classified as Major Aquifer (Highly Permeable) with soils of high to intermediate transmissivity, due to the exposed more permeable gritstone and shale geology. The main river valleys of the Soar and Wreake and their tributaries are classified as *minor aquifers (variable permeability)* with soils of high to intermediate transmissivity, due to the exposed river terrace gravels and alluvium deposits, which are of varying permeability.

Potentially, groundwater flooding may occur behind flood defences, where the defences either block the flow of water through floodplain sediments to the river, or during periods of flooding, where high river levels cause water to pass under flood defences and through the sub-strata and floodplain sediments and emerging within the low-lying defended area.

4.6.2 Sewer Flooding

Sewage and surface water drains pose a potential flood risk to development through a number of mechanisms. If stormwater flows exceed the capacity of the network, water can pond or flow above ground rather than draining via sewers, potentially inundating property. Where sewage and surface water drains are not fitted with one way valves, there is also a risk of floodwater backing up through the drainage network potentially inundating properties. Blockages in the sewerage network can have the same effect, indeed sewer flooding can occur outside of meteorological flood events.

In addition to considering the risks of sewer flooding on planned development, the effects of the development and the resultant increase in sewage flows and surface water runoff must be considered. Inappropriately managed, increased flows could increase the flood risk both at the site and to downstream areas.

Severn Trent Water is the water company responsible for sewage and surface water drainage in Charnwood Borough. They have been consulted to identify areas at risk of sewer flooding in the Borough. Severn Trent Water maintain a database of flood incidents associated with the sewerage network however, as works are carried out to resolve flooding problems, the relevant entries are removed from the database. Appendix D contains the Severn Trent database as it currently stands, which lists incidents by street for both surface water and sewage flood incidents. This list will be updated as upgrading and repair works are carried out, and as new incidents are reported. Furthermore, it does not present a definitive guide to sewer flood risk in the Borough as different areas may be at risk under different meteorological conditions, and new areas may be at risk from the effects of future urbanisation and/ or a 20% increase in flows (climate change scenario).

Nevertheless the database does highlight the importance of considering sewer flooding when planning development, and gives an indication of existing problem areas. Where development is planned, early consultation

[7] *Groundwater Vulnerability 1:100 000 Map Series*, Sheet 23: Leicestershire, Environment Agency.

with Severn Trent Water is necessary to identify potential risks to the development or issues associated with the additional load on the sewerage infrastructure, so that sewer flood risk can be appropriately managed.

4.6.3 Overland Flow

Overland flow can be defined as water flowing over the ground surface that has not entered a natural drainage channel or artificial drainage system. Overland flow flooding is sometimes also referred to as pluvial flooding or surface water runoff.

When the infiltration capacity of land is exceeded, excess rainwater flows overland; this water will collect in topographic depressions and at obstructions, and can inundate development downslope. The severity of the rainfall event, the degree of saturation of the soil before the event, the permeability of soils and geology, hillslope steepness and the intensity of land use all contribute to and affect the severity of overland flow. Rural land-use management can have significant impacts on the speed and volume of runoff produced. Areas with large upslope catchments will be particularly prone.

Large areas of the Borough are overlain by Pleistocene boulder clay drift. Alluvium occupies the valley bottoms of the River Soar, Wreake, Rothley Brook and the lower reaches of other watercourses in the Borough. These extensive areas of clay and the undulating topography result in catchments throughout the Borough responding quickly to rainfall events (i.e. heavy/prolonged rainfall quickly converts to surface runoff rather than infiltrating into the ground) and may pose a risk of overland flow flooding.

Different areas may experience problems with overland flow under different rainfall severities and patterns, antecedent conditions and land use. In particular, new development on greenfield land poses a risk of exacerbating problems through increased runoff and changes to natural drainage. PPS25 provides a mechanism for ensuring such effects are mitigated (e.g. through the use of measures such as SuDS, see Section 6.2.2) by requiring that when planning new developments, there must be consideration not only of the flood risks to the development itself but also the risks that the development poses to sites elsewhere.

At highest risk are sites which have a large, steep contributing catchment area upslope, particularly where local topography could concentrate flows, and where there are no watercourses to intercept overland flow. In Charnwood, sites most at risk are likely to be located along the valley sides, at the transition between the valley side slopes and the flat floodplain of the main watercourses. As a regional example overland flow due to heavy rainfall on saturated ground resulted in flooding at Asfordby in nearby Melton during the winter of 1998. On this occasion overland flow followed the local topography along a former watercourse causing flooding in Asfordby before flowing to the River Wreake. Within urban areas the surcharging of urban drainage systems can result in localised overland flow, and flooding of development located in associated flow paths.

In Charnwood flooding due to surface water occurred in Loughborough in 1998 during the periods of heavy rainfall which caused the severe floods of that year. In the summer of 2007, flooding due to overland flow occurred in parts of Swithland, Woodhouse Eaves, Rothley, Nanpantan and Newtown Linford; these settlements being located around the steep slopes of the Charnwood Forest area. The risk of flooding due to overland flow is not considered to be a constraint on potential development, however mitigations should be taken. There is therefore a particular need for new development in the areas that experienced recent flooding from overland flow to be designed to be unaffected by overland flows.

Since overland flow depths are generally shallow, flood risk can be managed by ensuring good urban design. By raising groundfloor levels 0.15m above the local topography and by ensuring levels are above those of surrounding roads which often convey flows, overland flow can be prevented from flowing directly into properties. Development should also be laid out so that gaps remain between houses, to pass on overland flow, rather than restricting flow and increasing flood depth and hence local damage. Further Guidance can be found in CIRIA C635 “Designing for Exceedance in Urban Drainage – Good Practice”. With topographical data further computer modelling could be carried out to identify locations particularly at risk of flooding from overland flow.

4.6.4 Blockage of Artificial Drainage Systems

Where watercourses have been enclosed there can be potential for blockage and/or insufficient conveyance of peak flows. Flooding can occur due to subsequent backing up of culverts so that water overflows the channel and follows the lowest topography overland. Culvert collapses, fallen trees, cars and skips are common causes of blockage. Whilst, the lack of an appropriate trash screen at a culvert entrance may exacerbate the risk of flooding due to the risk of blockage inside a culvert, trash screens themselves can cause flooding due to blockages; the risks must therefore be balanced.

Where a specific problem exists, the preferred option is to reduce the risk of flooding by opening up the culvert, a process known as ‘deculverting’ and an option for which new developments should aim for. If this is not possible, options to increase the culvert capacity and to improve the trash screens or provide adjacent ancillary storage to manage flooding up to design event flood flows should be investigated. Regular maintenance also minimises the potential for blockages to occur. There should be a presumption against the future culverting of open watercourses.

4.6.5 Flooding from Infrastructure Failure

In Charnwood, areas located downstream of large infrastructure assets includes:

- Downstream of the Blackbrook Reservoir - northern areas of Loughborough adjacent to the Black Brook;
- Downstream of Cropston and Swithland Reservoir – the Quorn Brook through Quorn; and
- Downstream of Nanpantan Reservoir – Wood Brook through Loughborough.

Where infrastructure exists that retains, transmits or controls the flow of water (such as reservoirs and canals), flooding may result if there is a structural, hydraulic, geotechnical, mechanical or operational failure. For large storage structures (e.g. reservoirs, detention dams etc), the Reservoirs Act 1975 requires the regular inspection by a

competent person of all water-retaining structures over 25 000 m^3. Provided these inspections are carried out regularly and thoroughly, the likelihood of a catastrophic breach can be considered minimal.

4.6.6 Highways

Flooding can occur due to a combination of overland flow, infrastructure failure and drainage capacity exceedance. Impacts are exacerbated by the effects of vehicles causing 'road wash' where waves of water displaced by passing vehicles pass into adjacent properties. Where redevelopment occurs adjacent to roads, the opportunity should be taken to set buildings back from the road edge, and/or to raise the groundfloor levels either above the road level, or where land slopes down away from the road above the local topography.

Appendix D contains details of the highways which Leicester County Council's Highways Division patrols at times of potential flooding. Details of roads which flooding due to the extreme rainfall during summer 2006 and 2007 are also included. These details should be used to inform the assessment of flood risk to potential development sites.

4.6.7 Instances of Flooding from Fluvial and Secondary Sources in Charnwood

Based on the information collected, a number of observations have been made about both fluvial and other sources of flooding in Charnwood Borough, Table 4.9 contains abstracts of flood incidents from the River Soar FRMS.

- **Fluvial flooding:** Fluvial flooding (due to natural out of bank flow, with the watercourse occupying its floodplain) has occurred along the Rivers Soar, Wreake and Rothley/Queniborough Brooks. In most other cases, channel constrictions and obstructions appear to be the main cause of flooding associated with a watercourse;

- **Drainage structures:** Ditches, culverts and other drainage structures appear to be common causes of flooding in the catchment, either due to blockages, asset deterioration or insufficient capacity (causing afflux) which has been potentially worsened by development in the catchment. Historic examples include:

  - Flooding associated with the Queniborough Parish Dyke (Jan. 1999) causes: restrictive (unconsented) culvert, siltation, channel obstruction and inadequate grillage;

  - The Nook, Anstey – regular flooding until: 1960s: diversion of upper 85% of catchment; mid-1990s: STW CSO reduction scheme reduced flooding occurrence. 2000s: structural failure of parts of the remaining Leicester Road culvert in Anstey, ~40 properties suffer from flood damage associated with culvert backing up;

  - Syston – severe flooding along the Barkby Brook in 1947, 1992 and 1993 ~140 properties estimated to be at risk. Channel capacity remains exceeded up to 20% of the time in a given year, with property flooding occurring 5%.

- **Overland flow**: Soar FRMS notes problems around Cossington.

- **Groundwater**: No recorded instances**;**

- **Sewage**: Severn Trent Water has installed attenuation storage at Shepshed. A CSO reduction scheme was commissioned at Anstey in the 1990s which consequently reduced flooding in The Nook;

- **Grand Union Canal**: Potentially flooding could occur if the Wood and Burleigh Brook drop culverts, and other culverts under the Grand Union Canal are blocked or of insufficient capacity to convey runoff from significant rainfall events, causing floodwaters to back up. At The Wharf in Loughborough Town Centre, levels typically fluctuate by 50-75mm. A connection exists between the Canal Basin and the Wood Brook controlled by a sluice. Depending on levels water can flow either way: during dry weather flows, water levels in the Wood Brook are lower than water levels in the canal; this situation can reverse during a flood event. In addition the canal potentially provides a direct flow path for the higher flood levels in the River Soar upstream of Loughborough into Loughborough. No notable flooding appears to have occurred through this mechanism historically, and it is not clear if an uninterrupted flow path exists to convey floodwaters.

Table 4.9 Key Flood Risk Locations from Soar FRMS

Location	Detail
Syston and Wanlip	Hope and Anchor PH, Old Junction Boatyard
Cossington	Cossington Mill from Soar, flooding due to overland flow elsewhere
Rothley	Flooding associated with backing-up of the Rothley Brook when the Soar is in flood.
Sileby	Sileby Mill – Engineering works adjacent to Sileby Brook-Soar confluence; regular flooding of roads across the floodplain in the area
Barrow Upon Soar	Meadow View Farm, Proctors Pleasure Park (caravan site), road between Barrow and Quorn.
Cotes	Several properties and the A60 road.
Loughborough	Wood Brook nr. The town centre and at the Belton Park Industrial Estate (flooding in 2000), properties at risk along the Black Brook and Burleigh Brook.

4.7 Existing Flood Alleviation Schemes

A number of flood alleviation schemes have been investigated and commissioned to alleviate flooding problems in Charnwood Borough. Historically, the River Soar Flood Alleviation Scheme in the 1980-90s included a series of works as far downstream as Quorn and has successfully reduced the risk of flooding. The River Soar FRMS (EA, 2006) includes the option for further improvements to flood conveyance downstream of Quorn along the Soar up to the confluence with the River Trent. The Borough Council is concerned to ensure that any further flood alleviation measures are designed to be compatible in scale and use of materials with the ecological and scenic value of the river valleys and does not increase flood risk elsewhere.

4.7.1 Brentingby – Melton Mowbray Flood Alleviation Scheme

Although located on the River Eye (Wreake) upstream of Melton Mowbray, the Brentingby online storage facility provides some reduction to flooding on the Wreake as far downstream as the Lower Soar/Wreake through Charnwood. For the 1% flood, the River Soar FRMS (Table 3.4 and 3.5) indicates a 40% reduction in both the amount of properties flooded, and in the present value damage. In Charnwood, the reduction is particularly notable at Syston.

In response to the Easter 1998 flood event, Melton Borough Council and the Environment Agency together with English Nature and Defra implemented the Melton Mowbray Flood Alleviation Scheme. This was completed in July 2001 and comprises an on-line storage upstream of Melton Mowbray at Brentingby on the River Eye. The structure consists of an earth embankment approximately 470 m long with a crest level 5 m above the floodplain. Floodwaters are controlled by automatic gates that are operated according to river level data supplied by gauging stations in the area. The scheme has been designed to attenuate flows in the Eye/Wreake of up to the 1 in 100 year flow down to a maximum of the 1 in 5 year flow.

The Melton Mowbray Flood Alleviation Scheme has a significant effect on downstream fluvial flood risk. As a direct result, large areas of Melton Mowbray and the natural River Eye/Wreake floodplain now benefit from the protection afforded by the dam. However, the Environment Agency has indicated that there is limited freeboard in this protection and that no allowance for climate change has been included. Areas in the downstream floodplain which are currently benefiting from the protection afforded by the dam remain in the Environment Agency's flood Zones 2 and 3, as although the flood risk has been significantly reduced, there remains 'residual' risk (see Section 4.8).

4.7.2 Existing Flood Defences

Details of existing flood defences in Charnwood have been abstracted from the Environment Agency's National Fluvial and Coastal Defence Database (NFCDD), and are provided in Appendix E and shown in Figure 4.17.

Broadly, in Charnwood defences with a 1% Standard of Protection (SoP) are found adjacent to the Loughborough, Quorn, Rothley and Thurmaston urban areas along the River Soar, Black Brook, Hermitage Brook, Rothley Brook and Quorn Brook. Large stretches of defences with a SoP of 10% also exist along the River Soar between Quorn and Zouch.

Further defences exist along several other watercourses in the Borough, notably the Fishpool and Sileby Brooks, however a SoP for these defences is not provided in NFCDD.

The NFCDD abstracts in Appendix E are not necessarily definitive, and additional localised private structures may exist. In some areas the walls of buildings and infrastructure not designed to act as a flood defence may be serving a flood defence purpose (termed 'informal' flood defences); typical examples include railway and canal embankments and old industrial buildings adjacent to watercourses. It is important that when brownfield sites in the vicinity of watercourses/flood risk areas are redeveloped structures acting as flood defences are identified, and mitigations taken so as not to increase the flood risk to adjacent people and property.

Under current predictions the SoP provided by defences will decrease with increased river flows and hence higher flood levels in the future due to climate change. In addition continued maintenance and investment is required into flood defences to ensure they remain in a suitable operational condition. The residual risk (see Section 4.8) of flood defences failing should also be considered.

4.7.3 Other Schemes/ Investigations

Various flood alleviation schemes have been proposed and investigated in Charnwood Borough to address a number of different flooding issues. Several projects have now been implemented. The main schemes and investigations are summarised in Table 4.10.

Table 4.10 Flood Alleviation Schemes and Investigations in Charnwood

Scheme	Year	Details
Implemented		
Wymeswold – Culvert Replacement	2005	Replacement of culverted, diverted stretch of the River Mantle in poor structural condition.
Melton Mowbray Flood Alleviation Scheme - River Eye/Wreake	2003	On-line flood storage at Brentingby upstream of Melton Mowbray on the River Eye to attenuate flows to a maximum of the 1 in 5 year flow (for up to the 1 in 100 year event).
Anstey Flood Alleviation Scheme	2003	Replacement of structurally defective culvert (<1 in 10), which had in places collapsed causing blocking the culvert. Replacement estimated to provide >1 in 100 SoP.
Sileby Flood Alleviation Scheme	2002	Widening and regrading of 900m of watercourse.
Queniborough Parish Dyke	2000	Improvements to inlet grillages after Jan. 1999 flooding. Subsequent inspection of watercourse and culvert alongside improvement in maintenance procedures and channel encroachment. Council operated telemetry system installed to warn of high levels. Subsequent use of developer betterments under S106 agreements.
Syston, Barkby Brook Flood Alleviation Scheme – Phase I – III	1995 - 1998	I – Syston Playing Fields: channel desilting and widening; II – Broad & Brookfield St: channel desilted and widened; III – Meadow Lane: channel desilted and widened, bypass culvert built to increase capacity. In addition maintenance and inspection has been carried out, alongside the identification of work required on private riparian land. Local Flood warning system instigated in co-operation with the EA.
Quorn Flood Alleviation Scheme, Leicester Road	Early 1990s	System of flood walls, flood embankments and channel improvements (realignment/removal of constrictions). Designed to 1% (1 in 100) SoP. Protects against flooding from either the River Soar or the Quorn Brook. Quorn Town Lands Park is integral to the scheme as a flood storage area.
Soar Valley Improvement Scheme	Early 1990s	Program of works carried out by STW along the River Soar, such as the Quorn FAS.
Frisby Balancing Lakes - River Wreake	Late 1980s	Creation of off-line storage in old gravel pits, to attenuate flows and increase protection downstream of Frisby.

Table 4.10 (continued) Flood Alleviation Schemes and Investigations in Charnwood

Scheme	Year	Details
Barrow Upon Soar	1980s	Flood relief walls
Black Brook – Thorpe Acre	1977 – 1980s	Construction of embankments and channelisation of the Black Brook through Thorpe Acre by Charnwood Borough Council. Later lining of channel with concrete and geotextiles.
The Nook, Anstey	1960s	BuS RDC – diverted 85% of the catchment via a new outfall to the Rothley Brook
	1990s	STW – CSO reduction scheme further reduced the occurrence of flooding
Quorn, Leicester Road		Flood relief culvert
Newtown Linford, Bradgate Road		Flood relief culvert
Stapleford		Replacement of collapsed culvert at Stapleford Park
Cossington, Main Street	?	Replacement of structurally inadequate culverts under highway. Flood Relief Ditch
Not Implemented		
Queniborough Flood Alleviation Scheme	2004	Three options: enhanced maintenance, culvert enlargement or flood storage. Cost benefit ratio of proposed scheme below unity. Minimal DEFRA priority score.
Syston, Barkby Brook Flood Alleviation Scheme – Phase IV	2004	Potential for upstream flood storage investigated. Limited cost-effectiveness, due to high land prices. Flood walls through Syston seen an option, but benefits limited to only a few properties and potential issues with separation of piped outfalls with non-return valves. Continued maintenance recommended together with provision for flood proofing measures for 1 property. FRA associated with redevelopment of remaining the property to reduce impact of flooding.
Swithland	2000	Watercourse improvements to lower flood risk to adjacent properties.
Rothley	2000	Watercourse improvements to lower flood risk to adjacent properties.
River Wreake	1980s	Feasibility investigations into improving flood conveyance in the Wreake through removal of structures. Not implemented, though some minor work was carried out at Cotes, Pillings and further down the Soar outside of Charnwood to increase channel capacity.

4.8 Residual Flood Risk

It is important to note that no flood alleviation scheme completely removes the risk of flooding. All schemes are designed to a specific design flood event and flooding will still take place if a more extreme event occurs. Furthermore, there is a risk that flood alleviation schemes could fail (either structurally or operationally).

The term 'residual risk' is used to describe the risk that remains after taking flood alleviation measures into account. Risk is a product of probability and consequence; therefore although areas protected by flood alleviation schemes may be at a low risk of flooding, if these failed, the consequences would be very high (i.e. in terms of the damage to property and risk to life). This risk remains whatever the standard of flood defence, and PPS25 will require an evaluation of this risk as part of the FRA for any development planned in a defended area.

With respect to development planning and the guidance in PPS25, areas in the high flood risk zone (i.e. Zone 3a) that are defended from flooding are not differentiated from those that are undefended, since there remains a residual risk if flood alleviation measures are overtopped or fail.

4.9 Climate Change

4.9.1 General Guidance

Over time, climate change could have a significant effect on flood risk, as it is expected to cause winters to become wetter and summers to become drier. The insurance industry has warned that premiums could rise as flood prone properties become more difficult to protect, and in future if insurance companies feel protection from flooding is not adequate, some properties may be unable to obtain insurance against flooding altogether. Climate change could mean that extreme weather events such as droughts, floods and storms could become more common. For the East Midlands, interpretation[8] of the UK Climate Impacts Programme (UKCIP) model predicts (High Emissions Scenario):

- By 2050, there could be up to a 15% increase in winter rainfall; and
- By 2050, there could be up to a 30% decrease in summer rainfall.

and:

- By 2080, there could be up to a 30% increase in winter rainfall; and
- By 2080, there could be up to a 45% decrease in summer rainfall.

Due to climate change it is currently thought that there will be an overall increase in total winter rainfall and an overall decrease in total summer rainfall. However, rainfall is likely to become much more intense, with rainfall (particularly in the summer months) increasingly falling in short duration high-intensity events.. This could potentially be exacerbated by urban heat island effects, associated with Leicester. Due to wetter winters, groundwater levels could increase in winter months, potentially exacerbating groundwater flooding problems in prone areas. PPS25 (Table B.2) recommends that there be an allowance for up to a 10% increase in peak river flows by 2025, and up to 20% by 2115 to account for the potential effects of climate change based on current guidance.

Increased storminess and higher peak rainfall values will also cause increases in runoff. Water companies have indicated that, under such scenarios, the current design standard for surface water drainage sewers will need to take climate change into account. PPS25 (Paragraph B10) recommends that there be an allowance for up to a 10%

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[8] The potential impact of climate change in the East Midlands - An update of the report for East Midlands Sustainability Round Table, published in July 2000, EMRA, 2004

increase in rainfall intensities by 2055, 20% by 2085, and up to 30% increase by 2115 to account for the potential effects of climate change based on current guidance.

4.9.2 Climate Change and Development Planning

PPS25 requires that flood risk and its mitigation are assessed for the lifetime of any proposed development. The Sequential Test guides new development to areas of low flood risk, i.e. Zone 1. However, where development is proposed for the higher risk flood zones, the climate change guidance provided in PPS25 (and outlined in Section 4.9.2) should be used to assess the effect of climate change on flood risk posed to new development, and to ensure the robustness of any mitigation measures. Changes in extents and depths of flooding due to climate change are discussed in detail in Section 4.3. Where modelling output is not available, the Environment Agency's flood zones can provide some indication of areas where climate change might cause the most lateral expansion of inundation, by comparing Zone 3a with Zone 2 to see how rare, more extreme flows affect the floodplain extents. For development proposed in or near the boundaries of the higher risk flood zones, a detailed assessment of flood risk, including the potential effects of climate change, will be required in the FRA.

In addition to fluvial flood risk, climate change must also be considered in the context of its potential to increase surface water runoff. An assessment of the potential effect of climate change on runoff and associated flood risk, and testing of mitigation measures for robustness, will be required in the FRA. Guidance on changes in rainfall intensity are provided in Table B.2 of PPS25.

The impacts of a 20% increase in river flows scenario has been investigated as part of the hydraulic modelling undertaken for the SFRA. Section 4.3 discusses the outcomes of this modelling; information on each modelled watercourse is provided in paragraphs 4.3.15, 4.3.20, 4.3.25 and 4.3.32 for the River Soar, River Wreake, Rothley Brook and the Black, Burleigh Wood Brooks respectively.

4.10 Land Use

Land use and land use change may have a more immediate effect on the hydrology of a catchment, where step-changes in land use effect changes in the catchment's responsiveness to rainfall events. The frequent location of development and urban areas in valley bottoms near major rivers often leaves them vulnerable to the effects of land use change in the upper catchment. The implications will depend on the extent of the land use change and the type of catchment (i.e. its geology, topography and the hydraulic connectivity of its watercourses, which largely affects how 'flashy' the catchment is in response to a rainfall event). The flow data and flood records available for Charnwood Borough indicate that its watercourses respond quickly to rainfall events. Broadly, land use change can be divided into two categories:

1. Change in agricultural land use;
2. Conversion from rural to urban land use.

Because a large proportion of Charnwood Borough's land is used for agricultural purposes, small changes in agricultural land use practices could have a significant effect on the proportion of rainfall that is intercepted by vegetation, or that infiltrates into the soil (and underlying aquifer), or that runs off as overland flow to watercourses. Where runoff presents local flooding problems, there may be potential for various mitigation measures and practices to be put in place in agreement with farmers and land owners to reduce peak runoff rates[9]. The Soar FRMS has identified the potential for reducing flood levels by improving rural land-management practices, but concludes that achieving reductions will be difficult given the complexity and distributed nature of the measures that would be required. However, through the identification of key sources of runoff and close working with landowners potential strategies with flood risk reduction benefits may be able to be identified.

In the case of increasing urbanisation, Sustainable Drainage Systems (SuDS) have been developed as a way to manage drainage to mimic the natural (greenfield) runoff rates. The implementation of SuDS systems in new developments is instrumental in ensuring that flood risk is not adversely affected by the planned development. This should be enforced at the development planning stage through PPS25.

Flood mitigation measures are discussed further in Section 7.3.

4.11 Assumptions and Uncertainty

4.11.1 Primary (Fluvial) Flooding

The assessment of fluvial flood risk in the Charnwood SFRA has been based on outputs from hydraulic models where available, and supplemented with the Environment Agency's flood zones. The use of output extents from hydraulic models is preferred since it provides a refined understanding of the potential flood levels. These models include a more detailed consideration of in-channel flow and of floodplain structures and flood alleviation schemes, producing a clearer outline of areas at risk and information on depth of flooding. In addition, historical flood extents have been used to further delineate areas potentially at risk from fluvial flooding.

The limitations of using the JFLOW derived flood zones have been outlined in Section 4.3.5. One key aspect to note is that JFLOW derived flood zones do not account for structures in the floodplain, which includes the various flood alleviation schemes outlined in Section 4.7 (principally the Melton Mowbray Flood Alleviation Scheme). As a result, there will be areas downstream of these schemes that are afforded some protection by these structures, but that remain in the high risk flood zone (i.e. Zone 3a).

This is in line with the approach to development planning as set down in PPS25, which recognises the residual risk associated with areas protected by flood alleviation schemes (see Section 4.6) and directs development to areas of

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[9] The Pontbren case study provides further information, see:
http://www.ceh.ac.uk/sections/bef/Pontbren.html; and
http://www.floodrisk.org.uk/content/view/89/1/

lower flood risk. However, there may be some cases where development is proposed in these areas to avoid urban blight, for example the redevelopment of brownfield sites in Loughborough. A detailed development-specific FRA will be required which considers the protection afforded by the respective scheme, and the residual flood risks associated with development in this area.

The borough wide assessment in this SFRA does not preclude the need for developers to produce a detailed site specific FRA where requested by the EA/LPA and/or identified as necessary by PPS25 Table D1 or the Flood Risk Matrix[10]

4.11.2 Secondary Sources of Flooding

A large amount of information concerning flooding from drainage systems, overland flow, blocked culverts has been collated for this study. Some records of sewer flooding have also been obtained from Severn Trent Water. However, it is noted that it is not possible to quantify the risk of future flooding from these historical flood records as they represent particular hydrological events, and more extreme, or different, events could present different levels of risk in different locations. Instead, they provide valuable background information to help identify and characterise the various flood risks present in Charnwood Borough. This information can then be used to guide the focus of more detailed FRAs to minimise the flood risk associated with developments through appropriate planning, design and mitigation measures.

[10] http://www.pipernetworking.com/floodrisk/matrix.html

5. Detailed Assessment of Potential Development Locations

5.1 Introduction

In line with the emerging development targets set out in the draft Regional Plan, Charnwood Borough Council is currently assessing its strategy for future development. As outlined in Section 2, it is estimated that, in addition to redevelopment of brownfield sites, potentially several hundred hectares of greenfield land will be required to meet local development needs. Consideration is to be given to the following potential locations for future development (see Figure 2.1 for locations):

- Within Loughborough Town Centre;
- Adjacent to Loughborough:
- West of Shepshed;
- West of Loughborough;
- South of Loughborough;
- East of Loughborough (east of the River Soar);
- North of Loughborough near Hathern;
- Wymeswold airfield;
- Adjacent to the Leicester PUA;
- East of Thurmaston and North of Hamilton;
- North of Birstall; and
- Adjacent to Glenfield within Charnwood south of Anstey.

Future development may also occur at:

- Other sites identified in the Housing Land Availability Assessment throughout the Borough;
- Loughborough Science Park (New Ashby Road).

Flood risk is an important consideration in guiding the location of new development in the Borough, highlighted by recent flood events that have inundated properties, some of which have been affected repeatedly. The key objective of this SFRA is to assess flood risk throughout the Borough, focussing on the potential areas of development, to ensure informed planning decisions that minimise flood risk associated with new development.

In prioritising the potential areas of development, PPS25 (based on its predecessor PPG 25, see Appendix A) will be the key policy driver. The PPS25 Sequential Test provides a rigorous process for assessing and prioritising the location of planned development with respect to flood risk. It is primarily based on the outcomes of the SFRAs flood risk mapping, or where mapping has not been undertaken the Environment Agency's Flood Zone Map. Other sources of flooding that must also be considered, and potential future flood risks (such as changes in land use or climate) and residual flood risks are outlined in Section 4 of this SFRA.

The overriding aim of the Sequential Test is to steer all new development to the lowest flood risk zone (i.e. Zone 1). Where this is not possible, development may be permitted in the higher risk flood zones depending on the vulnerability of the proposed land use, if the criteria of the Exception Test are met (see Section 3.2.2).

This section provides an assessment of the potential areas of development in Charnwood Borough in line with the objectives of the PPS25 Sequential Test, with a view to informing planning decisions on the location of future development in the Borough. The local flood risks identified in each area can then guide more detailed FRAs of sites selected for development.

To avoid repetition, flood risk issues that potentially affect all the proposed potential areas of development, in particular the control and management of development runoff, overland flow flooding and sewer flooding have not been included in this section. Note that these are all important issues that can have a substantial impact on flood risk associated with a new development, and their early consideration in the planning process is important in the success and efficiency of flood risk management. Section 7 contains further detail on flood risk mitigation for developments, including a discussion of drainage management.

5.2 Flood Risk to the Loughborough SUEs

The broad areas under consideration for a potential Sustainable Urban Extension (SUE) at Loughborough are indicated in Figure 2.1. The following sections comprise an assessment of the local flood risks affecting each of the broad areas.

5.2.1 Flood Risk – Potential West of Loughborough SUE (see Figure 2.1)

This SUE would be situated west of Loughborough, approximately between urban limit of Loughborough and the M1 motorway. Elevations range from approximately 70 to 50 m AOD. The area drains from the south towards the Black Brook and its tributary the Oxley Gutter which runs through the centre of the area under consideration. Both of these water courses are Main River, maintained by the Environment Agency. Detailed modelling of the Black Brook has been carried out to better define the extent of the flood zones shown in the EA Flood Map, whilst only a short section of the Oxley Gutter is featured on the EA's Flood Map. Historically, the Black Brook has been associated with flooding further downstream in the Thorpe Acre area. Potential flood risks to consider with respect to development in this area include:

- Fluvial flooding from the two Main River watercourses (known to be associated with downstream flooding) at present and under future climate change scenarios – Flood Zone only defined for the Black Brook, but not the Oxley Gutter;
- Overland flow from higher land to the south of the potential development areas;
- Blockages/ insufficient capacity of bridges/culverts on the two watercourses (including existing structures and any proposed in association with new development);
- Providing upstream balancing capacity to attenuate flood flows on the Wood Brook;
- Need to manage runoff in view of downstream flooding and backing-up of the Black Brook when the River Soar is in flood - SuDS important to attenuate increases in runoff; and
- Key issue: appropriate runoff management and flood flow balancing along the Wood Brook, especially with regards of flood risk to existing development downstream

5.2.2 Flood Risk – Potential South of Loughborough SUE (see Figure 2.1)

This SUE would be situated south of Loughborough. Elevations range from approximately 80 to 50 m AOD. The western area drains to the north east, into the Wood Brook; the eastern area drains into the Woodthorpe Brook and the Poultney Brook (which passes through Quorn before joining the Soar). Both of these watercourses are ordinary watercourses, except the lower stretch of the Poultney Brook through Quorn which has recently been enmained to Main River due to the potential properties at risk of flooding in Quorn. Some modelling of the Wood Brook has been carried out (see Appendix C) to better define the extent of the flood zones shown in the EA Flood Map. The EA Flood Map includes estimated flood extents for the Poultney Brook, but not the Woodthorpe Brook. The Wood Brook has been associated with flooding further downstream in the vicinity of Loughborough Town Centre. Potential flood risks to consider with respect to development in this area include:

- Fluvial flooding from the three watercourses (known to be associated with downstream flooding) at present and under future climate change scenarios – Flood Zone only defined for the Wood Brook and Poultney Brook, but not the Woodthorpe Brook;
- There are significant flood risk issues along the Wood Brook through as it passes through Loughborough. New development should ensure existing flood risk is not increased, and where possible seek to provide reductions in overall flood risk;
- Overland flow from higher land west and south of the potential development areas;
- Blockages/ insufficient capacity of bridges/culverts on the three watercourses (including existing structures and any proposed in association with new development);

- Need to manage runoff in view of downstream flood risk on the Wood and Poultney Brooks, through Loughborough and Quorn respectively - SuDS important to attenuate increases in runoff; and

- Key issue: appropriate runoff management, especially with regards of flood risk to existing development downstream

5.2.3 Flood Risk – Potential East of Loughborough SUE (see Figure 2.1)

This SUE would be situated east of Loughborough and east of the River Soar, creating a new urban area associated with Loughborough. Elevations range from approximately 70 to 45 m AOD. The area drains to the west, into the River Soar; via the Hoton, Burton and Walton Brooks. All three of these watercourses are ordinary watercourses (there is only isolated development adjacent at present). Due to the limited size of the watercourse and their catchments only basic modelling of the watercourses has been carried out for the EA Flood Map. Potential flood risks to consider with respect to development in this area include:

- Fluvial flooding from the River Soar at present and under future climate change scenarios – development areas need to be sufficiently set back from the extent of the River Soar floodplain, to avoid flood risk at present and in future;

- Fluvial flooding from the three watercourses at present and under future climate change scenarios, currently not a flood risk issue due to limited development, development should be set back from these watercourses and their associated flood zones;

- Overland flow from higher land east of the potential development areas;

- Blockages/ insufficient capacity of bridges/culverts on the three watercourses (including existing structures and any proposed in association with new development);

- Need to manage runoff in view of downstream flood risk along the River Soar - SuDS important to attenuate increases in runoff; and

- <u>Key issue: appropriate runoff management, especially with regards of flood risk to existing development downstream AND any new distributor road which will need to cross the Soar floodplain – this road would need to be designed so as not to impede flood conveyance and to remain operational at times of flooding at present and under future climate change scenarios (see SFRA para. 3.3.8).</u>

5.2.4 Flood Risk – Potential North of Loughborough towards Hathern SUE (see Figure 2.1)

This SUE would be situated north of Loughborough, approximately between the A6 and the Shepshed – Hathern Road. Elevations range from approximately 70 to 50 m AOD. The area drains from the north towards the Black Brook. The Black Brook is a Main River, maintained by the Environment Agency. Detailed modelling of the Black Brook has been carried out to better define the extent of the flood zones shown in the EA Flood Map.

Historically, the Black Brook has been associated with flooding further downstream in the Thorpe Acre area. Potential flood risks to consider with respect to development in this area include:

- Fluvial flooding from the Black Brook (known to be associated with downstream flooding) at present and under future climate change scenarios;
- Overland flow from higher land northwest of the potential development areas;
- Blockages/ insufficient capacity of bridges/culverts on black Brook (including existing structures and any proposed in association with new development);
- Need to manage runoff in view of downstream flooding and backing-up of the Black Brook when the River Soar is in flood - SuDS important to attenuate increases in runoff; and
- <u>Key issue: appropriate runoff management, especially with regards of flood risk to existing development downstream.</u>

5.2.5 Flood Risk – Potential Wymeswold Airfield SUE (see Figure 2.1)

This SUE would be situated east of Loughborough and east of the River Soar. Elevations range from approximately 90 to 70 m AOD. The western portion of the broad area drains to the south east, into the Burton Brook; the eastern area drains to the north into a tributary of the River Mantle, which joins downstream of Wymeswold, this watercourse is too small to have been included in the EA Flood Map. Both of these watercourses are ordinary watercourses; the River Mantle downstream of the site is classed as a Main River due to the potential properties at risk of flooding upstream of the confluence in Wymeswold. Due to the limited size of the watercourses and their catchments only basic modelling of the watercourses has been carried out for the EA Flood Map. Potential flood risks to consider with respect to development in this area include:

- Fluvial flooding from the tributary to the River Mantle – at present and under future climate change scenarios;
- Overland flow from higher land west and south of the potential development areas;
- Blockages/ insufficient capacity of bridges/culverts on the three watercourses (including existing structures and any proposed in association with new development);
- Need to manage runoff in view of downstream flood risk - SuDS important to attenuate increases in runoff; and
- Key issue: appropriate runoff management, especially with regards of flood risk to existing development downstream AND any new distributor road which will need to cross the Soar floodplain – this road would need to be designed so as not to impede flood conveyance and to remain operational at times of flooding at present and under future climate change scenarios (see SFRA para. 3.3.8).

5.2.6 Flood Risk – Potential West of Shepshed SUE (see Figure 2.1)

This SUE would be situated west of Shepshed, approximately between urban limit of Shepshed and the Charnwood Borough boundary. Elevations range from approximately 90 to 50 m AOD. The area drains towards the northeast, to the Black Brook which runs through the centre of the area under consideration and via several minor tributaries. The Black Brook is a Main River, maintained by the Environment Agency. Detailed modelling of the Black Brook has been carried out to better define the extent of the flood zones shown in the EA Flood Map. The Black Brook has been associated with flooding further downstream in the Thorpe Acre area. Potential flood risks to consider with respect to development in this area include:

- Fluvial flooding from the Black Brook Main River watercourses (known to be associated with downstream flooding) at present and under future climate change scenarios – Detailed Flood Zones modelled for the Black Brook;
- Blockages/ insufficient capacity of bridges/culverts on the two watercourses (including existing structures and any proposed in association with new development);
- Need to manage runoff in view of downstream flooding and backing-up of the Black Brook when the River Soar is in flood - SuDS important to attenuate increases in runoff; and
- Key issue: appropriate runoff management, especially with regards of flood risk to existing development downstream.

5.2.7 Flood Risk – Loughborough Science Park

A potential location for the Loughborough Science Park is west of Loughborough, approximately between the urban limit of Loughborough and the M1 motorway, south of New Ashby Road. Elevations range from approximately 80 to 60 m AOD. The area drains to the northeast into the headwaters of the Burleigh Brook which run through the centre of the area under consideration. Downstream of the site the Burleigh Brook has been enmained to Main River due to the flood risk to properties. The council hold a hydraulic model of the Burleigh Brook has been produced to better define the extent of the flood zones shown in the EA Flood Map. The Burleigh Brook has been associated with flooding further downstream in the Grand Union Canal Wharf area. Potential flood risks to consider with respect to development in this area include:

- Fluvial flooding from the Burleigh Brook (known to be associated with downstream flooding) at present and under future climate change scenarios;
- Overland flow from higher land south of the potential development area;
- Blockages/ insufficient capacity of bridges/ culverts on the watercourses (including existing structures and any proposed in association with new development);
- Need to manage runoff in view of downstream flooding - SuDS important to attenuate increases in runoff; and

- Key issue: appropriate runoff management, especially with regards of flood risk to existing development downstream AND potential for online storage on Wood Brook tributary

5.3 Flood Risk to the Leicester PUA Potential SUEs

Three potential SUEs have been identified adjacent to Leicester in Charnwood Borough:

- East of Thurmaston and North of Hamilton;
- North of Birstall; and
- Adjacent to Glenfield within Charnwood south of Anstey.

Figure 2.1 shows the location of these broad areas. Figures 5.7 to 5.8 provide a more detailed view of each area. The following sections comprise an assessment of the local flood risks affecting each potential SUE.

5.3.1 Flood Risk – Potential East of Thurmaston and North of Hamilton SUE (see Figure 2.1)

This SUE would be situated east of Thurmaston and the River Soar in the south of Charnwood Borough, north of Hamilton in neighbouring Leicester City. Elevations range from approximately 60 to 100 m AOD. The northern margin of the broad area drains to the Barkby Brook, which is associated with flooding problems downstream in Syston. The western margin of the broad area drains to the Thurmaston Dyke, which is severely constricted and culverted, and associated with flooding problems downstream in Thurmaston. Preliminary investigations appear to show that drainage in the area of Thurmaston east of the raised railway embankment, sits in a topographic ‘bowl’, with drainage potentially constricted by the capacity of the Thurmaston Dyke culvert and surface water drains under the railway embankment. An unnamed watercourse passes through the site, issuing near Hill Top Farm, flowing southwest to the Melton Brook, this watercourse is too small to have been included in the EA Flood Map. The eastern and southern portions of the broad area drain into the Melton Brook, which flows north of Hamilton and through Rushey Mead on the outskirts of Leicester City. All of these watercourses join the River Soar west of the potential development area, which then passes north through the Borough. The Barkby Brook is classed as a Main River, Thurmaston Dyke as a Ordinary Watercourse, although part was designated Critical Ordinary Watercourse, but was not enmained. Due to the limited size of the watercourses and their catchments only basic modelling of the watercourses has been carried out by the EA, for the Flood Map. Charnwood Borough Council’s Drainage Department has produced an Infoworks model of the Barkby Brook. Potential flood risks to consider with respect to development in this area include:

- Fluvial flooding from the three River Soar tributaries at present and under future climate change scenarios: Barkby Brook, Thurmaston Dyke and the Melton Brook;
- Overland flow from higher land adjacent to the potential development areas;

- Blockages/ insufficient capacity of bridges/culverts on the three watercourses (including existing structures and any proposed in association with new development);

- Need to manage runoff in view of downstream flood risk - SuDS important to attenuate increases in runoff; and

- Key issues: appropriate runoff management and preventing any increase in flood risk in the downstream areas of existing development adjacent to watercourses. Potential limitations of the Thurmaston Dyke should be investigated.

5.3.2 Flood Risk – Potential North of Birstall SUE (see Figure 2.1)

This SUE would be situated north of Birstall and west of the River Soar, in the south of Charnwood Borough. Elevations range from approximately 80 to 60 m AOD. The majority of the broad area drains northwards to the Rothley Brook, which is associated with flooding problems downstream in Rothley, before joining the River Soar. An unnamed ordinary watercourse (passing through Broadnook Spinney) issues and flows through the centre of the area, this watercourse is too small to have been included in the EA Flood Map. The area east of the A6 drains east directly to the River Soar. The Rothley Brook and River Soar are classed as Main Rivers. Detailed hydraulic models have been produced and maintained for the EA for both watercourses to supplement the Flood Map. Potential flood risks to consider with respect to development in this area include:

- Fluvial flooding from the Rothley Brook at present and under future climate change scenarios – the northern margin is adjacent to the Brook;

- Overland flow from higher land adjacent to the potential development areas;

- Blockages/ insufficient capacity of bridges/culverts on the Rothley Brook watercourses (including existing structures and any proposed in association with new development);

- Groundwater flooding associated with area of groundwater upwelling around the spring which feeds the unnamed watercourse;

- Need to manage runoff in view of downstream flood risk - SuDS important to attenuate increases in runoff; and

- Key issue: use of SuDS and storage options to prevent any increase in flood risk in the downstream areas of existing development adjacent to watercourses.

5.3.3 Flood Risk – Potential Adjacent to Glenfield within Charnwood south of Anstey SUE (see Figure 2.1)

This SUE would be situated in the south of Charnwood Borough, north of Glenfield and Leicester City and southeast of Anstey. Elevations range from approximately 100 to 70 m AOD. The area drains to the southeast into the Rothley Brook, which is associated with flooding problems downstream in Rothley. The Rothley Brook is classed as a Main River, for which detailed hydraulic modelling has been carried out. Potential flood risks to consider with respect to development in this area include:

- Fluvial flooding from the Rothley Brook to any development located in the lower portion of the area;
- Overland flow from higher land adjacent to the potential development area;
- Blockages/ insufficient capacity of bridges/culverts on the Rothley Brook (including existing structures and any proposed in association with new development);
- Need to manage runoff in view of downstream flood risk - SuDS important to attenuate increases in runoff; and
- Key issue: use of SuDS and storage options to prevent any increase in flood risk in the downstream areas of existing development adjacent to watercourses.

5.4 Charnwood HLAA and Local Plan Sites

A Housing Land Availability Appraisal has been commissioned by Charnwood Borough Council to assess the housing potential for under-utilised land within existing urban areas. This section appraises the flood risk concerns and constraints on the development of these sites.

5.4.1 Loughborough HLAA Sites

Table 5.1 details the flood risk concerns and constraints for HLAA sites in Loughborough. The Leicester Road/Aumberry Gap, part of the Baxter Gate, Burder Street and Devonshire square Opportunity sites would be developed as mixed-use schemes. These sites are shown on Figures 5.1, 5.2 and 5.3.

Table 5.1 Flood Risk for Identified HLAA Sites in Loughborough

Site(s)	Flood Risk Constraints	Flood Risk Concerns
Former Tuckers Brickyard, Beacon Road	No major flood risk constraints identified.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system and the downstream School Brook (if surface water routed towards). Potential for urban surface water flooding.
Radmoor House, Radmoor Road	No major flood risk constraints identified.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system and the downstream Wood or Burleigh Brook (if surface water routed towards). Potential for urban surface water flooding.
Land at True Lovers Walk/Frederick Street	No major flood risk constraints identified.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system and the downstream Wood Brook (if surface water routed towards). Potential for urban surface water flooding.
Land at rear of The Old Pack Horse, Pack Horse Lane; Leicester Road/ Aumberry Gap, Opportunity Site, excluding PH; Former Petrol Station, Pinfold Gate; Cherry Tree Inn, Hume Street; and Part of Baxter Gate Opportunity Site.	No major flood risk constraints identified.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system and the downstream Wood Brook (if surface water routed towards). Potential for urban surface water flooding.
Council Depot, Limehurst Avenue, Bridge Street (Corporation Yard)	Sites south-western boundary runs adjacent to the GU canal and Wood Brook. Part of site indicated as being in flood zones 3a and 2.	Watercourse flooding associated with the GUC and Wood Brook. SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface water flooding.
Dale Farm Depot, Thorpe Acre Road	Limited. Black Brook located 150m to the north. Located in Flood Zone 1, but in close proximity to flood zones 3a and 2. Formally located in EA Flood Zone 3, however removed from Flood Zone 3 as a result of the SFRA flood modelling and mapping process.	Watercourse flooding associated with the Black Brook. SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface water flooding.
136-144 Knighthorpe Road	Site mostly located in flood Zone 2 (and Flood Zone 1). Formally located in EA Flood Zone 3, however, are removed from EA Flood Zone 3 as a result of the SFRA flood modelling and mapping process.	Watercourse flooding associated with the Burleigh Brook. SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface water flooding.
Burder Street Opportunity Site	Parts of site located in Flood Zone 2 (and Flood Zone 1).	Watercourse flooding associated with the River Soar and Hermitage Brook. SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface water flooding.
Richard Roberts Factory, Clarence Street	Adjacent to GU Canal. Part of site located in Flood Zone 2 (and Flood Zone 1). Flood Zone 3a located to the immediate east of the site, associated with the River Soar to the east.	Watercourse flooding associated with the GUC, River Soar and Hermitage Brook. SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface water flooding.

Table 5.1 (continued) Flood Risk for Identified HLAA Sites in Loughborough

Site(s)	Flood Risk Constraints	Flood Risk Concerns
77 Meadow Lane and garages, Clarence Street	No major flood risk constraints identified.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface water flooding.
Devonshire Square Opportunity Site	Wood Brook partially culverted under site. Majority of the site indicated as being in Flood Zone 3a (remainder in Flood Zone 2).	Watercourse flooding associated with the Wood Brook SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface water flooding.
Land at Empress Road, Great Central Road, and Moor Lane Bridge	Site bisected by the GU Canal, school Brook and Hermitage Brook run along the sites eastern boundary. Parts of the site are in Flood Zone 3a and 2 (remainder in Flood Zone 1).	Watercourse flooding associated with the GUC, and School & Hermitage Brooks. SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface water flooding.

The majority of the sites identified do not at the strategic scale present any difficult flood constraints, and following the Sequential Test process, development could be allocated to these sites, preferentially on the basis of lowest flood risk. Flood risk issues are more severe for the Council Depot, Devonshire Square and Empress Road – Great Central Road – Moor Lane Bridge sites. For these to be developed it must be demonstrated that there are no suitable alternative sites identified by the Sequential Test. A detailed site specific Flood Risk Assessment and appropriate justification of the Exception Test alongside flood risk mitigations will then be required for the development of these sites. Where sites are progressed, development should be set out to allocate uses with the highest vulnerability classifications to the areas of lowest flood risk. The developer may have to accept that the whole site may not be developable and areas most at risk may need to be left as open space.

5.4.2 HLAA Sites in Charnwood outside of Loughborough

Table 5.2 details the flood risk concerns and constraints for HLAA sites in Charnwood outside of Loughborough. These sites are shown on Figures 5.2, 5.3, 5.4, 5.5 and 5.6.

Table 5.2 Flood Risk for HLAA Sites in Charnwood outside of Loughborough

Site (s)	Flood Risk Constraints	Flood Risk Concerns
Shepshed		
North of Spring Close	No major flood risk constraints identified. Site is 100m east of the Shepshed Brook, a small urban watercourse which is unmodelled.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.
Barrow Upon Soar		
Land off Nursery Grove / Nottingham Road Housing Allocation	Site is west of and adjacent to the Fishpool Brook (Main River), this watercourse is unmodelled. Significant flood risk and riparian maintenance issues associated with watercourse.	Watercourse flooding associated with the Fishpool Brook. SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.
136 Cotes Road	No major flood risk constraints identified.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding. Potential for surface water run-on.
Mountsorrel		
Disused Nursery, rear of 263 Granite Way	Potential. Small unnamed watercourse adjacent to site.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.
Linkfield Road	Adjacent to Sic Brook – flood extents unmodelled/not in flood map.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.
Day Centre, Berkeley Road; Rear of 249 – 263 Leicester Road	No major flood risk constraints identified.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.
Walkers Transport, Loughborough Road; 72 – 138 Loughborough Road	Located in Flood Zone 3a (River Soar Floodplain). Significant flood risk associated with location on edge of the River Soar's floodplain.	Flooding associated with the River Soar SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.
Sileby		
Barrow Road (9 King Street)	No major flood risk constraints identified.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.
Syston		
Land at Victoria Street; 93 St. Peter's Street	Located in Flood Zone 3a (flooding from the Barkby Brook). Significant flood risk and riparian maintenance issues associated with partially culverted watercourse.	Watercourse flooding associated with the Barkby Brook SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.
Brook Street	Located in close proximity to Flood Zones 2 and 3a (River soar to the north and Barkby Brook to the south. Possibility of historical flooding should be investigated.	Watercourse flooding associated with the Barkby Brook – limited capacity of channel, as low as 1 in 5. SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.

Table 5.2 (continued) Flood Risk for HLAA Sites in Charnwood outside of Loughborough

Site (s)	Flood Risk Constraints	Flood Risk Concerns
Anstey		
Albion Street, Roseberry Road, Kitchener Road; Part of H/2a Bradgate Road	No major flood risk constraints identified.	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.
Thurmaston		
Rear of 36-46 Colby Road; Rear of 149-155 Colby Drive and rear of 167-177 Colby Drive; Land to the rear of 53 & 55 Colby Drive	Limited drainage capacity of the Thurmaston Dyke – area to east of raised railway embankment is in a 'bowl' – is sufficient drainage available?	SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.

The majority of the sites identified do not at the strategic scale present any difficult flood constraints, and following the Sequential Test process, development could be allocated to these sites, preferentially to sites with the lowest flood risk. Flood risk issues are more severe for the Nursery Grove/Nottingham Road, Walkers transport, Victoria Street and Brook Street sites. For these to be developed there must be no suitable alternative sites identified by the Sequential Test. A detailed site specific Flood Risk Assessment and appropriate justification of the Exception Test alongside flood risk mitigations will then be required for the development of these sites. Where sites are progressed, development should be set out to allocate uses with the highest vulnerability classifications to the areas of lowest flood risk. The developer may have to accept that the whole site may not be developable and areas most at risk may need to be left as open space.

5.4.3 Undeveloped Local Plan Sites

Potential development areas identified in the old local plan and which remain to be developed have been assessed for flood risk constraints (Table 5.3). These sites are shown on Figures 5.2 and 5.4.

Table 5.3 Flood Risk for Local Plan sites in Charnwood

Site (s)	Flood Risk Constraints	Flood Risk Concerns
New Employment Allocations		
E/5(c), Dishley Grange and Derby Road, **Loughborough**	Majority of Dishley Grange site is in floodplain (mostly 3a, with some in flood zone 3b - River Soar and Black Brook). Site is indicated as having historically flooded (1977 flood extent). Derby Road site less problematic – small portion of site is indicated to have flooded historically. Most of site outside of flood extents produced by detailed hydraulic modelling (but inside the EA flood map - part in Flood Zone 3 and a larger area in Flood Zone 2).	Flooding associated with the River Soar - site has historically flooded, majority of the site in Flood Zone 3a. Area of the site shown to be in Flood Zone 3b. SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.
New Housing Allocations		
H/1(a) Land at Barrow Upon Soar	Potential. Site is west of and adjacent to the Fishpool Brook (Main River), although this watercourse is unmodelled and not covered by the EA Flood Zone map. Therefore the extent of flood risk in the vicinity is unknown. Significant flood risk and riparian maintenance issues associated with watercourse.	Watercourse flooding associated with the Fishpool Brook. SuDS required to ensure runoff attenuated appropriately. Capacity of drainage system. Potential for urban surface Water flooding.

Although previously allocated for development, the Dishley Grange and Barrow Upon Soar sites cannot be considered for development until they have passed through the Sequential Test, and if required the Exception Test. These sites should only be considered suitable for development if it can be demonstrated that there are no available and suitable sites as lower risk of flooding. A detailed site specific FRA will be required for each site, commensurate with the level of flood risk to each site. No development should occur in areas indicated as Flood Zone 3b. The FRAs should address the criteria laid out in Annex E of PPS25, to ensure that the development can proceed without increasing flood risk to people and property onsite and downstream. In particular there should be no increase in flood risk to third parties and no reductions in floodplain storage.

5.5 Brownfield and Infill Development within Charnwood

The sources of flood risk to brownfield and infill development within Charnwood are varied. Some sites are located adjacent to the floodplains of major rivers such as the River Soar and Wreake, whilst other sites are located adjacent to minor ordinary watercourses, where encroachment and constrictions such as under-capacity bridges and culverts have increased flood risk. Although in some locations flood defences significantly mitigate this fluvial flood risk, there remains a residual risk to development in these areas due to possible structural or operational failure of defences, or the possibility of a flood event occurring that is more extreme than that for which the scheme has been designed. There should therefore be a prioritisation of brownfield sites located outside the floodplain in

Zone 1. However, taking into account other planning considerations, including the preference for brownfield over greenfield development and the likely future expansion of Loughborough Town Centre to support the increasing population of Loughborough, it is likely that proposals for development in the higher risk flood zones will arise.

In Loughborough in particular, several of the council's key redevelopment sites are located in areas of flood risk adjacent to the River Soar and the Black, Burleigh and Wood Brooks, and it is likely that other sites at risk of flooding will come forward in future. In addition, further development associated with the University and Science Park needs to be managed to ensure there is no increase in the amount of flood risk to people and property along the Wood Brook. Section 3.3 summarises the requirements of PPS25 with respect to the level of flood risk appropriate to the various types of development in Charnwood. If the sites pass the Sequential test, many will be required to satisfy the criteria of the Exception Test and, in all cases, a PPS25 compliant FRA will be required.

The application of the Sequential Test is performed by the Council's planners, with the SFRA and in particular the SFRAs Flood Zone maps being the key data source on flood risk guiding decision making. Development of available sites should be prioritised according to flood risk, with sites at low risk of flooding moved forward for development first (Flood Zone 1, then Flood Zone 2 and finally Flood Zone 3a). For a site to pass the Sequential Test, the council must consider that at that time no suitable alternative site is available in an area with a lower flood risk.

Where areas at risk of flooding are to be developed (having passed through the Sequential and Exception Tests - as applicable to the development type), to reduce the flood risks posed to both people and property, land uses should be prioritised to place development with the lowest vulnerability to flooding in the areas of the site with the highest flood risk . For example, prioritising business use over residential, and 'less vulnerable' over 'highly vulnerable' residential development.

Where feasible, setting the redeveloped sites runoff at the greenfield rate could provide a significant betterment, in the speed and volume of runoff from developed areas. For the more difficult sites, strategic solutions may be required, such as the provision of, or contribution towards flood storage on-site or elsewhere in the catchment to reduce flood risk (options are discussed in Section 7.11), or even the relocation of development from areas of the site most at risk from flooding. Potentially sacrificing some sites to reduce flood risk may make alternative, adjacent sites more developable. In these cases, there may be possibilities to convert the site into 'water compatible' land uses, such as open amenity space and outdoor sports facilities.

In addition to addressing the risks posed by the main rivers, other sources of flooding will also require consideration at the detailed FRA stage, including groundwater, overland flow, sewer flooding and runoff control. Sizeable developments outside of the floodplain (i.e. in Zone 1) will also require a FRA addressing these issues. Where all of these PPS25 requirements are met, brownfield and infill development in Charnwood should still be able to contribute to the vitality of existing urban areas and Loughborough town centre, whilst managing flood risk to people and property.

5.6 Assessment of Existing Urban Areas

Table 5.4 details the primary flood risk to existing development in Charnwood, and is provided to give a summary of the degree of flood risk. The lack of any known secondary flood sources (groundwater, overland flow, sewer, collapse/blockage/insufficient capacity of structures), does not remove the need to assess these sources for any proposed development.

Table 5.4 Summary of Flood Risks Associated with Existing Development in Charnwood

Location	Major Fluvial (Flood Zone Map)	Other Fluvial
Anstey	Eastern area adjacent to the Rothley Brook	The Nook – Leicester Road Culvert. Should be checked in site specific FRA.
Barkby	Southern area adjacent to the Barkby Brook	Should be checked in site specific FRA.
Barrow Upon Soar	River Soar floodplain extends into western margin.	Fishpool Brook and Barrow Brook pass through. Should be checked in site specific FRA.
Birstall	Eastern area adjacent to River Soar	Minor watercourses. Should be checked in site specific FRA.
Burton on the Wolds	None.	Burton Brook. Should be checked in site specific FRA.
Cossington	Western area adjacent to River Soar floodplain. Cossington Brook.	Cossington Brook and tributary. Should be checked in site specific FRA.
Cropston	None	Should be checked in site specific FRA.
East Goscote	Southern edge adjacent to the Gaddesby Brook and Queniborough Brook floodplain, area northwest of railway adjacent to River Wreake floodplain.	Should be checked in site specific FRA.
Hathern	Eastern edge within River Soar floodplain (zone 3a)	Should be checked in site specific FRA.
Loughborough	River Soar, Black Brook, Burleigh Brook, Wood Brook all pose significant flood risks. The River Soar floodplain extends into the eastern margin of Loughborough, whilst the Black Brook poses a potential flood risk to northern parts of Loughborough.	Tributaries of the Burleigh and Wood Brook (OWs) as well as the Willow and School Brooks (OWs). Should be checked in site specific FRA.
Mountsorrel	Eastern margin within the floodplain of the River Soar (FZ 3a)	Sic Brook. Should be checked in site specific FRA.
Newtown Linford	Part of village in flood zone of the River Lin	Should be checked in site specific FRA.
Queniborough	Northern edge of village in the flood zone of the Queniborough Brook.	Should be checked in site specific FRA.
Quorn	Eastern edge of town adjacent to the River Soar. The Quorn Brook and Poultney Brook have a large catchment which drains through Quorn to the River Soar. A large swathe of the town is protected by flood defences along the Soar and Q and P Brooks.	Should be checked in site specific FRA.

Table 5.4 (continued) Summary of Flood Risks Associated with Existing Development in Charnwood

Location	Major Fluvial (Flood Zone Map)	Other Fluvial
Ratcliffe on the Wreake	Southern margin within the River Wreake floodplain (FZ 3a)	Should be checked in site specific FRA.
Rearsby	River Wreake floodplain extends approximately to railway line, which prevents flood zones extending further south towards Rearsby.	Rearsby Brook and adjacent area. Should be checked in site specific FRA.
Rothley	Rothley Brook floodplain – FZ 3a extends through the centre of the village	Should be checked in site specific FRA.
Seagrave	None	Sileby Brook passes through the village. Should be checked in site specific FRA.
Shepshed	Area north and west of Shepshed is is within the Black Brook's floodplain (FZ 3a)	Glenmore Park Brook and Shepshed Brook. Should be checked in site specific FRA.
Sileby	Western margin in the River Soars floodplain (FZ 3a)	Sileby Brook passes through the village. Should be checked in site specific FRA.
South Croxton	Area of FZ 3a through centre of village associated with the Queniborough Brook	Queniborough Brook. Should be checked in site specific FRA.
Syston	Area of FZ 3a associated with the River Wreake – Soar – Barkby Brook confluence	Should be checked in site specific FRA.
Thrussington	Southern extent of village adjacent to FZ 3a of the River Wreake. Flood Zone 3a extends into village alongside the Thrussington Brook	Thrussington Brook extends north-south through the village. Should be checked in site specific FRA.
Thurcaston	Northern extent of the village adjacent to FZ 3a of the Rothley Brook	Should be checked in site specific FRA..
Thurmaston	Western extent adjacent to the River Soar's floodplain and in FZ 3a and 2.	Thurmaston Dyke drains a large area of Thurmaston. Should be checked in site specific FRA.
Walton on the Wolds	None.	Should be checked in site specific FRA.
Wanlip	Eastern extent adjacent to the River Soar's floodplain and in FZ 3a and 2.	Should be checked in site specific FRA.
Woodhouse Eaves	None.	Tributaries of the Quorn Brook. Should be checked in site specific FRA.

5.7 Development Prioritisation

Based on the PPS25 Sequential Test, potential development should be prioritised in Zone 1 (low risk of flooding from major watercourses). It is however, recognised that the final selection of site(s) for future development will depend on a wider range of planning considerations. This prioritisation does not preclude the need for a more detailed assessment (in the form of an FRA) of the sites selected for future development. Whilst the primary and secondary sources of flooding have been assessed in this SFRA, these sources remain to be assessed in detail at the site specific FRA stage, where the site specific focus will allow a more detailed appraisal of any potential flood risk issues to be undertaken. The FRA should demonstrate that the development meets the Sequential Test (and

Exception Test if required), is adequately protected from flooding over the lifetime of the development (taking into account climate change), provides for surface water management with SuDS and adequately manages any residual flood risks. The FRA should demonstrate that flood Risk to third parties is not increased, and where appropriate opportunities exist flood risk is reduced.

5.7.1 Primary Sources

In terms of flood risk the principal aim is to locate new development outside of areas at risk from primary flooding sources (Main Rivers and those covered by the EA Flood Map). For the Charnwood SFRA detailed flood mapping has been collated based on the basic JFLOW flood extents, detailed hydraulic modelling and historical flood extents. **This amalgamated data set forms the basis of a SFRA Flood Zoning Map, which should be used to direct development to areas of lower flood risk.** Especially in the upper reaches of watercourses where the Flood Zoning Map is based on JFLOW flood extent and the NEXTmap topography, more detailed hydraulic modelling and a detailed site topographic survey may indicate that some sites are not at risk from flooding.

5.7.2 Secondary Sources

Many of the areas identified for further investigation have minor watercourses on site, or in close vicinity to the site. These watercourses are too small to feature on the Environment Agency flood zone map, but may still be associated with known flood problems. However, given how common flood problems along the minor watercourses are, detailed FRAs should still be prepared for all development sites selected. The culverting of watercourses should be avoided. Where possible, development should be set back from watercourses to allow for maintenance access. Set easements required for maintenance are:

- Main Rivers (EA) - 8m
- Ordinary Watercourses (CBC) - 5m

There are a number of springs in the area around Charnwood at the heads of minor watercourses. The presence of spring activity could present a risk to properties either as a result of existing spring flow or due to the potential for new springs to emerge if excess rainfall causes a rise in groundwater levels. Although there have been no specific problems due to this type of flooding in Charnwood to date, there have been incidents reported nearby (along the River Wreake valley). Further investigation into the local geology will be required to ensure any areas at risk are identified so that development is appropriately located and designed.

The tendency for development to be located near valley bottoms means that most of urban areas are surrounded by upslope areas, with most of this being farmland. All of the potential areas of development face some level of risk due to overland flow. The upstream catchment should be defined for all sites selected for development, and the drainage strategy will need to manage overland flows from both the uphill catchment and the site itself in an appropriate manner.

Structures in the floodplain and ordinary watercourses can exacerbate flooding as a result of either blockages and/or insufficient capacity to convey peak flows. Problems are not restricted to structures on-site, as constrictions downstream could cause floodwaters to back-up and pond or flow via other overland routes. Any new structures planned as part of new development (e.g. road crossings of watercourses) may also present new, additional risk. All of the potential areas of development have watercourses present on-site and nearby and therefore all must consider the risk associated with existing/ new structures. A detailed assessment of the nature of this risk should be undertaken for sites selected for development in order to identify and incorporate any necessary mitigation measures into the development layout and design.

5.7.3 Sustainable Drainage Systems (SuDS)

As per current guidance SuDS should be included in all development; to control runoff and reduce downstream flood risk, CIRIA provide a range of guidance documents on the design and construction of SuDS. PPS25 requires that SuDS are implemented in new development wherever practical to prevent the generation of additional runoff. In particular problem areas, SuDS can also be retrofitted to existing development to alleviate downstream flooding. SuDS are discussed further in Section 7.

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Creating the environment for business

6. Minerals and Waste Development Framework

6.1 Purpose

Leicestershire County Council is producing a Minerals Development Framework covering the County of Leicestershire and, jointly with Leicester City Council, a Waste Development Framework covering the County and Leicester City areas.

In accordance with good practice and advice from the Department of Communities and Local Government (CLG) the SFRA has considered the flood risk implications of mineral extraction and waste management development. This has included having regard to the potential sites identified by the Minerals Development Framework and Waste Development Framework within or close to the Charnwood Borough boundary. These are sites put forward for consideration by landowners or developers and are not necessarily sites which will go forward for allocation in the Mineral and Waste Frameworks. The consideration of the flood risk implications of these sites is part of the evidence gathering required by the plan making process.

Consultation on the spatial strategies for the Minerals and Waste Development Frameworks took place in late October and November 2007. The spatial strategies do not identify individual sites for development but rather identify broad areas where minerals or waste development would be preferred. It is intended that further work will be done on site allocations for the Minerals and Waste Frameworks once the non site specific Core Strategy documents have been submitted to the Secretary of State next year. Other sites, apart from those considered in this SFRA, may come forward in future and the SFRA, along with other SFRAs covering other parts of the County and City, will be used to assess the flood risk implications of such sites. Further consultation on preferred sites for the Mineral and Waste Frameworks is programmed to take place in 2009.

6.2 Flood Risk Appraisal of Waste and Minerals Sites

Figure 6.1 shows the broad location of the Waste and Minerals sites alongside the Mineral Safeguarding Areas. All seven potential sites in Charnwood are detailed in Table 6.1, and two additional sites located adjacent to Charnwood are detailed in Table 6.2. Within Charnwood there are four mineral resources of particular interest: Igneous Rocks, Gypsum, Brick Clay and Sand and Gravel. It is principally the sand and gravel resources – waterlain deposits, which by definition occur in flood risk areas.

Table 6.1 Waste and Minerals Sites in Charnwood

Potential Site	Use	Flood Zone
Waste		
Loughborough Civic Amenity site	Extension to existing waste transfer site	Flood Zone 1
Mountsorrel Quarry	Extension to recycling and transfer facility (two sites)	Flood Zone 1
Newhurst (Shepshed)	Mechanical Biological Treatment, Materials Recovery Facility, In-vessel composting, Non-hazardous landfill, Biomass waste-to-energy plant;	Flood Zone 1
Thurcaston	Waste recycling/reuse/transfer Site	Flood Zone 3b, 3a, 2 and 1
Wymeswold	Waste treatment	Flood Zone 1
Sand and gravel		
Wanlip	Waste recycling/refuse	Flood Zone 3b

Table 6.2 Waste and Minerals Sites adjacent to Charnwood

Potential Site	Use	Flood Zone
Waste		
Brooksby	Non-hazardous landfill and waste processing i.e. composting, Materials Recovery Facility (MRF) and Aggregates recycling	Flood Zone 3, 2, 1
Sand and Gravel		
Brooksby	Sand and Gravel	Flood Zone 3, 2, 1

In terms of Primary flood risk in Charnwood the Thurcaston and Wanlip sites are located in or adjacent to areas of Flood Zone 3(a or b) both associated with the River Soar, these sites are considered further individually. The Loughborough Civic Amenity site is located in Flood Zone 1, but could potentially be cut off at times of flood. The Brooksby site, located in Melton Borough is located partially in EA Flood Zone 3 and 2, operations here could potentially alter the level of flood risk downstream in Charnwood.

The Sequential Test aims, as far as possible, to allocate all development to the available sites with the lowest flood risk. PPS25 (Table D.2) classifies minerals working and processing (except for sand and gravel) as Less Vulnerable, and sand and gravel workings as Water Compatible;

Landfill and waste facilities fall into two flood vulnerability categories:

- More Vulnerable – Landfill and sites used for waste management facilities for hazardous waste; and

- Less Vulnerable – Waste treatment (except landfill and hazardous waste facilities).

Sand and gravel processing (Water Compatible development) is considered compatible development (PPS25 Table D.3) in all Flood Zones. For More Vulnerable waste uses, PPS25 Table D.3 considers these uses compatible with Flood Zones 1 and 2, and if the Exception test is passed Flood Zone 3a. For Less Vulnerable waste uses, PPS25 Table D.3 considers these uses compatible with Flood Zones 1 and 2, and 3a. Waste uses are not compatible with Flood Zone 3b.

6.2.1 Site Specific Flood Risk Appraisals

The **Thurcaston Sewage Works** site is shown in Figure 6.2, with Table 6.3 detailing the percentage of the site located in each Flood Zone. It should be noted that the SFRA modelling and zoning work concentrated on improving the delineation of flood zones 3a, 3a with a 20% increase in peak flows (climate change scenario) and 3b. SFRA flood zone 3a was found to be more extensive than the EA's Flood Zone 3, effectively shrinking the area shown in Flood Zone 2. More detailed modelling of Flood Zone 2 would likely show this to be more extensive. Figure 6.2 shows that the extent of Flood Zone 3a is predicted to increase under this climate change scenario.

It is potentially proposed to develop the site as a waste recycling site. If no hazardous waste is to be processed, this would be classified as a Less Vulnerable land use, permissible within the area of the site not falling in Flood zone 3b. However, alternative lower flood risk sites should be prioritised, with this site only being developed if a suitable site at a lower risk of flooding is not available. If the site is selected, the design of the site should seek to place development in the areas of the site least at risk from flooding. A detailed topographic site survey should be compared with flood levels adjacent to the site (Appendix C) to verify the extent of Flood Zone 3a.

A FRA and consultation with the Environment Agency will be required if any development is to be placed in areas of the site outside of Flood Zone 1, the FRA should include details of the Sequential Test process used to justify the selection of this site. Regardless of location, suitable arrangements for the management of surface water runoff will be required, which if the development area is over 1 ha in Flood Zone 1 should be provided as a FRA.

Table 6.3 Flood Risk to Thurcaston Sewage Works Site

Flood Zone	Percentage of Site
EA Flood Zone 1	42
EA Flood Zone 2	0
SFRA Flood Zone 3a	10
SFRA Flood Zone 3a+CC	5
SFRA Flood Zone 3b	43

The **Wanlip** site is shown in Figure 6.3, with Table 6.4 detailing the percentage of the site located in each Flood Zone. The site is entirely located in Flood Zone 3b (functional floodplain).

It is proposed to develop the site as a waste recycling/reuse site, which PPS25 classifies as Less Vulnerable Development, incompatible with Flood zone 3b.

Given the sites location in Flood Zone 3b it is unlikely that the site could be brought for waste use.

Table 6.4 Flood Risk to the Wanlip Sand and Gravel Site

Flood Zone	Percentage of Site
SFRA Flood Zone 3b	100

The land identified for a potential expansion of the **Loughborough Civic Amenity** site (Figure 6.4) is located in Flood Zone 1, on a 'dry island' within Flood Zone 3a and 2. Therefore, at times of flood the site may become cut-off from surrounding areas of Flood Zone 1 and the implications of this for operation of the Civic Amenity site need to be considered. An FRA will be required which should confirm the flood zone boundaries in relation to the site and cover such issues as the amount of time the site may be un-usable and the depth and duration of flooding of the access routes to and from the site. Arrangements such as signing up to the Environment Agency's Flood Warning System will be necessary to ensure that the site is appropriately evacuated in advance of a flood event. The FRA should also demonstrate that the sequential test has been followed in choosing this site. Regardless of location, suitable arrangements for the management of surface water runoff will be required.

Table 6.5 Flood Risk to the Loughborough Civic Amenity Site

Flood Zone	Percentage of Site
SFRA Flood Zone 1	100

The **Brooksby** site is located partially in EA Flood Zone 3 (Rearsby Brook). The Melton SFRA has not sub-divided Flood Zone 3 into Flood Zones 3a and 3b for the Rearsby Brook, since no hydraulic model was available and no development has been allocated to the area by Melton Borough Council. Further modelling work to better define these zones would therefore be required if the site is to be developed for sand and gravel extraction. Sand and gravel extraction could take place without subsequent use of the site for landfilling, the resulting void could be either left without infill, or infilled with non-hazardous waste.

The area of the site potentially proposed for Non-hazardous waste processing i.e. composting, a Materials Recovery Facility (MRF) and for Aggregates recycling, would be classified as Less Vulnerable land use, permissible within

areas of the site not falling in Flood zone 3b. However, alternative lower flood risk sites should be prioritised, with this site only being developed if a suitable site at a lower risk of flooding is not available. If the site is selected, the design of the site should seek to place this development in the areas of the site least at risk from flooding. A detailed topographic site survey should be compared with flood levels adjacent to the site (Appendix C) to verify the extent of Flood Zone 3a.

A FRA and consultation with the Environment Agency will be required if any development is to be placed in areas of the site outside of Flood Zone 1, the FRA should include details of the Sequential Test process used to justify the selection of this site. Regardless of location, suitable arrangements for the management of surface water runoff will be required, which if the development area is over 1 ha in Flood Zone 1 should be provided as a FRA.

6.2.2 Potential for Site Restoration to aid Flood Risk Management

Where voids left by the extraction of sand and gravel located in Flood Zone 3b and 3a, are to be restored following extraction, the potential exists to provide a contribution to reducing flood risk. If final restoration levels are set lower than the original ground levels additional floodplain storage volume can be generated which may contribute to flood management within the catchment as a whole. However, absolute increases in floodplain capacity are only provided by restoration that leaves lower ground levels lower than before extraction. Where the void fills with groundwater no extra flood-peak storage volume will be provided, since it will be filled by groundwater or the rising limb of a flood event.

A site specific investigation would be required to investigate whether these facilities should be designed to function online or offline. Online storage is storage provided directly within the watercourse or its floodplain that fills as river levels rise, providing storage throughout a flood event. Offline storage is an engineered facility controlled by inlet and outlet structures to flood at a certain point during a flood event, ensuring that the available volume of flood storage is used to best effect. Offline facilities may require more extensive engineering to provide embankments and ancillary control structures and to protect the facility from undesired inundation by groundwater.

6.2.3 General Guidance

A FRA will be required for all sites greater than 1ha located in Flood Zone 1 to ensure that flood risk is not increased by increases in surface water runoff from new hardstanding.

Surface water management procedures will need to ensure there are adequate pollution controls and discharge consents may be required to control both quality and quantity of discharge.

Land drainage consents will be required where works adjacent or over watercourses are proposed.

Where de-watering is to occur in support of minerals extraction an assessment of the hydro(geo)logical impact will be required, to ensure that nearby water resources are not detrimentally impacted.

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7. Flood Risk Mitigation

7.1 Introduction

This SFRA has identified the flood risk constraints to potential development sites in Charnwood in order to assess their suitability for development. These sites are generally broad greenfield areas selected to be outside of Flood Zones 3b, 3a and 2. However, pockets of land within existing urban areas have been identified for regeneration and infill development, some of which are located in medium or high risk flood zones. Even though PPS25 directs planned development towards Zone 1, there will be occasions where planning permission is sought in the higher risk flood zones, particularly with respect to redevelopment of brownfield sites in line with sustainability objectives. Therefore if the site does pass the PPS25 Sequential Test, more detailed flood risk mitigations may be required to support the Exception Test.

Furthermore, development in Zone 1 must still consider other flood risks, particularly secondary sources of flooding and the potential impact that the development's drainage and surface water runoff may have on flood risk elsewhere. When planning development, flood mitigation measures should be considered as early as possible in the development process to reduce and manage the flood risks associated with development.

7.2 Drainage

All planned development, whether in the floodplain or not, must consider the implications for its drainage on flood risk. In particular, this applies to development of greenfield sites, for which the significant increase in impermeable area can considerably increase runoff volumes and rates from the site. A strategic approach to the drainage of new urban areas is necessary to ensure that drainage and flood risk management proposals effectively manage runoff changes whilst reducing the flood risks associated with new development. A strategic approach will reduce the chance of cumulative piece-meal additions to drainage systems causing future problems, and allow for the identification and betterment of existing systems with known issues. The CIRIA report C635 – 'Designing for Exceedance' provides detailed guidance for engineers and planners on the design of urban surface water management systems to mitigate the impacts of these systems being overwhelmed during extreme rainfall events. Methods include the design of buildings with raised thresholds above road level and the use of controlled flooding of designated spaces as temporary storage areas.

7.2.1 Integrated Drainage Strategy

Opportunities for developing an Integrated Water or Drainage Management Strategy across development site boundaries is recommended, and ideally a catchment-led approach should be adopted. This has been recognised in the recent consultation paper by DEFRA, Making Space for Water. Experience shows that integrated approaches often lead to a much more efficient and reliable surface water management system at a comparatively lower cost because it enables a wider variety of potential flood mitigation options to be used, and a better overall design can be achieved. Integrated management of surface water has potential benefits in addition to flood risk, and can include improved water quality through the use of SuDS (see next section) and reduce water demand through grey water recycling/ rain water harvesting. In Charnwood, once the preferred development area(s) have been selected, consideration should be given at an early stage to the best way to manage drainage to maximise benefits.

7.2.2 Sustainable Drainage Systems (SuDS)

PPS25 requires that new development does not exacerbate flood risks elsewhere, which means there is a need to control drainage and runoff to ensure there are no increases in overland flow as a result of the development. SuDS are designed to prevent new developments generating additional runoff. When considered at the planning stage, they can be implemented to reduce flood risk to downstream areas.

> *"The philosophy of SuDS is to replicate as closely as possible the natural drainage from a site before development… so reducing the impact on receiving watercourses. This requires a reduction in the rate and volume of runoff from developments..."*[11]

The ability to appropriately manage surface water from a development site should be demonstrated in any FRA. Specifically, CIRIA guidance on SuDS states these potential benefits[12]:

- *"Lowering peak flows to watercourses or sewers, thereby reducing the risk of flooding downstream;*
- *Reducing volumes and frequency of water flowing directly from developed sites to watercourses or sewers, to replicate natural land drainage and reduce flood risk;*
- *Improving water quality over conventional surface water sewers by removing pollutants from sources such as cleaning activities (vehicles, windows), wear from tyres, oil leaks from vehicles or atmospheric fallout from combustion (in rural areas this can include runoff from fields where fertilisers and biocides are used);*
- *Improving amenity through the provision of features such as wildlife habitat;*
- *Reducing the number of times that combined sewer overflows (CSOs) operate and discharge polluted water to watercourses;*
- *Replicating natural drainage patterns so that changes to base flows are minimised;*
- *Finally, by increasing base flow to watercourses (through slow release of water)."*

[11] *Sustainable Drainage Systems*, CIRIA Report C609, 2004.

[12] *Sustainable Drainage Systems*, CIRIA Report C609, 2004.

SuDS techniques have been successfully used in the UK and abroad for over 20 years, with techniques that can be used in both impervious and pervious catchments. Examples of techniques and their application are shown in Figure 7.1. A more detailed description of individual techniques is given in the CIRIA guidance, in particular in CIRIA C697 "*The SUDS Manual*" published in March 2007 and at http://www.ciria.org.uk/suds.

To maximise benefits and minimise costs, SuDS should be incorporated at the feasibility stage of a planned development, rather than being inserted later on as an afterthought. SuDS incorporated into developments can contribute to an attractive high-quality urban environment, with no increase in off-site runoff above greenfield levels.

Retrofitting of SuDS to existing developments can be considered as a flood alleviation measure in certain particular problem areas. SuDS will not, however, protect an area from flooding due to upstream causes (such as overland flow from an upstream catchment or runoff from upslope developments).

As with all drainage systems, SuDS systems will only perform as well as they are designed and maintained. However, 'Whole life costs' associated with SuDS (i.e. taking into account their environmental benefit and runoff management) compare favourably with conventional urban drainage systems[13].

It is particularly important to define a suitable maintenance regime - with responsibilities clearly defined for SuDS schemes throughout the design life of the development.

7.3 Agricultural Runoff

Agriculture is the predominant land use throughout Charnwood. Land use exerts a strong control on the response of upstream catchments to rainfall in generating flooding and overland flows that pose a flood risk to development downslope. Where this is the case, measures can potentially be implemented to manage runoff and reduce risks. However the link between agricultural practices and flooding is not straightforward, even with improved land management practices, flooding will still occur after periods of prolonged/extremely heavy rainfall. Betterment is more likely in a reduction in smaller flood events generated by more common storms of lower return periods. At a strategic level, this can occur through the identification of and incorporation of agricultural land into schemes such as DEFRA's Environmental Stewardship Scheme (ESS) allowing surface runoff to be reduced through improved management practices. Examples of these practices include:

- Buffer strips (thicker established vegetation aids sediment removal/slows flow);
- Counter ploughing (ploughing across slopes rather than top to bottom);
- Reduced stocking levels (reduces soil compaction, allowing more infiltration);

[13] *Sustainable Drainage Systems,* CIRIA Report C609, 2004.

- Detain excess flows in throttled depressions;
- Reduced autumn sowing of grain crops (reduction in 'sealing' of freshly tilled ground by heavy rain); and
- Improvements to hedgerows, ditches and gate locations.

These methods can all reduce the volume of agricultural runoff reaching watercourses, or flowing overland into developed areas. In areas such as Charnwood with large areas of relatively impermeable geology this approach could contribute to a reduction in flood risk. The Environment Agency's *River Soar Flood Risk Management Strategy* suggests that peak flood levels for the 1 in 100 year event could be reduced by up to 0.3 m along the River Wreake and the River Soar through the use of these techniques. Despite the difficulties of quantitatively linking land management changes to the reduction in flood occurrence and magnitude, localised opportunities may exist to alleviate flood risk associated with specific flood risk problems.

7.4 Construction Site Runoff

Construction site runoff is an important but often over-looked area of catchment hydrology, causing local short-term but potentially significant changes in local flood risk.

The clearance of vegetation (and modifications to drainage infrastructure on brownfield sites) may lead to increased runoff above pre-construction rates. The management of runoff during the construction period is an important consideration particularly for large sites and details of measures to mitigate for this phase of development are required as part of an FRA. The Water Framework Directive (WFD) places specific requirements on the management of non-point source pollution such as that from construction site silts. Methods to reduce the volume of solids (and runoff) leaving the site include:

- Phased removal of surface vegetation at the appropriate construction phase;
- Provision of a grass buffer strip around the construction site and along watercourses;
- The covering of stored materials;
- Ensuring exposed soil is re-vegetated as soon as feasibly possible;
- Protection of storm water drain inlets; and
- Silt fences, siltation ponds and wheel washes.

7.5 Flood Risk Management

The Insurance Industry standard for accepting flood risk is 1.33% (1 in 75). Potentially in undefended areas at greater (Significant) risk of flooding, insurance against flooding may not be available or will include a significant excess.

National guidance for England (PPS25) aims to ensure that new greenfield development is located in areas with less than a 1% probability of fluvial flooding (0.5% coastal) in a given year, both at present and with climate change. In addition, brownfield development should be designed in order to avoid flood damage up to the 1% plus climate change threshold.

There will likely be areas of existing historical development located in areas at greater flood risk, although the risk at some of these locations will be managed by flood defences. The general upkeep of these defences and improvement in light of climate change will be required in order to manage flood risk to these properties. Where feasible, opportunities should be taken to provide protection to existing undefended properties at risk of flooding. However due to the limited cost effectiveness of flood protection schemes for isolated properties the onus may be on property owners themselves. In these cases, flood resilience and resistance options may be appropriate and the Development Control process should be used to encourage the uptake of these methods when and if redevelopment occurs.

7.6 Flood Avoidance, Resistance and Resilience

Where buildings must be located in areas with medium to high levels of flood risk, the incorporation of flood avoidance, resistance and resilience at the planning and design stage can reduce the impacts should inundation occur. Standard measures include the provision of a minimum freeboard above ground or predicted flood level, and the use of resilient fixtures and fittings within. CIRIA and the Association of British Insurers (ABI) produce guidance on suitable measures of flood protection.

The CLG has recently published guidance on 'Improving the Flood Performance of New Buildings - Flood Resilient Construction', which can be found at:

http://www.planningportal.gov.uk/uploads/br/flood_performance.pdf

Where the Sequential and Exception Tests have been passed, the guidance detailed in this document should be used as the basis for the design of flood avoidance and resistance measures for incorporation in the redevelopment of brownfield sites at risk of flooding, and greenfield sites where residual risks remain.

The report provides guidance on avoidance and resistance options such as:

- Site design and layout;
- Landscaping, drainage, boundaries; and

- Floor levels and thresholds.

With the possible exception of Water-compatible Development, all new build should be designed to avoid and resist flooding through the use of these avoidance and resistance mitigation measures. The report provides further guidance on resilience options (Water Exclusion Strategy and Water Entry Strategy), which are detailed below and are intended to reduce the flood impact to the existing built environment, rather than as a mitigation in support of justified development in flood risk areas. Flood resilience options may also be relevant to Water-compatible Development.

Water Exclusion Strategy (emphasis on reducing water entry) options include:

- Use of water resistant construction materials to reduce water ingress rates;
- Fitting one way valves to sewage pipes, or the use of temporary bungs;
- Sump and pump systems to remove water from buildings faster than it enters;
- Temporary door or air vent flood boards to stop the entry of flood water.

Water Entry Strategy (emphasis on allowing water entry, and facilitating draining and drying[14]) options include:

- Use of water resistant construction materials the integrity of which is unaffected by flood water and quickly dry;
- Design of buildings such as townhouses with lower floors occupied by garages and utility areas, minimising the damage caused when flooded;
- Location of boilers, and electricals above the possible flood level;
- No chipboard or MDF Kitchen units, instead using plastic and metal alternatives;
- Lime plaster or cement render rather than conventional gypsum plaster.

Importantly the two strategies are not mutually exclusive, and the adoption of both strategies may provide the best strategy in helping to reduce flood damages.

Retrofitting flooded properties during the repair procedure with these is common practice. These measures are not necessarily more expensive than conventional techniques, but over repeated flood events will reduce damages, cost and time to repair if properties are flooded. Comprehensive guidance on incorporating flood resilience measures in the repair of flooded building is available from CIRIA at: http://www.ciria.org/flooding/ . Adopting these measures

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[14] This option is favoured when the difference between outside and inside flood depths is greater than 0.6 metres, since structural damage can result from greater depth differences.

can reduce future flood damages and the disruption caused by flooding, uptake should therefore be encouraged. The ABI gives details of potential cost savings at:

http://www.abi.org.uk/Display/File/Child/553/Flood_Resilient_Homes.pdf

Importantly these costs do not include the indirect costs of disruption and temporary accommodation whilst repair occurs.

Flood resilience measures also provide a means for individuals in the local community with properties at risk to protect their property. An array of products such as door and window boards and air brick covers specifically designed to make these openings watertight are commercially available at reasonable prices. Given sufficient notice these can markedly reduce the ingress of flood water into properties. It is however recommended that a professional survey is carried out to identify the key ingress points for flood water into properties. Some degree of water ingress may still occur due to the multiple pathways for floodwater to enter an individual property.

7.7 Flood Warnings

The Environment Agency provides flood warnings for Charnwood Borough for the following watercourses:

- River Wreake from Stapleford (upstream of Melton Mowbray) to the River Soar;
- River Soar from Sharnford (upstream of Leicester) to the River Trent; and
- The Rothley Brook from Glenfield to the River Soar.

The Environment Agency's Flood Warning System is available for the entire reach of all three watercourses within Charnwood. In addition, the Environment Agency will issue a more generalised warning of flood risk for Leicestershire; this warning may provide a general warning of flooding from watercourses across the Borough not covered by specific flood warnings.

It is important to note that the Environment Agency flood warnings will not be able to provide advance warning for all different flood mechanisms. Warnings will not be available in advance notice of flooding from structural failures, culvert blockages or from groundwater. Intense rainfall events may also generate localised and severe rapid onset floods that are very difficult to predict.

The Agency's flood warnings are provided for existing developments at risk from flooding. They should not be considered as a mitigation measure for new and planned developments.

7.8 Emergency Planning

In light of this SFRA the council should take the opportunity to review its Emergency Planning procedures in the event of widespread flooding in the Borough. In the event of flooding it is the Council's role, supported by the emergency services, to coordinate procedures and responses. Key issues that should be covered in an emergency plan are:

- Responsibilities and roles of key services and communication protocols;
- Susceptibility of key emergency response centres (council offices, fire and police stations and hospitals) to flooding;
- Evacuation routes and reception centres; and
- Contingency plans for the loss of power and/or water.

There is likely to be several days notice of meteorological predictions of prolonged frontal rainfall that could cause major flooding along the catchments of the larger Rivers Soar and Wreake. Whilst on the Rothley and Black Brooks, other watercourses and urban areas flood events may exhibit a more ‘flashy’ response due to convectional storms and rapid runoff rates.

Residents in areas of flood risk should be encouraged to sign up to the Environment Agency’s Flood Warning System (Section 7.7), particularly those identified as living in isolated properties in Flood Zone 3b (functional floodplain), where waters would likely rise most rapidly and access routes may become cut off.

Emergency Planners have a key role in commenting on planning applications for specific developments in areas at high-risk of flooding. The FRA will need to adequately address any issues raised in-connection with the development.

7.9 Future Proofing

It is important that new developments, particularly in the higher risk flood zones, are designed in a precautionary manner, given the possible range of potential climate change impacts that may occur. Proposed flood mitigation measures should be reviewed at the detailed FRA stage, paying particular attention to the potential implications of future changes in climate and of land use. The application of the precautionary principle and the provision of freeboard and flood resistance and resilience in buildings can mitigate future increases in flood risk at relatively low cost if incorporated at the design and construction stage.

Measures to mitigate the risks of flooding both to and from development are not necessarily limited to those above. Depending on the specific risks relating to a site, the following investigations/options may need further consideration at the detailed FRA stage of development planning:

- Provision of a suitable, dry access/evacuation route (above the level of the 1% annual probability flood);
- Flood resistance/resilience measures specific to the potential for groundwater flooding;

- Management of surface 'run-on' (i.e. overland flow and runoff entering the site from upslope areas) as part of the development's drainage strategy;

- Maintenance/improvement of watercourses, culverts, drains and sewerage networks to reduce associated flood risks.

Detailed guidance on site design in terms of surface water management is provided in "*Sewers for Adoption*" (6th Edn.), CIRIA C635 *"Designing for Exceedence"* and CIRIA C697 "*The SUDS Manual*". The recently published CLG document "*Improving the flood performance of new buildings - flood resilient construction*" provides detailed guidance on the design or new buildings to maximise their flood resilience.

7.10 Options for Flood Alleviation

The Environment Agency's *River Soar Flood Risk Management Strategy* identifies some potential future strategic options for the Rivers Soar and Wreake. The strategies overall aim is to:

> *"assess current and future flood risk and propose fluvial flood risk management options that are technically, environmentally, economically and socially acceptable, both now and under possible future changes".*

Six options were evaluated: Do Nothing; Do Minimum; Storage; Structural Protection; Conveyance Management; Land Management sensitivities; Flood Warning Improvements. 'Do Nothing' considers what would happen if existing structures were abandoned and maintenance stopped – it provides a baseline for comparison purposes. 'Do Minimum' equates to maintaining the present standard of defence and upkeep. The FRMS notes the positive effect of storage on the Upper Wreake on reducing flood levels in the Lower Soar, that structural defences have limited impact on water levels in most parts of the catchment, that increased maintenance and removal of weir structures could reduce flood levels in the Lower Soar, and that land-use management would have a long-term positive impact. Storage is found to be a viable option to mitigate the impacts of climate change, although the SoP provided would gradually diminish. In sensitivity terms the Wreake is most sensitive to changes caused by increased development and the impacts of climate change.

On-going objectives identified:

1. Encourage SuDS;
2. Ensure appropriate land development / redevelopment policies;
3. Encourage the implementation of property flood proofing, where refurbishments are being undertaken and where appropriate;
4. Encourage land use management improvements to aid flood risk management; and
5. Monitor national policies with regards to the Soar; and
6. Provide advice and support to isolated properties at risk.

Short term objectives (5 years):

1. Flood warning improvements;
2. Leicester feasibility study (upstream storage Leicester/Syston) and associated EIA;
3. Support CBC with Loughborough FRA (Burleigh and Wood Brooks); and
4. Improve communications with local communities, by encouragement of fluvial groups.

Long term objectives:

1. Review of the operation rules at Brentingby flood storage area; and
2. Lower Soar Feasibility study and associated EIA (improve flood conveyance of weirs, i.e. Cossington).

7.11 Additional Options for Flood Risk Management

A strategic approach to the identification of potential options and locations for key future Flood Risk Management (FRM) infrastructure will ensure that FRM options are incorporated in development plans and avoid opportunities being missed. Key Flood Risks in Charnwood are associated with the main rivers which flow through the Borough.

Potential options and locations for flood attenuation along watercourses in Loughborough for the attenuation of flood flows, subject to the design of an appropriate engineering scheme include:

1. Black Brook – the open land between Buckingham Drive and Mount Grace Road, and upstream of Mount Grace Road provides valuable storage space for the Black Brook upstream of the embanked section through Thorpe Acre. This land should be protected from encroachment by development;

2. Burleigh Brook – the strip of grassed/shrub covered land between the A512 New Ashby Road and Loughborough University; and

3. Wood Brook - Nanpantan Reservoir, land southwest of Nanpantan Road/Watermead Lane, land west of Moat Road/Bramcote Road, Queens Park near Pantain Road, and Devonshire Square.

Additional locations may exist where potential schemes are possible, Charnwood's planners should liaise with the Drainage Department to ensure potential sites are identified at the early stages of development proposals.

The river corridors associated with watercourses adjacent to potential future development areas could be enhanced as part of development proposals. Opportunities may exist to enhance the ecology along these watercourses with the incorporation of river rehabilitation and restoration techniques as applicable. Beneficial floodplain creation and storage may be achievable through the creation of additional low-lying areas adjacent to watercourses, and the reuse of spoil where required elsewhere in parts of the development site outside of Flood Zone 3a and 2. Green

SuDS options such as green roofs, reed beds and swales can be designed to provide additional areas that provide ecological benefits alongside there surface water management role.

Examples of potential schemes include:

1. Proposed Loughborough Science Park near M1, south of A512 – potential for flood attenuation on upper tributaries of the Wood Brook; and

2. East of Thurmaston and North of Hamilton SUE – new access roads will be required to support the proposed extension to the Leicester PUA. Since these roads cross the Barkby Brook, the potential may exist to engineer the road embankment to create an online flood storage area upstream, reducing flood risk downstream in Syston.

Where FRM schemes are associated with large development schemes there may be potential for developer contributions and the inclusion of flood attenuation in the site master-planning.

The Development Control process will provide the key mechanism for reducing flood risk in the Charnwood area in two ways: a) ensuring new construction is flood resistant; and b) appropriate runoff management. Over time, with redevelopment these will aid reducing the amount of people and property at risk of flooding.

Charnwood Borough Council should ensure the application of the Flood Avoidance, Resistance and Resilience options detailed in section 7.6. Reductions in the amount of people and property currently at risk of flooding may be achieved by increasing the uptake of flood resilience strategies on existing property at risk of flooding.

In addition to engineering options planning conditions can be used to require reductions in runoff from brownfield sites upon redevelopment, which over time will produce a cumulative reduction in peak runoff volumes. Scope may exist for the identification of the largest contributors to un-attenuated runoff in problem location and the identification of schemes for runoff attenuation. At present requirements are for a 20% reduction in runoff from a redeveloped site compared to the existing runoff from the brownfield site. These requirements could be increased so that (wherever feasible) runoff from brownfield redevelopment is attenuated to the greenfield rate.

7.12 Future Hydraulic Modelling

There are several existing hydraulic models of the major watercourses of Charnwood Borough prepared by the Environment Agency and Charnwood Borough Council. Broadly, the representation of flood extents (and depths) by these models is understood to be within the typical bounds of accuracy/representativeness for typical SFRM flood modelling exercises.

Nevertheless, sections of the models correlate less well with observed historical data (see Appendix C), and especially if discrepancies exist between the extents of future flood events and modelled extents, the models will require updating to improve their representativeness.

The complex flow of water between the Burleigh and Wood Brooks, the Grand Union Canal and the River Soar, and in times of flood the resulting out-of-bank flow through central Loughborough would be best approached through the use of 2D modelling (i.e. the widely used TUFLOW software). This would though, require the acquisition of further Environment Agency LiDAR data to cover Loughborough. However, the resulting model would provide a far more satisfactory representation of the extent of areas at risk of flooding, flood pathways and the resulting depths of water.

Large parts of Quorn are protected by a combination of localised relatively high topography and additional flood defences, it is unclear from the existing River Soar model, and the lack of a Quorn Brook model what the exact flood risk is. The limited available historical flood extents examined indicate that notable flooding has not occurred, however current information makes the assessment of future changes in flood risk due to climate change difficult.

The functioning of flood defences along the Rothley Brook in Rothley under future climate change is also unclear.

Breach modelling of the embanked section of the Black Brook through Thorpe Acre would provide a more detailed assessment of the potential extent of flood risk to people and property in this area. Current modelled extents are based on either a *no-defences* or a *defended* scenario.

8. Conclusions and Recommendations

8.1 Flood Risk in Charnwood Borough

The main objective of the Charnwood SFRA is to inform the Local Development Framework by assessing the local flood risk issues in order that the Sequential Test can be applied to allocate future development within Charnwood Borough. Based on a number of key factors, including the history of flooding in the Borough and specific development needs together with the potential areas for new development identified, a tailored approach to the SFRA has been developed to best meet this objective.

In line with the general approach for all SFRAs, a sequential, risk-based approach to assessing development and flood risk has been used, in line with the guidance outlined in PPS25 *"Development and Flood Risk"* (based on its predecessor PPG 25) and the accompanying PPS25 Practice Guide. The overriding aim of the PPS25 Sequential Test is to steer all new development to areas of lowest flood risk. This requires both an understanding of potential flood risks in Charnwood Borough together with an assessment of the specific risks posed to the areas of search on a local scale.

Flood risk was characterised throughout the Borough based on a range of information sources. The risks associated with primary fluvial flooding were predominantly based on the Environment Agency's flood zones, supplemented where appropriate with data from hydraulic modelling and historical sources. However, these do not take into account flooding from minor watercourses or other secondary sources of flooding. Previous studies and investigations into these flood issues, were particularly useful in identifying other key risks, including flooding due to minor watercourses, groundwater, overland flow, constriction at structures, and insufficient sewer capacities.

Under the climate change scenario used (a 20% increase in peak flows), hydraulic modelling has indicated that there will be a limited (but locally important) increase in the extent of Flood Zone 3a. The scenario mainly indicates an increase in the depth of flood water, particularly upstream of in-channel structures such as bridges. This occurs due to local topography; since relatively steep sides to the floodplain allow depth to increase without the overall floodplain extent increasing. Planners should be aware of the potential for lateral and vertical changes to flood extents, and a suitable FRA may need to be requested to demonstrate that the proposed development, if justified, will not at risk be at risk from flooding now and in the future.

The resulting GIS extents delineating flood risk have been supplied to CBC for use by their Planning and Development Control teams. Within this report, Table 4.3 provides a summary and brief description of the flood extent figures included in this report identifying which should be used by Development Control (figures follow at end of Section 4).

8.2 Prioritisation of Potential Development Areas

The flood risk associated with the broad potential development areas in Charnwood has been assessed, with a view to prioritising those with the lowest associated flood risk. This information can now be used in the application of the PPS25 Sequential Test in order to allocate development as part of the LDF process. This should be used by the council's planners to preferentially place development in areas of lowest flood risk and to, as far as practicable, avoid placing new development in areas of flood risk and in seeking solutions that reduce flood risk to existing development. The key conclusions arising from this process:

8.2.1 Development adjoining Loughborough (SUEs):

Six broad options are being investigated by Charnwood Borough Council (west of Shepshed, west, south and north of Loughborough, and across the River Soar, immediately east of Loughborough, and at Wymeswold Airfield);

1. Development in all of these areas would be sited to remain away from Flood zones 3b, 3a and 2 of the SFRA Flood Map
2. There are therefore only limited issues with primary (fluvial) flood sources, and the main requirements for the development of these areas will be the management of surface water runoff through appropriate SuDS and by ensuring that secondary flooding sources are adequately addressed at the planning, design and construction stages;
3. Care should be taken to identify critical areas, which if developed could increase the flood risk to existing development downstream. This is particularly important for sites adjacent to and within existing urban areas, where increased loading may potentially be placed on the existing drainage system leading to increased flood risk downstream. For larger new developments, it is likely that the supporting modern SuDS will allow flood risk to be managed. In either case, a FRA commensurate with the scale of the proposed development will allow potential increases in flood risk to be avoided;
4. The identification of areas where flood attenuation schemes (potential schemes are listed under paragraphs 7.11.2 bullet points 1, 2 and 3 and 7.11.5 – bullet point 1) could be used to reduce the flood risk to existing development downstream, would allow these to be incorporated in site master-planning and green space provision, and could potentially be funded via developer contributions; and
5. The Council will need to consider further the significant flood risk constraints of the potential new road infrastructure (see Section 3.3) that would be required if new development was to be located to the east of Loughborough across the River Soar from Loughborough, and to relieve the A6 through Loughborough Town Centre. When comparing the potential Loughborough SUEs through the Sequential Approach, the significant flood risk constraints against the construction of new road infrastructure to serve a new development east of the Soar floodplain should be included in the assessment, alongside flood risk constraints specific to each SUE. The design would need to avoid increasing flood risk to people and property in the vicinity and such that the road remains operational at times of flooding.

8.2.2 Development adjoining Leicester (SUEs):

1. Three broad options are being investigated by Charnwood Borough Council (East of Thurmaston and North of Hamilton, North of Birstall, and adjacent to Glenfield within Charnwood south of Anstey);

2. All of these areas would be sited to remain away from Flood zones 3a and 2 of the SFRA Flood Map;

3. There are therefore only limited issues with primary (fluvial) flood sources, and the main requirements for the development of these areas would be the management of surface water runoff through appropriate SuDS and by ensuring that secondary flooding sources are adequately addressed at the planning, design and construction stages;

4. Care should be taken to identify critical areas, which if developed could increase the flood risk to existing development downstream. The identification of areas where flood attenuation schemes (potential schemes are listed under paragraph 7.11.5 – bullet point 2) could be used to reduce the flood risk to existing development downstream, would allow these to be incorporated in site master-planning and green space provision, and could potentially be funded via developer contributions; and

5. Flood risk will likely only be a minor limitation on new roads for the identified options for development adjacent to the Leicester PUA. The key road crossing will be associated with the Barkby Brook. Again, justifications for the new road infrastructure (see Section 3.3) will be required. The design would need to avoid increasing flood risk to people and property in the vicinity and such that the road remains operational at times of flooding. An opportunity may exist to reduce the flood risk downstream in Syston by creating an online storage area upstream of the road bridge. Detailed feasibility studies would however be required to further assess the possibility of this measure.

Flood Risk Summary for use in applying the Sequential Test to SUEs

Based on the Sequential Approach to prioritising the sites, Section 5.3 and points 8.22 and 8.23 above, the SUEs can be divided into three bands (1, 2 and 3 with increasing magnitude of flood risk issues).

Band 1 – *Potential West of Shepshed, West, South and North of Loughborough and North of Birstall, and adjacent to Glenfield within Charnwood south of Anstey SUEs* **-** In terms of flood risk all of the above sites could be considered suitable to be moved forward for development, due to their location in Flood Zone 1 with no access constraints.

Band 2 – *Potential East of Thurmaston and North of Hamilton SUE* – There appears to be a potentially significant drainage issue with the Thurmaston Dyke under the Leicester railway line. The capacity of this culvert to take additional flows should be examined in relation to the proportion of the proposed SUE which drains towards the Dyke is promoted for development.

Band 3 - *Potential East of Loughborough and Wymeswold Airfield SUEs* – These sites have the same issues as Band 1 sites, however the flood-risk constraints of any proposed supporting road infrastructure which crosses the Soar floodplain needs to be assessed via the sequential test process (see 8.2.2, bullet point 6).

Flood Risk Summary for use in applying the Sequential Test to Brownfield and Infill Development

For brownfield and infill development within Charnwood, particularly in Loughborough the council should follow the sequential approach and prioritise sites in Flood Zone 1 for development, followed by sites in Flood Zone 2, and finally Flood Zone 3a.

If a site is at high risk of flooding and is deemed to have passed the Sequential Test, it must be clearly demonstrated that each of the three criteria set out by the Exception Test has been satisfied. For sites in Flood Zone 3a or even 3b at particularly high risk of flooding, it may be necessary to consider parts of (or even the whole area) to be undevelopable.

Where no other alternatives exist to sites in Zones 2 and 3a, land uses should be allocated according to vulnerability, with the development types considered most vulnerable placed in the areas of the site least at risk of flooding. In all instances of infill or brownfield development, the FRA must show that any development is safe for the residents or users of the facility.

Based on the Sequential Approach and Section 5.4 the following HLAA sites can be divided into three bands (1, 2 and 3 with increasing magnitude of flood risk issues). Band 1 contains sites located in Flood Zone 1, Band 2 sites in Flood Zone 2 and/or near OWs, and Band 3 sites in Flood Zone 3a and/or adjacent to watercourses with known flood issues (further details in Table 5.2 and 5.3):

- Band 1 –
    - Former Tuckers Brickyard, Beacon Road, Loughborough;
    - Radmoor House, Radmoor Road; Land at True Lovers Walk/Frederick Street, Loughborough;
    - Land at rear of The Old Pack Horse, Pack Horse Lane, Loughborough;
    - Leicester Road/ Aumberry Gap, Opportunity Site, excluding PH, Loughborough;
    - Former Petrol Station, Pinfold Gate, Loughborough;
    - Cherry Tree Inn, Hume Street, Loughborough;
    - Part of Baxter Gate Opportunity Site, Loughborough;
    - 77 Meadow Lane and garages, Clarence Street, Loughborough;
    - North of Spring Close, Shepshed;

- 136 Cotes Road, Barrow-upon-Soar;
- Day Centre, Berkeley Road, Mountsorrel;
- Rear of 249 – 263 Leicester Road, Mountsorrel;
- 9 King Street, Sileby;
- Albion Street, Roseberry Road, Kitchener Road, Anstey;
- Part of H/2a Bradgate Road, Anstey.

- Band 2 –
  - Dale Farm Depot, Thorpe Acre Road, Loughborough;
  - 136-144 Knighthorpe Road, Loughborough;
  - Burder Street Opportunity Site, Loughborough;
  - Richard Roberts Factory, Clarence Street, Loughborough;
  - Disused Nursery, rear of 263 Granite Way, Mountsorrel;
  - Linkfield Road, Mountsorrel;
  - Rear of 36-46 Colby Road, Thurmaston;
  - Rear of 149-155 Colby Drive and rear of 167-177 Colby Drive, Thurmaston;
  - Land to the rear of 53 & 55 Colby Drive, Thurmaston.
- Band 3 –
  - Council Depot, Limehurst Avenue, Bridge Street (Corporation Yard) , Loughborough;
  - Devonshire Square Opportunity Site, Loughborough;
  - Land at Empress Road, Great Central Road, and Moor Lane Bridge, Loughborough;
  - H/1(a) Land at Barrow Upon Soar, Barrow Upon Soar;
  - Land off Nursery Grove / Nottingham Road Housing Allocation, Barrow-upon-Soar;
  - Walkers Transport, Loughborough Road, Mountsorrel;
  - 72 – 138 Loughborough Road, Mountsorrel;
  - Land at Victoria Street, Syston;

- 93 St. Peter's Street, Syston;
- Brook Street, Syston.

It is not possible to include the Dishley Grange/Derby Road employment site in a sequential list for application of the Sequential Test based on flood risk, as it is the only employment allocation identified at present. The flood risk issues are detailed in Table 5.3, and the Council will need to demonstrate that there are no alternative suitable locations, located in lower risk Flood Zones. Part of the land is within Zone 3b and this should be taken into account in any future proposals (and associated Flood Risk Assessments) for the site.

Mineral and Waste Framework Sites

Potential Mineral and Waste Sites within Charnwood have been evaluated in the context of flood risk. The majority of the sites are not considered to be at risk from flooding, and could be brought forward for development subject to the appropriate pollution and surface water management arrangements. Several of the sites (Thurcaston Sewage Works, Loughborough Civic Amenity Site) do have potential issues, however, subject to an appropriate site-specific FRA, may still be developed. However, the Wanlip site is located in Flood Zone 3b, which PPS25 classifies as unsuitable for development for all waste uses.

8.3 Underlying Assumptions

The investigation of potential development areas has been undertaken with a view to ensuring development planned for Charnwood Borough is located to minimise flood risk. The sequential, risk-based approach therefore focussed on the local flood risks faced by each potential development area. The underlying assumptions in this approach include the following:

- The prioritisation of a site(s) above does not remove the need for a more detailed assessment (in the form of an FRA) should the site be selected for future development. This includes a need to consider flooding from risks specifically assessed in the sequential approach (i.e. from major and minor watercourses, and spring activity) as the preferred sites are only considered to have the lowest relative flood risk - flood risk is never eliminated altogether;

- Other local risks that were assessed and found to affect all the areas of search to some degree (i.e. overland flow and constrictions at structures) will also need to be assessed in further detail in the FRA;

- Issues common to all new development including the control and management of runoff with appropriately designed SuDS and sewer flooding will also need to be assessed in further detail in the FRA;

- Where the potential development areas were investigated, and no known source or occurrence of particular types of flooding was found, this does not necessarily mean there are no associated flood risks. This has merely been used as a means to prioritise sites based on a preference for those that have no, or fewer, known historical flooding problems;

- It is recognised that the final selection of areas for future development will depend on a range of planning pressures. As with all new development, the guidance in PPS25 will determine whether development may be permitted, including a requirement to satisfy the criteria of the Exception Test (where applicable) and the FRA;

- The provision of an FRA does not mean that planning permission will necessarily be granted. Permission will only be granted if the FRA is considered to show the site is appropriate for development.

8.4 Application to the Planning Process

The transition from the Charnwood Local Plan to the Local Development Framework following the Planning and Compulsory Purchase Act 2004 provides an ideal opportunity for Charnwood Borough to review and update its policies on flood risk, and to ensure consistency with national guidance and regional planning policy.

Highlighted by recent flood events in the Borough, it is essential for Charnwood Borough Council to develop clear and robust policies related to flood risk management. These will need to be readily understood by applicants and development control staff with regard to the preparation and determination of planning applications. PPS25 will be the principal reference point in this process. The interaction of PPS25 with other Planning Policy Guidance and Statements is acknowledged, particularly in relation to PPS 3 *Housing* where there is scope to combine the sequential test for flood risk with reviews of urban capacity and housing land allocations.

The detailed flood risk maps produced in the preparation of the SFRA (See Table 4.3) for the main watercourses in the Borough should be used as the first point of reference in determining the level of flood risk posed to a development. Where appropriate, reference to this resource should be made in the council's policies regarding flood risk.

The concept of 'residual risk' needs to be understood within the planning process in Charnwood Borough. Notwithstanding the protection afforded by flood alleviation schemes in the Borough, the consequences in terms of damage and risks to people remains significant, should a flood defence scheme fail. In line with the sequential approach applied above, development should be avoided in areas of residual risk. Where this is not possible, developments must be adequately defended by secondary defence measures and flood resistant designs. Particularly vulnerable uses should not be located in areas of high residual flood risk.

8.5 Application to Development Control

It is important that Charnwood Borough Council is fully informed in relation to the assessment of development and flood risk in order that it may liaise with other responsible authorities (e.g. the Environment Agency and Severn Trent Water). The Sequential Test outlined in PPS25 must be at the centre of spatial planning and development control decisions related to flooding, with sites prioritised for development in Zone 1 wherever possible. A further sequential approach should then be applied to other secondary sources of flood risk.

A Strategic Flood Risk Assessment (SFRA) is a strategic exercise providing an assessment over a wide area. It does not preclude the need for local, site-specific flood risk assessments (FRAs) as part of the application process for particular developments.

Applicants should be encouraged to identify and implement flood mitigation and management measures in a way that reduces risks in a sustainable manner, observing good standards of urban design and finding ‘green’ solutions which enhance recreation and amenity, and avoid damage to local ecology. Planning conditions should be used to improve flood resilience of buildings where risks exist. The Environment Agency’s standard planning conditions on flood risk are a useful aid to development control officers.

8.6 Draft Policies for Local Development Documents

Some suggestions are set out below, which may form the basis of draft policies for Local Development Documents. Clearly, these may need modification and tailoring to local circumstances and may need to be summarised in order to achieve the right balance alongside other planning policies. Greater detail can be provided within a Floods Planning Policy such as that shown in Box 8.1.

Box 8.1 Example Floods Planning Policy
The Council will have regard to PPS25 “Development and Flood Risk” and to the most recent Strategic Flood Risk Assessment for Charnwood Borough in assessing the suitability of land for development. Development will only be considered in the higher risk flood zones (Zones 2 and 3) if there are no land use vulnerability constraints, the Sequential Test and Exception Test has shown the alternatives to be exhausted, and it has been demonstrated that there will be no detriment to other interests. If such a development is to be considered the Council will require the mitigation measures accompanying the planning proposals to be subject to a sustainability appraisal. There will be a presumption in favour of measures that employ good standards of urban design and high flood resilience; enhance local recreation and amenity; protect ecology; safeguard water resources and utilise sustainable urban drainage systems. Unsustainable solutions such as the culverting of watercourses will be resisted and other engineered solutions will be scrutinised in order to determine whether a more environmentally sustainable alternative may be more appropriate. For all development in higher risk flood zones, as well as major development in areas of low flood risk (Zone 1) where surface water runoff can cause flooding will be required to be accompanied by a site-specific Flood Risk Assessment which will be a material consideration in the determination of planning applications. This assessment will need to include a consideration of other secondary sources of flooding and residual flood risk where applicable. It will also need to assess the vulnerability to flooding over the lifetime of the development and the potential for the development to increase flood risk elsewhere. Depending on the outcome of the site-specific Flood Risk Assessment, the Council may require flood protection and mitigation measures to be included in developments that may be on- or off-site. In such cases, planning permission may be granted subject to appropriate planning conditions or planning obligations. Production of a Flood Risk Assessment does not guarantee the granting of planning permission.

8.7 Recommendations for Future Work

8.7.1 Updates to the SFRA

The results of the SFRA should be used to inform the Local Development Framework. Provisions should be made for updating the SFRA outputs on a regular basis with the latest available information and in any case before the LDFs are due for revision.

8.7.2 Surface Water Management Plans

It is strongly recommended that Surface Water Management Plans are developed for all major areas of allocated urban development in line with Defra's policy and emerging advice on Integrated Urban Drainage (IUD), the pilot studies for which will conclude in 2008. Surface water Management Plans are intended to provide a holistic plan for managing urban drainage and would include masterplanning e.g. strategic areas set aside for flood attenuation or excess flow conveyance allied to green space provision. as well as other issues such as funding and adoption for operation and maintenance. Recommendations for taking these forward are likely to emerge over the next 12 months.

8.7.3 Knowledge Management

The way information about past flood events is recorded, disseminated and used is material to the development of flood risk knowledge and the development of solutions to risk avoidance and reduction. The Environment Agency maintains records of past flood events and these are used in the preparation of the flood risk maps which are regularly revised and publicly available on the internet. Record keeping by the local authority of the occurrence and type of flooding can provide a key input into characterising flood risk. Severn Trent Water also keep records of sewage and surface water flooding arising from surcharging of drains and sewers within its responsibility which will be key in reducing the risks to new development associated with sewer flooding.

Without proper management, this invaluable information on past flood events can be lost, particularly where knowledge resides with officers of longstanding employment who can recall past flood events, their causes, effects and any remedial measures from memory. This SFRA has attempted to collate multiple sources of local information. It is highly recommended that this database of knowledge is expanded and updated as new information arises, ideally through the identification of a single officer, responsible for the codification of information about flood risk in the Borough and for improving communication between departments.

There may be concern that organising data in this way may give rise to blighting of properties (similar to the concerns raised over the Register of Contaminated Land). This could be a real issue in the context of the Freedom of Information Act and needs legal investigation before proceeding.

We would advise against allocating this responsibility to the Environment Agency, as it is essential to build the capacity of local authorities for dealing with this issue. However, there is a need to improve and maximise liaison between Charnwood Borough Council, the Environment Agency and Severn Trent Water on flood risk matters and, in this respect, there may be considerable value in meetings on a regular basis after the SFRA itself is complete.

8.7.4 Guidance for Developers

To complement the findings and recommendations of the Charnwood SFRA with respect to development and flood risk in Charnwood Borough, it is recommended that a set of guidance notes are produced setting out the requirements for both private and commercial developers. This could comprise documentation, leaflets and flow charts covering the correct procedure(s) for the various types of application in relation to flood risk, including:

- Production of preliminary or Stage 1 FRAs;
- Production of detailed or Stage 2 FRAs;
- Assessment of surface water runoff from large and small developments;
- Use of SuDS and long term maintenances;
- Assessment of historic flows off brownfield sites;
- Monitoring of post development runoff;
- Strategic solutions to flood risk;
- Culverting policy and environmental gain.

9. References

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Creating the environment for business

Appendix A
SFRA Planning Background

1.1 National Planning Policy

Planning and Compulsory Purchase Act

1.1.1 The SFRA has taken place in a period during which planning authorities have been implementing the provisions of the Planning and Compulsory Purchase Act 2004 and accompanying planning guidance, including PPS 1 Delivering Sustainable Development and PPS 12 Local Development Frameworks. This affected all tiers of the planning system and has necessitated major changes at both the regional and local level which will impact on the way in which planned development is reflected in the regional strategy and delivered locally.

1.1.2 Planning Policy Guidance Notes (PPGs) are being reviewed by Government and will be updated and replaced by Planning Policy Statements (PPSs), although Government has indicated that PPGs will be reviewed and replaced as and when considered necessary in the light of their policy and strategic significance.

1.1.3 Regional Planning Guidance has now been transformed into Regional Spatial Strategies (RSSs) with the East Midlands RSS published in March 2005. However, this was developed before the new legislation came into effect and therefore does not fully conform to the new requirements (e.g. up-to-date housing figures for local authority areas). The plan is currently being reviewed and it is anticipated that the revised RSS will be published in 2008.

1.1.4 At a Local Planning Authority (LPA) level, Local Plans are being phased out and replaced by Local Development Frameworks (LDFs), a folder of planning documents that will guide decisions on the development and use of land. LPAs were required to produce a Local Development Scheme under the new regulations set out in the Planning and Compulsory Purchase Act 2004, setting out their programme for the production of the new development plan and summarising the documents that will, collectively, make up the LDF.

Development and Flood Risk – Planning Guidance

1.1.5 This SFRA has been undertaken in accordance with the guidance provided in PPS 25 and its accompanying Practice Guide.

1.1.6 The introduction of PPG 25 Development and Flood Risk in July 2001 reinforced the responsibility of LPAs to ensure flood risk is understood and managed effectively as part of the planning process. PPG 25 represented a marked shift in the management of flood risk from reactive solutions (such as flood defences) to the more preventative approach of managing and reducing flood risk through land use planning. In March 2005, the Government announced a revision of PPG 25 to strengthen planning policy on development and flood risk. While it is generally agreed that PPG 25 has worked well, and highlighted the importance of flood risk in the development process, there was a need to focus on core policies, and be clearer and easier to understand. PPS 25 was adopted and PPG 25 thereby cancelled in December 2006, and an accompanying Practice Guide to PPS 25 was issued in February 2007.

1.1.7 In revising PPG 25, the Government sought to provide clarity on what is required at a regional and local level to ensure that appropriate and timely decisions are made to deliver sustainable planning for development. The key planning objectives as stated in PPS25 are that:

"Regional planning bodies (RPBs) and local planning authorities (LPAs) should prepare and implement planning strategies that help to deliver sustainable development by:

APPRAISING RISK

- *Identifying land at risk and the degree of risk of flooding from river, sea and other sources in their areas;*
- *Preparing Regional Flood Risk Assessments (RFRAs) or Strategic Flood Risk Assessments (SFRAs) as appropriate, as freestanding assessments that contribute to the Sustainability Appraisal of their plans;*

MANAGING RISK

- *Framing policies for the location of development which avoid flood risk to people and property where possible, and manage any residual risk, taking account of the impacts of climate change;*
- *Only permitting development in areas of flood risk when there are no reasonably available sites in areas of lower flood risk and benefits of the development outweigh the risks from flooding;*

REDUCING RISK

- *Safeguarding land from development that is required for current and future flood management eg conveyance and storage of flood water, and flood defences;*
- *Reducing flood risk to and from new development through location, layout and design, incorporating sustainable drainage systems (SUDS);*
- *Using opportunities offered by new development to reduce flood risk to reduce the causes and impacts of flooding eg surface water management plans; making the most of the benefits of green infrastructure for flood storage, conveyance and SUDS; re-creating functional floodplain; and setting back defences;*

A PARTNERSHIP APPROACH

- *Working effectively with the Environment Agency and other stakeholders to ensure that best use is made of their expertise and information so that decisions on planning applications can be delivered expeditiously; and*
- *Ensuring spatial planning supports flood risk management and emergency planning."*

1.1.8 PPS 25 specifies that LPAs should adopt a risk-based approach to planned development through the application of a Sequential Test, prioritising allocations and planning permission for development in areas with the lowest flood risk. The Sequential Test should be based on the flood zones and flood risks delineated in this SFRA.. It also sets out the need to consider other sources of flood risk (such as groundwater, overland flow and sewer) when planning development on a local level. PPS 25 emphasises application of the precautionary approach in the planning of sustainable development, including consideration of the implications of climate change on flood risk.

1.1.9 Additionally, PPS 25 introduces the Exception Test which allows some scope for departures from the sequential approach where it is necessary to meet the wider aims of sustainable development. The criteria for exception include where the development makes a positive contribution to sustainable communities and managing flood risk, redevelopment of brownfield land (or no alternative), and where it can be demonstrated that the residual flood risks are acceptable and satisfactorily managed.

1.1.10 PPS 25 also clarifies that the possible impacts of climate change should be addressed in Flood Risk Assessments, and includes advice on current sources of information on climate change, to ensure that plans and planning decisions are fully informed about climate change impacts.

1.1.11 The Town and Country Planning (Flooding) (England) Direction 2006 has made the Environment Agency a Statutory Consultee on all applications for development in flood risk areas (except minor development), including areas with critical drainage problems and for developments exceeding 1 hectare outside of flood risk areas. After discussion with the Environment Agency LPAs are required to notify the Secretary of State if they remain minded to approve a planning application contrary to a sustained objection by the Environment Agency.

Other Planning Policy Statements

1.1.12 PPS 1 Delivering Sustainable Development published in February 2005, sets out the overarching planning policies for the delivery of sustainable development across the planning system and sets the tone for other PPSs that will follow. PPS 1 explicitly states that development plan policies should take account of flooding, including flood risk. It proposes that new development in areas at risk of flooding should be avoided. Planning authorities are also advised to ensure that developments are "sustainable, durable and adaptable" including taking into account natural hazards such as flooding.

1.1.13 PPS 1 also places an emphasis on 'spatial planning' in contrast to the more rigid 'land use planning' approach which it supersedes. Planning authorities will still produce site-specific allocations and a proposals map as local development documents, but their core strategy will be more strategic and visionary in content and will take into account the desirability of achieving integrated and mixed use development and will consider a broader range of community needs than in the past. With regard to flood risk, it will be important for the core strategies and accompanying supplementary planning documents to recognise the contribution that non-structural measures can make to flood management.

1.1.14 Whilst not directly relevant to the development of a SFRA, it is important to recognise that the exercise takes place within the context of other planning policy statements, some of which also require sequential testing of site allocations and development proposals. PPS 3 Housing, PPG 4 Industrial and Commercial Development and Small Firms and PPS 6 Planning for Town Centres are intrinsic within the planning process, and therefore an understanding of the constraints faced as a result of this additional policy guidance is imperative.

1.2 Regional Planning Policy

RSS 8 Regional Spatial Strategy for the East Midlands

1.2.1 A Regional Spatial Strategy (RSS) provides a spatial framework to inform the preparation of local development documents, local transport plans and regional and sub-regional strategies and programmes that have a bearing on land use activities. It forms part of the key development plan for the purposes of determining planning applications and has statutory force under the new Planning and Compulsory Purchase Act.

1.2.2 RSS 8, the Regional Spatial Strategy for the East Midlands, was published by the Secretary of State in March 2005 providing a broad development strategy for the East Midlands to 2021.

1.2.3 There are five main priority areas which the strategy aims to address:

- Affordable housing and prioritising brownfield land;
- Economy and regeneration: Policies on employment land and town centres;
- Natural and cultural resources: New targets on biodiversity, waste reduction and management, and flood risk;
- Regional transport strategy: Aims to reduce the need to travel, reduce traffic growth, improve public transport;
- Monitoring and review: Initial priorities of the next RSS review.

1.2.4 The plan divides the region into sub-areas. Charnwood lies within the three cities sub-area which includes Derby, Leicester and Nottingham where the overall aim is to encourage and create more sustainable patterns of development and movement between the city areas. Loughborough is the main settlement in Charnwood Borough Council and is identified within the Plan as a sub-regional centre where future development is encouraged.

1.2.5 The plan recognises the need for a regional approach to managing flood risk and land drainage, especially after the extensive flooding which occurred in 2000/01, which highlights its importance as a key future spatial planning issue. The plan outlines that LPAs should apply the sequential approach outlined in PPS 25 in determining areas for future development, linking it with the complementary advice given in PPS 3, particularly in the context of re-using previously developed land. SFRAs are recognised as an important method of identifying mitigation measures to limit flood impact and are particularly useful in the context of strategic site identification and previously developed land evaluation.

1.2.6 The regional approach to managing flood risk is outlined in Policy 36 of the plan:

"Development Plans, future Local Development Frameworks, and strategies of relevant agencies should:

- *Be informed by the use of appropriate Strategic Flood Risk Assessments in order to evaluate actual flood risk and should include policies which prevent inappropriate development either in, or where there would be an adverse impact on, the coastal and fluvial floodplain areas;*
- *Deliver a programme of flood management schemes that also maximise biodiversity and other regeneration benefits; and*

- *Require sustainable drainage in all new developments where practicable.*
- *Development should not be permitted if, alone or in conjunction with other new development, it would:*
- *Be at unacceptable risk from flooding or create such an unacceptable risk elsewhere;*
- *Inhibit the capacity of the floodplain to store water;*
- *Impede the flow of floodwater;*
- *Have a detrimental impact upon groundwater storage capacity;*
- *Otherwise unacceptably increase flood risk; and*
- *Interfere with coastal processes.*
- *However, such development may be acceptable on the basis of conditions or agreements for adequate measures to mitigate the effects on the overall flooding regime, including provision for the maintenance and enhancement (where appropriate) of biodiversity. Any such measures must accord with the flood management regime for that location.*
- *Strategic flood risk assessments should be carried out where appropriate to inform the implementation of this policy."*

Draft East Midlands Regional Plan

1.2.7 The draft East Midlands Regional Plan revises the Regional Spatial Strategy for the East Midlands (RSS8) and maps out the future development of the region up to 2026.

1.2.8 The plan provides new housing provision figures as annual build rates for the period 2001-26 covering the whole region which works out at 20,418 houses per year. Also included are targets for affordable housing (32 per cent) and development on brownfield land (60 per cent) for the period.

1.2.9 The plan proposes a requirement of 19,000 dwellings for Charnwood, to be delivered between 2001 and 2026 (equivalent to 760 per annum). The draft policy proposes that 195 dwellings per annum of this requirement should be delivered as a sustainable urban extension to the Principal Urban Area of Leicester (to provide 4,875 dwellings in total). It also proposes that development in the remainder of the District should be focused primarily on the Sub-Regional Centre of Loughborough, including 195 dwellings per annum as a sustainable urban extension to the town (4,875 dwellings in total).

1.2.10 It should be noted that in response to the Draft Regional Plan, Leicestershire County Council have suggested that the scale of growth in Charnwood should increased to 21,500 dwellings (860 dwelling per annum). They suggest this should include delivering 320 dwellings per annum as part of sustainable urban extensions to Loughborough (a total of 8,000 dwellings) and 175 dwellings per annum as a sustainable urban extension to the Principal Urban Area of Leicester (to provide 4375 dwellings in total).

Leicestershire Transport Assessments

1.2.11 During late summer / autumn 2006 Leicestershire County Council carried out an *'Assessment of Highways and Transportation Implications of Sustainable Urban Extensions at Selected Broad Locations in Leicestershire'* to establish in broad transport terms whether there was a workable location for a SUE in each of the five broad areas defined in the draft Regional Plan; it took as its basis the areas and scales of development as set out in the draft Regional Plan. As identified above two of the five possible broad areas for SUEs defined within the draft regional Plan fall within Charnwood, one adjoining the Principal Urban Area of Leicester and one adjoining the Sub-Regional Centre of Loughborough.

1.2.12 With regard to Loughborough, the original analysis revealed considerable difficulty in accommodating the SUE in the broad area tested; other options were therefore examined. The outcome of this pointed toward the need for a significantly larger SUE than originally envisaged, in order to fund a very substantial package of measures. Principal amongst these is an eastern distributor road, required to unlock opportunities to improve public transport, walking and cycling facilities in the town.

1.2.13 The project and its outcomes are summarised in the December 2006 technical report, which was used to inform the County Council's Cabinet approval for the following revised advice on housing and employment provisions for Charnwood:

- In Charnwood, adjoining Leicester: 4375 dwellings + 25ha of employment
- Loughborough: 8000 dwellings + 25ha of employment
- A separate 50ha extension to the Loughborough Science Park

1.2.14 In relation to the east of Loughborough SUE the findings of a 'Further Assessment of Highways and Transportation Implications of Urban Extensions at Selected Broad Locations in Leicestershire – Technical Report' by the County Council in April 2007 identifies two strands of inter-connected work, one of which refers to flooding stating:

'Examine flooding issues to the east of the town, predominately in terms of the routeing of an eastern distributor road, but also in terms of implications for the delivery of an SUE in this broad location'

'The line of the proposed eastern distributor road, runs through the flood plain of the River Soar and its tributaries. Management of the flood risk must be addressed if it is to have a chance of being delivered. (Failure to address the flood risk issue is understood to be delaying the proposed Dishley Grange employment site to the north of the town.)'

1.2.15 The report is broadly supportive of the original conclusions that in transportation terms the option for a larger SUE of 8000 dwellings broadly to the east of Loughborough appears to provide the best opportunity to deliver a sustainable development that can be satisfactorily accommodated.

1.2.16 Paragraph 4.61 of the Further Assessment states that:

"Flooding issues: *The flood risk issue has a very significant impact on the viability of delivering an eastern distributor road, and hence on the viability of an SUE in this particular broad location. Useful progress has been made during this project in identifying further work that will need to be done to:*

- *develop alternative route options to minimise flood plain impacts; and*

- *put together a supporting case to seek to demonstrate that the proposal is sequentially preferable and compliant in PPS25 terms, and also in identifying a potential solution to accommodate the distributor road without increasing the flood risk."*

East Midlands Regional Flood Risk Appraisal

1.2.17 To comply with national planning policy guidance, the East Midlands Regional Assembly commissioned a Regional Flood Risk Appraisal (RFRA) which would inform the Regional Sustainability Appraisal (RSA) as part of the development of the Regional Spatial Strategy (RSS). The RFRA would be used to assist in the allocation of housing numbers and in the development of flood risk management policies.

1.2.18 The Study outlines that within Leicestershire only Leicester City and Charnwood District have more than 10% of Zone 3 land (ie. the high risk flood zone as designated by the Environment Agency). The RFRA notes that Charnwood Borough Council considers flood risk to be a significant issue. The Study recognises that the issue of flooding is a problem in Charnwood giving it a 'medium' rating which is a considerably higher than the other Districts surveyed. There is recognition that flooding has been a problem previously and will continue to be in the future unless measures are taken to mitigate the problem.

Leicestershire Sustainable Urban Extensions Sustainability Appraisal

1.2.19 The Sustainability Appraisal of Sustainable Urban Extensions points to the Planning Portal glossary definition of an urban extension as development that:

"Involves the planned expansion of a city or town and can contribute to creating more sustainable patterns of development when located in the right place, with well-planned infrastructure including access to a range of facilities, and when developed at appropriate densities."

1.2.20 Twelve areas of search for SUEs were originally identified, seven adjoining the Leicester Principal Urban Area (PUA) and a further five adjoining the Sub-Regional Centres (SRCs) of Loughborough, Hinckley, Melton Mowbray and Coalville. The relevant ones to Charnwood are:

- PUA 1- North of Leicester: In Charnwood, to the north of Leicester, between the Leicester City boundary and the Rothley Brook bordered by the River Soar in the east and the outer edge of the National Forest to the west.
- PUA 2 – North East of Leicester: In Charnwood, to the north east of Leicester, between the Leicester City boundary, the River Soar and Thurmaston in the west, the outer edge of Scraptoft in the south and extending into open countryside to the east towards Barkby.
- PUA 7 – North West of Leicester: In Hinckley and Bosworth, Blaby and Charnwood districts to the north west of Leicester, between the Leicester City boundary, Kirby Fields and Kirby Muxloe in the south, Rothley Brook in the north, extending out towards the National Forest and Ratby and Groby.
- Sub Regional Centre: In Charnwood surrounding Loughborough and Shepshed from the county boundary in the north, to the M1 and beyond Hathern in the north-west, towards Wymeswold, Burton on the Wolds and

Barrow upon Soar to the east, to Quorn, Woodhouse and the National Forest in the south and south west.

1.2.21 The recommendations in the report outlined that PUA 1 and PUA 2 could be taken forward. It is recognised that there are floodplain limits the developable area in PUA 1 and public transport improvements would be required although there are fewer environmental and heritage constraints than some other areas and there is access to local jobs and services.

1.2.22 PUA 2 is similar in many ways, although it has slightly more potential issues with respect to the environment, landscape and heritage, and transport connections are not as strong but land is more readily available for the development of an SUE.

1.2.23 The report states that the SRC with the greatest potential for an SUE in terms of employment, services and strategic infrastructure is Loughborough and Shepshed. However, this area also exhibits the most severe environmental and heritage constraints, although these are less prevalent to the east of the River Soar Valley. The geographical layout of Loughborough itself, with the town centre being tightly constrained in terms of the road network and its physical environment is a particular issue. A relief road to address this could have potentially major significant environmental consequences. Further, the report notes that transportation investigations into this area of search by LCC identified that to make this location viable, 8,000 houses rather than 4,500 would be required. This would be necessary to justify the significant capital costs involved in providing the necessary infrastructure to serve the SUE.

Leicestershire, Leicester and Rutland Structure Plan

1.2.24 The Structure Plan provides the strategic planning framework which will guide decisions on development, transport and environmental matters in Leicestershire, Leicester and Rutland until the East Midlands Regional Plan is adopted and replaces this strategic policy. This Regional Plan is expected to be adopted in Autumn 2008.

1.2.25 The Structure Plan demands a sequential approach towards the location of development and makes a provision for 63,000 dwellings within the Plan Area between 1996 and 2016, of which about 31,500 dwellings shall be located in the Central Leicestershire Policy Area.

1.2.26 The southern part of Charnwood Borough Council lies within the Central Leicestershire Policy Area and is allocated 2,950 dwellings, with the rest of the Council area allocating 6,450 dwellings giving a total of 9,400 for the Borough.

1.2.27 Additionally no more than 15 hectares of new greenfield housing land will be allocated on Strategic Greenfield Housing Sites.

1.2.28 With regard to flooding issues, Policy 17 recognises:

"The strategic importance for flood relief and biodiversity of the Rivers Soar, Trent, Welland, Wreake, Chater, Gwash, Mease, Eye, Sence (eastern) and Sence (western) and their floodplains will be recognised. Measures will be taken along these corridors through an integrated approach to protect and enhance:

- *Their capacity to function as natural floodplains;*

- *Their linear continuity in the interests of biodiversity; and*

- *The form, local character and distinctiveness of the natural, historic and built environment.*

Proposals for improving access, recreation and tourism along these corridors will be encouraged where they do not have an unacceptable effect on the above interests."

The River Soar is the main watercourse which flows through the Borough.

1.3 Local Planning Policy

Introduction

1.3.1 As a result of the Planning and Compulsory Purchase Act 2004, the way in which development plans are prepared is changing. With the aim of speeding up and simplifying plan preparation and improving community involvement, development plans in their current form are to be abolished and replaced with a new development plan system, the Local Development Framework (LDF). This transition provides an ideal opportunity for Charnwood Borough Council to review and update their policies on flood risk to ensure consistency with national guidance and regional planning policy.

Charnwood Local Plan

1.3.2 In 2004, Charnwood Borough Council adopted the Charnwood Local Plan. The Local Plan identifies particular areas as suitable for housing, industry, retail and other uses and sets out the policies that the Council applies in deciding whether or not development will be permitted.

1.3.3 All adopted Local Plan policies were saved for three years when the Planning and Compulsory Purchase act 2004 was introduced. In September 2007 the secretary of state issued a direction to save a number of policies in the Local Plan beyond this three year period. The policies not listed in the Direction expired on the 27th September 2007. The expired policies included the policies in the Local Plan on flood risk.

1.3.4 The Local Plan included two policies, on the protection of floodplains and the design of flood alleviation measures. These policies both expired on the 27th September 2007. The first has expired as it repeats the national policy set out in PPS25 and delineates a floodplain on the Proposals Map which has since been updated by the Environment Agency's Floodplain maps. This study will provide a further update of the flooding zones, which will be used to inform development control and policy decisions. The second policy has expired as it is no longer necessary as the work it refers to is exempt.

The Emerging Local Development Framework

1.3.5 The Local Plan is in the process of being replaced by the Local Development Framework (LDF). The LDF will take the form of a portfolio of plans and documents made up of several Local Development Documents (LDDs). Some

LDDs will have a statutory status (Development Plan Documents, DPDs) and others will be adopted as local guidance documents. The documents deal with different issues or areas, and may be prepared at different times, but when taken together they will set out the Council's policies for how it will assess development proposals and direct future growth.

1.3.6 The LDF also includes a Statement of Community Involvement (SCI) that describes how a local planning authority intends to carry out its public consultation arrangements. The SCI and all other DPDs will be submitted to the Secretary of State. They will be subject to an independent examination that is led by a planning inspector.

1.3.7 The full Charnwood LDF will eventually comprise:

- Development Plan Documents (DPDs);
- Supplementary Planning Documents (SPDs);
- A Statement of Community Involvement (SCI);
- An Annual Monitoring Report (AMR);
- A Local Development Scheme (LDS).

Mineral and Waste Frameworks

1.3.8 Leicestershire County Council is responsible for the planning and provision for mineral extraction and waste services in Charnwood. The current strategies are set out in the Leicestershire Minerals Local Plan and the Leicestershire and Leicester and Rutland Waste Local Plan respectively. These documents will be replaced in 2008 by the Leicestershire Minerals Development Framework and the Leicestershire and Leicester Waste Development Framework which will cover the period until 2021.

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Appendix B
Flood Risk Vulnerability Classification

Table B1 PPS 25 Flood Risk Vulnerability Classification

Flood Risk Vulnerability Classification	Land Use
Essential infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk, and strategic utility infrastructure, including electricity generating power stations and grid and primary substations.
Highly vulnerable	• Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement Dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent.
More vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's' homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses, student halls of residence; drinking establishments; nightclubs and hotels. • Non-residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, **subject to a specific warning and evacuation plan.**
Less vulnerable	• Buildings used for: shops; financial, professional and other services; restaurants and cafes; hot food takeaways; offices; general industry; storage and distribution; non-residential institutions not included in 'more vulnerable'; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working) • Water treatment plants • Sewage treatment plants (if adequate pollution control measures are in place)

Table B1 (continued) PPS 25 Flood Risk Vulnerability Classification

Flood Risk Vulnerability Classification	Land Use
Water compatible development	Flood control infrastructure. Water transmission infrastructure and pumping stations. Sewage transmission infrastructure and pumping stations. Sand and gravel workings. Docks, marinas and wharves. Navigation facilities. MOD defence installations. Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. Water-based recreation and tourism (excluding sleeping accommodation). Lifeguard and coastguard stations. Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. Essential ancillary sleeping or residential accommodation for staff required by uses in this category, **subject to a specific warning and evacuation plan**.

Notes:

1. This classification is based partly on the Defra/Environment Agency research on Flood Risks to People (FD2321/TR2) and also on the need of some uses to keep functioning during flooding.

2. Buildings that combine a mixture of uses should be placed into the higher of the relevant classes of flood risk sensitivity. Developments that allow uses to be distributed over the site may fall within several classes of flood risk sensitivity.

3. The impact of a flood on the particular uses identified within this flood risk vulnerability classification will vary within each vulnerability class. Therefore, the flood risk management infrastructure and other risk mitigation measures needed to ensure the development is safe may differ between uses within a particular vulnerability classification.

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Appendix C
Charnwood SFRA - Flood Modelling, Mapping and Zoning

Charnwood SFRA – Modelling/Mapping and Flood Zoning

1. Supplied Data

1.1 Environment Agency

The Environment Agency supplied data on a DVD. The data supplied consisted of:

- Soar Strategy (Jacobs Babtie):
  - Soar Strategy Report A04.pdf (Jan 2006)
  - Technical Appendices inc. 'Appendix C (Hydrology & Hydraulics) A01.pdf' but no GIS data or Models supplied. Note for Halcrows 2007 study of the Wreake they state in Appendix A that the EA supplied to them 'The River Soar Strategy Report, associated model, survey data, hydrological data, and flood outlines prepared by BBR (2002 &2005).'
- Black Brook SFRM (Capita Symonds):
  - MD666 Black Brook SFRM.pdf (Dec 2006)
  - Technical Appendices inc. 'Appendix N - Design Return Period Flow Levels and Flows' (in MS Excel format); all Digital data inc. outlines for the 25yr 100yr and 100yr+20% CC events and; 'Appendix R - Model and Results files'
- Spreadsheets with level comparisons between models:
  - A comparison of Halcrows 1996 levels on the Soar, Wreake and Rothley Brook with Jacobs Babties 2006 levels.
  - A comparison of Babties 2006 levels on the Wreake with Halcrows 2007 levels.
- Flood Levels:
  - Autocad drawings of previous floods on the Soar and Wreake.
- Halcrow 1996 Soar/Rothley models:
  - Soar ISIS models and results for Q5, Q10, Q25, Q50, Q100 and Q150 design events and 1998 actual event.
  - Rothley Brook ISIS models and results for Q5, Q10, Q25, Q50, Q100 and Q150 design events.
  - Autocad drawings of outlines and cross section locations.
- Wreake SFRM study (Halcrow March 2007):

- FINAL REPORT_v1_5MAR07_v1.doc.
- Technical Appendices inc. GIS outlines for the Q100 defended and undefended design events.
- Model results for Q100 defended and undefended and Q100+20%CC defended and undefended.
- Models for defended and undefended scenarios with hydrology IED files for Q100 and Q200 events.
- DTM ‘photo_ldr3.asc’
- GIS files of river centreline, model nodes, reservoir units.
- Previous flood outlines (JBA and Babtie).
- OS mapping.
- Supplied data from previous studies including the latest Babtie Wreake model and Melton Mowbray FAS model.

1.2 Charnwood Borough Council

Four Infoworks RS models were supplied by the council.

- The Burleigh and Wood Brooks through Loughborough
- The Barkby Brook through Syston
- The River Soar at Loughborough
- Sileby Brook, Sileby

There is no associated report supplied with these models and a separate DTM has not been supplied for models. There is a ground elevation model data supplied within the Infoworks models; this is based on EA river cross sections and manhole cover level data. A Triangulated Irregular Network (TIN) technique is used to join these elevation points together into a DTM.

2. Gaps in the Data

2.1 Outlines

For the purposes of the SFRA outlines (and ideally additional information such as depth grids) are required for the 1% event, the 1%+climate change event and the 5% event (required to aid delineation of the functional floodplain as defined in PPS 25).

Where models exist we have identified gaps in the data where additional model runs are required (or supplied results need mapping) to produce required outlines.

Table 2.1 – Do we have existing outlines? Yes/No

	Model	5% Event	1% Event	1% Event +CC
	SOAR (Babtie latest model)	No	Yes (need mapping for DG)	No
	ROTHLEY (Babtie latest model)	No	Yes (need mapping for DG)	No
	WREAKE (Halcrow 2007 model)	No	Yes	No
	Loughborough (Infoworks)	Yes	Yes	Yes
	Syston (Infoworks)	Yes	Yes	Yes
	Soar (Infoworks)	Not required	Not required	Not required

DG = Depth Grid

3. Additional work undertaken

3.1 Wreake model

3.1.1 Background

The River Wreake model extends from Stapleford to its confluence with the River Soar. It was originally constructed using ONDA river modelling software in 1995 by Halcrow and was part of the Soar: Leicester to Kegworth and Rothley Brook model. It was later converted to ISIS in 1996. There are several existing recalibrated models of the River Wreake which have been developed and updated over time. JBA were commissioned to undertake recalibration of the Wreake model, which was completed in 1998. The model was then developed independently for two separate projects, (i) Soar Strategy by BBR (2002) and (ii) Melton Mowbray FAS (EA, 2003). The BBR River Soar Strategy was updated in January 2005.

The most up to date model of the Wreake is a 2007 ISIS model by Halcrow. This noted that the Babtie Soar Strategy had re-calibrated the model but had not updated the structures. However the Melton FAS model had updated the structures in the town of Melton Mowbray. Therefore the Halcrow model was decided to transfer the structures from the Melton model to the Soar model to give the final base model.

3.1.2 Model Runs

The model was supplied as two ISIS models representing the defended and undefended flood extents. The Brentingby online storage facility reduces flows downstream through Melton Mowbray down to the 20% (1 in 5 year flow) up to the 1% flood event, providing a significant reduction in flood extents. The reduction in flood extent remains notable in along the Wreake at Syston. IED hydrology files were supplied for the 1% and 0.5% events and results were supplied for the 1% and 1%+CC events.

It was therefore necessary to re-run the model for the 5% event. This was achieved by altering the flood return period entered in the FEH inflow boundaries and keeping the hydrograph scaling factors constant. This created a new IED file that could be used with the models.

The 5% event was run for both the defended and undefended scenarios and results were extracted for mapping.

3.1.3 Flood Mapping

The only outlines supplied were for the 1% defended and undefended scenarios. Therefore it was necessary to produce outlines for the 5% event and the 1%+CC event. As a by product of outline creation is a depth grid it was decided to also recreate the outlines for the 1% events to provide depth grids for use in the SFRA. This also enabled an additional check that could be made by comparing our 1% outlines to those generated by Halcrow to ensure that the flood mapping techniques were broadly consistent.

Therefore 6 outlines and associated depth grids were produced for the 3 design events (defended and undefended).

Outline creation requires DTM data and peak water levels at cross sections. The model node locations were supplied by Halcrow and cross sections (flood spreading sections) were digitised for each GIS model node and extended as far as high ground on either side of the channel using Flood Zone 2 as a guide. Maximum water levels extracted from the model/supplied by Halcrow were then attributed to these cross sections. The DTM was supplied by Halcrow as used for their flood mapping.

Mapinfo Professional V8.0 was then used to interpolate a water surface for each event. The DTM was then subtracted from this water surface to derive a depth grid. Finally the depth grid was contoured to remove areas of non-flooding leaving the flood outline.

3.2 Soar/Rothley Brook model

3.2.1 Background

The original River Soar model extended from Loughborough Road, Leicester to Kegworth Gauging Station and was constructed by Halcrow in 1995 using ONDA software. This model also included the River Wreake. This model was converted to ISIS in 1996 and comprises several complex weir structures, channel loops and a complex interaction between channel and floodplain flows.

The model was obtained by Babties for their Soar Strategy Study and after minor adjustments to the logical rules of certain sluice operations it was accepted for use.

Rothley Brook was originally modelled as a separate watercourse due to its relatively steep nature. It extended from the outlet at Thornton Reservoir to its confluence with the River Soar.

The Babtie study combined the Soar model (Leicester to Kegworth) with the Wreake model, the Rothley Brook model and a lower Soar model (Kegworth to the River Trent Confluence) to generate a combined Lower Soar Model. The benefits in doing this are that the combined mathematical model would be better suited to simulate the backwater effects in the vicinity of the confluences.

This combined Lower Soar Model represents the latest available model for the Soar and Rothley Brook. As the Wreake model has been more recently modelled by Halcrow the results of the Halcrow study are used for this river in the SFRA.

3.2.2 Model Runs

The only models supplied for the River Soar/Rothley Brook are ISIS models that use the old FSR hydrology found on the DVD at "Charnwood BC - SFRA - Modelling & Survey Data\Halcrow 1996 Modelling - Soar & Rothley Bk". It appears that these are the original Halcrow models from the 1996 study but have subsequently been updated by JBA in January

1999. One model includes the Soar from Leicester to Kegworth and the River Wreake. Rothley Brook is provided as a separate model with its outflow from the downstream end required as an inflow to the Soar/Wreake model. The Rothley Brook model was found to run but the Soar model does not, most likely due to compatibility issues with later versions of ISIS. These compatibility issues are further noted by Babties in their River Soar Strategy – Appendix C Hydraulic Modelling Report '*Since the majority of original models were constructed in versions 1.2 and 1.3 of ISIS and each new version is an improvement on the previous version, it was evident that there would be problems of compatibility in various areas of representation. For example for Version 2.2 or above, the logical rules used to define the movement of sluice gates had to be definite without any overlapping of commands. Consequently, some minor refinement of the control units, without changing the integrity of the unit was required for representations with earlier versions of ISIS*'.

In addition to refining the models for use with later versions of ISIS Babties also revisited the hydrology and updated the existing FSR hydrology with improved FEH techniques. According to the Babtie report design events ran included the 5% event, the 1% event the 0.5% event and the 1% event plus climate change. Results have been supplied in a spreadsheet for the 5%, 1% and 0.5% events for the Soar and Rothley Brook **but not for the 1% event plus climate change**. As the most recent model for the Soar/Rothley Brook is not available (at the moment) it is not possible to perform re-runs to obtain results for the 1% plus climate change event. A potential solution if the model is not found is to use the 0.5% event as a surrogate for the 1% plus climate change event (this was confirmed with the EA at the interim Charnwood SFRA meeting).

As models for Rothley Brook were not supplied from the most recent study and the original Rothley Brook model runs in the current version of ISIS it was decided to re-run this model to obtain results for the 1% event plus climate change. This involved scaling up the inflows by 20% following guidance in PPS 25 for a climate change allowance over the next 100 years. It should be quite clearly understood that the inflows use FSR data and this has now been superseded by FEH data. Nevertheless use of this model to derive levels for the 1% event plus 20% flow increase will allow for a useful comparison to levels/outlines produced for the 0.5% climate change surrogate event.

3.2.3 Use the 0.5% event to represent the 1% event plus climate change

The 0.5% event obviously represents a worse case than the 1% event and so could be considered as a 1% plus climate change event. However, it is important to get a feel for how the 0.5% event may compare against the 1% event with 20% extra flow which is used in common practise to represent an allowance for climate change.

As we have been supplied with the older Soar/Rothley Brook models there is the potential to run these for the 1% event with 20% additional flow. However, as mentioned above the Soar model does not run due to compatibility issues. This leaves the Rothley Brook model.

Initially an understanding of how levels have changed as a result of the updated hydrology/models is required. This has been provided for the 1% event on the supplied DVD at:

D:\Charnwood BC - SFRA - Modelling & Survey Data\Comparision Battie - Halcrow ModelsLower Soar Existing - Compare Babtie and Halcrows Models.xls

For Rothley Brook it can be seen that the average change in levels between the two models is 0.11m with the higher levels generally seen in updated model (FEH hydrology). It should be noted that the largest change in levels occurred at the downstream end of the model near the confluence with the River Soar. Here the difference in levels reaches a maximum of 0.67m.

For the Soar the average change in levels is an increase of 0.27m for the updated model with FEH hydrology over the older model with FSR hydrology. The largest change in levels occurred just upstream of the confluence with the Wreake where the maximum change in level was 0.98m (Section SA41).

A comparison of the Rothley Brook updated model 0.5% event with the older models 1% event +20% flows indicated that, on average, flows were 0.19m higher in the 1% +CC model although flows remain much higher for the 0.5% event for the downstream end of the model near the confluence with the Soar (see: Rothley final results for mapping.xls)

It can therefore be concluded that for Rothley Brook when the 0.5% event is used as a surrogate for the climate change event this may lead to an underestimation of flood levels. However it was also noted that when the levels are mapped even areas that exhibited the maximum change in levels did not produce too dissimilar outlines.

3.2.4 Flood Mapping

As mentioned in 3.2.2 without the latest Soar/Rothley Brook model from Babtie it has not been possible to perform any re-runs. However where existing results have been supplied for the Soar/Rothley Brook for the 5%, 1% and 0.5% events, these can be mapped to produce outlines and depth grids with the assumption that the 0.5% event can act as a surrogate for the 1% plus climate change event.

Additional mapping of the Rothley Brook 1% event plus climate change (old model) was undertaken for purposes of comparison to the 0.5% events.

The DTM used for mapping was that supplied with the Halcrow study of the Wreake (2007). This DTM is the original provided from Babties supplemented by additional survey, LiDAR and SAR. No GIS format data was supplied giving information on cross section/model node locations. Autocad drawings were located from the Halcrow 1996 study which showed the location of cross sections on the Soar and Rothley Brook. These were then translated into GIS format and cross section labels had to be manually attributed to the data reading information from the autocad drawings.

The outline creation process is the same as that outlined in 3.1.3. Outlines for the 1% event show a very good comparison to those provided from Babties study. It is noted that differences in levels seem to translate into very marginal increase in flood extent. The surrogate climate change event shows very little increase in extent over the 1% event. It is most likely that if the latest model results for the 1% event plus 20% increase in flows were mapped these would also show very minimal increases in extent.

3.3 Loughborough Infoworks model

The Loughborough Infoworks model was supplied by Charnwood Borough Council, no supporting reports were available with the model.

The model group is titled ‘Loughborough(Wood and Burleigh Brooks)’, and the submodel used for the runs is titled ‘WoodBrook’. The model is dated the 23rd of January 2006. Inflows and results files for the 1% event were supplied and as a check the models were re-run. The models ran but all were noted as having some minor instabilities. Checks on the flood graphs did show some minor spikes in the data none of which were deemed to be significant as they did not affect peak levels.

There was no data for the 5%, (20 year return period event) and the 1% (100 year event) plus 20% climate change. This data was obtained by altering the flood return period in the rainfall boundary section in the event file supplied, to either 20 years, or 120 in the case of the 1% event with 20% climate change. Both these events also showed signs of minor instabilities also.

3.4 Syston Infoworks model

The Syston Infoworks model was supplied by Charnwood Borough Council, no supporting reports were available with the model.

The model group is titled Syston, and the submodel used for the runs is titled 'existing 2003-rev1a. The model is dated the 22nd of December 2004.

It was supplied with the runs and data for a 1% event. These were rerun, the models ran but all were noted as having had instabilities. Checks on the flood graphs did show some minor spikes in the data none of which were deemed to be significant.

There was no data for the 5%, (20 year return period) event and the 1% (100 year) event plus 20% climate change. This data was obtained by altering the flood return period in the rainfall boundary section in the event file supplied, to either 20 years, or 120 in the case of the 1% event with 20% climate change. Both these events also showed signs of instabilities also.

4. Outstanding Data

4.1 Outstanding Data

The key areas identified as having limited information are:

- The Soar/Rothley Brook 1% event plus climate change
- Variability of ground elevation data in the Infoworks models ideally LiDAR data may be available in future.
- Documentation for the Infoworks models on data sources, degree of confidence in the model, and if there are any model audits.

Ideally results from Babties 1% + Climate Change run or the model itself would have been supplied. Nevertheless a surrogate climate change event using the 0.5% event has been used and this approach was seen as acceptable at the interim SFRA meeting.

Since the Infoworks models have limited accompanying information, they have been used in an 'as supplied' state to support the SFRA.

5. Creation of SFRA Flood Zoning

5.1 General Method

At the interim SFRA meeting on 29th June 2007 the creation of the SFRA output Flood Zone Maps for Charnwood was discussed and a way forward agreed. It was agreed that maps would be produced based on a combination of:

- Hydraulic Model Output;
- The EA Flood Map (JFLOW); and
- Historical Flood Outlines.

Digital outlines of these flood datasets were manipulated in a GIS to produce outputs for the SFRA, Table 5.1 details the sources of information from which the zoning was produced.

Table 5.1 – Sources of Information for Flood Zoning

Flood Zone	Zones combined in Production of SFRA Flood Zoning
3b (5% or greater)	Modelled FZ3b (5%)
3a (1% or greater)	Modelled FZ3a + EA FZ3 + Historical
3a (1% or greater)	Modelled FZ3a+20% CC + EA FZ3 + Historical
2	Existing JFLOW Flood Zone 2

As a general approach the modelled Flood Zones were tidied to remove any jagged boundaries, small isolated polygons within the zones were infilled and any hydraulically unconnected isolated polygons away from the main model output were removed. Overall it was found that only limited trimming and tiding of the zones was required.

The finished SFRA Flood Zones do not supersede the Environment Agency's Flood Zone Map, but should be used as an additional guide in triggering the requirement and setting the scope for a Flood Risk Assessment.

More detailed considerations relating to the different risk zones are given below.

5.2 Functional Floodplain (Flood Zone 3b)

For Charnwood the approach agreed with the Environment Agency was based on guidance set out within PPS 25 and the Practice Guide Companion.

PPS 25 Practice Guide Companion provides guidance as to how functional floodplain should be defined. The key points to note

- Where land would flood with an annual probability of 1 in 20 (5%) or at another probability to be agreed between the LPA and the Environment Agency
- Where land is *designed* to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and the EA – hence it should include any designated flood storage areas or conveyance routes
- Flood Zone 3b should not include areas which are prevented by flooding by existing infrastructure or buildings or by flood defences or other flood risk management measure
- It relates only to areas of fluvial (or coastal) flooding, not flooding from other sources

Based on the above principles it was agreed with the EA that in some areas the modelled FZ3b should be adjusted. In particular was trimmed to remove any urban areas where the watercourse is constrained by existing buildings /development.

In summary Flood Zone 3b has been defined as the floodplains of the Rivers Soar and Wreake and the Rothley and Black Brooks together with some small areas within Loughborough that are designed to flood. The extent is derived solely from the output of the hydraulic models for these rivers.

5.3 Zones 3a and 3a+Climate Change

Flood Zone 3a effectively triggers the need for flood risk assessment and therefore a precautionary approach has been agreed with the EA. Where there is doubt, land will be included in the zone rather than excluded. On this basis our general approach has been to define the Zone as the combined extents of the historic, JFLOW and 1% hydraulic model outputs.

In a similar way Flood Zone 3a + Climate Change was again defined by the addition of historic, JFLOW but with the 1%+CC hydraulic model output.

However there are some anomalous areas where the results of the modelling and/or JFLOW outlines are clearly questionable. In these cases we have reviewed the anomalous area and in most cases adjusted the boundary. These are described below.

5.4 Zone 3a and 3a+CC - Areas Removed from Modelled Outline

Two areas indicated as being flooded by the hydraulic model outputs were trimmed back. All these areas lie outside the boundary of the historical flood map and Area 1 is also located outside of Flood Zone 3 in the Environment Agency's flood zone map. These areas and the reasons for changing them are detailed below.

1 – Barrow-Upon-Soar – Two areas north and east of Town Centre

The projected flood levels for zones 3a and 3a+CC were trimmed since the railway embankment means that this area is not directly hydraulically connected to the River Soar at its nearest point to this area. The flood level elevation at the nearest point on the River Soar in direct hydraulic connectivity with this area of Loughborough was used to demarcate the flood zones in this area. This was found to give good agreement with the historical flood extent. This area is not indicated as being in the EA Flood Zone Map at present.

2 – Loughborough - Area between Burleigh Brook and Black Brook

The EA Flood Map is based on JFLOW modelling for this area. The lower length of the Burleigh Brook has not been picked up by the model, and instead flood water associated with the Burleigh Brook has been routed north to the Black Brook. LiDAR data is available for the Black Brook, approximately extending south to the watershed between the two brooks. Examination of the elevations within the LiDAR data showed that ground levels were all above the flood levels predicted for the Burleigh Brook using the Council's Infoworks model. Flood extents produced for the EA's Black Brook SFRM Study show that flooding from the Black Brook does not extend as far south as Burleigh Brook. Therefore for Flood Zone 3 there is no hydrological connectivity between the two watercourses.

The SFRA Flood Zones 3a and 3a+CC were produced by using the outline of the Black Brook SFRM flood zones and historical information as the new boundary along the Black Brook. Along the Burleigh Brook comparison of elevation data in the model with predicted flood levels was used to determine the extent of the flooding along the Burleigh Brook. Elevation data in the model showed the flood extent would extend approximately up to New Ashby Road, this was therefore used as the new boundary for the Burleigh Brook Flood Zones.

5.5 Key Areas added into the Flood Zones 3a and 3a+CC

The outputs of the hydraulic modelling were found to be in good agreement with the EA Flood Zone Map in most areas. Key discrepancies were:

1 – Loughborough – Three areas north and east of Town Centre

Area including the industrial estates north of Belton Road West Extension, the area west of Meadow Lane between Bottleacre Lane and the railway line and the southern part of Falcon Street and Morley Street were identified as being at risk of flooding. At present flood defences protect some of these areas (such as parts of the industrial estates in the north). The degree of protection (if any) provided by the railway embankments adjacent to this area is unclear. This area is not indicated as being in the EA Flood Zone Map at present

2 – Quorn – Area between the Poultney Brook and the River Soar

Projected flood levels indicated Quorn is potentially liable to flood but is protected by flood defences along the River Soar, Poultney Brook and Quorn Brook and the A6 embankment. This area is not indicated as being in the EA Flood Zone Map at present.

3 –Lower Wreake and the Soar in Charnwood Borough south of the Wreake confluence

The Flood outlines (3a and 3a+CC) based on hydraulic modelling were not as extensive as the historical or EA Flood Zone Map, in addition the ground elevation model included in the Soar and/or Wreake models does not extend into the area south of Syston Road, Cossington. The historical and EA Flood Zone Map outlines were therefore used to supplement model output boundaries.

4 – Rothley and Queniborough Brook

The extents of the Rothley and Queniborough Brook Flood Zone 3a and 3a+CC were extended using historical information.

5 – Black Brook

Information on the historical extent of flooding associated with the Black Brook was used to supplement Flood Zones 3a and 3a+CC. The historical flood extents include an additional area extending eastwards from the Black Brook (as it turns northwards in Thorpe Acre) towards the A6 and Willow Brook.

6 – River Soar between Loughborough and Hathern

The Environment Agency's Flood Zone Map and the output of the River Soar hydraulic model indicate flooding to be less extensive than the historical outline in this area. The historical extent was therefore used to supplement and extend Flood Zones 3a and 3a+CC in this area.

6. Hydraulic Model Results

Table 6.1 Water Levels from River Soar ISIS model

EASTING_1	NORTHING_1	Q20	Q100	Q200	Climate Change – increase in depth
459990	308650	50.17	50.39	50.49	0.10
459940	309150	49.69	49.85	49.94	0.10
460370	309380	49.59	49.68	49.76	0.07
460748	309369	49.46	49.51	49.57	0.06
460792	309422	49.46	49.51	49.57	0.06
460860	309484	49.46	49.51	49.57	0.06
460766	309408	49.02	49.29	49.47	0.18
460806	309578	49.00	49.28	49.47	0.18
460855	309658	48.98	49.26	49.45	0.19
460870	309920	48.95	49.24	49.43	0.19
460800	309960	48.58	48.94	49.23	0.29
460460	310280	48.45	48.89	49.20	0.31
460450	310600	48.38	48.85	49.18	0.32
460430	310780	48.33	48.82	49.15	0.33
460290	311050	48.13	48.74	49.10	0.36
460350	311410	48.07	48.71	49.08	0.37
460250	311470	48.06	48.70	49.07	0.37
460130	311810	48.02	48.68	49.06	0.38
459690	311980	47.98	48.67	49.05	0.38
459540	312380	47.96	48.65	49.04	0.38
459455	312788	47.96	48.65	49.04	0.38
459550	312800	47.86	48.47	48.80	0.32
459480	312990	46.83	47.34	47.70	0.35
459500	312614	46.63	46.98	47.19	0.20
459428	312736	46.62	46.97	47.17	0.20
459408	312992	46.57	46.91	47.12	0.21
459320	313350	46.57	46.91	47.12	0.21
459431	312940	46.56	46.89	47.09	0.19
459453	312916	46.56	46.89	47.09	0.19
459560	313760	45.86	46.02	46.10	0.09
459380	314700	45.58	45.65	45.70	0.05
459345	314685	45.58	45.65	45.70	0.05
459420	314250	45.55	45.59	45.62	0.02
459307	314902	45.07	45.33	45.51	0.18
459242	314625	45.05	45.32	45.50	0.18
459142	314728	44.66	44.91	45.07	0.17
459131	314794	44.55	44.83	45.00	0.17
459089	314770	44.52	44.82	45.00	0.19
458967	314869	44.44	44.77	44.96	0.20
458870	315080	44.44	44.77	44.96	0.20
458746	315465	44.39	44.70	44.89	0.19
458767	315507	44.39	44.70	44.89	0.19
458664	315659	44.38	44.70	44.89	0.19
458589	315722	44.38	44.70	44.89	0.19
458506	315869	44.38	44.69	44.89	0.19
458512	315961	44.38	44.69	44.88	0.19
458443	316026	44.37	44.69	44.88	0.19

EASTING_1	NORTHING_1	Q20	Q100	Q200	Climate Change – increase in depth
458404	316110	43.05	43.12	43.16	0.04
458326	316222	42.90	42.97	43.02	0.04
458297	316384	42.71	42.78	42.83	0.05
458380	316760	42.45	42.50	42.59	0.09
457915	316796	42.37	42.47	42.62	0.14
457812	316766	42.37	42.47	42.62	0.14
457750	316630	41.97	42.38	42.58	0.20
457400	316390	41.43	41.78	42.00	0.21
456930	316260	41.37	41.74	41.96	0.22
456580	316440	41.28	41.68	41.91	0.23
457720	316560	41.38	41.68	41.85	0.18
456640	316820	41.23	41.63	41.86	0.23
457030	317130	41.04	41.40	41.61	0.21
457250	317410	40.60	40.77	40.87	0.10
457104	317540	40.42	40.51	40.56	0.04
456956	317667	40.40	40.49	40.53	0.04
456826	317810	40.37	40.47	40.52	0.05
456678	317941	40.32	40.42	40.47	0.05
456511	318270	40.13	40.23	40.27	0.05
456451	318604	39.58	39.67	39.73	0.05
456308	318745	39.56	39.65	39.70	0.05
456235	318931	39.55	39.64	39.69	0.05
456546	318421	39.54	39.62	39.67	0.05
456225	319125	39.48	39.57	39.62	0.05
456149	319303	39.43	39.51	39.56	0.05
456026	319461	39.41	39.49	39.54	0.05
455880	319520	39.36	39.44	39.50	0.06
455778	319618	39.31	39.38	39.44	0.06
455702	319855	39.29	39.36	39.42	0.06
455599	320038	39.25	39.33	39.41	0.08
455347	320184	39.20	39.30	39.38	0.09
455269	320269	39.21	39.29	39.38	0.09
455336	320520	38.28	38.83	39.08	0.24
455271	320814	38.02	38.39	38.55	0.16
455118	320917	37.99	38.38	38.57	0.19
454993	320873	37.89	38.28	38.48	0.20
455084	320819	37.87	38.24	38.45	0.20
454877	321013	37.82	38.23	38.45	0.22
454627	321289	37.64	37.99	38.17	0.19
454823	321191	37.57	37.89	38.08	0.19
454506	321456	37.43	37.73	37.90	0.17
454200	321712	37.25	37.52	37.68	0.16
454054	321820	37.19	37.47	37.63	0.16
453957	321966	37.14	37.42	37.59	0.16
453842	322041	37.10	37.39	37.55	0.16
453649	322024	37.07	37.36	37.52	0.16
453135	322188	36.79	37.09	37.27	0.17
453033	322177	36.71	37.01	37.19	0.18
452788	322021	36.54	36.79	36.91	0.12
452603	321876	36.38	36.65	36.78	0.13
452438	321897	36.36	36.63	36.76	0.13
452311	321854	36.28	36.57	36.70	0.14
452180	321986	35.98	36.22	36.34	0.12
452044	322083	35.85	36.14	36.32	0.18
451944	322374	35.80	36.13	36.33	0.20
451978	322273	35.77	36.09	36.30	0.21
451933	322632	35.73	36.08	36.29	0.21
451890	322816	35.69	36.07	36.28	0.21
451750	322947	35.65	36.06	36.28	0.21
451594	323068	35.56	36.01	36.26	0.25
451184	323359	35.49	35.93	36.18	0.25
450958	323375	35.46	35.90	36.15	0.25
450813	323403	34.97	35.35	35.52	0.17
450494	323336	34.87	35.25	35.39	0.15
450669	323311	34.86	35.16	35.26	0.10
450646	323341	34.86	35.16	35.26	0.10
450205	323250	34.74	35.09	35.22	0.13
450108	323407	34.68	35.02	35.15	0.13
450373	323221	34.67	34.97	35.09	0.12
				Mean Depth Increase	0.17
				Maximum Depth Increase	0.38

Table 6.2 Water Levels from River Wreake ISIS model

X_1	Y_1	Q20	Q100	Q100rerun	Q100and20	DefQ20	DefQ100ori	DefQ100rer	DefQ100and	Climate Change – increase in depth With Brentingby	Climate Change – increase in depth Without Brentingby
466331	316135	57.11	57.47	57.47	57.68	56.89	57.14	57.14	57.30	0.16	0.20
466261	316046	57.02	57.43	57.43	57.64	56.75	57.06	57.06	57.24	0.18	0.21
465631	315709	55.51	55.99	55.99	56.09	55.34	55.53	55.53	55.71	0.18	0.09
465364	315647	55.49	55.99	55.99	56.08	55.30	55.51	55.51	55.70	0.19	0.09
465038	315690	55.43	55.99	55.99	56.07	55.14	55.46	55.46	55.69	0.23	0.09
465019	315650	55.41	55.98	55.98	56.07	55.10	55.44	55.44	55.68	0.24	0.09
465045	315402	55.33	55.94	55.94	56.03	54.96	55.36	55.36	55.62	0.26	0.09
464648	315328	54.68	55.28	55.28	55.38	54.48	54.69	54.69	54.80	0.10	0.11
464420	315172	54.66	55.12	55.12	55.24	54.33	54.68	54.68	54.84	0.16	0.13
464196	315025	54.61	55.09	55.09	55.22	54.31	54.63	54.63	54.80	0.17	0.13
464166	314904	54.56	55.05	55.05	55.19	54.24	54.58	54.58	54.75	0.18	0.13
464115	314736	53.17	53.56	53.56	53.75	52.97	53.23	53.23	53.37	0.14	0.19
463003	314121	52.66	53.28	53.28	53.64	52.14	52.66	52.66	52.92	0.27	0.37
463718	314507	52.57	53.06	53.06	53.36	52.41	52.58	52.58	52.78	0.19	0.30
463542	314109	52.51	53.05	53.05	53.33	52.12	52.51	52.51	52.75	0.24	0.29
463123	314129	52.64	53.05	53.05	53.33	52.13	52.63	52.63	52.83	0.20	0.29
463189	314191	52.51	53.02	53.02	53.32	52.11	52.51	52.51	52.73	0.22	0.30
462704	313774	51.83	52.21	52.21	52.41	51.55	51.85	51.85	52.04	0.19	0.21
462668	313290	51.34	51.80	51.80	52.03	51.09	51.46	51.46	51.70	0.24	0.24
462390	312719	51.16	51.78	51.78	52.07	50.88	51.43	51.43	51.76	0.32	0.29
462684	312991	51.08	51.57	51.57	51.83	50.90	51.29	51.29	51.55	0.27	0.26
462241	312923	50.80	51.28	51.28	51.63	50.61	50.98	50.98	51.26	0.28	0.35
461713	312679	50.35	51.07	51.07	51.46	50.00	50.68	50.68	51.05	0.37	0.39
461948	312879	50.39	50.96	50.96	51.29	50.23	50.65	50.65	50.94	0.30	0.33
461603	312571	49.81	50.26	50.26	50.52	49.61	50.00	50.00	50.26	0.25	0.27
461306	312246	49.39	49.72	49.72	49.97	49.25	49.52	49.52	49.75	0.23	0.26
461167	312119	48.86	49.09	49.09	49.35	48.72	48.94	48.93	49.10	0.16	0.26
461112	312111	48.81	48.97	48.97	49.08	48.71	48.83	48.83	48.96	0.13	0.11
460921	312192	48.71	48.77	48.77	48.82	48.68	48.70	48.70	48.71	0.01	0.05
									Mean Depth Change	0.21	0.21
									Maximum Depth Change	0.37	0.39

Table 6.3 Water Levels from Rothley Brook ISIS model

Easting_1	Northing_1	Q20	Q100	Q200	Q100_20	Depth increase due to climate change
454462.2	307419.3	64.63	64.76	64.82	65.31	0.56
454524.4	307492	64.44	64.55	64.61	65.11	0.55
454551.7	307580.6	64.36	64.46	64.52	65.00	0.53
454629.7	307666.2	64.19	64.31	64.36	64.83	0.53
454665.3	307724.5	64.05	64.16	64.21	64.65	0.49
454677.4	307759.3	63.92	64.03	64.09	64.53	0.50
454716.9	307720	63.81	63.92	63.97	64.42	0.51
454801.7	307764.6	63.62	63.74	63.80	64.29	0.55
454874.5	307758.6	63.46	63.60	63.66	64.19	0.59
454862.4	307809.3	63.37	63.51	63.58	64.13	0.62
454887.4	307855.5	63.32	63.46	63.53	64.09	0.63
454916.9	307910.8	63.23	63.36	63.43	63.97	0.61
454959.4	307971.4	63.17	63.30	63.37	63.92	0.62
455039.3	308045.4	63.14	63.26	63.33	63.89	0.63
455087.3	308079.5	63.12	63.25	63.32	63.89	0.64
455129.6	308101.4	62.15	62.42	62.51	62.98	0.56
455131.2	308211.1	62.13	62.39	62.50	62.97	0.58
455153.2	308302.1	62.11	62.38	62.49	62.96	0.58
455188.1	308402.8	62.06	62.35	62.46	62.94	0.59
455199.5	308476	61.86	62.21	62.34	62.89	0.67
455286.5	308518.2	61.37	61.51	61.56	61.81	0.30
455366.2	308558.8	61.26	61.39	61.45	61.68	0.29
455347.5	308649	61.03	61.17	61.24	61.50	0.33
455353.2	308718.1	60.83	60.98	61.06	61.38	0.39
455383.2	308761.1	60.74	60.91	60.99	61.33	0.42
455486.5	308763.6	60.70	60.86	60.95	61.30	0.44
455490.6	308795.3	60.64	60.81	60.90	61.27	0.46
455533.6	308807.4	60.59	60.78	60.87	61.25	0.48
455570.2	308858.6	60.54	60.73	60.84	61.23	0.49
455621.5	308884.6	60.51	60.71	60.82	61.22	0.51
455637.7	308945.6	60.08	60.21	60.26	60.45	0.25
455615.8	309029.3	59.93	60.04	60.10	60.29	0.25
455638.5	309096.7	59.77	59.90	59.96	60.16	0.27
455671	309160.9	59.70	59.83	59.89	60.10	0.27
455684.1	309222.6	59.64	59.77	59.84	60.05	0.28
455731.2	309285.2	59.49	59.63	59.69	59.90	0.27
455812.5	309295.7	59.42	59.56	59.63	59.83	0.27
455875.9	309275.4	59.30	59.44	59.51	59.72	0.28
455932.8	309342	59.05	59.24	59.33	59.56	0.33
455901.1	309379.4	58.99	59.18	59.27	59.52	0.34
455966.2	309407.9	58.88	59.10	59.21	59.47	0.37
456001.9	309440.4	58.78	59.03	59.14	59.43	0.40
455987.3	309503.7	58.75	59.00	59.12	59.41	0.41
455977.6	309576.8	58.72	58.99	59.11	59.40	0.41
456010.1	309619.9	58.71	58.98	59.10	59.39	0.41
456002.8	309689.8	58.70	58.97	59.09	59.38	0.41
456025.5	309776.7	58.69	58.96	59.09	59.38	0.41
456078.4	309832.8	57.98	58.36	58.46	58.76	0.40
456105.2	309900.2	58.07	58.34	58.46	58.74	0.40
456127.1	309964.4	57.73	57.99	58.09	58.35	0.36
456111.9	310042	57.35	57.61	57.70	57.90	0.29
456052.8	310098.7	57.29	57.42	57.49	57.63	0.20
456000.1	310097.1	57.16	57.30	57.37	57.50	0.20
455933.2	310089.2	56.88	57.01	57.08	57.23	0.22
455924.5	310185.2	56.74	56.87	56.94	57.10	0.23
455933.2	310256	56.58	56.72	56.79	56.98	0.26
455939.5	310333.9	56.43	56.60	56.68	56.88	0.29
455944.2	310426.7	56.34	56.53	56.63	56.83	0.31
455929.2	310516.4	56.25	56.46	56.57	56.79	0.33
455949.6	310565.8	56.01	56.16	56.24	56.39	0.23
455972.5	310649.3	55.91	56.07	56.16	56.32	0.25
456015	310699.7	55.82	55.99	56.07	56.24	0.25
456052.8	310724.9	55.76	55.93	56.02	56.19	0.26
456079.6	310768.9	55.65	55.83	55.92	56.10	0.27
456157.5	310759.5	55.59	55.77	55.86	56.04	0.27
456148.1	310819.3	55.43	55.63	55.73	55.92	0.29
456229.2	310796.4	55.37	55.58	55.67	55.87	0.29
456309.5	310844.4	55.30	55.50	55.60	55.80	0.30
456402.3	310821.6	55.26	55.46	55.57	55.76	0.30
456472.4	310856.2	55.22	55.43	55.53	55.73	0.30
456470	310911.3	54.91	55.11	55.21	55.39	0.28
456526.7	310945.9	54.88	55.08	55.17	55.35	0.28
456579.5	310992.3	54.73	54.93	55.02	55.21	0.28
456554.3	311113.5	54.38	54.60	54.69	54.88	0.28
456481.1	311154.4	54.30	54.52	54.61	54.81	0.29
456454.7	311220.7	54.07	54.21	54.22	54.34	0.13
456546.4	311330.6	53.43	53.81	53.90	54.11	0.30
456617.3	311328.2	53.33	53.64	53.77	54.01	0.37
456709.4	311360.5	53.34	53.61	53.74	53.99	0.38
456799.9	311354.2	52.97	53.16	53.27	53.47	0.31
456906.2	311438.4	52.86	53.08	53.20	53.42	0.34

Easting_1	Northing_1	Q20	Q100	Q200	Q100_20	Depth increase due to climate change
456928.2	311502.1	52.78	53.03	53.15	53.39	0.36
456949.5	311613.8	52.65	52.94	53.09	53.34	0.40
456985.7	311657.1	52.60	52.91	53.06	53.33	0.42
456962.1	311716.9	52.48	52.73	52.86	53.14	0.41
457018.7	311754.6	51.99	52.24	52.33	52.64	0.40
457121.1	311889.9	51.85	52.05	52.17	52.36	0.31
457161.2	311951.3	51.77	51.99	52.12	52.32	0.33
457229.7	312011.9	51.69	51.92	52.06	52.28	0.36
457261.2	312041	51.62	51.87	52.03	52.25	0.38
457103.8	311808.1	51.73	51.81	51.87	52.36	0.55
457305.3	312125.1	51.39	51.71	51.90	52.16	0.45
457404.5	312144.8	50.62	50.84	50.99	51.32	0.48
457541.4	312179.4	50.13	50.47	50.63	50.84	0.38
457477.6	312164.6	50.09	50.45	50.61	50.81	0.36
457630.4	312187.3	50.07	50.42	50.58	50.80	0.38
457708.3	312221.1	50.02	50.37	50.54	50.76	0.39
457766.6	312140.1	49.90	50.31	50.49	50.72	0.41
457851.9	312104.4	49.84	50.27	50.45	50.70	0.43
457950.2	312080.6	49.74	50.20	50.38	50.58	0.38
458008.3	312107.1	49.73	50.19	50.38	50.57	0.38
458061.8	312156.6	49.56	50.07	50.26	50.47	0.41
458129.5	312219.5	49.56	50.06	50.25	50.47	0.41
458160.8	312233.1	49.16	49.57	49.71	49.89	0.32
458246	312240	49.14	49.47	49.60	49.78	0.31
458274.3	312291.9	49.08	49.39	49.50	49.65	0.27
458337.3	312367.4	48.84	49.14	49.21	49.35	0.22
458407.4	312432	48.65	48.94	49.01	49.07	0.13
458463.3	312469.7	48.33	48.72	48.91	49.10	0.38
458508.9	312488.6	48.26	48.48	48.58	48.68	0.20
458557.7	312524	48.07	48.24	48.35	48.48	0.24
458621.5	312536.6	48.01	48.13	48.22	48.29	0.16
458731.7	312571.2	47.85	48.06	48.17	48.27	0.21
458745.1	312682.1	47.60	47.83	48.01	48.11	0.28
458725.4	312731.7	47.59	47.83	48.01	48.10	0.28
458787.6	312771.8	47.52	47.79	47.98	48.07	0.28
458714.4	312837.1	47.18	47.46	47.64	47.54	0.08
458675	312983.4	46.98	47.34	47.56	47.35	0.02
458663.2	313074.7	46.94	47.31	47.54	47.31	0.23
458697.1	313161.2	46.88	47.29	47.53	47.26	0.24
458730.9	313188.7	46.84	47.27	47.52	47.23	0.25
458771.9	313245.4	46.81	47.26	47.51	47.20	0.25
458786.8	313297.3	46.78	47.24	47.50	47.17	0.26
458859.2	313303.6	46.75	47.23	47.49	47.15	0.26
458917.5	313317	46.72	47.22	47.48	47.11	0.26
458976.5	313333.5	46.71	47.21	47.48	47.10	0.27
459027.4	313342.8	46.70	47.21	47.47	47.09	0.27
459063.3	313354.6	46.50	46.85	47.05	46.26	0.21
459163.9	313309.8	46.51	46.85	47.06	46.29	0.21
					Mean Depth Increase	0.36
					Maximum Depth Increase	0.67

Table 6.4 Water Levels from Black Brook ISIS model

Label	Max Stage	Max Stage	Depth increase due to climate change
BB-07038U	59.66	59.83	0.17
BB-07038IntD	59.49	59.57	0.08
BB-06963	59.08	59.15	0.07
BB-06888	58.68	58.74	0.06
BB-06813	58.28	58.33	0.05
BB-06737	57.89	57.94	0.05
BB-06661	57.47	57.50	0.04
BB-06585	57.12	57.15	0.03
BB-06513	56.87	56.89	0.02
BB-06441	56.65	56.66	0.01
BB-06369	56.43	56.44	0.01
BB-06297	56.23	56.23	0.01
BB-06224	56.04	56.04	0.00
BB-06151	55.86	55.87	0.00
BB-06076U	55.80	55.80	0.00
BB-06076IntD	55.53	55.53	0.00
BB-06002	55.31	55.31	0.00
BB-05927	55.12	55.12	0.00
BB-05825	54.91	54.91	0.00
BB-05723	54.77	54.78	0.00
BB-05621U	54.71	54.71	0.00
BB-05621IntD	54.69	54.69	0.00
BB-05599U	54.68	54.68	0.00
BB-05599D	54.68	54.68	0.00
BB-05570	54.67	54.68	0.00
BB-05541U	54.67	54.67	0.00
BB-05541IntD	54.67	54.67	0.00
BB-05517	54.66	54.66	0.00
BB-05471	54.66	54.66	0.00
BB-05471IntD	52.31	52.31	0.00
BB-05443IntU	52.29	52.29	0.00
BB-05443IntD	51.76	51.94	0.18
BB-05427	51.79	51.97	0.18
BB-05392	51.79	51.97	0.18
BB-05357	51.78	51.96	0.18
BB-05322	51.78	51.96	0.18
BB-05287U	51.78	51.96	0.18
BB-05287D	51.78	51.96	0.18
BB-05271U	51.72	51.91	0.19
BB-05271IntD	51.28	51.48	0.20
BB-05254	51.21	51.43	0.22
BB-05244U	51.15	51.39	0.23
B-05244U	51.15	51.39	0.23
BB-05244D	50.84	50.96	0.13
BB-07038FP	59.11	59.11	0.00
BB-06963FP	58.72	58.72	0.00
BB-06888FP	58.32	58.32	0.00
BB-06813FP	57.92	57.92	0.00
BB-06737FP	57.50	57.50	0.00
BB-06661FP	57.11	57.11	0.00
BB-06585FP	56.77	56.80	0.03
BB-06513FP	56.26	56.29	0.03
BB-06441FP	55.69	55.73	0.04
BB-06369FP	55.14	55.20	0.05
BB-06297FP	54.57	54.63	0.06
BB-06224FP	54.08	54.23	0.14
BB-06151FP	53.61	53.64	0.03
BB-06126	53.67	53.73	0.05
BB-06101	53.67	53.73	0.05
BB-GD-00U	52.10	52.20	0.09
BB-GD-00D	52.04	52.12	0.08
BB-DG-064IN	42.85	43.05	0.20
BB-01183AIN	38.05	38.21	0.16
BB-DG-040B	38.23	38.23	0.00
BB-DG-017FP	37.31	37.39	0.08
BB-04798U	49.30	49.34	0.04
BB-04741	49.10	49.14	0.04
BB-04684	48.91	48.95	0.04
BB-04627	48.72	48.76	0.05
BB-04570	48.54	48.59	0.05
BB-04513	48.38	48.43	0.06
BB-04456	48.25	48.31	0.06
BB-04399	48.15	48.21	0.06
BB-04342	48.06	48.12	0.06
BB-04285	47.99	48.03	0.05
BB-04228	47.82	47.87	0.05
BB-04158	47.57	47.62	0.05
BB-04088	47.32	47.38	0.06
BB-04018	47.06	47.13	0.08
BB-03948	46.79	46.88	0.09
BB-03878	46.53	46.63	0.10
BB-03808	46.30	46.40	0.09

Label	Max Stage	Max Stage	Depth increase due to climate change
BB-03737IntU	46.15	46.23	0.08
BB-03737IntD	45.86	46.09	0.23
BB-03680U	45.75	45.93	0.18
BB-03680D	45.67	45.78	0.10
BB-03630	45.53	45.64	0.11
BB-03580	45.39	45.49	0.10
BB-03530	45.25	45.35	0.10
BB-03480	45.11	45.20	0.09
BB-03430	44.96	45.05	0.09
BB-03380	44.82	44.90	0.08
BB-03330	44.68	44.76	0.08
BB-03280	44.55	44.63	0.08
BB-DG-075	44.42	44.50	0.08
BB-DG-074	44.39	44.46	0.07
BB-DG-073U	44.34	44.42	0.07
BB-DG-073D	44.05	44.18	0.13
BB-03177U	44.05	44.14	0.09
BB-DG-072D	43.91	43.96	0.05
BB-DG-071	43.71	43.81	0.10
BB-DG-070	43.51	43.63	0.12
BB-DG-069	43.24	43.36	0.12
BB-DG-068	42.95	43.07	0.13
BB-DG-067	42.76	42.93	0.18
BB-DG-066	42.76	42.93	0.18
BB-DG-065	42.87	43.06	0.20
BB-DG-064U	42.85	43.05	0.20
BB-DG-064D	42.85	43.05	0.20
BB-DG-063	42.85	43.05	0.21
BB-DG-062	42.85	43.05	0.21
BB-DG-061	42.84	43.05	0.21
BB-DG-060	42.77	42.98	0.21
BB-DG-059	42.65	42.86	0.21
BB-DG-058	42.63	42.86	0.22
BB-DG-057	42.63	42.85	0.22
BB-DG-056	42.53	42.77	0.24
BB-DG-055	42.38	42.69	0.31
BB-DG-054	42.26	42.64	0.38
BB-DG-053U	42.28	42.60	0.32
BB-DG-053D	42.13	42.33	0.20
BB-DG-052U	42.17	42.39	0.22
BB-DG-052D	42.07	42.21	0.14
BB-DG-051	42.05	42.20	0.14
BB-DG-050	41.91	42.05	0.14
BB-DG-049	41.68	41.82	0.14
BB-DG-048U	41.64	41.77	0.13
BB-DG-048D	41.64	41.77	0.13
BB-DG-047	41.51	41.65	0.14
BB-DG-046	41.43	41.57	0.14
BB-DG-045	41.37	41.51	0.14
BB-DG-044	41.06	41.20	0.14
BB-DG-043	40.83	40.96	0.13
BB-DG-042U	40.69	40.82	0.13
BB-DG-042D	40.69	40.82	0.13
BB-DG-041	40.53	40.65	0.12
BB-DG-040A	40.19	40.32	0.13
BB-DG-039A	39.88	40.02	0.13
BB-DG-038A	39.84	39.98	0.14
BB-DG-037A	39.83	39.96	0.13
BB-DG-036A	39.79	39.92	0.13
BB-01628A	39.50	39.63	0.14
BB-01618A	39.43	39.56	0.14
BB-DG-032A	39.41	39.54	0.13
BB-DG-031A	39.35	39.48	0.13
BB-01518A	38.97	39.08	0.12
BB-01410A	38.46	38.59	0.13
BB-01319A	38.23	38.40	0.16
BB-DG-025A	38.21	38.38	0.16
BB-DG-024A	38.22	38.38	0.16
BB-01183AU	38.05	38.21	0.16
BB-01183AD	38.05	38.21	0.16
BB-01125A	37.76	37.91	0.15
BB-01105A	37.59	37.75	0.16
BB-DG-019A	37.58	37.73	0.15
BB-DG-018AU	37.62	37.79	0.17
BB-DG-018AD	37.56	37.69	0.13
BB-01055A	37.44	37.50	0.07
BB-DG-017	37.44	37.50	0.07
BB-DG-016	37.29	37.36	0.07
BB-DG-015U	37.21	37.24	0.03
BB-DG-015D	37.21	37.24	0.03
BB-DG-014	37.26	37.32	0.06
BB-DG-013	37.23	37.30	0.07
BB-DG-012	36.91	36.96	0.05
BB-DG-011	36.80	36.85	0.04
BB-DG-010U	36.71	36.74	0.03

Label	Max Stage	Max Stage	Depth increase due to climate change
BB-DG-010D	36.70	36.73	0.03
BB-DG-009	36.60	36.64	0.04
BB-DG-008	36.44	36.50	0.06
BB-DG-007	36.14	36.18	0.03
BB-DG-006	36.18	36.23	0.05
BB-DG-005D	36.12	36.16	0.03
BB-DG-004	36.05	36.07	0.02
BB-DG-003	35.99	36.00	0.01
BB-DG-002	35.95	35.96	0.01
BB-DG-001	35.92	35.92	0.00
BB-DG-039B	38.16	38.16	0.00
BB-DG-038B	38.16	38.16	0.00
BB-DG-038DB	38.16	38.16	0.00
BB-DG-037UB	38.16	38.16	0.00
BB-DG-037B	38.16	38.16	0.00
BB-DG-036B	38.15	38.15	0.00
BB-01628B	37.85	37.85	0.00
BB-01618B	37.84	37.84	0.00
BB-01618DB	37.84	37.84	0.00
BB-DG-031UB	37.79	37.79	0.00
BB-DG-031B	37.78	37.78	0.00
BB-01518B	37.55	37.57	0.02
BB-01410B	37.44	37.50	0.07
BB-01319B	37.44	37.50	0.07
BB-01319DB	37.44	37.50	0.07
BB-DG-024UB	37.44	37.50	0.07
BB-DG-024B	37.44	37.50	0.07
BB-01183B	37.44	37.50	0.07
BB-01125B	37.44	37.50	0.07
BB-01125DB	37.44	37.50	0.07
BB-01099UB	37.44	37.50	0.07
BB-01099B	37.44	37.50	0.07
BB-01055B	37.44	37.50	0.07
BB-DG-015DFP	37.26	37.33	0.07
BB-DG-014FP	37.21	37.28	0.07
BB-DG-013FP	37.14	37.20	0.06
BB-DG-012FP	37.01	37.05	0.05
BB-DG-011FP	36.80	36.84	0.05
BB-DG-010DFP	36.65	36.70	0.04
BB-DG-009FP	36.52	36.57	0.05
BB-DG-008FP	36.42	36.48	0.06
BB-DG-007FP	36.14	36.19	0.05
BB-DG-006FP	35.79	35.81	0.03
BB-DG-005DFP	35.71	35.73	0.02
BB-DG-004FP	35.68	35.70	0.02
BB-DG-003FP	35.67	35.68	0.01
BB-DG-002FP	35.66	35.67	0.01
BB-DG-001FP	35.65	35.65	0.00
		Mean Depth Increase	0.10
		Maximum Depth Increase	0.38

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Appendix D
Sewer and Highways Flooding Records

Table D.1 Sewer Flooding Records (Severn Trent Water)

Brook Street	Shepshed	LE12 9RF	Q-933-02
Brook Street	Shepshed	LE12 9RF	Q-933-02
Countryman Way	Shepshed	LE12 9RA	Q-933-02
Field Avenue	Shepshed	LE12 9SH	Q-933-02
Glenmore Avenue	Shepshed	LE12 9LQ	Q-933-02
Lacey Court	Shepshed		Q-933-02
Loughborough Road	Shepshed	LE12 9DN	Q-933-02
Newark Close	Shepshed	LE12 9PJ	Q-933-02
Nursery Close	Shepshed	LE12 9SN	Q-933-02
Nursery Close	Shepshed	LE12 9SN	Q-933-02
Nursery Close	Shepshed	LE12 9FN	Q-933-02
Nursery Close	Shepshed	LE12 9SN	Q-933-02
Nursery Close	Shepshed	LE12 9SN	Q-933-02
Nursery Close	Shepshed	LE12 9SN	Q-933-02
Nursery Road	Shepshed	LE12 9SN	Q-933-02
The Meadows	Shepshed	LE12 9QN	Q-933-02
Althorpe Drive	Loughborough	LE11 4QT	Q-933-01
Baxter Gate	Loughborough	LE11 1TH	Q-933-01
Benscliffe Drive/Highfields	Loughborough		Q-933-01
Bramcote Road	Loughborough	LE11 2SA	Q-933-01
Brookfield Avenue	Loughborough	LE11 3LN	Q-933-01
Castledine Street Extension	Loughborough	LE11 2NT	Q-933-01
Castledine Street Extension	Loughborough	LE11 2NT	Q-933-01
Frederick Street	Loughborough	LE11 3BJ	Q-933-01
Frederick Street	Loughborough	LE11 3BJ	Q-933-01
Garendon Green	Loughborough	LE11 4QA	Q-933-01
Griggs Road	Loughborough	LE11 2LL	Q-933-01
Griggs Road	Loughborough	LE11 2LL	Q-933-01
Kenilworth Avenue	Loughborough	LE11 4SL	Q-933-01
Maxwell Drive	Loughborough	LE11 4RZ	Q-933-01
Middleton Place	Loughborough	LE11 2BY	Q-933-01
Nanpanton Road	Loughborough	LE11 3SU	Q-933-01
Nanpanton Road	Loughborough	LE11 3ST	Q-933-01
Outwoods Drive	Loughborough	LE11 3LU	Q-933-01
Park Road	Loughborough	LE11 2HG	Q-933-01
Park Road/Parklands Drive	Loughborough	LE11 2HF	Q-933-01
Rosebery Street	Loughborough	LE11 5DX	Q-933-01
Shelthorpe Road	Loughborough	LE11 2PE	Q-933-01
Shelthorpe Road	Loughborough	LE11 2PE	Q-933-01
Thirlmere Drive	Loughborough	LE11 3SY	Q-933-01
Thorpe Hill	Loughborough	LE11 4SQ	Q-933-01
Tiverton Road	Loughborough	LE11 2RZ	Q-933-01
Tiverton Road	Loughborough	LE11 2RZ	Q-933-01
Toothill Road	Loughborough	LE11 1PW	Q-933-01
Valley Road	Loughborough	LE11 3PX	Q-933-01
Valley Road	Loughborough	LE11 3PX	Q-933-01
Wharncliffe Road	Loughborough	LE11 1SN	Q-933-01
Melton Road	Thurmaston	LE4 8EE	Q-933-04
Mill Lane	Thurmaston	LE4 8AF	Q-933-04

Hill Rise	Birstall	LE4 4LH	Q-933-03
Roman Road	Birstall	LE4 4BA	Q-933-03
Roman Road	Birstall	LE4 4BA	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Saltersgate Drive	Birstall	LE4 3FE	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Saltersgate Drive	Birstall	LE4 3FG	Q-933-03
Stonehill Avenue	Birstall	LE4 4JA	Q-933-03
Wanlip Lane	Birstall	LE4 4GP	Q-933-03

Highway Flooding Locations Charnwood District

Leicester County Council Highways division have made the following information available with regards to highways in Charnwood. The following roads, (generally along the River Soar and River Wreake floodplains) are at times of flood covered by regular flood patrols:

- Mountsorrel – Slash Lane;
- Mountsorrel Sileby Road;
- Mountsorrel A6 Slip Road South;
- Mountsorrel Granite Way;
- Thrussington Rearsby Road;
- Rearsby Brookside;
- Rothley Cossington Lane;
- East Goscote Broome Lane;
- Thurcaston Mill Road;
- Wymeswold Brook Street; and
- Thurmaston Churchill Road.

Roads that flooded during the extreme rainfall in summer 2006/2007 included:

- Birstall Greengate Lane area;
- Loughborough Valley Road area;
- Loughborough Park Road area;

- Syston Fosse Way;
- Syston High Street;
- Woodhouse School Lane;
- Thurmaston Melton Road/Manor Road Junction;
- Barkby Thorpe Lane; and
- Swithland Main Street (Brook overflow onto highway).

Creating the environment for business

Appendix E
Existing Flood Defences (abstract from EA NFCDD)

Appendix E Existing Flood Defences in Charnwood (abstracts from the Environment Agency National Fluvial and Coastal Defence Database)

Maintainer	Asset Description	Asset Location	Asset Length	Defence Type	Design Standard	Bank	Watercourse Reference	Year Built	Flood Map Ind	Grid Reference
EA	FLOODBANK	ZOUCH	57.5	minor	10	left	River Soar	1993	considered and rejected	SK5062923292
EA	FLOODBANK	ZOUCH	264.2	minor	10	left	River Soar	1993	considered and rejected	SK5062923292
EA	FLOODBANK	ZOUCH	114	minor	10	left	River Soar	1993	considered and rejected	SK5087223373
EA	FLOODBANK	ZOUCH	435.2	minor	10	left	River Soar	1993	considered and rejected	SK5020323215
EA	FLOOD BANK	NORMANTON ON SOAR	2055.5	minor	10	left	River Soar	1994	not yet considered	SK5098123365
EA	HUMP IN ROAD - NORMANTON TO STANFORD ROAD	STANFORD ON SOAR	15.8			right	River Soar		not yet considered	SK5442321788
EA	FLOODWALL	BISHOP MEADOW	626.7	minor	10	left	River Soar	1994	not yet considered	SK5289421493
EA	FLOOD BANK	Bishop Meadow Bridge	310.2	minor	10	left	River Soar	1994	not yet considered	SK5240021759
EA	FLOODBANK	NORMANTON	906.9	minor	10	right	River Soar	1994	not yet considered	SK5231421876
EA	FLOODBANK	COTES	1644.8	minor	10	left	River Soar	1994	considered and rejected	SK5442521504
EA	Flood wall	Weir Lower Mill cottages Nottingham Road left bank on River Soar	65.5	major	10	left	River Soar		not yet considered	SK5536520667
EA	FLOODBANK	COTES	227.9	minor	10	right	River Soar	1994	considered and rejected	SK5543720600
EA	FLOODBANK	COTES	248.5	minor	10	left	River Soar	1994	considered and rejected	SK5535720604
EA	FLOODBANK	COTES	119.5	minor	10	left	River Soar	1994	considered and rejected	SK5522620405
EA	FLOODBANK	COTES	109.3	minor	10	right	River Soar	1994	considered and rejected	SK5533820417
EA	FLOODBANK	COTES	1053	minor	10	left	River Soar	1994	considered and rejected	SK5526920298
EA	FLOODBANK	COTES	989.6	minor	10	right	River Soar	1994	considered and rejected	SK5532120311
EA	FLOOD BANK	WALTON BROOK	676.3	minor	10	right	River Soar	1997	not yet considered	SK5572019984
EA	FLOOD BANK		151.4	minor	10	right	River Soar	1997	not yet considered	SK5545720117
EA	FLOODBANK	LOUGHBOROUGH	188	minor	10	left	River Soar	1994	considered and	SK5582819495

Maintainer	Asset Description	Asset Location	Asset Length	Defence Type	Design Standard	Bank	Watercourse Reference	Year Built	Flood Map Ind	Grid Reference
		MOORS							rejected	
EA	FLOODBANK	LOUGHBOROUGH MOORS	708.5	minor	10	left	River Soar	1994	considered and rejected	SK5601319430
EA	FLOODBANK	LOUGHBOROUGH MOORS	1238.4	minor	10	right	River Soar	1994	considered and rejected	SK5586919558
EA	FLOODBANK	QUORN	1058.2		10	left	River Soar	1996	considered and rejected	SK5651818214
EA	FLOODBANK	QUORN	206.1		10	left	River Soar	1996	considered and rejected	SK5715417490
EA	WALL	QUORN	59.5		10	left	River Soar	1996	considered and rejected	SK5723817364
EA	FLOODBANK	QUORN	429.1		10	left	River Soar	1996	considered and rejected	SK5719717324
EA	WALL	QUORN	613.8		100	left	River Soar	1996	considered and accepted	SK5684017092
EA	WALL	QUORN	72.6		100	left	River Soar	1996	considered and accepted	SK5649016661
EA	FLOODWALL	THURMASTON	43.3	major	100	right	River Soar	2005	considered and accepted	SK6094409417
EA	FLOODBANK	THURMASTON GARAGE TO BUSINESS PARK	370.9	major	100	right	River Soar	2002	considered and accepted	SK6094309413
EA	BRIDGE BUSINESS PRK FLOODWALL	THURMASTON	296.8	major	100	right	River Soar	2002	considered and accepted	SK6074909218
EA	FLOODBANK SOAR CONFL TO FOOTBRIDGE	CONFL TO FOOTBRIDGE	351.3		100	left	Black Brook		considered and accepted	SK5203822017
private	HIGH GROUND	D/S A6	124.7		100	right	Black Brook		considered and accepted	SK5181721172
EA	FLOODBANK	A6 TO PIPE CROSSING	1126.6	major	100	left	Black Brook	1979	considered and accepted	SK5175521041
EA	FLOODBANK	A6 TO PIPE CROSSING	1162.7	major	100	right	Black Brook	1979	considered and accepted	SK5177221036
EA	FLOODBANK	D/S STONEBOW BRIDGE	240.9	major	100	left	Black Brook	1979	considered and accepted	SK5123820327
EA	FLOODBANK	Dishley	820.1	major	100	left	Black Brook	1979	considered and accepted	SK5101420361
EA	FLOODBANK	BUCKINGHAM DRIVE	590.5	major	100	right	Black Brook	1979	considered and accepted	SK5124120310

Maintainer	Asset Description	Asset Location	Asset Length	Defence Type	Design Standard	Bank	Watercourse Reference	Year Built	Flood Map Ind	Grid Reference
private	HIGH GROUND D/S OF TIP SITE	D/S TIP SITE	177.3		100	left	Hermitage Brook		considered and accepted	SK5449320574
EA	FLOODBANK	D/S A60	909.7	minor	10	right	Hermitage Brook	1994	considered and rejected	SK5440021495
EA	FLOODBANK and FLOOD ARCHES		249.7	minor	10	right	Hermitage Brook	1994	not yet considered	SK5455320584
private	HIGH GROUND D/S TIP SITE	D/S TIP SITE	60.9		100	left	Hermitage Brook		considered and accepted	SK5446020370
EA	FLOODBANK	U/S TIP SITE, dismantled railway near Falcon Street	283		100	left	Hermitage Brook		considered and accepted	SK5435320003
EA	FLOODBANK	'THE WOODIES'	78		100	left	Rothley Brook	1982	considered and accepted	SK5853012550
private	FLOODBANK	D/S HALLFIELDS LANE	80		100	right	Rothley Brook	1982	considered and accepted	SK5862012540
EA	FLOODWALL TIE INTO RD BRIDGE	TOWN GREEN STREET	5		100	left	Rothley Brook	1982	considered and accepted	SK5845012490
EA	FLOODBANK	HALLFIELDS LN TO TOWN GREEN ST TRACK	355		100	left	Rothley Brook	1982	considered and accepted	SK5845012490
EA	FLOODBANK	PARALELL TO HALLFIELDS LANE	130		100	right	Rothley Brook	1982	considered and accepted	SK5850012550
EA	FLOODWALL/ TOWN GREEN FLOOD DEFENCES	78-76 TOWN GREEN ST, ROTHLEY	53.7		100	left	Rothley Brook	1982	considered and accepted	SK5816012250
EA	FLOODWALL	FLOODWALL IN PRIVATE GARDEN	41		100	left	Rothley Brook	1982	considered and accepted	SK5817012240
EA	FLOODBANK (Protects road but no properties)	BROOME LANE	175.4		100	left	River Wreake		considered and accepted	SK6351214084
EA	FLOODBANK	D/S STAFFORD LODGE	115.3		100	left	Quorn Brook	1996	considered and accepted	SK5647016591
EA	FLOODWALL	STAFFORD LODGE	36		100	left	Quorn Brook		considered and accepted	SK5649016500
EA	FLOODBANK	D/S SCHOOL LANE	47.5		100	left	Quorn Brook		considered and accepted	SK5644816489
EA	FLOODWALL	QUORN COUNTRY HOTEL	103	major	100	right	Quorn Brook		considered and accepted	SK5651316385
EA	FLOODBANK	QUORN COUNTRY	123.7		100	right	Quorn Brook		considered and	SK5650116455

Maintainer	Asset Description	Asset Location	Asset Length	Defence Type	Design Standard	Bank	Watercourse Reference	Year Built	Flood Map Ind	Grid Reference
		HOTEL							accepted	
private	HIGH GROUND	SCHOOL LANE PARK	138.9		100	left	Quorn Brook		considered and accepted	SK5638016510
EA	floodwall	SCHOOL LANE	73			left	Quorn Brook		not yet considered	SK5624316537
EA	FLOODWALL	D/S WRIGHTS MILL	34.6		100	left	Quorn Brook		considered and accepted	SK5620216466
EA	FLOODWALL	QUORN MILLS	59.8		100	right	Quorn Brook		considered and accepted	SK5638016500
private	HIGH GROUND	QUORN MILLS	71.5		100	right	Quorn Brook		considered and accepted	SK5632016500
EA	FLOODWALL	QUORN MILLS	20.1		100	right	Quorn Brook		considered and accepted	SK5624916503
EA	FLOODWALL	D/S WRIGHTS MILL	33.7		100	right	Quorn Brook		considered and accepted	SK5621316466
EA	FLOODWALL	QUORN MEMORIAL	78.5		100	left	Quorn Brook		considered and accepted	SK5617216425
EA	FLOODWALL	MEETING STREET	1		100	left	Quorn Brook		considered and accepted	SK5613016400
EA	FLOODWALL	MEETING STREET	120.7		100	left	Quorn Brook		considered and accepted	SK5611316383
EA	FLOODWALL	MEETING STREET	148.6		100	left	Quorn Brook		considered and accepted	SK5605316327
EA	FLOODWALL	HALL LEYS	112.7		100	right	Quorn Brook		considered and accepted	SK5619316419
EA	FLOOD BANK	BILAMORIS FLOOD BANK	67		100	right	Quorn Brook		considered and accepted	SK5617616326
EA	Railway embankment	Between railway bridges	353	minor		left	Barkby Brook		not yet considered	SK6197011739
EA	Raised wall	Saunders Road	83.7	minor		left	Poultney Brook		not yet considered	SK5600716304
EA	Railway embankment.	Brook Street, Sileby.	197.9	major		left	Sileby Brook		not yet considered	SK6029415106
EA	Embankment.	Heathcote Drive, Sileby.	93.4	major		left	Sileby Brook		not yet considered	SK6098015585
EA	Railway embankment.	Brook Street, Sileby.	182	major		right	Sileby Brook		not yet considered	SK6029415106
EA	Embankment.	Sileby Memorial Park.	103.5	major		right	Sileby Brook		not yet considered	SK6059415357
EA	Embankment.	Haybrooke Road, Sileby.	114	major		right	Sileby Brook		not yet considered	SK6071615465
EA	Embankment.	Gibson Road, Sileby.	62.6	major		right	Sileby Brook		not yet considered	SK6081115443
EA	Embankment.	Gibson Road, Sileby.	298.5	major		right	Sileby Brook		not yet considered	SK6078415468
EA	FLOODBANK		848.1	minor	10	left	River Soar	1994	not yet considered	SK5231021551

Maintainer	Asset Description	Asset Location	Asset Length	Defence Type	Design Standard	Bank	Watercourse Reference	Year Built	Flood Map Ind	Grid Reference
EA	Wall.	U/S of the GUC.	124.2	minor		left	Burleigh Brook		not yet considered	SK5301220297
EA	Wall.	Edward Street, Loughborough.	124.9	minor		right	Burleigh Brook		not yet considered	SK5301720295
private	Rail embankment.	Barrow on Soar.	76.7	minor		left	Fishpool Brook		not yet considered	SK5810917075
EA	Embankment.	Melton Road FSA.	132.5	minor		left	Fishpool Brook		not yet considered	SK5818017442
private	Flood wall.	38 Sileby Road.	24.9	minor		right	Fishpool Brook	1998	not yet considered	SK5804116977
private	Rail embankment.	Barrow on Soar.	87.7			right	Fishpool Brook		not yet considered	SK5810917075
private	Bank defence.	U/S of Melton Road.	84.7	minor		right	Fishpool Brook		not yet considered	SK5817517438

Blank spaces indicate no data was available in NFCDD
Shaded cells highlight defences providing the 1% SoP